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Expanded nuclear power capacity in Europe, impact of uranium mining and alternatives

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Abstract

The nuclear industry has recently undergone what the nuclear lobby called a 'nuclear renaissance', with several countries planning to construct or constructing new plants or prolonging the life of existing reactors. However, this 'nuclear renaissance' has encountered difficulties in Europe: new reactors currently under construction in Finland and France have been delayed and are running over-budget, while in Germany, Belgium, Switzerland and Italy nuclear energy expansion has been put on hold in the aftermath of the Fukushima accident. In the present report we explore the situation in Bulgaria and Slovenia. For both countries nuclear energy is an important part of the national energy mix and both have plans for new nuclear power plants (NPPs).

We closely analyse the history and present situation of nuclear energy in these countries and the internal debate that has evolved in relation to the construction of new plants. Despite many particularities, there are common traits that are also shared in the rest of Europe, notably, the debate over whether to maintain and/or increase a powerful and relatively autonomous source of energy in the face of the high costs of construction and environmental and health risks nuclear energy and radiation entail. The report describes the expansion of nuclear energy – two new planned power plants in Bulgaria and the prolongation of one plant and the construction of a second one in Slovenia. First an overview of the energy mix in both countries is offered. Then a chronology of the nuclear projects is outlined, highlighting the main risks and problems, including social and environmental issues. This overview concludes with an analysis of the cost and benefits of the planned power plants. We also look at the often forgotten first stage of nuclear energy production: uranium mining. We describe the current status and main problems of the closed mines of Bulgaria and Slovenia. Then we analyse alternatives to nuclear projects by focusing on different energy scenarios. With the objective of envisioning a sustainable energy future, we analyse the costs and benefits, and thus the potential for Renewable Energy Sources (RES) as an alternative to NPP expansion.

Keywords

nuclear power

uranium mining

nuclear renaissance

Bulgaria

public participation

energy mix

scenarios

Slovenia

Contents

Acronyms

ASE Atomstroyexport JSC
ASUNE Act on Safe Use of Nuclear Energy
AS GAS Additional gas scenario
AS NS Additional nuclear scenario
BAS Bulgarian Academy of Science
BEH EAD Bulgarian Energy Holding
BGN Bulgarian national currency "Lev" (1EUR = 1,956 BGN fixed rate)
BS Basic scenario
CHP Combined heat and power
CSO Civil society organizations
CEE Central and Eastern Europe
CRIIRAD Commission for Independent Research and Information about RADiation
CZK Czech Crone
EBRD European Bank for Reconstruction and Development
EC European Commission
EEB European Environmental Bureau
EIA Environmental Impact Assessment
EIB European Investment Bank
EJO Environmental justice organizations
ELES Elektro Slovenija
EMI Energy Management Institute
ESO Electricity System Operator (ESO EAD)
ETS Emissions trading scheme
EU European Union
G20 Group of Twenty Finance Ministers and Central Bank Governors
GAS Gas scenario
GDP Gross domestic product
GHG Greenhouse gas
GSPP Gas and steam power plants
HEP Hrvatska elektroprivreda
HPP Hydro power plant
HSE Holding slovenske elektrarne
IAEA International Atomic Energy Agency
ICRP International Commission on Radiological Protection
IME Institute for Market Economics (Bulgaria)
INT Intensive strategy
LIBOR London Interbank Offered Rate
LILW Low and intermediate level waste
MC Republic of Bulgaria's Ministerial Council
MEET Ministry of Economy, Energy and Tourism
Mtoe Million tonnes of oil equivalent
MW Mega watt
NEC or NEK National Electricity Company ("Nacionalna Elektricheska Kompania") (Bulgaria)
NEK Nuklearna elektrarna Krško (NPP Krško)
NEP National Energy Program
NERA NERA Economic Consulting
NGO Non-governmental organisation
NPP Nuclear power plant
NPPK Nuclear Power Plant Krško
NPPK2 Nuclear power plant Krško, second reactor
NRA Nuclear Regulatory Agency
NRC Nuclear Regulatory Commission
NS Nuclear scenario
NSI National Statistical Institute
PLEX Plant Life Extension
PSR Periodic Safety Review
PV Photovoltaic
PWR Pressurised water reactor
REF Reference strategy
ReNEP Resolution on the National Environmental Action Plan for 2010
RES Renewable energy sources
REV 1-5 TEŠ6 Investment program, revisions 1-5
RZV Rudnik Žirovski vrh (uranium mine Žirovski vrh)
SDS Special drawing rights
SEWRC State Energy and Water Regulatory Commission (Bulgaria)
SFR Spent fuel repository
SNSA Slovenian Nuclear Safety Administration
TEŠ6 Thermal power plant Šoštanj, block 6
TPP Thermal power plant
TWh Terra watt hours
USA United States of America
US NRC US Administration for Nuclear Safety
ZEG Zveza ekoloških gibanj (Association of ecological movements)

Foreword

Conflicts over resource extraction or waste disposal increase in number as the world economy uses more materials and energy. Civil society organizations (CSOs) active in Environmental Justice issues focus on the link between the need for environmental security and the defence of basic human rights.

The EJOLT project (*Environmental Justice Organizations, Liabilities and Trade*, www.ejolt.org) is an FP7 Science in Society project that runs from 2011 to 2015. EJOLT brings together a consortium of 23 academic and civil society organizations across a range of fields to promote collaboration and mutual learning among stakeholders who research or use Sustainability Sciences, particularly on aspects of Ecological Distribution. One main goal is to empower environmental justice organizations (EJOs), and the communities they support that receive an unfair share of environmental burdens to defend or reclaim their rights. This will be done through a process of two-way knowledge transfer, encouraging participatory action research and the transfer of methodologies with which EJOs, communities and citizen movements can monitor and describe the state of their environment, and document its degradation, learning from other experiences and from academic research how to argue in order to avoid the growth of environmental liabilities or ecological debts. Thus EJOLT will increase EJOs' capacity in using scientific concepts and methods for the quantification of environmental and health impacts, increasing their knowledge of environmental risks and of legal mechanisms of redress. On the other hand, EJOLT will greatly enrich research in the Sustainability Sciences through mobilising the accumulated 'activist knowledge' of the EJOs and making it available to the sustainability research community. Finally, EJOLT will help translate the findings of this mutual learning process into the policy arena, supporting the further development of evidence-based decision making and broadening its information base. We focus on the use of concepts such as ecological debt, environmental liabilities and ecologically unequal exchange, in science and in environmental activism and policy-making.

The overall **aim** of EJOLT is to improve policy responses to and support collaborative research on environmental conflicts through capacity building of environmental justice groups and multi-stakeholder problem solving. A key aspect is to show the links between increased metabolism of the economy (in terms of energy and materials), and resource extraction and waste disposal conflicts so as to answer the driving questions, such as 'Which are the causes of increasing ecological distribution conflicts at different scales, and how to turn such conflicts into forces for environmental sustainability?'.

In a bid to reduce carbon emissions, some European countries are increasing their use/production of nuclear energy. However, what the nuclear energy industry and European citizens often overlook is that nuclear reactors are just one part of the nuclear chain. EJOLT will contribute to an improved understanding among European citizens and policy-makers about the impacts of nuclear power production using a cradle to grave analysis, from the extraction of uranium, to the operation of the plants to the disposal of toxic nuclear waste.

To establish the place of nuclear energy in the overall energy picture of Bulgaria and Slovenia, as well as to build awareness of the complete nuclear cycle, this report examines the history and present situation of nuclear energy in these countries as well as debates that are emerging in relation to the construction of new plants. The report looks at three cases of nuclear energy expansion, two in Bulgaria and one in Slovenia. It describes the current status of closed uranium mines and the legacy of negative impacts that has lasted for decades since the end of mining activities. It also looks into alternatives to nuclear based electricity generation: energy efficiency and use of renewable sources of energy.

The report concludes that both in the case of Bulgaria and Slovenia the assessments of energy needs have been exaggerated, and the full costs of new NPPs have been underestimated or poorly defined due to differences in opinion with regard to what costs should be included. In addition, the environmental risks are not fully accounted for. There are still numerous serious issues open, such as the issue of liability (liability for nuclear damage covers less than 1% of the total costs of the damage in the case of an accident of the size of Chernobyl or Fukushima) or long-term storage of radioactive waste (no permanent solutions are available, not only in Bulgaria and Slovenia, but also elsewhere in the world). On the matter of whether sufficient potential for RES exists in Bulgaria and Slovenia to avoid the construction of new nuclear capacities, this report has shown not only that such potential is available, but economically justified and needs less risk capital.

Claims that RES are more expensive than energy from existing fossil fuel capacities, are only valid if one disregards the ecological price of the pollution caused by the latter, and the fact that investments made in fossil fuel production with public money in socialist times remain unpaid. What is clear is that a more ecologically friendly energy future is not just possible, but already evolving as the RES share increases. However, it is important to remember that RES is no ‘silver bullet’, and sometimes leads to environmental conflicts, especially when projects (such as hydropower) are situated in ecologically sensitive areas such as NATURA 2000 zones.

1 Introduction

The use of nuclear energy has changed since its inception. It was initially developed for military use with the creation of the atomic bomb in 1940s. Later on, with the development in the 1960s of nuclear power plants (NPPs) for electricity generation it was mostly used for civilian purposes. The industry underwent a 'bust' during the late 1980s and 90s after the Chernobyl and Three Mile Island NPPs accidents. More recently however it has undergone what the nuclear lobby has called a 'nuclear renaissance', with several countries (mostly in Asia but a few in Europe) planning to construct or constructing new plants (World Nuclear Association, 2011a).

At present the largest producer and promoter of nuclear energy in Europe is France, with 58 reactors and over 75% of its electricity being provided by nuclear (World Nuclear Association, 2013a). But France is not alone. Nuclear generates about 30% of the electricity produced in the EU, and for countries like Belgium and Slovenia it is even more significant, with around 55% of its energy coming from nuclear (ENS, 2013).

According to the World Nuclear Association (2013a), fifteen countries in the European Union have 132 NPPs: Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. While some reactors are being decommissioned, others are having their working lives extended, and some new units as shown in the cases presented in this report are planned or under construction. In addition to power reactors, a full range of fuel cycle plants (from enrichment to waste storage and reprocessing) are in operation in Europe. It is the responsibility of each EU Member State to decide on its preferred choice of energy mix (ENS, 2013, World Nuclear Association, 2013a).

The 'nuclear renaissance' has encountered difficulties in Europe, making it difficult to increase or even maintain the existing number of NPPs

The 'nuclear renaissance' has encountered difficulties in Europe, making it difficult to increase or even maintain the existing number of NPPs (Schneider et al., 2011). New reactors currently under construction in Finland and France were meant to lead this European renaissance. However these projects have been delayed and are running over-budget. The 2011 Japanese Fukushima nuclear accident further altered the course of nuclear energy expansion, with Germany being the first country to halt construction of new NPPs. As anti-nuclear demonstrations intensified, the German government decided to shut down eight reactors immediately (August 6th, 2011) and to have the other nine taken off the grid by the end of 2022. Renewable energy will be pushed instead. Switzerland has abandoned plans to replace its outdated nuclear reactors and will take the last one offline in 2034. Italy voted in a country-wide referendum to keep their country non-nuclear whilst Spain banned the construction of new reactors. Other countries with ageing reactors, notably the UK and France, are also seeing increased civil opposition (Schneider et al., 2011). In contrast, enthusiasm for new facilities for nuclear power production has not faded in many other countries outside Europe. The majority of new construction is taking place in China, India and Russia (New Scientist, 2013) and a new market for NPPs seems to be developing countries in the near east and Eastern Europe.

Italy voted in a country-wide referendum to keep their country non-nuclear whilst Spain banned the construction of new reactors

Other countries with ageing reactors, notably the UK and France, are also seeing increased civil opposition

In the present report we explore the situation in Bulgaria and Slovenia. For both countries nuclear energy is an important part of their energy mix and as such, both have plans for new NPPs. We closely analyse the history and present situation of nuclear energy in these countries and the debates emerging in response to the construction of new plants. The Bulgarian section of the report situates nuclear power vis-à-vis renewable sources of energy. The Slovenian analysis adds coal as an energy path, not because the analyses show that it is a sustainable option but because a new coal power plant is currently under construction. Comparing the three energy paths we observe that the Slovenian energy sector has failed to see the best way forward. Despite many particularities, there are common traits across European energy debates, opposing viewpoints with regard to maintaining and/or increasing a powerful and relatively autonomous source of energy vs. the high costs of construction and environmental and health risks nuclear energy and radiation entail.

1.1 Uranium mining, the origin of nuclear power[1]

The ’nuclear renaissance’ translated into increased uranium exploration efforts, which soared between 2003 and 2009. During this period 400 exploration companies formed or changed their orientation to raise USD 2 billion for uranium exploration.

The global metabolism of nuclear energy can be conceptualised in terms of a commodity chain, starting with exploration and extraction and ending with consumption and disposal. Uranium-235 (^{235}U), the isotope required for the production of a fission chain reaction, is constituted of less than 1% of natural uranium (IAEA, 2009).

The first step for obtaining ^{235}U is the mining of economically viable ores. Traditionally this has been done with either open-pits or underground mines. The ore extracted is crushed, ground, and milled to obtain yellow cake powder. The yellow cake is then transported via truck, train or ship to a processing facility, where it is transformed into Uranium Hexafluoride and enriched to the desired proportion of ^{235}U. It is then turned into a hard ceramic oxide (UO_2) for assembly into rods specifically designed for each type of reactor. The rest of the material,

[1] This section partially reproduces contents from Conde and Kallis (2012), with permission.

At each step of the nuclear chain, including the transportation of yellow cake, enriched uranium or spent fuel, radiation poses health risks for employees and local communities

mostly U238, is called depleted uranium, and can be used with reprocessed plutonium extracted from nuclear waste to produce MOX fuel, an alternative nuclear fuel. France enriches most of the uranium in Europe together with the Netherlands, United Kingdom and Germany. Uranium fuel rods are then transported to the various NPPs. Russia is one of the key players in the nuclear industry, building nuclear units and providing the fuel for them, especially in Eastern Europe. After the nuclear fuel has spent about three years in a reactor to produce electricity, the used fuel may go into temporary storage or reprocessing. At present there are no disposal facilities (as opposed to storage facilities) in operation into which used fuel, not destined for reprocessing, can be placed (World Nuclear Association, 2011b; IAEA, 2009).

At each step of the nuclear chain, including the transportation of yellow cake, enriched uranium or spent fuel, radiation poses health risks for employees and local communities (see, for example, Rashad and Hammad, 2011). When considering the entire nuclear production chain, uranium mining is the often forgotten first step. Its risks to health and biodiversity are not as grave as those of radiation leakage from a melting nuclear reactor, but they too can be grave (Chareyron, 2008; IEER, 2006; ECRR, 2003).

Given the low concentration of uranium in natural ore, considerable quantities of residues are produced during extraction and processing, including heavy metals and radioactive decayed elements. Such residues, contained in ponds or dams near the mill, can leach into underground and surface water sources. Worse still, they can escape into the environment if dams break. Decades after the shutdown of uranium mines and mills, the radioactive contamination of the environment will remain. This is due to the fact that they contain radioactive metals from the uranium decay chain that are not extracted in the milling process. Thorium 230 and radium 226 for instance have half-lifes of 75,000 years and 1,600 years respectively (Chareyron, 2008).

Most of the radiation typically emitted in a mining site is considered low level radiation (<100 millisieverts-mSv). The health impacts of ionizing radiation even at low doses include the increase of various types of cancers, genomic instability, life-shortening, and negative impacts on all the body functions (Chareyron, 2008). The National Research Council in the US (IEER, 2006) reminds us that although cancer risk is expected to decline along with declining dose rates, "*it is unlikely that there is a threshold below which cancers are not induced*"'.

External irradiation (beta and gamma) as well as internal radiation resulting from the inhalation of radon gas, radioactive dust and contaminated water and food, constitute major hazards in and around uranium mines. Many epidemiological studies carried out, notably on former workers of the Wismut mine that operated until 1990 in East Germany, have shown links between exposure and diseases such as bronchial and lung cancer (Kreuzer et al., 2010).

Uranium mining was developed in Europe for the most part after the end of WWII. Although East Germany, Czechoslovakia and France were the largest producers, many countries in Eastern Europe, under the instigation of the Soviet Union, carried out uranium mining at one point, including Hungary, Bulgaria, Poland, Rumania, Ukraine, Russia, Slovenia.

Currently the only mines in operation in the EU are in the Czech Republic and Romania. All other uranium mines were closed as production moved to countries with larger deposits like Canada or Australia, or where it would be easier to mine because of weak environmental legislation or governance structures, for example, Kazakhstan, Niger or Namibia (Conde and Kallis, 2012). However with the steep rise in uranium prices between 2004 and 2007, companies renewed their interest in opening uranium mines in Europe. Several exploration companies began to examine potential deposits in Portugal, Italy, Spain or Finland (Wallner and Stein, 2012).

This report analyses the past and present of uranium mining in Bulgaria and Slovenia to exemplify the role this industry has had and the impacts that are still being generated even decades after the closure of mines.

The health impacts of ionizing radiation even at low doses include the increase of various types of cancers, genomic instability, life-shortening, and negative impacts on all the body functions

1.2 Short overview of the report

This report provides an overview of the expansion of nuclear energy in Europe with a focus on Bulgaria and Slovenia. It looks into the economics of nuclear power, and analyses the impacts of uranium mining as well as alternatives to nuclear power in the two countries.

Chapter 2 covers Bulgaria, starting with an overview of the energy situation in the country. It goes on to describe two cases of nuclear energy expansion in Bulgaria: the new site of Belene NPP, and Kozloduy 7, a new unit on the existing Kozloduy NPP site. A chronology of the projects is presented, outlining the main risks and problems, including social and environmental issues. Further on, an analysis of the costs and benefits of Belene NPP is elaborated. The chapter also describes the involvement of the public in discussions about the new NPPs. To demonstrate the potential impact of the entire nuclear chain, the chapter gives an overview of the current status of closed uranium mines in Bulgaria. The chapter concludes with a discussion of alternatives to nuclear energy, whereby a full analysis of the potential for renewable energy sources in Bulgaria is provided.

Similarly, **Chapter 3**, which covers Slovenia, provides a description of the national energy situation and presents two nuclear cases – the prolonging of the lifespan of the currently operating Krško NPP, and the concurrent construction of a new block called Krško II. The chapter presents a chronology of events and outlines the main risks and problems. To illustrate the problems that uranium mining has caused in Slovenia, the chapter examines a closed uranium mine, Žirovski vrh. The chapter concludes with a discussion about alternatives to nuclear energy in Slovenia.

2 Expansion of nuclear energy in Europe

The case of Bulgaria

2.1 Overview of the energy situation in Bulgaria, perspectives and the role of nuclear energy

2.1.1 Energy situation in Bulgaria

Bulgarian electricity system has a significant overcapacity, as a result of exports falling by 40% in the first quarter of 2013.
Meanwhile 61% of the Bulgarian population lives in 'energy poverty'

Drawing from independent reports produced by the World Bank and the European Commission, the Bulgarian Energy Minister in a speech on May 29, 2013 warned, *"if Bulgaria does not reduce its power capacity, it will continue having an excess of electricity production in the next 15 years, which will be the reason for the financial deficit in Bulgarian energy system"* (Stambolski, 2013).

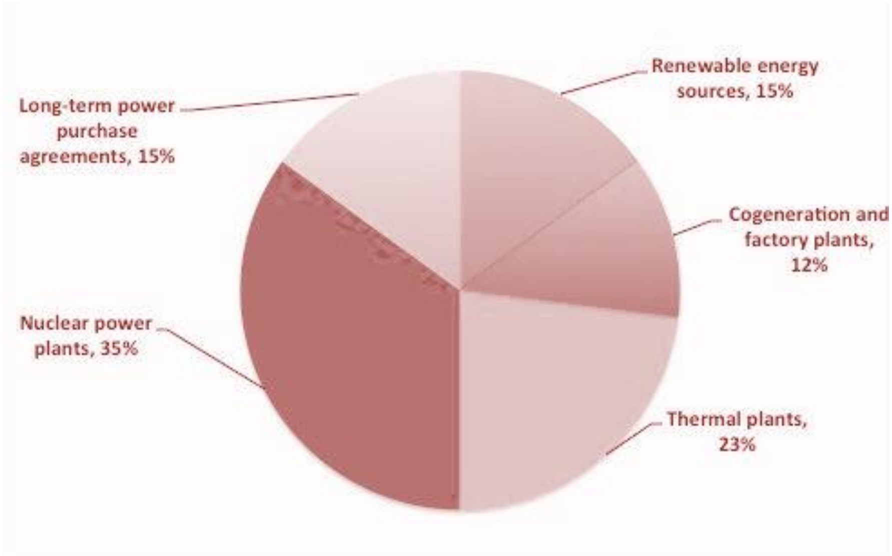
The report of the Commission found that the Bulgarian electricity system has a significant overcapacity, as a result of exports falling by 40% in the first quarter of 2013, and a decrease in domestic consumption. This trend would seem to be structural since there is such high potential for substantial efficiency improvements and low cost electricity generation in neighbouring countries in the future. The report further states that 61% of the Bulgarian population lives in 'energy poverty', spending over 9% of monthly revenues on energy bills (European Commission, 2013).

Thermal power plants, where lignite and brown coal make up 90% of thermal production, represent 23% of the generative capacity in Bulgaria. Renewable Energy Sources (RES) comprise up to 15% of all energy generation, while nuclear energy sources (from the two unites in Kozloduy NPP site) represent the highest proportion, with 35% (**Figure 1**).

Fig. 1

Structure of energy generation in 2012 (TWh), Bulgaria

Source: World Bank, May 2013



The transmission network of the country is comprised of the following transmission lines - 400 kV (2451 km), 220kV (2805 km) and 110kV (9 954 km) (**Fig. 2**).

Fig. 2

Interconnectors scheme of Bulgaria and neighbouring countries

Source: State Energy and Water Regulatory Commission (SEWRC) Bulgaria

With a rate of imported energy sources at 71 – 72% (see Appendix 1, Kovatchev 2012), Bulgaria is the most energy dependent country in Europe. However, this fact has not featured in the public discourse of the last two governments in Bulgaria. Both the tripartite coalition government (2005-2009), as well and the GERB government (2009-2013) have consistently claimed a much lower rate of energy dependence of 46.6%, a figure based on a Eurostat methodology that views nuclear energy as an indigenous energy source. Moreover, the government claims that Bulgaria's energy dependence will increase to a maximum of 48% by 2020, implying (contrary to reality) that Bulgaria is already, and will remain, one of the most energy-independent countries in Europe.

With a rate of imported energy sources at 71 – 72%, Bulgaria is the most energy dependent country in Europe

Unfortunately, this is not a misprint. Eurostat statistics and its Bulgarian source,

It is hard to understand why imported oil and gas is clearly regarded as imported energy while imported uranium is regarded as a domestic source of energy

the National Statistical Institute (NSI), do in fact consider nuclear energy an indigenous energy source. It is hard to understand why imported oil and gas is clearly regarded as imported energy while imported uranium is regarded as a domestic source of energy. This is especially the case as after it has been burnt in Russian designed and built nuclear reactors, the nuclear fuel imported from Russia is returned there for reprocessing, before the highly active waste is returned to Bulgaria for long-term storage. In this way Bulgaria is completely dependent, not only on the import of uranium fuel, but also on the whole fuel cycle and Russian nuclear technology.

2.1.2 Stakeholders and players

According to the two reports published in May by the World Bank and the European Commission, there seems to be very little public trust in the different players of the energy system in Bulgaria. This is due to suspicion over corrupt practices and a lack of independence among the different institutions, especially those related to energy regulation (World Bank, 2013, European Commission, 2013).

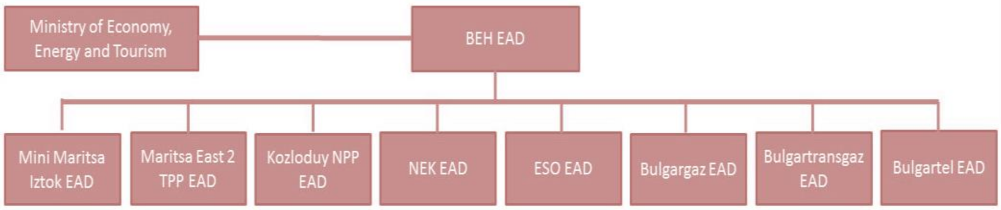


Fig. 3

Structure of state-owned Bulgarian energy holdings – BEH EAD

Source: BEH, 2013, http://www.bgenh.com/en/index.php

The most significant player in the Bulgarian electricity market is the state-owned Bulgarian Energy Holding (BEH EAD) (**Fig. 3**). It owns the only NPP in the country - Kozloduy NPP, a major lignite-fired power plant, Maritza East II, and the main national hydro producer and electricity wholesaler, the National Electricity Company (NEK EAD). The BEH group produces around 60% of the total electricity output of Bulgaria. Six other producers operate medium to large thermal power plants.

The Bulgarian state electricity company NEK owns a significant part of the productive market and the transmission network. In January 2007, the Electricity System Operator (ESO EAD), a daughter company of NEK, was established as a system operator. ESO EAD is responsible for the functioning of the transmission network and the organisation of the balancing energy market. It has a separate accounting system from NEK, an independent legal statute and a Council of Directors. These measures were undertaken in order to follow EC rules calling for the unbundling of transmission networks from those of production.

It seems unlikely that Bulgarian efforts to unbundle production from supply have been effective, as confirmed by a EC report released in May 2013. On the contrary, some European institutions claim that independent producers of RES lack equal access to the electricity network. However, there is insufficient evidence to prove these claims.

2.1.3 Nuclear energy and the long-term vision of the energy sector

Research has shown that in the period 2003 – 2005 the energy demand in Bulgaria was exaggerated, thus justifying the construction of a new nuclear power plant (NPP) – the Belene NPP. Evidence of this exaggeration is found in more recent assessments, including the analysis of the current study, proving a different reality.

In the period 2003 – 2005 the energy demand in Bulgaria was exaggerated, thus justifying the construction of a new nuclear power plant

With a 5.6 annual growth rate of the GDP for the period 2001-2008 (World Economic Situation and Prospects 2010) the energy consumption has not increased. The projections of the Ministry of Economy, Energy and Tourism (MEET) coincided with those of the Bulgarian Academy of Science (BAS). The traditionally higher projections of the NEK than those of the BAS and MEET are attributable to a need to justify its investment policy (**Table 1**).

Table 1

Projections for energy consumption for 2020 in TWh

Source: Za Zemiata, Bulgaria

Ministry of Economy, Energy and Tourism (MEET)	Bulgarian Academy of Science (BAS)	NEK
39,3 TWh	39,3 TWh	42,09 TWh

Speculation on electricity prices has been used by the strong powerful national nuclear lobby to promote the construction of an abandoned NPP near the town of Belene, on the Romanian border, as well the extension of the existing power plant, the Kozloduy 7 (**Fig. 4**).

Fig. 4

Map of Bulgaria with the sites of the existing Kozloduy NPP and the planned Belene NPP project

Source: own elaboration using http://en.wikipedia.Bulgaria_location_map.svg

Bulgaria's first commercial nuclear power reactor began operating in 1974 and developed over the years into six functioning units at the Kozloduy NPP site, near the Danube bordering Romania. The pressurized water reactors are of Russian design with total electricity generation capacity of 3,760 MW. During European Union (EU) accession negotiations with the EC, Bulgaria committed to closing Kozloduy Units 1 and 2 by the end of 2002 and Units 3 and 4 by the end of 2006.

All four units were V-230 model VVER-440 reactors, which the EC had earlier classified as non-upgradeable. However, units 3 and 4 were of an improved design and closer to the later V-213 design than any others of their class (World Nuclear Association, 2013). Since the beginning of 2007, only the VVER-1000 units have remained operational and thus the Kozloduy NPP annual share in the overall national electricity generation for that year was 34%, remaining the largest electricity generating plant in the country (Kozloduy NPP official website, 2013).

Reactor	Type	Model	Net MWe	First power	30-year life to
Kozloduy 5	VVER-1000	V-320	953	11/87	2017
Kozloduy 6	VVER-1000	V-320	953	8/91	2019
Total (2)			**1906**		

Table 2

Operating nuclear power reactors in Bulgaria

Source: World Nuclear Association, 2013

At present, Bulgaria continues to operate two nuclear reactors, generating about 35% of its electricity (for 2012) (see **Table 2**). As cited by the World Nuclear Organisation, the government commitment to the future of nuclear energy is strong, although no finance has been secured.

There have been different options considered – with construction started only to be abandoned for various reasons. There are three possible scenarios for expansion of the nuclear capacities in Bulgaria – the construction of a new nuclear power plant - Belene NPP project near the Danube river, an expansion of the Kozloduy NPP site with a new unit Kozloduy 7 of 1000 MW, and/or reopening the closed 3 and 4 units (see **Table 3**).

Reactor	Type	Model	Net MWe	Construction start	Startup
Belene 1	VVER-1000 (AES-92)	V-466	1000	cancelled	-
Belene 2	VVER-1000 (AES-92)	V-466	1000	cancelled	-
Kozloduy 7	VVER-1000 (AES-92) or western PWR	V-466B or AP1000	1000 or 1200	2014?	2022
Total planned (1)			1000 or 1200		

Table 3

Planned and proposed nuclear power reactors in Bulgaria

Source: World Nuclear Association, 2013

Box 1 Energy-related myths in energy policy in Bulgaria: What should be known if new nuclear capacities are built?

Source: Based on the work of Kovatchev (2013)

As in the past, certain political parties and media have been, and continue to monger myths about values and indicators that are far from reality and from development goals. Institutes and non-governmental NGOs have developed a counter-argumentation of five myths that have been presented over the years to the Bulgarian society.

Myth 1: Bulgaria is an energy centre of the Balkans. Much has been written about the resource and financial absurdity of this myth. Unfortunately, the current energy strategy again leaves space for extensive development in the energy field and allows for the construction of new electric power plants for electricity export. The construction of new electric power plants in Bulgaria uses: a) imported capital that must be returned with an interest; b) imported equipment and technologies the repair and upgrade of which are part of the subscription package, as they are unique for each producer and are not replaceable without compromising security. It is c) followed by an uninterrupted import of fuel, the processing of which, releases harmful emissions; and d) the storage of high-level radioactive waste in the case of NPP. Given that the electricity buyer is unknown and does not take any physical or financial risks, means that Bulgaria is to take only the negative consequences, while others will get the benefits.

Myth 2: Bulgaria's energy intensity is 89% below that of the EU. This myth, repeatedly appearing in energy strategies of the last decade, threatens to push energy efficiency out of the priority list. EU sustainable development indicators measure energy intensity in reference to real gross domestic product. According to Eurostat on EU member-states' intensity for 2008 Bulgaria's energy intensity is 5.65 times greater than the average for EU-27 and 6.29 times greater than the average for EU-15.

Myth 3: The cheapest electricity comes from NPP. This myth is the key argument for those who propose new nuclear capacities, guided by foreign corporate interests. It must be emphasised that nuclear power plants are some of the most capital-intensive energy technologies and the investment comprises about 80% of the cost price of the electricity generated by such power plants. According to data from the working group on NPP Belene at the Great National Assembly (Appendix 1 to Chapter 1 of the 'White book' by the Bulgarian Academy of Sciences), the investments for units 1-4 of NPP Kozloduy amount to 140 EUR/KW, while units 5-6 of the same NPP cost 1103 EUR/KW. The capital investment necessary for the two 1000 KW units of the planned NPP Belene, exclusive of the price for necessary reserve capacities, is EUR 10.23 billion, that is approximately 5113 EUR/KW (10,000 BGN/KW). NPP Kozloduy currently sells electricity to NEK for 2.2 eurocents/KWh. Based on a study for the Russian Duma on the cost price of Russian reactors for Turkey; the cost price of NPP Belene units is estimated at around 10 eurocents/KWh. These calculations lead to the conclusion that the statement that "The cheapest electricity comes from NPP!" is not true. The real cost of energy from a NPP depends on when it was built, and to what extent the main fixed costs are included in its price.

Myth 4: New nuclear capacity is needed because of Bulgaria's growing electricity demand. Figure 5 illustrates the picture that results from systematically manipulated forecasts in favour of the realisation of extensive development. Detailed independent modeling in the book "*Bulgaria's Electric Power Sector: Development and Public Costs"* proves that the projected electric power demand by 2030 is not as high as the one projected by the nuclear lobby. (The system operator's forecasts for 2012 are close to those found in the book). The rejection of extensive development in exchange for common-sense development means EUR 14.4 billion worth of investments saved by 2020 and EUR 16.6 billion by 2030 (Tsvetanov et al., 2009).

Myth 5: Lacking new capacities, Bulgaria will be forced to import electricity and its price will rise. The open single market will give access to and choice by electricity price from generators in every country, and usually the price goes down. The belief that imported electricity is more expensive is not justified even today. Currently Bulgaria has a surplus of energy capacities of over 30%. Without getting into the details of regimes, load schedules, fees, value added tax, etc., it is sufficient to note that Bulgaria has long been exporting electricity to Turkey, Greece, Serbia and other countries, however, Bulgarians are poorer than the citizens of those countries.

2.2 The cases of the Belene and Kozloduy nuclear power plants in Bulgaria – NPPs in the making

2.2.1 The Belene Nuclear Power Plant project

Overview and history of the Belene Nuclear Power Plant project

The Belene NPP project envisages the construction of a new NPP with 2000 MW capacity in the North of Bulgaria, on the river Danube and the border of Romania.

The Belene NPP project was initiated in 1981 when the government decided to build six new nuclear units nearby the Danube River. After political changes in 1989 that saw the communist regime coming to an end, it became clear that the project was not economically viable. Therefore it was dropped in 1992. In 2002, the government in power led by Simeon Saxe-Coburg Gotha announced that Belene NPP would be constructed. The idea this time was to build 2 new reactor blocks (1000 MW each). The decision of the government was a way to circumvent legislation – it was for 'prolongation' of the old project instead of a decision to construct of a new NPP with new procedures, tenders for technology and Environmental Impact Assessments.

Box 2 Timeline of project development Source: Own elaboration
1981, 20th March - the ruling Communist government approves the site of Belene for the construction of a 2nd power plant in Bulgaria. In the period 1981 - 1987 a technical project is prepared for the building of 4 blocks. In 1985 the preparatory works commence and in 1987 and in 1989 the power plant is 40% finalised.
1990 – The first protests against the project. The project is been reduced to the construction of two blocks due to lack of funding.
1991 - The first democratically elected government freezes the project due to lack of funding and growing protests.
1996 - Unsuccessful attempts by the socialist government in power to revive the project mainly due to the high price of the energy that will be produced. Almost all significant equipment is delivered (from Skoda & others), and USD 1300 million are already invested; but the completion of the first unit lacks another 700 million USD (ÖÖI, 2013).
2002 – The Prime Minister Simeon Saxe-Coburg Gotha (representing the political party National Movement Simeon II (NMSII), announces that Belene will be constructed. The Bulgarian Council of Ministers decides on 19 December 2002 to resume construction of the Belene NPP
The Bulgarian Academy of Science publishes a study called "The White Book" in which detailed arguments are given showing the seismic risk and the lack of economic viability of the project.
2004, April – the government takes a decision to finalise the construction of Belene NPP (Stantchev, 2004) and in November an Environmental Impact Assessment is carried out without a clear idea what the design of the reactor will be. After four public hearings in Bulgaria and one in Romania, Bulgarian and Romanian NGOs as well as international organisations (Greenpeace, CEE Bankwatch Network, EEB) heavily criticize the quality and conclusions of the EIA report.
2004, December – Bulgarian state power utility NEK selects 'Parsons Europe' and 'Risk Engineering' to design and supervise the construction of Belene NPP (Mediapool, 2004).

Box 2 Timeline of project development (Cont.)

2005, February – NEK selects Deloitte Central Europe Limited and Norton Rose to act as financial advisers. Bulgaria aims for the state to keep a majority in the Belene NPP, but also expects foreign investors to take stakes and provide financing.

2005 April – decision No260 is issued for the construction of a NPP with 2000 MW reactor followed by a procurement procedure launched for two reactors (Russian type WWER 1000, applied currently at Kozloduy's 5th and 6th units).

2005, 27th July – A new, Socialist-led government comes to power in Bulgaria. Rumen Ovcharov, a former nuclear physicist, replaces the Minister of Economy Milko Kovachev.

2006, February – there is interest from Russian and Czech consortia - Atomstroyexport / Areva NP and Skoda Alliance. In October NEK announces Russia's Atomstroyexport to be the winner of the tender. Two reactors of new type AES-92 VVER-1000/B466 will be constructed with total capacity of 2120 MW.

2006 - It becomes clear that Gazprom-owned companies lead both consortia, which leads to discussions in the Bulgarian media about lack of a proper tender process. Links are made to Bulgaria's gas-deals with Gazprom.

2006, 31th December – Bulgaria closes reactors 3 and 4 of the operating Kozloduy NPP, as agreed in the EU accession treaty for Bulgaria.

2007 – NEK launches procurement for a loan of EUR 250 million and informs the European Commission for its intent to construct Belene NPP according to Article 41 of the Euratom Treaty. BNP Paribas has been selected; NEK issues a tender procedure for a strategic investor. In the budget of 2008, there is EUR 600 million benchmarked. The EC announces its positive assessment for the construction of Belene NPP.

2008 - There is a contract signed with ASE for almost EUR 4 billion. Standard and Poor decreases the credit rating of Bulgaria. There is an agreement signed with RWE Power for a common company for the project development.

2009 - The government gives to Bulgarian Energy Holding EAD EUR 400 million for the project (Mediapool, 2009). The Belgium Electrabel declines participation with RWE Powers. In May Russia proposes a credit of EUR 3.9 billion.

2009, July – there is a new government in power – GERB, which freezes the project with no clarity on when it will be continued. In November the German RWE Power leaves the project, in December – BNP Paribas also leaves (Peeva, 2009).

2010, January – there is a procedure for the selection of a new consultant; the Nuclear Regulatory Agency returns the project to NEK EAD (Mediapool, 2010a). A series of contradicting statements are coming from the Prime Minister Borisov who is against the construction of the NPP and then becomes full supporter of it “for pragmatic reasons” (Mediapool, 2010b). The Prime Minister Borisov claims that the price of the project is close to EUR 8.59 billion. The English bank HSBC has been selected as a project consultant: There is a memorandum signed for the creation of the project company: the Bulgarian state NEK EAD – 51%, Russia – 47%, the French ‘Altran’ and the Finnish ‘Fortrun’ – 15 each. The National Atomic Agency returns the project once again.

2011 – The technical documentation of the NPP is still not approved while in parliament Prime Minister Borisov claims that there will be increases in the electricity prices if Belene NPP is not constructed. The opposition also claims that Bulgaria will fall into energy poverty if the project doesn’t happen. They also claim that the price of the electricity produced in Belene NPP will be 3 to 5 times cheaper than that from lignite coal, 12 times cheaper than the wind and 52 cheaper than the solar (Dimitrov, 2011).

2012, March – the government officially cancels the Belene NPP project. Still additional payments of EUR 140 million need to be made for ‘completion’ of the first ordered reactor. A loan of EUR 250 million has to be paid to BNP Paribas. Payments may also be needed for the potential court case between the Russian and the Bulgarian side.

2013, May – the newly elected Socialist government reopens the topic of Belene NPP.

Problems with the Belene NPP

a) Questioned economic viability of the project

The cost of the project has significantly increased since its inception (**Fig. 5**) and there has been no definite price announced, casting heavy doubts on its economic viability. The projected costs were stated and contracted at EUR 4 billion at its start but the actual estimation of the project in 2010 exceeded EUR 10 billion. The calculation does not include the costs for the grid, spent fuel and radioactive waste management.

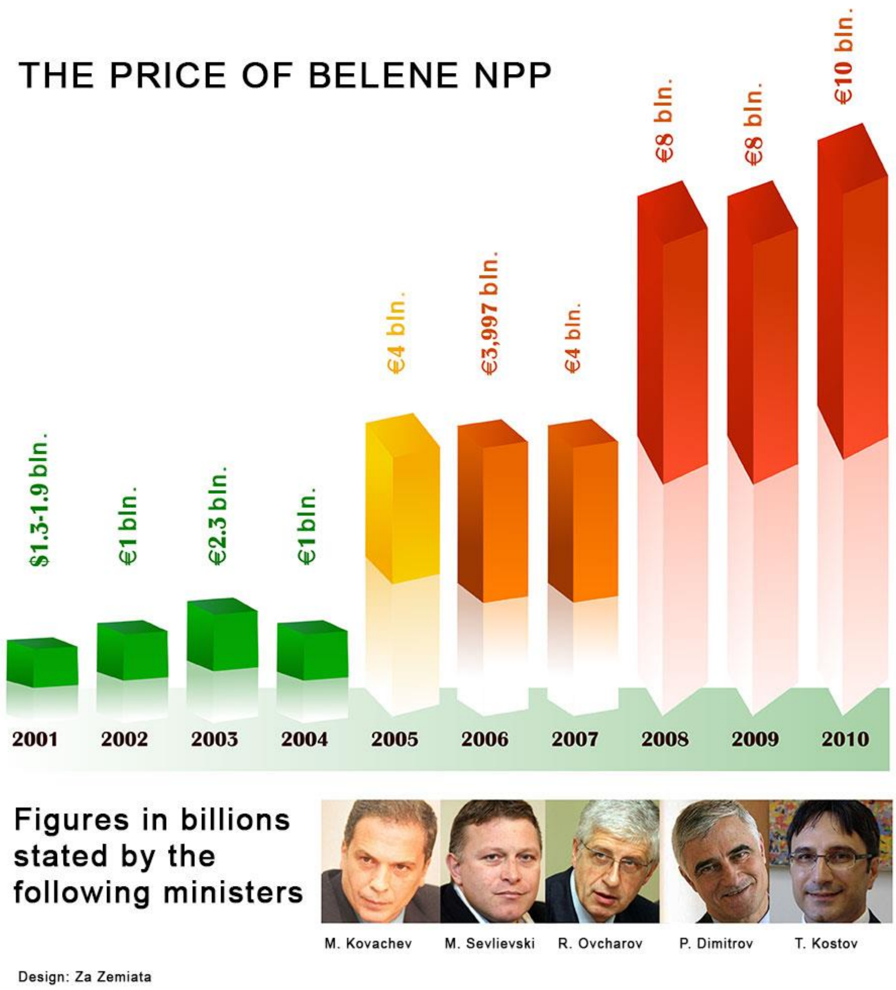


Fig. 5

Evolution of costs of Belene NPP across different governments

Source: Za Zemiata

On 30th October, 2006, the tender for construction was awarded to the Russian company Atomstroyexport for the price of EUR 3.997 billion, on the condition that the old equipment of the Belene site would be used. Later it became clear that the old equipment could no longer be of any use – a fact that experts had already declared before the so-called 'tender procedure'. In 2009 the Russian company officially offered a price of EUR 6 billion. The arguments used for the increase of the price included the application of a different index, increased construction and material costs, inflation, etc.

In 2011, the British bank HSBC, selected by the Bulgarian government to do the economic analysis of the project, declared that the actual cost would be EUR 10.352 billion (HSBC Project Finance, 2011). On 29th November 2006 a Framework Agreement was signed between the Bulgarian National Electric Company and Atomstroyexport, binding the companies to sign a future contract for engineering, supply and construction.

All agreements between NEK and Atomstroyexport, as well as the transferred payments of over EUR 810 million had been made in violation of the Public procurement law

However, the actual contract for the overall implementation of the project was never signed. On 10th June 2008 NEK and Atomstroyexport signed Annex №3 to the Agreement from 2006 in which they defined the activities that would not be integrated in the project, namely, the removal of the buildings and the existing constructions. This additional cost of EUR 100 million was not part of the Agreement but was contracted under Annex 3.

Throughout the signing of all additional annexes the project remained unlicensed by the Bulgarian Nuclear Regulator. Despite this, the two companies signed Annex №5 in 2008 which included basic equipment such as the reactor vessel, steam generators, passive-defence systems, cranes, etc. The overall price of the equipment exceeded the initial price by an additional EUR 500 million. All agreements between NEK and Atomstroyexport, as well as the transferred payments of over EUR 810 million had been made in violation of the Public procurement law. This was discovered during an inspection by the State Financial Agency, the report of which was published in April 2012. However, the inspection did not declare an act of violation due to the fact that three years had passed since it was incurred, exceeding the time limitation as defined by law.

b) Seismic risks of the Belene NPP

The Belene NPP project is characterised by a high seismic risk on the project site. In 1984, a letter from the Director of the Central Laboratory on High Geodesy, from the Bulgarian Academy of Science, stated: "*There are more than 400 NPPs constructed worldwide and another 300 are under construction, but none of these are situated in such a complicated from a seismic point of view area as the Belene NPP site is*" (Georgiev, 1984).

There are several seismic centres in the vicinity of the project site. One of these in Vrancha, Romania (situated around 150 km from the site) has been the centre of a series of heavy earthquakes. The last one in 1977 caused the death of 1400 people in Romania, and was felt strongly in the towns nearby Belene. In the town of Svishtov, which is 10.5 km from the site, several blocks were destroyed, taking the lives of over 130 people. The earthquake was classified in the range of 7.2 – 7.6 according to the scale of MSK-64 (**Fig. 6**).

In 1990, there was a comprehensive study undertaken by a group of scientists from BAS who issued a report known as 'the White Book' confirming the high seismic risk of the site. According to the map of the European Seismological Commission, the seismic risk at the site of Belene is 'average', with a tendency toward 'high', considerably higher than that of Kozloduy site. When building high-risk projects, there is a need to account for a much longer time period, up to 100 thousand years, in which there could be strong earthquakes.

Fig. 6

Images from Svishtov after the earthquake in 1977 that measured 7.3 on the Richter scale

Svishtov is only 10.5 km from the Belene site. Over 130 victims perished in Svishtov with more than 1000 buildings destroyed

Source: City museum of Svishtov

The Japanese experience has in fact proven the irreversible consequences of project planning without properly accounting for high seismic risk. In 2007, when a strong earthquake hit Japan, the world's largest NPP, Kashivazaki-Kariva, was heavily affected, leading to its complete closure for 2 years. Since then only some of the reactors have been put into operation, causing severe economic impacts. In comparison, the more recent powerful earthquake of March, 11th 2011 in Fukushima, Japan, resulted in the emission of high levels of radioactivity into the air, soil, drinking water, milk and vegetables. The Fukushima accident has been rated the second most serious, after Chernobyl.

c) Technical design - a technology not proven by practice

The technology for the nuclear reactor selected for the future Belene NPP is Russian. Known as AES-92, it is an intermediate design between the BBEP-1000 and BBEP-1200/MIR-1200 models. This model is currently not used anywhere else but is foreseen to be put into serial production, with no operational experience as of yet. There are two operational units of the previous model – AES-91 – in Taiwan (China), the construction of which was delayed for two years. A similar design – the Kudankulam NPP in India – was being built but was delayed for over one year.

The model of the nuclear reactor selected for the future Belene NPP is currently not used anywhere else but is foreseen to be put into serial production, with no operational experience as of yet

What is more problematic is that in practice, only the Russian regulatory authorities can license the AES-92. There is option for an independent assessment of this model. Moreover, the only certificate that has been issued for the AES-92 has been done so under the European Utility Requirements, which is not a regulatory agency, but an association of 16 European producers and operators of NPPs. In 2011, the Bulgarian Nuclear Regulatory Agency (NRA) still had not approved the technology, rejecting the project twice.

d) Radioactive waste

Proponents of the Belene NPP have not proposed any solutions for the end product of NPP production – radioactive waste. Nuclear waste has a considerably long life and is likely to burden future generations for millions of years. Furthermore, secure disposal of nuclear wastes is still not clear-cut issue.

e) Manipulated and redundant procedures

There have been severe problems with tendering procedures, with numerous claims that the tender process for the construction of the NPP was manipulated to allow only Russian companies to be eligible.

The Environmental Impact Assessment, although expensive was improperly done. It contained no emergency plans, lacking plans for the spent fuel and for decommissioning. It was carried out without any clarity regarding the type of reactor design to be selected.

The Environmental Impact Assessment was carried out without any clarity regarding the type of reactor design to be selected

f) Exaggerated energy demand

There is no explicit need for Bulgaria to build new nuclear capacities for its energy balance. The project was developed with the intention of selling electricity to external markets. So far, there has been no contract signed with a neighbouring or other country that would be willing to buy electricity from the Belene NPP.

g) Energy dependence

The Belene NPP project would not decrease the energy dependence of Bulgaria from Russia. On the contrary, it would be increased even more, as Russia is the only country that could provide the nuclear fuel needed for the reactors planned for Belene NPP. In Russia the project was presented as a breakthrough for Russian technology in EU.

Engagement of the public: the referendum in 2013

The campaign in support of the construction of Belene NPP

According to Bulgarian legislation, a referendum can be called with the gathering of 770,000 signatures.[2] Initiated by the Bulgarian Socialist Party and supported by far-right nationalist formations Attack and VMRO[3], an initiative committee was created, headed by the president of the BAS Academician Stefan Vodenicharov called for the construction of Belene NPP, and in the summer of 2012 collected over 520,000 signatures to call for a referendum. Yavor Kuyoumdzhiev of the Initiative Committee stated that Bulgaria was not close to being forced in the near future to import electricity, predicting that domestic consumption of electric energy would be twice that of the amount produced.

Among the reasons highlighted by the protagonists of the project, is the economic viability of Belene NPP, which is in an advanced stage and it is argued, can begin operating within a year's time from the time of the referendum. According to the committee, the absolute benefit from the functioning of the NPP would be close to 200 billion BGN (approximately EUR 102 billion) for 60 years of exploitation.

The committee of Vodenicharov and the Socialist party warns that in the next 20 years, more than 70% of existing energy power plants and energy capacities in

[2] According to art. 10, al. 2 of Law on Direct Participation of Citizens in State Government and Local Self-Government, 2013.

[3] Internal Macedonian Revolutionary Organization, Bulgarian National Movement (Bulgarian: ВМРО – Българско Национално Движение, VMRO – Bulgarsko Natsionalno Dvizhenie) is the oldest nationalist political party in Bulgaria.

the country (including the Kozloduy NPP and the Maritza Iztok Thermal Power plant II) will cease to be in operation, and Bulgaria will face an unprecedented deficit with heavy electricity shortages.

By implementing this project, claims the Initiative Committee, Bulgaria will not only ensure its energy independence but will also affirm its position in the world's elite nuclear club. This is an important claim, as, according to nuclear advocates, Bulgaria is the sole country in the region of South-East Europe which has the potential, the capacity, knowledge and nuclear specialists, to develop nuclear energy.

Among the additional arguments in support of Belene NPP is one that promotes nuclear energy as 'green' energy, producing no CO_2 or other harmful emissions. According to the Committee, without Belene NPP, Bulgaria will have to import electricity from Turkey or Romania at high market prices. It could also be forced to develop the extraction of shale gas using the controversial 'fracking' technology. There has been a strong public opposition across Europe against the development of shale gas industry using fracking methods.

Civil society campaign against Belene NPP

The campaign against the development of Belene NPP has been carried out on local, national and international levels, and can be traced back to 1990. Local citizens organised in opposition to the project and spread information in the towns and villages in the proximity of the NPP site. Some 17 Bulgarian organizations and citizens groups gathered to form the '*No to BeleNE*' coalition, in cooperation with Romanian NGOs. Several international organisations such as Greenpeace, Friends of the Earth, CEE Bankwatch Network, the European Greens, and *urgewald* - Germany, took part, as well as the *Campagna per la Riforma della Banca Mondiale*, an Italian organisation targeting foreign banks and potential investors. One of the key issues was (and continues to be) the financing of the project. After an international campaign 12 Western banks withdrew their initial interest in participation, including Deutsche Bank and the UniCredit Group. Protests in front the branches of the banks in 22 European cities and a mass mailout to the banks were carried out. NGOs participated in the AGMs of the banks and potential investors.

Local citizens organised in opposition to the project and spread information in the towns and villages in the proximity of the NPP site

Some 17 Bulgarian organizations and citizens groups gathered to form the 'No to BeleNE' coalition

Several court cases were launched against the decision by the government to begin construction and its approval of the EIA. These legal battles were not successful but caused delays to the project. The Macedonian NGO EcoSvest filed a complaint at the Sofia High Administrative Court because Macedonia had not been informed of the project under the Espoo Convention. Bulgaria had only informed Romania of its intentions.

Over the years there were protests, media events, press-conferences, exhibitions, info-tours, meetings with politicians, MPs and mayors, constant official requests for information and court cases. These incited robust reactions, including threats against anti-nuclear activists.

The referendum in 2013

The first referendum in the democratic, post-socialist history of Bulgaria ultimately seemed to be a political exercise. It was initiated by the leaders of the Bulgarian Socialist Party, and driven by the need to legalize and justify its spending of over EUR 1 billion on the construction of the power plant during its previous political term. The question for the referendum was crafted in Parliament by the ruling centre-right party GERB, in an ambiguous manner. Citizens were asked: "*Should we develop the nuclear energy sector in the Republic of Bulgaria by the construction of a new nuclear power plant?*" Such a framing meant that both an affirmative and a negative answer would leave space for speculative interpretations and thus the nuclear lobby will be successful in any case. The powerful lobby group included organisations and individuals contracted for the construction of the Belene NPP.

The debates surrounding the referendum in the media were suppressed and led by politicians, while views against nuclear energy were muted

The referendum – media and politics

The debates surrounding the referendum in the media were suppressed and led by politicians, while views against nuclear energy were muted. There were few arguments raised publicly about the risks and fundamental problems with nuclear energy such as waste, corruption, lack of transparency, and disregard for safety regulations.

The reality that Bulgaria has the poorest energy efficiency index in the EU, spending 5.6 times more energy per production unit, while having a 40% surplus of produced energy was ignored. Instead there was speculation that Bulgaria was facing an energy deficit and would need to import electricity from Turkey. Economic and technological myths about 'clean, cheap and safe' nuclear energy were mobilized with full force. Consultants from HSBC meanwhile, estimated that the Belene NPP would produce in the range of 6.44 – 11.37 euro cents per KWh, a rate several times higher than the current price from the Kozloduy NPP. This fact did not feature in public debate. Instead, simplified slogans such as "Nuclear energy is cheap" were deployed with the aim to achieve mass disinformation.

Nationalism however, did feature in the debate. Geopolitical myths about the energy independence of the country were generated, along with promises that Bulgaria would become the energy hub of the Balkans. All of these claims sounded absurd to experts who were well aware that Bulgaria is 100% dependent on Russian nuclear fuel imports and reactors.

According to a survey conducted by Eurobarometer in 2008, Bulgarians are the most uninformed citizens in the EU regarding nuclear energy. Yet at the same time, they are its biggest supporters. Taking advantage of ignorance, political parties have captured the referendum as a pre-election campaign opportunity and encouraged citizens to vote for or against the government and not for or against nuclear energy development in Bulgaria.

The results of the referendum on January 27th 2013 are difficult to interpret: 61% voted 'yes' and 38% 'no'. Only approximately 1,500,000 people turned out to vote (20.2% of the turnout for the last parliamentary election), which is below the required 4,350,000 votes to make the vote valid. Such low voter turnout could be attributed to popular disappointment with the abuse of the referendum by political parties, among other reasons.

One month later, on February 27th, the Parliament took a final decision to end the 'Belene' project. Since most of the votes at the referendum were positive, it was decided to extend the life of reactors 5 and 6 and to initiate research on the construction of a new reactor at the Kozloduy NPP site.

Costs and benefits of Belene NPP project[4]

In order to claim that a project will be a worthwhile investment it is necessary to argue that the income flows (or benefits, using the terminology of cost/benefit analysis) it generates are greater than its costs. An overview of methods of socioeconomic analysis, and in particular an explanation of cost-benefit analysis used in the context of environmental justice conflicts can be found in the EJOLT report 16 (Zografos et al., 2014).

While there are numerous risks associated with the Belene NPP project as presented above, the most divisive issue for Bulgarians is related to the costs of the NPP project and the question of whether projected revenues will exceed construction and management costs. A range of political interests are reflected in the assessments of numerous experts, which differ one from another in several ways – in their main assumptions, in the methodologies used for the assessment of the costs and benefits, and in the key variables that have been included in the assessments.

For the purposes of this report, we have analysed the main expert assessments, reviewing and summarising all possible costs and benefits. We present two scenarios – a pessimistic and an optimistic one. The assessment would be more precise if we could present operational costs as well as total capital costs, juxtaposing them with total income generated by the activity of the power plant during its overall operational cycle. However, this exercise would be purely speculative, as it is not possible to precisely project electricity prices for the coming decades. Nor is it possible to project energy demand by external markets, which is where the energy produced by the future Belene NPP is expected to be sold.

The most divisive issue for Bulgarians is related to the costs of the NPP project and the question of whether projected revenues will exceed construction and management costs

Main assumptions

The main assumptions in underpinning our analysis are based on the technical and financial parameters that can be found in the different agreements for the construction and financing of the Belene NPP. We have prioritised the parameters of HSBC bank's the report and in the cases where the experts' opinions differ we have attempted to present different scenarios. The assumptions are:

- The power plant is operational for 50 years. Some expert assessments assume that this would be 40 years, but in practice, the lifetime of a power plant can be extended with rehabilitation and the granting of an extended lifetime license.

[4] The chapter is based on Slavov (2013).

Both options are used to create 'pessimistic' and 'optimistic' scenarios.

- The total installed capacity is 2,000 MW (2 reactors x 1,000 MW).
- The price of the KWh and the operational costs increase by 2% each year.
- The power plant is financed by credit for 15 to 25 years at an interest rate of 8% per annum.
- Costs are amortized at a rate of 4% per annum, implying the full amortization of power plant costs over 25 years.
- Annual production of Belene NPP is around 14 bln KWh.
- The use of the installed capacity for production, or 'availability', is 90%.

Defining the expenditures for Belene NPP

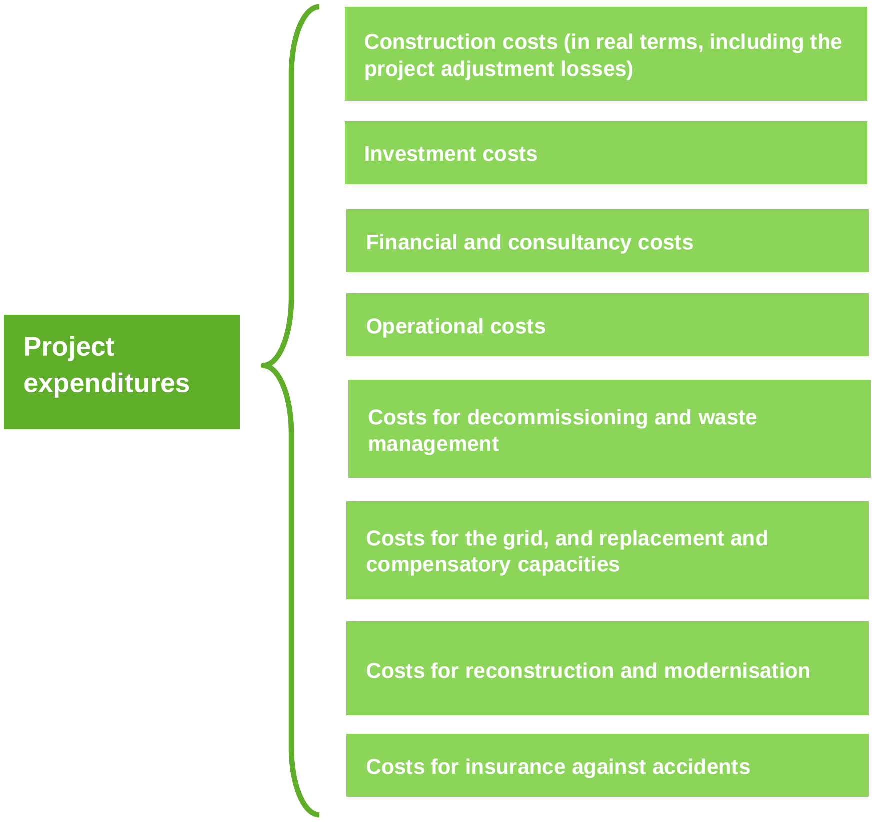
One of the most debated topics in recent years about Bulgarian energy development has been that of the cost for the construction of the Belene NPP. Facts related to this topic have been shrouded in secrecy due to the nature of dealings and contracts with the Russian firm Atomstroyexport. Only in the last two years, due to the public pressure and conflicting political interests, has more information on the project been made public. This includes the publication of several expert reports on the topic.

Taking into account the information available about this project, and assessments done for other similar investments, the scope of costs for the Belene NPP can be estimated as shown in **Fig. 7**:

Figure 7

Scope of costs for the Belene NPP

Source: Own elaboration



In **Tables 4** and **5** we present the various costs for construction and exploitation related to the Belene NPP. These figures are as stated in the contract, taken from official sources such as reports, expert assessments, government programme documents and projections, and from our own assessments. We present a detailed description of each cost, and describe a range of scenarios.

The main reports used to build the scenarios are that of the HSBC bank (NERA economic consulting, 2011), the Institute of Market Economy – IME report (IME, 2011, Energy Management Institute (EMI, 2011), Nigmatulin (Nigmatulin 2012), and the National Electricity Company (NEK 2012).

Project costs	Minimum scenario [in million EUR]	Maximum scenario [in million EUR]	Other estimations [in million EUR]	Notes
CONSTRUCTION COSTS				
Construction works	6131.6 (HSBC)	6300 (Institute of Market Economy - IME; Nigmatulin - statement of Rosatom)	6000 - 7000 (Energy Management Institute - EMI)	'Overnight cost' plus escalation
Total Preparatory Works Costs	2017.5 (HSBC)			
BE unit 1: Costs (O&M, working capital, tax)	169 (HSBC)			
Building infrastructure of the plant		630 (Nigmatulin)	500 (IME)	
FINANCIAL AND CONSULTANCY COST				
Interest during construction and fees	1809 (HSBC)	3200 (Nigmatulin)	2700 – 3000 (EMI)	
Prefunded Debt Service Reserve Account (DSRA)	225 (HSBC)			
Consultancy services	210 (Government)	210 (Government)		Public costs
Financial cost insurance (capitalized for 7 years building phase)			1764 (IME)	
Dept costs related to supporting grid, transformation and compensating capacities		2160 (Nigmatulin)		
OTHER COSTS				
Building the Supporting Grid, transformation and compensating capacities		2700 (Nigmatulin)	350 (IME); 290 NEK)	HSBC included in preparatory work cost of 600 km grid Public costs
Decommissioning		1400 (ZZ)		Private costs. Based on Kozloduy 1-4
Waste short term management and storage		700 (IME)		Public costs
Long term waste storage plant (share)	750 (IME)	1500 (ZZ)		Public costs
Substituting capacities (800 or 620 MW on gas)		800 (Nigmatulin)	350 (IME)	Private costs
Compensating capacities (500MW hydro)			450 (IME)	Private costs
Connecting with the EU grid			500 (IME)	Public costs

Table 4: Estimated main project costs of the Belene NPP

Source: Slavov, 2013

Debate over the construction costs of the Belene NPP is not only attributable to the lack of transparency of contracts with Atomstroyexport, but to the different estimations of costs announced by changing governments over the 20+ year history of the project (in the previous chapter, this report noted that the costs of the project have increased tenfold in under one decade).

Construction costs for the power plant, between EUR 6.1 and 6.3 billion, are substantially higher than the EUR 3.9 billion set out in the Agreement between NEK and Atomstroyexport

The costs discussed in this report are based on those last provided by Atomstroyexport. According to the contract with Atomstroyexport (according HSBC report 2011), the cost of building the reactors and related facilities are listed as 'overnight costs', i.e. the cost of the construction based on current available prices, if it were to be built overnight. In addition to these costs among counterparties to the contract – investors and the builders, others have been negotiated applying different indices. Both sources – the report of the HSBC bank and the Institute for Market Economics (IME), have come to similar conclusions, assessing construction costs for the power plant at between EUR 6.1 and 6.3 billion, an amount substantially higher than the EUR 3.9 billion set out in the Agreement between NEK and Atomstroyexport.

The summary of the report by HSBC revealed that a substantial amount was allocated to 'Total Preparatory Works Costs' – a sum of EUR 2 billion. As the full report is confidential (and thus inaccessible to the authors of the present report), an exact accounting of these costs is impossible, and leaves much room for interpretation. Some critics who have had access to the full report claim that these costs include the construction of the connecting grid, which legally should not be subject to expenditures by investors.

On the other hand, the high-voltage electricity transmission network is the responsibility of the Electricity System Operator – ESO, which is a third party and by law, is not obliged to invest its own funds in the construction of the connecting grid. That means that if the investor has an interest in connecting its capacities to the existing high-voltage grids, they need to participate in covering the costs for the construction of the necessary transmission lines. At present, only electricity distribution companies are bound to connect RES producers to the network, but they also obliged to participate financially in the construction of the network, covering the vicinity in which the capacities have been produced.

In its discussion of the cost of the Belene NPP the IME report unbundles the costs for the 600 km high-voltage grid in a separate budget, totalling these in the area of EUR 350 million. This amount is based on the costs outlined in the national strategy for the development of the electricity transmission grids, to which EUR 290 million has been allocated. In this light it seems likely that the calculations of the IME report includes costs for the electricity transmission network related to additional replacement and compensatory capacities.

Another important cost included in the IME report are those related to 'Building infrastructure of the plant', in the area EUR 500 million according to experts. A similar cost is foreseen related to the site of the first unit of Belene NPP (BE unit 1: Costs - O&M, working capital, tax), in the amount of EUR 169 million.

The highest estimate of infrastructure costs, which excludes the costs of networks and transforming capacities, is offered by B.Nigmatulin. It is based on the Russian practice of assessing these expenditures for infrastructure at a rate of 10% of construction costs, in this case, EUR 630 million.

Financial and consultancy cost

Since the Bulgarian counterparty, NEK, did not have the financial resources to secure its 51% of the investment, it was in need of additional credit from banks. However, as this report has already pointed out, many banks, after assessing the project, or due to public pressure caused by international NGOs had withdrawn offers of credit for the project. This situation was highly problematic for the implementation of the project Furthermore, fluctuating interest rates created generated large discrepancies between the cost of the project that had been announced publicly and the actual costs of the Belene NPP project.

The project consultant HSBC projected financial costs for 'Interest during construction and fees' of EUR 1,809 million and estimated a 'Prefunded Debt Service Reserve Account' of EUR 225 million. Similarly, the IME team forecast 'Financial cost insurance' (capitalized for 7 years building phase) at EUR 1,764 million. Generally, the two teams have similar assessments of financial costs, despite having different scenarios for paying off the credit and variations in the interest rates.

In contrast, the assessment of costs by Nigmatulin is higher, as it reflects an increase in debt costs during the construction phase with no benefits from the project, a period forecast to last no fewer than 8 years. Thus, he foresees that the cost of credit for the construction of the power plant (including replacement capacities – 2 blocks of 400 MW gas-powered vapour plants, which need to be constructed in parallel with the power plant) will amount to EUR 3.2 billion. In addition to these costs, Nigmatulin takes into account expenditures for the accompanying construction costs of the power plant, i.e. the costs related to the supporting grid, and transformation and compensating capacities of EUR 2.6 billion (accounting for an interest rate of 6% (LIBOR + 4%) for a 15-year period, with a 23 year duration of paying off the credit, including the construction period.

Some of the more controversial expenditures in the project budget to date are those associated with consultancy costs already, amounting to EUR 210 million. A substantial part of this amount has been paid to WorleyParsons, EUR 203 million with no apparent (at least not to the public) output. The unprecedented high cost of their services has spurred critiques of the government (at the time) and claims of corruption, pointing out that such an expertise cannot cost more than EUR 2 million.

Some of the more controversial expenditures in the project budget are those associated with consultancy costs, amounting to EUR 210 million

Other costs

Disparities in the various cost assessments by experts' and politicians is often a result of consideration of generated costs, which are not directly related to the construction of the power plant, but without which, the plant will not be able to operate. According to the IME report: "*The total size of the initial investment, related to Belene NPP, is related to the construction of the infrastructure of the* *site, an industrial unit for processing waste and for temporary storage, permanent storage in the territory of the country, transmission lines, automation systems, sub-stations, compensatory capacities, links with the electrical energy system and increase of the capacities of the existing capacities, which is necessary to ensure the functioning of the plant. These costs will be incurred by the BEH or NEK, and financed from the state budget, i.e. from the Bulgarian taxpayers. In addition, the already incurred and accounted for costs for consultancies, project design, preparation of the site and equipment, need to be included in the calculation*".

All these costs will be incurred by the BEH or NEK, and financed from the state budget, that is, from the Bulgarian taxpayers

When analysing these costs, the pro-nuclear lobby excludes costs for the replacing capacities, the transmission grid, the waste management, etc., in contrast to the anti-nuclear lobby. According to the IME, total costs should include those for the replacement capacities of 620 MW – natural gas powered plants for EUR 350 million, and compensatory capacities of 500 MW water power plants for EUR 450 million. The cost that the experts foresee for the necessary links with the European energy system (including that of Moldova), and the increase of existing capacities is substantial, and amounts to EUR 500 million.

The highest assessment of costs again comes from Nigmatulin, according to whom the total cost of the grids, the power transforming sub-stations and the manoeuvring capacities amounts to EUR 2.7 billion.

Decommissioning costs

Traditionally, decommissioning costs are defined as 10-15% of total capital costs. In other words, if we assume that the costs for the Belene NPP are in the area of EUR 10 billion, decommissioning costs would be between EUR 1 and 1.5 billion. The costs foreseen for the decommissioning of the six blocks of Kozloduy NPP, with a total installed capacity of 3,760 MW (after indexation that accounts for the inflation), come to EUR 3 billion. We can therefore empirically estimate that the decommissioning costs for the 1,000 MW capacity will vary between EUR 700 million and EUR 1 billion (based on current prices). For the maximum scenario we have estimate a conservative cost of EUR 1.4 billion for both blocks of Belene NPP. This is a realistic estimation, considering that the UK, for instance has fixed an amount of GBP 1 billion per reactor. Currently, according to EMI's calculations, there is around 1.8 EUR/MWh in the Kozloduy NPP decommissioning fund.

Waste management costs

The most unpredictable costs for a nuclear power plant are the costs for waste management after its closure, which, according to many specialists, can continue for the period of several thousands of years. There are different technologies for long-term waste storage. However, no site has been selected for long-term waste storage on Bulgarian territory. Nor has a particular technology been selected. IME expert assessments for the long-term waste storage plant amount to EUR 750 million. In comparison, the analysis of Environmental Association Za Zemiata, based on international experience, foresees a cost of EUR 1,500 million. This figure does not account for operational costs of waste management over the years or the relevant amortisation costs and inflation indices. Considering the negative experience with the rehabilitation of uranium mines (to be discussed further in this

Only one-fifth of the EUR 2.6 billion deemed necessary 10 years ago for decommissioning the Kozloduy NPP has been collected. No site has been selected for long-term waste storage on Bulgarian territory

report), we anticipate that the costs foreseen by the project promoter will not reflect the 'polluter pays' principle, as has been the case in the majority of industrial projects. These expenditures to a large extent will be paid for by citizens.

The short-term and long-term storage of the highly radioactive waste is foreseen to be stored for the most part on the site of the power plant in water pools. Based on current costs of managing the Kozloduy NPP, the IME estimates the cost of an industrial unit for waste treatment and temporary storage at EUR 700 million.

Decommissioning involves the dismantling and decontamination of the power plant, clean up, treatment and storage of radioactive waste and dangerous spent nuclear fuel. This requires significant investment in the area of 10-15% of initial costs of the power plant. Neither of the expert teams included these costs in their accounting, as normally these costs are covered by established designated funds (instalments for which are counted in operational costs). History shows however, that these funds have been insufficient. For instance of the BGN 5.2 billion (EUR 2.6 billion) deemed necessary 10 years ago for decommissioning the Kozloduy NPP, only one-fifth has been collected. This means that approximately 50% of these costs will have to be paid by Bulgarian taxpayers.

Operational costs and price per kWh

When calculating the cost of electricity produced from Belene NPP, it is important to consider not only the costs for the capital as of today, but to also factor in the financial costs, and the additional investment expenditures related to the project. It is necessary as well to be aware of operational costs, which in this case include annual production costs, maintenance costs and costs related to securing fuel. Annual reports of nuclear power plants furthermore contain tax expenditures, social and pension securities for workers, costs for modernization and others related to loans.

Operation and maintenance costs	Minimum	Maximum	Other estimations
Operational cost (eurocents/kWh)	1,2	1,3	
Electricity price (LEC) (eurocent/kWh)	3,7 (max - 7,49) Hristov)	9,54 (max 14,6)	6,44 - 11,37 (HSBC) 3,7 - 16,1 (IME)
Insurance in case of accident	No data	No data	No data
Waste maintenance costs (500 - 10 000 years)	No data	No data	No data
Reconstruction and rehabilitation		500 (data for K5-6*)	

Table 5

Estimated operational costs and price per kWh Belene NPP

*K5-6, unit 5 and 6 Kozloduy NPP

Source: Slavov, 2013

Traditionally, the operational costs of a nuclear power plant are considered substantially lower than capital costs, which typically range from 60-80% of total costs. Expert reports use different methodologies to calculate these costs, which are about 1.2 – 1.3 eurocents/KWh, in line with costs estimated by the Kozloduy NPP.

The IME, for instance, has assumed operational costs to be in the range of 40-

50%, a rate similar to American NPPs, since NEK and the Ministry of Economy, Energy and Transport do not provide such information. Thus, taking into account all relevant costs, the IME calculates one of the highest price levels per KWh, in the order of 14 eurocents/KWh. This is comparable to the current subsidized price of wind power plants in Bulgaria. By comparison, the price of electricity for Bulgarian consumers in 2012 was around 0.07 EUR /KWh, without VAT (0.068 EUR/KWh for economic consumers and 0.071 EUR /KWh for households). When assessing the economic impact of the Belene NPP, IME researchers estimate that: "*When the selling electricity price is lower than 9.54 eurocents/KWh for electricity produced by Belene NPP, the overall net result for the economy will be negative"* (IME, 2011: 54). In other words the financial flow will not be sufficient to secure the necessary return of 8%.

Taking into account all relevant costs, the estimated price levels per KWh are in the order of 14 eurocents/KWh. This is comparable to the current subsidized price of wind power plants in Bulgaria

These losses will amount to EUR 8 billion at an electricity price of 6 eurocent/KWh, and EUR 1.2 billion at 9 eurocent/KWh. In order to secure a 4% rate of return, the minimum sell price per KWh needs to be at least 6.27 eurocent/KWh, which is significantly higher than that set for the Kozloduy NPP.

If we assume an annual rate of production from Belene NPP at 15,898 TWh, and calculating 'overnight' costs of EUR 8.149 billion in capital with 3,844 EUR /KWh installed capacity, HSBC calculates a cost of electricity at 74.9 EUR /MWh (or 0.0749 EUR /KWh). This is based on an estimate of operational costs at a rate of 1.21 eurocent/KWh, with a discount rate of 8.23% and an 8% rate of interest.

One financial and energy expert employed by Risk Engineering, a pro-nuclear enterprise, made a critical assessment of HSBC's report. In this report, N. Hristov (2012) observes that the published summary does not provide clarity on the cost effectiveness of Belene NPP. He also indicates that the capital cost has been overestimated at EUR 0.9 billion, and that the discount rate of 8.23 % used in the assessment was relevant for 2008, but is no longer relevant today, taking into account the rate recommended by the EC, of no more than 3.4% (Hristov, 2012).

Risk Engineering considers different scenarios with different initial data, for example using two options - an interest rate of 4% and of 8%. They rightly state that to compare the price of the electricity produced by Belene NPP with current existing prices (of Kozloduy NPP, the average for the country), it is necessary to define the current value of the production cost of electricity (current cost), by de-indexing the standard price as of 2012. Usually, critiques of nuclear energy compare the current price of alternative energy sources with the standard NPP price, calculated as the average cost of the entire exploitation period (based on the initial selling price and estimated future increases). In other words, the justification of a low current price is based on assumptions of increases in the market price of the electricity, and anticipation that over time, nuclear energy will generate substantially higher profits as operational costs decrease over the lifetime of exploitation.

In summary, the standardized price of the Belene NPP electricity should vary between 37 and 75 EUR/MWh, depending on what alternatives it is being compared to and what standardized price is used for these alternatives for a 30-

year time period (which is the lifetime of the alternatives), or a 60-year period (a period possible only for the exploitation of a NPP).

The report further affirms that the current value of the production cost of the Belene NPP (22 EUR/MWh) is comparable with the current price of the electricity produced in Kozloduy NPP (21 EUR/MWh). It claims that both prices are around two times lower than the average electricity price in Bulgaria (40.5 EUR/MWh). According to the author of the report: "*The fall in overall consumption during the last year together with the critically low export of electric energy is due to the high taxes on the energy export*" (Hristov, 2013).

On the other hand, these are very optimistic suppositions, characteristic of national energy reports over the last two decades, which aim to persuade citizens of the need for overproduction. For instance, the author supposes that Turkey will increase its demand from 225 TWh in 2012 to 700 TWh in 2050, while Greece is predicted to increase its demand from the current 64% to 157%. This latter assumption is doubtful, considering the ongoing crisis and the expected decrease in electricity consumption related to EU climate policies and energy efficiency policies.

The EMI model is rather simplified and illustrative, however it presents an interesting comparison of the role of the construction deadline and the interest rate on electricity prices. The EMI estimates the price of electricity at between 3.7 and 16.1 eurocent/kWh based on assumptions that operational costs are 1.3 euro cents per kWh. This is consistent with current levels of actual costs and includes provisions for decommissioning and waste storage and capital expenditures of 2,500 EUR/ kW, or EUR 5 billion in total.

Interest rate (%)	3 years	4 years	5 years	7 years
5	3.7	3.9	4.2	4.9
6	4.1	4.4	4.8	5.9
7	4.6	4.9	5.5	7.2
8	5.0	5.5	6.3	9.0
9	5.6	6.3	7.4	11.7
10	6.2	7.1	8.6	16.1

Table 6

Adjusted costs / price per kWh (in euro cents / kWh) and their sensitivity to the duration of construction and interest conditions

Source: EMI, 2011

The problem with the EMI's methodology is that it is unlikely that the NPP will be constructed in less than 8 years, taking into account the statements of Russian specialists in the area. For this timeline, the price of electricity, calculated using the lowest possible interest rate (5%) will be EUR 4.9 cents / kWh. Applying an interest rate of 8%, as the HSBC does, the price increases to 9 eurocents / kWh.

Projections and conclusions on the economic viability of the Belene NPP project

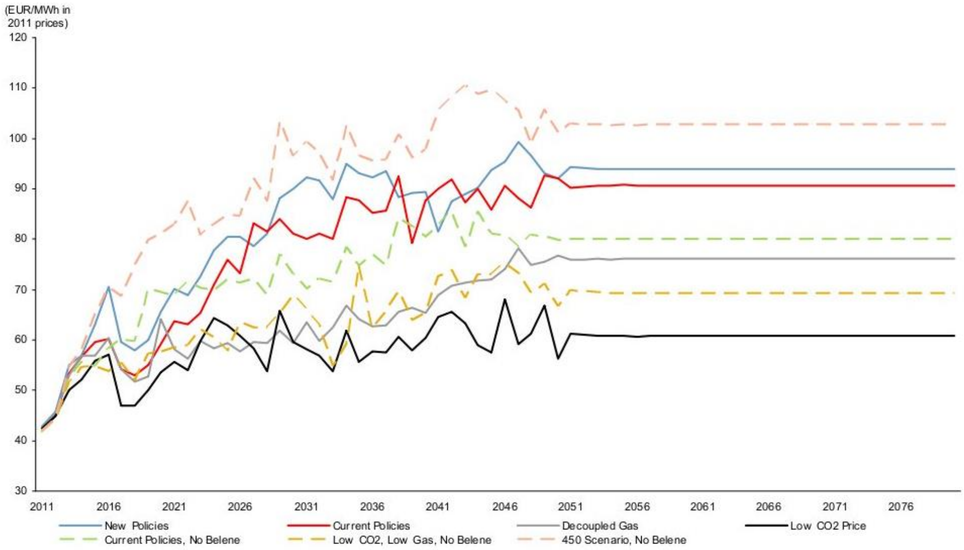
As this report has shown, projections regarding the price of electricity to be produced by the Belene NPP, although they vary, are presented in such a way to make the project appear profitable. If construction were to begin immediately, the power plant could not start operating and generating income until 2020 at the earliest. The market price of electricity by 2020 will be set in a liberalized market, although it will be connected to European market prices. The profitability of the project thus will depend on future European market prices.

The HSBC report projects market prices of electrical energy from Belene NPP using three different scenarios: of existing policies; of 'new policies' connecting respect for the environment with energy security; and a scenario in which the EU introduces a stringent policy for restricting the concentration of greenhouse gas emissions to 450 ppm CO_2 equivalent.

Fig. 8

Power price forecasts for Bulgaria based on different scenarios

Source: NERA, 2011



Final notes on the profitability of the Belene NPP project

Assuming that by 2020, the average price of Kozloduy NPP increases to 0.03 EUR /KWh, even under an optimistic scenario (with an interest rate of 5% and a maximum pay-off period of 26 years on loans with a low rate of return of 4%) the minimum possible initial price of electricity from Belene NPP would be 0.05 EUR /KWh. In the context of a competitive, liberalized market, an excess of electricity production, decreasing domestic consumption, improved energy efficiency and decreasing energy intensity, it is unclear how the price of energy produced by the Belene NPP in the future could be competitive. Unless the Belene NPP can count on selling at least 85% of its production annually, the viability of this project is questionable. The maximum total construction costs sum up to about 19.6 billion EUR including costs for decommissioning and waste maintenance. There are also operational costs 10.9 billion for 40 years with 2% growth per year.

Unless the Belene NPP can count on selling at least 85% of its production annually, the viability of this project is questionable

2.2.2 Kozloduy 7[5]

Overview and history of Kozloduy NPP[6]

By 2009, the Bulgarian government did not have a clear concept either for the development of the energy sector, and thus reacted to any internal or external stimuli in an inconsistent and self-contradictory manner

In the early 1980s it was decided to add new nuclear units at NPP Kozloduy's site after units 1 to 4 became exhausted. While units 5 and 6 were under construction, three potential sites for new units were contemplated. The notion of adding new units remained popular, especially due to the early closure of units 1 to 4 related to EU accession.

The construction of a new, seventh, unit, NPP Kozloduy (K-7) was again discussed in 2009. At this time government had developed the idea of the parallel construction of nuclear units at NPP Kozloduy and NPP Belene. This phase can be viewed as an attempt by the government to 'distribute' international interests in the Bulgarian energy sector along both Russian and Western (USA, EU) lines. As such the construction and, possibly, the management of the new units at Kozloduy would be carried out by US and European companies. Admittedly, the Bulgarian government of that period (2009-early 2010) did not have a clear concept either for the development of the energy sector, or for nuclear energy in particular, and thus reacted to any internal or external stimuli in an inconsistent and self-contradictory manner.

During 2009-2010 a feasibility study for adding new units at the Kozloduy site was conducted. It was carried out jointly by NPP Kozloduy and Spanish Iberdrola Group. According to the then executive director of the plant, the study was done free of charge. Some sources have it that "*the study confirms the economic expediency of adding one or two new units, using the existing assets of the NPP, such as power and technical infrastructure, operational reliable radiation monitoring system, an operational emergency plan, facilities for secondary treatment of radioactive waste and spent fuel storage, qualified and experienced staff, planned construction of a national storage for low- and middle-range radioactive waste in the vicinity of the NPP, etc.*". Once again, there was talk of compensation of the closure of units 1 to 4, while securing a reliable power source. However, the proposed need for compensation for the closed units has never been proven empirically, and the subsequent crash of the Bulgarian economy, and of power consumption in particular, confirmed its fallacy.

On 29 March 2012, the Republic of Bulgaria's Ministerial Council (MC) requested that the Minister of Economy, Energy and Tourism submit a proposal for the construction of a new nuclear unit at NPP Kozloduy's site (DMC No. 250 / 29.03.2012, article b).

On 11 April 2012, the MC gave its general consent to carry out actions necessary for the construction of a new unit at NPP Kozloduy. The MC bound the Minister of Economy, Energy and Tourism to submit a report in keeping with article 45, point

[5] Chapter based on Kovatchev, P. 2013.

[6] Based on various sources, such as: http://www.npp-nb.bg/index.php/proektat-ot-a-do-ya/proekt-zaizgrazhdane-na-novi-yadreni-moshtnosti-na-ploshtadka-kozlodui, http://www.monitor.bg/article?id=232454

2 of the Act on the Safe Use of Nuclear Energy (ASUNE) for taking a fundamental decision, and another report on the legal and organisational conditions necessary for the project's realisation. The foreseen technology to be used for generating power from a nuclear source would be a second or third generation Pressurised Water Reactor (PWR) using light water as coolant and moderator.

On 3 May 2012 the Board of Directors of NPP Kozloduy decided to create a new subsidiary company to execute the 'general' decision of the MC to establish a structural unit to initiate the realisation of the investment proposal for construction.

On 5 May 2012, the Bulgarian Energy Holding (BEH), in its capacity of principal, gave the necessary permission. The project company NPP Kozloduy – New units EAD (Sole owner joint-stock company) was thus established on 9 May 2012. The main purpose of the new company (whose capital was solely owned by NPP Kozloduy) was the planning, licensing, construction and commissioning of a new nuclear unit of the latest generation, with an installed power capacity of 1200 MWe, on the site of the NPP Kozloduy. The capital allocated to the new company's amounted to 2 million BGN (EUR 1.02 million)[7], while its budget for 2013 was 12 million BGN (EUR 6.14 million). In December, the Nuclear Regulatory Agency received an official request for the selection of a site for the future nuclear capacities (NRA 2012).

It should be noted that all 'general' decisions taken by the MC have been in breach of the Act on The Safe Use of Nuclear Energy (ASUNE). They quote article 45 of the Act, while artificially dividing it to 'preliminary' and 'final' decisions. In this way, the MC sanctions the organisation and preparation of the assessments required in point 2 of that article, placing an 'umbrella' over actions that would otherwise be the responsibility of the Minister of Economy, Energy and Tourism (article 8, point 4 of the Energy Act), the Nuclear Regulatory Agency (NRA), and even of the potential investor. Thus the MC gives its prior approval, acting not as an arbiter that assesses and sanctions the actions of other institutions, as is the law, but it steps in as a prior warranty that any barriers, including objective ones, would be eliminated, if needed, with the force of the state apparatus. This kind of approach predetermines all faults in the project, including the use of incomplete and false information, because the key proponent of a new nuclear project now is the Ministerial Council.

Kozloduy NPP – New units EAD Company

NPP Kozloduy – New units EAD ('the Company') is a sole-owned joint-stock company registered in 2012. According to the Kozloduy NPP official website, (2013), the Company's purpose includes:

1. *Construction of power units for a nuclear power plant, including design, construction and commissioning of power units, as well as associated studies, licenses, reports and assessments, in accordance with applicable legislation, as well as receiving the necessary licenses for exploitation;*

2. *The use of nuclear energy for generating power and heat, on the condition of*

All 'general' decisions taken by the Ministerial Council have been in breach of the Act on The Safe Use of Nuclear Energy

[7] 1 Bulgarian Lev (BGN) = 1.95583 EUR

possession and maintenance of a valid power and heat generation license by a power generation capacity, specified by the license, and provided it has valid licenses issued by the Nuclear Regulatory Agency for the exploitation of nuclear facilities, according to the ASUNE;

3. *Import and export of fresh and spent nuclear fuel;*
4. *Investment activities in relation to the Company's activities, as specified in its purpose;*
5. *Construction, assembly and repair works in the field of power and heat generation;*
6. *Sale of electric power – high and middle voltage, and of heat power;*
7. *Exploitation of a radioactive waste facility, on the condition of possession of a valid license in line with the ASUNE.*

In accordance with the Company's statutes, its ruling organs are the sole owner of the capital and the Directors' Council.

An analysis of the Statement of Purpose of the Company points to the fact that, *de jure*, a third company has been created for the generation of nuclear power in Bulgaria, or, in other words, a third NPP. This fact raises several key questions about the operation of the new nuclear unit, and whether it should be built and put into operation. The Statement of Purpose of the Company allows the new nuclear unit to act as an independent commercial subject ('A third NPP'), entitled to all the rights of an electric and heat power producer and trader.

Simultaneously, the new NPP opens the door to fresh financial speculation and the re-allocation of funds from the owner to this new subject, for concealing costs and / or benefits, and for achieving different ends (e.g., artificially decreasing investment costs for the new unit). Establishing an independent company with such a purpose as a whole increases the possibilities for financial speculation along the entire nuclear power chain: BEH-NPP Kozloduy – NPP Kozloduy – New Units EAD, especially in the period of preparation and construction of the new unit.

In this situation, cheap electric power from the new nuclear unit is an impossibility as the new company would have to set its own cost price. That price could not legally be part of a 'mix' of the prices of existing nuclear units and the newly built one, in an attempt to obtain an 'average' ('cheap') price of nuclear power. That such an approach is in fact under preparation is evident from the words of the NPP's executive director, Mr. Valentin Nikolov:

"When will it be clear how much the new unit will cost exactly?"

"We expect that the new economic analysis will provide approximate prices for the specific producers, which inform us whether the return on investment would be worth it. We must also know if the region would need electricity and at what price, who are the key competitors. NPP Kozloduy, however, has one major advantage. It produces cheap electric power, with which a competitive mix can be created. Because no NPP can pay off in conditions of market stress, as in present, in which the price of electricity is 60 BGN (EUR 30.7)."

The ‘Third NPP’ will also have to bear the burden of investment costs, in the form of loans, loan interests, financing for balancing capacities (e.g. hydro power plants), etc. Point 3 in the Company's Statement of Purpose – “Import and export of fresh and spent nuclear fuel” raises the issue of the control over those activities already at present, inasmuch as this business is risky for the Bulgarian energy sector (for financial and fuel quality reasons), as well as globally (non-proliferation of nuclear materials for military purposes).

The Statement of Purpose for NPP Kozloduy – New Units EAD ought to be urgently reviewed, so as to allow the Company to focus solely on its specific goal - the development of a new unit - until it is put in operation, or until the project is terminated due to its infeasibility.

The project – state of affairs and problems with the planned Unit 7 at Kozloduy NPP site

There is little information in the public sphere about the project for a new Unit 7 at NPP Kozloduy. The information publicised by the media is based mainly on individual judgments, comparisons and extrapolations by various experts, insofar as neither official, nor unofficial studies on the project are quoted.

As of April 2013 the following parameters have been discussed:

1. Capacity – various options ranging from 1000-1050 MW to “ca. 2000 MW”.
2. Type of reactor: PWR (generation III or III+), with light water as cooler and moderator.
3. Generator/Provider of the reactor: a US company or Atomstroyexport from Russia[8]
4. Project costs: unknown
5. Completion date: 2023 (BTV, 2013)
6. Return of investment period: 18 years (BTV, 2013)
7. Price of electric power generated: unknown[9]

Despite the absence of concrete data, the proponents of Unit 7 talk freely about 'low prices', 'fixed prices for long periods', 'generation III or III+', etc. Public opinion is already being prepared for an uncritical acceptance of the construction of a new nuclear unit. Reality in Bulgaria, as well as in other countries developing nuclear power, shows however that the real costs for the construction of a nuclear project, and hence, its price-cost and the final price of the electricity it generates, will always considerably exceed those presented initially.

There is little information in the public sphere about the project for a new Unit 7 at NPP Kozloduy

[8] In this case the already produced reactor for the unrealised NPP Belene would most likely be used.

[9] In BTV (2013) , V. Nikolov claims the price will be „under 100 BGN“, and that at a „fixed price for 18 years“.

Feasibility studies (technical-economic analyses)

Before any interim information on the technical and economic parameters had become available, the issue of how the new unit would be built and exploited was already being discussed

There are media reports that confirm that feasibility studies have been contracted to Westinghouse at the cost of EUR 999 500 (Duma, 2013). More details can be found on the subsidiary company's ('New Units' EAD) website (Kozloduy NPP - New Capacities EAD, 2013). The complex assessment of construction options is in its early phase.

The public, however, is not familiar with the cited socio-economic analysis. This raises the question about the possibility of socio-economic aspects being assessed by independent analysts and compared with other possible alternatives for development – both for the energy sector and for the concerned region of Bulgaria. As of April 2013 such a license had not been issued.

Meanwhile, before any interim information on the technical and economic parameters had become available, the issue of how the new unit would be built and exploited was already being discussed. Again, this is possible thanks to the media – interviews, statements, etc., and not through official institutions, accompanied by the cost-benefit analyses. For example, in an interview given by NPP Kozloduy's Executive Director, Valentin Nikolov for the Bulgarian newspaper Capital (Capital, 2013), he claimed that with regard to the construction of Unit 4, "*There has been interest from USA, Japan, China, but I can't quote any names*". He continued, stating that those companies would hold 49%, and NPP Kozloduy would keep the major share. Nikolov further stated, *"At a time when we will be making the greatest investments in this project, we will have already received a license for Units 5 and 6 and we will be able to invest entirely in Unit 7. Let's say that the project costs around 6 billion BGN (EUR 3.05 billion), our share of 49% will be a little under 3 billion BGN (EUR 1.53 billion). We should subtract the assets from this amount – the licensed site, feasibility studies executed, which means that we will have to invest roughly around 2 billion BGN (EUR 1.02 billion)."*

This approach of 'warming up' Bulgarian public opinion by means of some seemingly considerable international interest in nuclear projects is not new. In the same manner, ministers, members of parliament, experts and lobbyists have for many years been portraying enormous interest in the construction of NPP Belene by investors and banks from around the world – an interest that was finally reduced to a sole company Atomstroyexport, Russia.

At the same time, the proposition is made that the state – directly or through the state-owned NPP Kozloduy – is prepared to provide part of the financing needed for the new unit. However, that would have a direct impact on the price of electricity for the population already during the project development phase, and not after this new unit would start producing and selling electric power. This is the case because financing must be found from somewhere, but neither the budget, nor the NPP currently have available capital. Two options remain: burdening the budget with a loan, raising taxes, or rapidly increasing of the price of the 'cheapest' power – that coming from Kozloduy.

Benefits of building the new nuclear unit at NPP Kozloduy

According to the website of NPP Kozloduy – New Units EAD (Kozloduy NPP - New Capacities EAD, 2013a), the benefits of building Unit 7 at NPP Kozloduy are obvious. In particular, they argue that the foreseen benefits, achievable within 60 years of the construction and commissioning of the new nuclear unit, are:

- Economic feasibility and efficiency of using the full capacity and resources of available infrastructure on the site of NPP Kozloduy;
- Direct and indirect increases to employment for the population of Northwest Bulgaria;
- Maintenance of the scientific and technical potential of the Republic of Bulgaria in a high tech field, and a strong stimulus for the growth of the Bulgarian economy;
- An opportunity to export electric power to countries in the Balkan region;
- A secure, reliable energy supply, and a peaceful expansion of nuclear power in a way that guarantees safety and security, and minimises the risk of nuclear material proliferation;
- A considerable decrease of total greenhouse gas emissions through the development of nuclear energy, together with the application of other effective measures, such as energy conservation, increased energy efficiency and increased use of renewable energy sources;
- Implementation of the Republic of Bulgaria's Energy Strategy until 2020 under the section referring to promoting the development of nuclear energy.

Final considerations about the project

These claimed benefits are questionable. Based on the current state of the project to construct the new Unit 7 at NPP Kozloduy, the following conclusions can be drawn:

1. The **procedure for re-initiating the project has been discredited**. As was the case with NPP Belene, the project has been inititated by the Ministerial Council rather than the Minister of economics, energy and tourism, or a potential investor. This sends a clear signal that there is a political umbrella over the project. In Bulgarian context, this means uncontrolled spending of public funds, non-consideration of energy alternatives or more efficient opportunities for energy development, corruption and increasing poverty for the population.
2. Once again, as with NPP Belene, **information about the properties of the proposed reactors is lacking**. This is particularly the case with regard to control and safety systems. Stated intentions to install second or third generation reactors serve the purpose of falsely advertising technological developments in the nuclear reactor sector that simply have not occurred.
3. The unfolding economic crisis in the nation and region demonstrates that **currently the market does not support the construction of a new large-scale energy capacity** that Unit 7 promises to deliver. With poor economic

There is a political umbrella over the Belene NPP project. This means uncontrolled spending of public funds, non-consideration of energy alternatives or more efficient opportunities for energy development, corruption and increasing poverty for the population

Bulgaria's poor-quality energy infrastructure could lead to a collapse about the energy system should a new unit of 1200 MW be added

forecasts for the short-term and a vague and unstable outlook in the long run, it would seem wiser to postpone the taking of decisions, especially in light of existing unused capacities.

4. The rate of poverty in Bulgaria is estimated at 49% according to the latest data, the highest in the EU. For this reason it would seem unreasonable to burden the state with new large-scale nuclear projects. As over 80% of costs are accountable to initial capital investments, **every nuclear project entails the risk of deepening poverty in the country**.

5. The **current political situation in the country is not favourable** to the development of new energy projects. These project will likely be prolonged during the coming few years, since there are forecasts for at least one more round of elections in 2014, after one scheduled for May 2013. For this reason we argue that the project should be put on hold at least until political stability is achieved. This is crucial to guarantee fair and transparent procedures, discussion of effective alternatives for the sector and the country, and to prevent corruption.

6. Bulgaria's **poor-quality energy infrastructure could lead to a collapse** about the energy system should a new unit of 1200 MW be added. Generally, investments in energy infrastructure focusing on building 'smart grids' and systems must be priority for the sector during the next decade.

7. Over the course of previous decades it has become clear that NPP Kozloduy is a bottomless sink of iniquity, nepotism, political games and embezzlement schemes for personal and political party benefit. As such, **one can expect hidden problems will be likely to impact construction**. For this reason it is necessary to conduct a comprehensive independent audit of all parameters of the NPP Kozloduy project, before making any decisions on new capacities.

2.2.3 Liability for nuclear damage in case of accidents

In 1997 world governments took a significant step forward in improving the liability regime for nuclear damage. Delegates from over 80 States adopted a Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage. The Protocol of the International Atomic European Agency (IAEA) to Amend the Vienna Convention set the possible limit of operator liability at no less than about EUR 360 million. The convention entered into force in 2003, however with few signatories. It broadened the definition of nuclear damage to include the concept of environmental damage and preventive measures, and extended the geographical scope of the Convention, and the period during which claims may be brought for loss of life and personal injury (IAEA, 2004).

Bulgaria did not sign the Protocol to Amend the Vienna Convention, which established special drawing rights (SDRs) of EUR 300 million (increased from USD 443 million, or EUR 358 million in July 2004) as the minimum amount that a country must make available under its national law to compensate nuclear damage. In Bulgaria, civil liability for nuclear damage in the case of an accident is legally set at BGN 96 million (EUR 49 million). Compared to the Western countries

(USD 12.5 billion in Germany), it is insignificant. In light of the serious impacts of the accidents in Three Mile Island, Chernobyl and Fukushima, as well as the projected significant participation of foreign companies in Belene NPP, there is a need to update and increase responsibilities for potential nuclear damage (Tsvetanov and Kovatchev, 2013).

Individual countries of mainland Europe have legislation in line with international conventions with varying cap levels. Germany has unlimited operator liability and requires EUR 2.5 billion security which must be provided by the operator for each plant. This security is partly covered by insurance, covering up to EUR 256 million. France requires financial security of EUR 91 million per plant. Switzerland (which has signed but not yet ratified the international conventions) requires operators to insure up to EUR 600 million. It has proposed to increase this to EUR 1.1 billion and intends to ratify the Paris and Brussels conventions.

If Bulgaria is to sign the Protocol to Amend the Vienna Convention, insurance levels should be expected to be close to those of other European countries. According to international conventions, the limited liabilities of possible nuclear damage are significantly minor compared to the real damages caused by the two accidents in Chernobyl and Fukushima. In 2012 officials of Tokyo Electric Power Co suggested the costs of compensation and decontamination could double to 10 trillion yen, or USD 124.55 billion (Reuters 2012).

In practice, countries do not want to take responsibility for the real risk of accidents, or to plan levels of responsibility that can be covered by the operator, the insurance company, the country or public funds in the case of an accident.

2.3 Impacts of uranium mining in Bulgaria

2.3.1 Background

In 2007-2008 Za Zemiata, a Bulgarian NGO, together with the Institute for Green Economy, conducted an investigative tour on the state of uranium mine closures in Bulgaria. During the tour, photos and radiation measurements at selected uranium mines were taken to illustrate the actual environmental conditions around uranium mines. The photos were publicly shown in a travelling exhibition demonstrating the environmental degradation from uranium mining.

In 2011 Za Zemiata re-launched its work on uranium mines through its engagement in the EJOLT project. With a radiation specialist from CRIIRAD[10], also a partner in EJOLT, Za Zemiata did a toxic tour to some former uranium mines[11]. The tour focused on collecting water samples that were later analysed in CRIIRAD labs, and on searching for pollution hot-spots in the area through measurements with a Radex dosimeter. The conclusions presented in this chapter are based on these fact-finding tours by Za Zemiata and CRIIRAD.

[10] CRIIRAD (Commission for Independent Research and Information about radiation) is based in France.

[11] We visited Buhovo, Novi Han, Kremikovtzi and Seslavtzi, all in the vicinity of Sofia – Bulgaria's capital city.

2.3.2 Overview of uranium mining in Bulgaria

Uranium was mined in Bulgaria from 1946 to 1992. The change of political regime following the collapse of the Soviet Union – the main market for the Bulgarian uranium industry – instigated the government's decision to liquidate the uranium extraction industry. This was followed by the privatisation of uranium processing plants, the closure of uranium mines and the commencement of a national program to address the environmental impacts of uranium mining activities. The early stages of mine closures and recultivation and rehabilitation processes were characterised by chaos, a lack of institutional and technical readiness, and overall poor coordination, A lack of monitoring on top of these shortcomings meant that to very few results were produced (Petrova, Kovachev 2007).

EU membership requirements increased pressure on the Bulgarian government to tackle the negative environmental impacts of uranium mining. A special chapter on uranium mine closures in pre-accession talks addressed the legacy of uranium mining in the country.

Over twenty years on since the liquidation of the uranium industry, the results of recultivation and restoration efforts are dubious: some projects were finalised successfully, while others were abandoned without long-term monitoring. In some cases recultivation and restoration occurred only on paper.

As a consequence, environmental standards have been breached at multiple former uranium mine sites. There are on-going environmental conflicts with no clear state programme for cleaning up contamination. Meanwhile, residents of affected areas have resigned themselves to living in fear of radiation, and most have lost the motivation to stand up for their right to a clean and healthy environment.

2.3.3 History of uranium mining

Uranium extraction in Bulgaria was developed in 35 locations (**Figure 8**). Besides the many closed and open pit mines, in the period between 1958 and 1975 two plants for uranium processing and production of uranium concentrate (U3O8) were built in Buhovo and Eleshnitsa. The final product of these plants was destined for the Soviet Union.

In 1990, after the collapse of Central and Eastern European communist states, Bulgaria arranged to sell its U3O8 on the global market, for half the price it had received from the Soviet Union. Before long, the Bulgarian uranium industry found itself in a gridlock. By 1992 the Bulgarian government decided to terminate uranium mining because it was economically uncompetitive on the global market, and had caused serious long-term environmental damage.

Fig. 9

A map of Bulgaria showing the uranium mines and uranium processing facilities in the country as of 1989

Source: Anonymous

2.3.4 The uranium industry liquidation process

Initially the government aimed to finalise the liquidation of the uranium industry within 3 years of 1992. A legitimate plan for mine closure and the production of uranium derivatives and concentrates was elaborated. Responsibilities in this process were allocated among the Ministries of Environment, Finance, Industry, and Healthcare.

Soon it became clear however that the time that had been provisioned for liquidation was insufficient. Mine closure activities could not be finalised within the initial timeframe and the government adopted a staged approach with new time lines focusing on the technical liquidation of the mines, technical and biological re-cultivation, and water restoration and monitoring. In the meantime, the plants in the uranium industry underwent a hasty process of self-closure.

In 1998 the uranium mine closure plan was once again found to be inappropriate and the government decided to change its strategy by creating a state-owned company, Ecoengineering Ltd. It was to be responsible for all liquidation activities. The responsibilities of the company were defined as follows:

- technical liquidation of mines and all processing installations;
- technical and biological re-cultivation of all affected territories polluted with radionuclide, heavy metals and other chemical compounds;
- radiation monitoring of affected areas, including monitoring of underground and surface waters, soils, sediments, vegetation and air quality;

- water purification and installations for the same;
- investment activities;
- managing of projects in the Phare12 programme of the EU.

2.3.5 Activities addressing the adverse effects of uranium mining undertaken by the state

In 1992 the Bulgarian Academy of Science carried out several studies near mines to allow the actual state of environmental degradation to be assessed, and for concrete actions for the mine closure and rehabilitation to be suggested. The studies documented:

- high levels of natural gamma ray radioactivity 60% above the national average taken from multiple locations;
- proven serious health risks for the population;
- elevated concentrations of uranium and radium in soil;

A follow-up report set the scope of future mine closure activities and recommended a forest-biological re-cultivation of waste piles with a maximum possible sealing of mines and a ban on pasture and foliage use in affected areas.

Data provided by Ecoengineering Ltd. (a state-owned company) on activities finalised between 1998 and 2007 showed that technical liquidation had been carried out on 10 sites, biological and technical recultivation on 23 sites and water purification at 24 sites, with all sites subject to monitoring during that period.

Besides these government funded projects, several projects were also funded by the EU Phare programme in the period of 1995-2004. These were managed by various companies with the help of EU experts and consultants. However, most of these initiatives did not lead to significant progress in eliminating the impacts of uranium mining

Observations from the National Environmental Agency for the period 1998-2006 showed that:

- at some sites there had been no monitoring network and hence no on-site monitoring;
- in many affected regions post-mining sites had been abandoned, and water purifying installations were non-functioning, with water quality indicators above the national standard for radioactivity;
- the sealing of mine entrances was damaged, most probably by thieves, who had removed valuable metal parts to be sold as scrap at recycling points;
- the signs that indicate the places where polluted mine waste waters were drained were missing;

[12] The Phare programme is one of the three pre-accession instruments financed by the European Union to assist the applicant countries of Central and Eastern Europe in their preparations for joining the European Union.

- warning signs indicating that the use of certain lands for pasture was prohibited were missing; and
- access of humans and livestock to the affected areas had not been restricted, with livestock often drinking radioactive water.

There is no single example of successful re-cultivation.
On most sites, the installations remain abandoned and the soil is still contaminated by mining waste

As a result of the efforts of Ecoengineering, the negative environmental impacts of uranium mining can be described as partially or in some cases, entirely unsolved. There has no persistent control of the mine closure process or consequent recultivation activities. This is illustrated by the fact that the rehabilitation process of affected regions remains unfinalised. There is no single example of successful re-cultivation, and a full assessment of polluted areas and the state of the environment has yet to be produced. On most sites, the installations remain abandoned and the soil is still contaminated by mining waste (Petrova, Kovachev 2007).

This is why environmental, health and social impacts directly resulting from the closure of uranium mining persist in the affected areas. At some locations the re-cultivation and rehabilitation works were unsuccessful and high levels of gamma radiation continue to be measured. The results of soil and water sample analyses are also a cause for concern, with higher than accepted radiation levels. Yet, the quality of information available to the public about the risks of living in post uranium-mining areas is poor. To date no assessment or explanation of the risks has been conducted; hence people often remain in ignorance, failing to take appropriate personal safety measures in an environment of high radiation.

On the other hand, there has been no clear stage-by-stage planning for long-term rehabilitation. Nor has a national strategy on uranium mining been produced, which is vital to successful mine closure.

2.3.6 Case studies at former uranium mines in Bulgaria

In 2007 Za Zemiata and the Institute for a Green Economy undertook independent studies at five former uranium mining sites: Buhovo, Senokos-Brezhani, Eleshnitsa, Dospat-Barutin and Smolian. During the site visits information was gathered through meetings with municipal leaders, workers, citizens and experts.

Buhovo

The village of Buhovo was home to a uranium processing plant and a tailings pond. After several rehabilitation projects, two of which were financed by Phare, the ponds are still uncovered. Moreover in March 2006, the reinforced wall of the pond collapsed, threatening water bodies and sources in the region with contamination. According to documentation provided by the Ministry of Economy and Energy, one mine closure activity maintained the tailings pond in a pre-liquidation state from 1998 to 2006. This was a highly inefficient and suspicious strategy, and there are still no plans for the final closure of the pond. The history of contamination in fact dates back to 1956, when there was no pond and the highly radioactive wastewaters from uranium extraction were released directly into the environment. Thus the heavy fraction settled in the soil while the liquid fraction was channelled into the local Buhovska River - an indirect tributary to the longest river in Bulgaria – the Iskar, thus spreading the pollution in a very large territory.

Fig. 10

Abandoned uranium ore processing plant in Buhovo, 2008

Source: Za Zemiata

For the processing plant (**Fig. 10**) there were two ponds built. The waste stored there had a complex composition of inert mass, uranium and thorium radionuclide, plumb, zinc, arsenic, copper and other heavy metals, sulphates, carbonates, nitrates and metal salts. At the time of their construction, the bottoms of the ponds were not sealed with a hydro isolating layer. This lead to the infiltration of all radioactive and polluting substances into groundwaters. In the past, the ponds were indicated with warning signs, however most of these have long been removed or stolen. The fences preventing humans and livestock from entering have moreover been removed.

Fig. 11

On site radiation monitoring station out of order, 2011

Source: Za Zemiata

While one of the ponds is now dry, with no aquifer or surface waters entering, a second pond seems practically eternal. It stores radioactive waste from processed uranium, including uranium isotopes 238 and 235 with a very long half-life period. There are two aquifers at the bottom of the pond with incoming surface waters from nearby springs. Although the capacity of the pond is limited, polluted water is accumulating. This means that without measures for draining and closure, the water will eventually exceed its capacity and advance downstream to nearby villages. This will leave the territory polluted with radiation, and the population vulnerable to serious environmental and health risks.

Virtually all of the 120 mine entrance shafts in the areas of Buhovo are open, although they were once sealed. Access to the shafts is free and as a consequence waste metals left behind in the mines have been stolen and sold for scrap. Atmospheric weathering has also occurred, which leads to the spread of radioactive dust in the nearby territories. Moreover, the on-site monitoring system is not functioning (**Fig. 11**).

Senokos-Brezhani

Information gathered by the mayors of the two settlements has revealed that the shafts in Brezhani were reportedly buried, while in Senokos the open pit mine was simply abandoned. Although an installation for waste water purification was built, at present it is not functioning due to the theft of the absorbing column.

Piles of waste were recultivated by planting trees on the terraces of the pit. During the on-site visit, Za Zemiata found that the trees were unstable and erosion was occurring on the mine pit slopes (**Fig. 12**).

Fig. 12

Recultivated open pit mine at the village of Senokos, 2008

Source: Za Zemiata

According to data available from the National Environmental Agency, the wastewater is still high in uranium content. These waters leaked out from under the mine and entered the river Yana, used for irrigation. From Yana the radiation spread further to the river Struma that goes into Greece and the Aegean Sea.

The municipality and locals are interested in improving the image of the region with the aim of developing eco-tourism, but this will be difficult if problems resulting from uranium mining continue unabated.

Eleshnitsa

In Eleshnitsa the initial separation of ore by flotation was done in a local mill, whilst the production of yellow cake was carried out in Buhovo. The mayor of Eleshnitsa reported that the mill had been closed without any plan, leading to uncontrolled stealing of materials and machines. In 1998 the tailings pond was sealed. It was covered with one metre of isolation material and vegetation planted on top. Locals however were reported to be unsatisfied with the re-cultivation works, stating that huge amounts of money had been stolen during the Phare projects, that workers had been subject to unhealthy conditions, and that water leakages still polluted groundwater and rivers downstream. On-site observations by Za Zemiata discovered the re-cultivation of the pond to insufficient - with the land masses covering it eroded, and uranium contaminated soil leaking down the slopes (**Fig. 13**).

Fig. 13

Re-cultivated uranium mining tailings pond at the village of Eleshnitsa, 2008

Source: Za Zemiata

The system for automatic radiation control, and measuring air quality, had not been effective. Environmental measurements were done only sporadically by the Regional Environmental Agency, while health observations were not done by any authority.

Dospat-Barutin

The rehabilitation process in 2005 involved the transformation of the open pit mine of Barutin into municipal landfill for four municipalities (**Fig. 14**).

Fig. 14

Former uranium open pit mine transformed into a landfill at the village of Barutin, 2008

Source: CEIE, Bulgaria

The project was completed through a Phare funding. The shafts were sealed, but there was no permanent monitoring system and rarely measured by the Regional Environmental Agency. It had been recommended not to use the pastures and waters close to the mine. Locals explained that they knew where the problematic area was and did not need signs warning them of the possible hazards. They, however occasionally used the land in the area of the mine shafts as pastures.

Smolian

Closure is planned for the mine in Smoljan. At present the terraces of the pits are collapsed, the waste piles are not vegetated and when floods occur, waste material is being washed away. No absorption columns for water purification have been installed and after 1995 there was no state funding for any mine closure or restoration activities. Soil from the waste piles is being used as rubble.

2.3.7 CRIIRAD findings

As part of the EJOLT project, in the summer of 2011, Za Zemiata organised further visits to former uranium mines near Buhovo, Seslavtzi, Kremikovtzi and Novi Han, three settlements north of Sofia where uranium mining has left severe environmental impacts. In the course of this mission, carried out between 6th and 8th June 2011, a scientist[13] from CRIIRAD laboratory took radiation measurements in situ, collected water samples and participated in training activities and lectures with the local communities (**Fig. 15**). The CRIIRAD visit helped to identify some hotspot locations around former uranium mines and re-activate public attention. The main hazards posed by the closed uranium mines are presented as follows:

Fig. 15

CRIIRAD scientist on investigative mission in Bulgaria, 2011

Source: CRIIRAD

[13] The findings from the CRIIRAD mission to Bulgaria are written by B. Chareyron, engineer in nuclear physics who performed the monitoring in June 2011.

Contamination of water

Even decades after the closure of the mines, the water flowing from some of them is still carrying high concentrations of radioactive substances

The results of the radiological and chemical analysis of five water samples taken by CRIIRAD showed that even decades after the closure of the mines, the water flowing from some of them is still carrying high concentrations of radioactive substances (uranium) and chemicals, including heavy metals and toxic substances (e.g. arsenic). Uranium concentration was found to be 197 µg/l in a small river downstream. A drain from the water treatment facility of the Chora mine (Buhovo) measured 350 µg/l a few meters from the entrance of the Gabra mine (Novi Han).

Another measurement of 1 653 µg/l was taken in a drain at the lowest horizontal former adit (Adit 93) of a mine in Kremikovtzi. In the case of Kremikovtzi, the situation is well known to the authorities as a mine water drainage treatment plant was planned but has not been completed. The elevated uranium concentration in the water sampled downstream from the Chora mine demonstrates that either contaminated water is running from the sampling point without treatment, or that the effectiveness of the water treatment facility is questionable.

In Seslavtzi there is a large pond (about 270 meters long) where contaminated water from mines had been able to settle before being discharged into the river. The pond is now dry but its bottom is lined with contaminated mud and sediments (**Fig. 16**). One meter above ground the dose rate is about 0.6 µSv/h in most of the surrounding area. These radioactive sediments should be transferred to a repository designed for the confinement of long-lived radionuclides (the half-life of ^{238}U is 4.5 billion years).

Fig. 16

Unprotected pond with radioactive mud at the village of Seslavtzi, 2011

Source: CRIIRAD

Box 3 The case of Les Bois Noirs mine, France

Source: CRIIRAD

Environmental monitoring near former uranium mines in France by the CRIIRAD laboratory has been used to argue that the standards for water contamination accepted by the authorities are too high, and that companies are not able to design and operate efficient water treatment plants. For example, in the case of Les Bois Noirs mine (Rhône-Alpes region), the radium 226 content of the treated water is in conformity with the official standards (0.3 Bq/l is the mean value for year 2012 while the standard is 0.37 Bq/l). However, radioactive metal present in the water from the treatment facility has accumulated in vegetation growing in the watercourse downstream from the treatment facility. CRIIRAD monitored radium 226 contamination of 160,000 Bq/kg in plants sampled in October 2012. These samples effectively constitutes radioactive waste. This is to say that there is no safe standard for concentration limits regarding water pollution.

Radioactive rubble

Waste rocks containing radioactivity can still be found in areas easily accessible to the public. For example the dose rate monitored on the picnic tables at the Seslavtzi monastery is 0.35 µSv/h. The radiation comes from the radioactive rubble located less than 1 meter from the tables. A dose rate of 0.88 µSv/h has been monitored one meter above the rocks. Some waste rocks show high radiation doses like 110 µSv/h to the skin[14] (**Fig. 17**). Such a dose rate is about 500 times above the typical natural level. If a child comes into contact with such radioactive rocks he/she can receive substantial doses of radiation.

Fig. 17

110 µSv/h radiation dose rate from a waste rock at picnic spot near the Seslavtzi monastery, 2011

Source: CRIIRAD

The dose rate monitored 1 meter above ground on the main uncovered waste rock pile located about 100 meters from the monastery was between 0.6 and 0.9 µSv/h. The dose rate to the skin from such samples is 50 µSv/h (about 250 times above the typical natural level). The same is the case for piles of rubble at the former uranium crusher in Seslavtzi (0.88 µSv/h one meter above ground and 20 µSv/h on the rocks).

[14] Hp 0.07 dose to the skin monitored with an electronic professional dosemeter EPD.

Fig. 18

Waste pile near Seslavtzi easily accessible to the public, 2011

Source: CRIIRAD

An on-going problem is the theft of radioactive materials, mostly metals, from the mine galleries

In Buhovo city, rocks containing radioactive waste were used for road surface repair between the school and the hospital. There the dose rate is 0.46 µSv/h (1 meter above ground) and more than 4 µSv/h on the road surface. In Novi Han some roads are filled with radioactive waste rocks from the Gabra mine. The dose rate measured in the soil at the mine entrance is between 0.6 µSv/h and 5.5 µSv/h. In addition, the fluctuation of gamma radiation rates near an opening in the wall sealing the mine entrance suggests high emanation of radon gas from the mine. The opening was made by thieves, which points to another on-going problem – the theft of radioactive materials, mostly metals, from the mine galleries. Moreover, the fact that radioactive waste rocks are openly accessible (**Figs. 18** and **19**) means that no effort has been made to reduce their radiological impact. Local people are therefore exposed to ionizing radiation through many pathways: external irradiation by powerful gamma radiation, inhalation of the radon gas permanently emitted into the atmosphere by the rocks, inhalation of radioactive dust dispersed from waste rock dumps, contamination of surface water in contact with the rocks (through dissolution of mobile radionuclides such as uranium and radium), and contamination of food due to livestock grazing on contaminated areas.

Fig. 19

The Seslavtzi monastery - a tourist attraction situated at the edge of the waste pile, 2011

Source: Za Zemiata

Fig. 20

Dust from a waste pile on a picnic table at the Seslavtzi monastery, 2011

Source: CRIIRAD

The population should be informed and fully aware of the environmental conditions they are living in and receive clear instructions on activities they should abandon to lower their exposure and avoid risk.

Box 4 AREVA – forced to clean up radioactive polluted sites in France

Source: CRIIRAD

In France, CRIIRAD together with 13 other NGOs associated under the name 'Uranium mines group' is putting pressure on the French authorities and the company AREVA to clean up all the areas where radioactive waste rocks have been reused. AREVA has also been obliged to make maps of radioactive contamination in the vicinities of about 200 uranium mines publicly available. This work was done using helicopter mapping and on-site checking with portable radiation meters. To date a few places have been cleaned, including a school yard, the car park of a restaurant, and a saw mill. In some cases the annual doses accumulated by inhabitants has been far above the annual dose limit of 1 mSv/a milliSievert per year (see Euratom Directive 96/29). The highest doses occurred when waste rocks were used ikn the construction of public buildings or private houses. In such cases the highest part of the dose comes from the inhalation of radon from radioactive rocks.

2.3.8 Health studies

The National Centre for Protection from Radiation in Bulgaria has assessed the carcinogenic disease risk for the population in former uranium mining areas. Reports from the years 2003, 2004 and 2005 indicate:

- high radiation risk in Eleshnitsa, Yana and Seslavtsi, where the annual individual effective doses of radiation were above 10 mSv/a;
- relatively high radiation risk in Buhovo, Gorni Bogorov and Dolni Bogorov, where the annual individual effective doses of radiation were above 5 mSv/a;
- the village of German is in an environmentally clean region;
- the monitoring data are identical for three consequent years showing a higher risk of gastrointestinal cancer in the settlements with high and relatively high

radiation exposure compared to the control village of German. Mortality rates in the high-risk locations is higher compared to those of the control village, although not very different from average mortality figures for Bulgaria. The standardised mortality from lung cancer for the two settlements is higher compared to the control village and Bulgaria.

Box 5 Health effects of radiation exposure

Source: CRIIRAD

Even at very low doses, ionizing radiations have a negative impact on health. The dose above which the long-term risk of cancer is considered as unacceptable by the ICRP is 1 milliSievert per annum (mSv/a). This corresponds to 17 cancers for each 100 000 exposed persons. It should be noted that for many independent scientists the figures provided by the ICRP publication N°103 (year 2007) underestimate the actual level of risk. The limit of 1 mSv/a is the reference in Europe (see Euratom Directive 96/29). This limit does not apply to natural background radiation and radiation associated with medical practices.

In the case of nuclear reactors, the dose due to natural background has to be subtracted from the total annual dose received by to the local population in order to evaluate the impact of nuclear activity alone. In practical terms, the impact of uranium mines has to be calculated using the contributions of all pathways (ingestion of contaminated water or food, inhalation of radioactive dust and radon gas, exposure to external irradiation). The sum of all the contributions from all sources will then be compared to the limit of 1 mSv/a. Such evaluations require a great deal of scientific data and effortsto modelling peoples' way of life.

For example, if the ambient natural dose rate in a given area is equal to 0.2 µSv/h, the natural cumulated dose after one year (8760 hours) is 1 752 µSv/a or 1.75 mSv/a (this dose is the contribution of external irradiation from the soil only). Let us assume that radioactive rocks from a uranium mine are used at this place for landfill, with a new dose rate increased from 0.2 (natural before mining activities) to 1.0 µSv/h (post mining situation). The additional external irradiation due to the mining activity will be 1.0-0.2 = +0.8 µSv/h. The cumulated external irradiation will depend on the time spent at this location by the population. If people spend one hour per day at this place, the annual impact will be 1 hour/day * 365 days/a *0.8 µSv/h = 292 µSv/a =0.292 mSv/a (external irradiation only). Then it will be necessary to add to this number the doses due to inhalation of the radon gas emitted by the rocks, the doses due to ingestion of contaminated food or water, and the doses from external irradiation at possible other hot spots in the area. The cumulated dose may well exceed 1 mSv/a when all contributions are added.

In the case of Bulgaria, if radioactive waste rocks were used for the construction of buildings as well as for road repair, people could be exposed to radiation for 10 hours per day (instead of one hour), The additional dose would be 2.92 mSv/a instead of 0.292 mSv/a. In this case, people would also receive an internal dose through the inhalation of the radon gas permanently produced by the radium 226 in the rocks. This additional internal dose could reach a few mSv/a and sometimes a few dozen of mSv/a. If levels were to reach 5 mSv/a, then the global impact would rise to 2.92+5 = 7.92 mSv/a. Again the evaluation of total impact would require taking into consideration all other sources (ingestion, other hot spots, etc.).

2.3.9 Recommendations to the authorities in charge of mine closure

Za Zemiata argues that it is necessary for responsible institutions to plan and carry out a series of measures to safely finalise all uranium mine closures. These measures would include rehabilitation of the affected terrains and protection of the local population and livestock from the negative impacts of radiation from former mines. The following steps are essential:

1. An on-site assessment of the actual state of the mines and installations by

experts, and not through existing documentation.

2. Analysis of the financial needs for uranium mine closures for the whole country.

3. On the basis of the assessment and the analysis (points 1 and 2), the update of rehabilitation programs and development of a long-term mine closure programme, including obligatory procedures, prioritising environmental restoration and human health protection.

4. Studies on radon concentration in private buildings in the affected regions and implementation of measures for the protection of the population where needed.

5. Increased control of the activities of Ecoengineering ltd., including through independent control institutions.

The continuous control of the mine closure process should be jointly done by the Nuclear Regulation Agency and the Environmental Agency

Za Zemiata also suggests that the continuous control of the mine closure process be jointly done by the Nuclear Regulation Agency and the Environmental Agency. This should include:

- Control of the safety of all mine closure procedures complying with the laws for radiation protection;
- Control of the radiation in the soils, air, waters and vegetation in the territories of all the uranium mines and processing installations.

2.4 Alternatives to nuclear power in Bulgaria

Having considered the costs and impacts of nuclear energy, and the risks that this energy path entails, we now examine some alternatives. In the next section of this report we introduce different energy scenarios. Then in the final chapter, we present a quantitative cost analysis of different renewable energy sources (RES) in order to compare them with nuclear energy.

2.4.1 Energy Scenarios

Bulgaria is committed to the EC 2020 strategy of reaching the target of deriving 16% of its energy consumption from RES by 2020. In recent years, there has been rapid development of the RES sector. Various scenarios have been presented on the future development of Bulgarian energetics, following trends in energy development in the EU. Apart from the Government's energy strategy by 2020, more progressive strategies have been developed. The team of Plamen Tsvetanov from the BAS, for instance, makes projections until 2030. This is one of the most competent long-term visions. Another comes from Environmental Association Za Zemiata, which includes energy for heating and cooling, making projections to 2050. Both projected scenarios demonstrate that there is no need for new capacities at least until 2030.

There are several reasons for this, among them decreased consumption in the production sector due to financial recession, the temperature rise and the shortening of the winter season as a result of the climate change, and the decline in the export of energy, which traditionally compensated for the difference between internal consumption and the production of currently existing installed capacities. An illustration of the inaccuracy of the projected scenarios according to which consumption was foreseen to increase in parallel with the GDP, can be drawn from the energy surplus crisis in April 2013, when with 12,000 MW installed, energy consumption fell to a record low 2,400 MW. Power plants, especially the RES power plants were systematically disconnected from the grid (except for the large Water Power Plants for security reasons), and total production decreased by 40%.

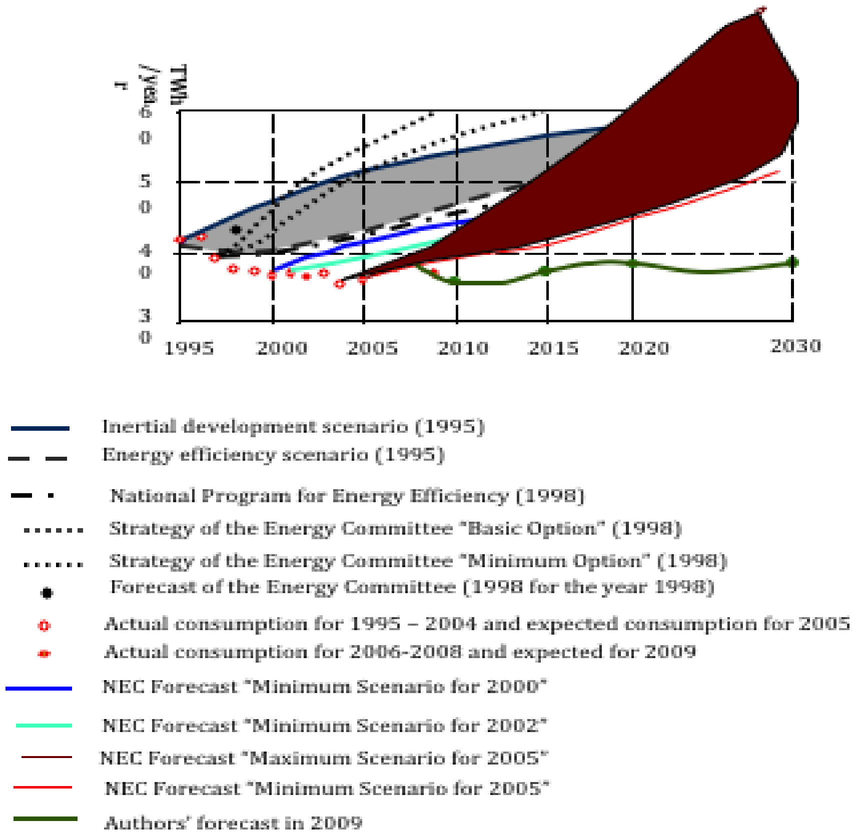


Fig. 21

Chronology of official forecasts for electricity consumption in Bulgaria

Source: "Energy development of Bulgaria: challenges and problems", SRA Plamen Tsvetanov, Petko Kovachev

The scenario for 2005, which excluded the construction of Belene NPP in 2011, projected an energy deficit on the internal market. This proved incorrect and in 2010 and 2011 Bulgaria exported record quantities of energy, equal to 2/3 of production from Kozloduy NPP.

Even the scenario of Energy System Operator (ESO)[15] from 2009 (ESO, 2009) did not project the need to constrict the new NPP Belene. At that time ESO had projected the closure of several Thermal Power Plants (TPP) as of 2015, which would continue to function several years more under a regime of replacing capacities.

[15] The company of the Electricity System Operator - ESO EAD has been established on January 4th, 2007 as a subsidiary of the National Electrical Company - Natsionalna Elektricheska Kompania - NEK EAD.

Alternative energy scenario 2050 by EA Za Zemiata[16]

In 2008 the Bulgarian NGO Environmental Association Za Zemiata created an alternative energy scenario for the development of the energy sector in Bulgaria by 2050. The purpose of the scenario was to explore whether Bulgaria could be energy independent by 2050, based entirely on renewables. For countries without sufficient RES potential, such a scenario would be impossible due to the need to rely on energy imports. The scenario for Bulgaria, developed in cooperation and using the methodology of INFORSE-Europe, shows that energy independence based on RES is possible, even when using conservative data from official sources.

The purpose of the scenario was to explore whether Bulgaria could be energy independent by 2050, based entirely on renewable energy sources

The most important future developments, under this scenario, are:

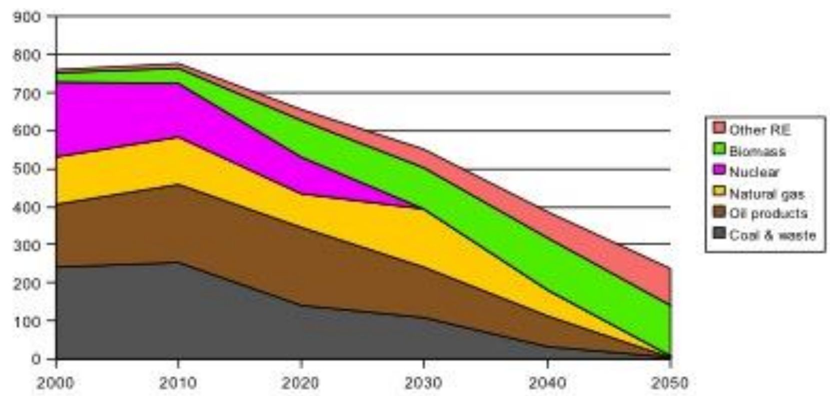
- Wind power - with the development of 1700 MW on land until 2020 and a total of 3000 MW until 2030 including offshore wind turbines in the Black Sea.
- Biomass - including the important use of agricultural land for biomass plantations, and use of straw for heating and CHP production. Straw, which today is burned on the fields, can be used for energy. The potential is estimated to 35PJ, equivalent to 35% of the Bulgarian straw production from wheat and barley. The use of agricultural land for energy plantations is expected to increase to 1700 km2 until 2030, similar to 42% of the current area of non-used agricultural land.
- Solar heating - with 1 million m2 by 2020 and 7.5 million m2 in 2050.
- Solar PV – experts and the governmental strategies did not predict the boom of the PV sector, which, after the feed-in-tariff Law was passed in 2007, lead to 879 MW installed capacity in 2013. Solar PV is also expected to play a role after 2020, with 49 million m2 installed by 2050.

Fig. 22

Change in primary energy supply (PJ) in Bulgaria, following the Za Zemiata vision

The decrease after 2020 is because of assumptions of less material growth than today and strong emphasis on energy efficiency

Source: INFORSE-Europe and Za Zemiata, 2008



In addition, geothermal, biogas and hydropower energy play an important role in the vision, though that of hydropower has been limited due to problems with new developments. There were 1,659 RES plants installed by May 2013 in Bulgaria.

[16] Based on "Bulgarian Vision for Sustainable Energy" (INFORSE-Europe and Za Zemiata, 2008).

Figs. 22 and **23** illustrate the distribution of different energy sources for primary energy supply and energy production. The complete phase out of nuclear capacities appears possible around the year 2030 with the expiration of the last two nuclear reactors of Kozloduy NPP.

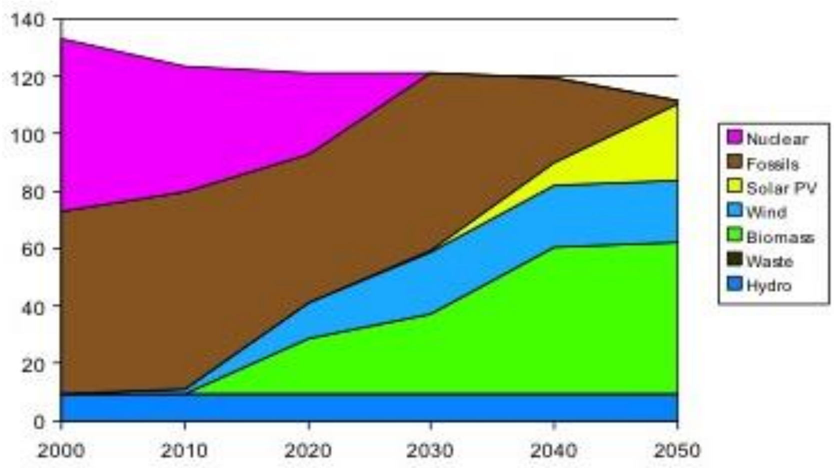


Fig. 23

Development of electricity production and sources in Bulgaria, following Vision 2050

Source: INFORSE-Europe and Za Zemiata, 2008

Energy Efficiency

The 2050 vision for Bulgaria is based on increasing energy efficiency by 2050 using the best available technologies today. A number of studies have shown that with the best available technologies on the market, or close to market introduction, it is possible to increase energy efficiency with a by a factor of four or above. This would require large efficiency gains, similar to an annual efficiency increase of over 2% per year (starting from 2010). However, given that the actual rate of technological development in EU countries has been about 1% per year, such gains seem unlikely. To be cost-effective, concerted actions from all stakeholders on an EU-scale will be required, providing a large market for each new generation of efficient equipment. Energy savings could then offset the extra equipment costs. To realise this plan however, requires going beyond the conservatism of many market players in this field, and developing a truly enabling market for energy efficiency across society. A factor four increase in efficiency is possible for most of Bulgaria, apart from the agricultural sector with its low electric intensity, and for road transport and for industrial heating and fuel demands, according to Gunnar Boye Olesen (INFORSE-Europe and Za Zemiata, 2008).

2.4.2 Analysis of alternatives - from Renewable Energy Sources (RES) to nuclear energy in Bulgaria

The use of renewable energy sources dates back to the early history of mankind and its use of waterwheels, windmills, and windpower for sailing. RES encompasses a wide range of technologies from diverse sources such as biomass, biogas, wind, solar, hydro, tidal, and geothermal (Johansson and Turkenburg, 2004). They are proposed as a sound means of climate change mitigation, along with nuclear energy, due to absence or low levels of carbon emissions (Verbruggen, 2008). Despite the fact that the market for RES is subsidised, the potential use of RES in Bulgaria faces obstacles in terms of reliability and other technical aspects. This is especially the case for wind and solar energy. It is crucial to point out, however, that their maximum production coincides with energy consumption peaks.

This chapter investigates the question of whether the planned capacity to be produced by the 2000 MW unit at Belene NPP could be produced by RES instead, for a competitive price. To do so we first discuss each type of RES in terms of its available potential and economic viability

Although Bulgaria does not need new capacities at present due to overproduction and decreased consumption, the cost-benefit analysis, which considers social and environmental issues, will assist in exploring whether old capacities need to be replaced, and whether new capacities can be developed from RES rather that nuclear power. Our final goal is to build a sustainable energy model which balances financial, environmental and social criteria and responds to the question of what shape a sustainable energy mix should take for Bulgaria over the coming decades.

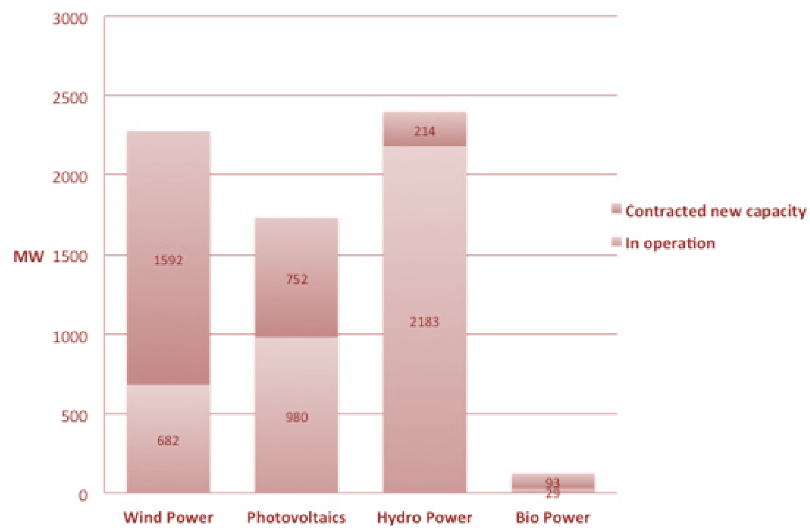
2.4.2.1 Background: RES in Bulgaria – targets and conflicts

Instead of importing energy and exhausting centralised conventional fossil fuel sources, a mix of RES combined with a rational consumption of energy, could offer a sustainable solution to issues related to energy supply security, environmental protection and economic development.

Fig. 24

Renewable energy capacity, Bulgaria, March 2013

Source: MEET



The continuous and deepening energy deficit caused by fossil fuel dependence in European countries, including in Bulgaria, is increasing. The economic dependence of the European economy on countries that export oil, natural gas and other scarce primary energy sources is also on the rise. In this context there is already a trend toward the development of RES in Europe, with significant foreseen in the use of alternative and renewable energy source for achieving self-sufficiency (**Table 7**, see also **Appendix 1**).

Member State	2005 RES share	2010 RES share	1st interim target	2020 RES target
Austria	23.3%	30.1%	25.4%	34%
Belgium	2.2%	5.4%	4.4%	13%
Bulgaria	9.4%	13.8%	10.7%	16%
Cyprus	2.9%	5.7%	4.9%	13%
Czech Republic	6.1%	9.4%	7.5%	13%
Germany	5.8%	11.0%	8.2%	18%
Denmark	17%	22.2%	19.6%	30%
Estonia	18%	24.3%	19.4%	25%
Greece	6.9%	9.7%	9.1%	18%
Spain	8.7%	13.8%	10.9%	20%
Finland	28.5%	33%	30.4%	38%
France	10.3%	13.5%	12.8%	23%
Hungary	4.3%	8.8%	6.0%	13%
Ireland	3.1%	5.8%	5.7%	16%
Italy	5.2%	10.4%	7.6%	17%
Lithuania	15%	19.7%	16.6%	23%
Luxembourg	0.9%	3%	2.9%	11%
Latvia	32.6%	32.6%	34.0%	40%
Malta	0%	0.4%	2.0%	10%
Netherlands	2.4%	3.8%	4.7%	14%
Poland	7.2%	9.5%	8.8%	15%
Portugal	20.5%	24.6%	22.6%	31%
Romania	17.8%	23.6%	19.0%	24%
Sweden	39.8%	49.1%	41.6%	49%
Slovenia	16.0%	19.9%	17.8%	25%
Slovakia	6.7%	9.8%	8.2%	14%
UK	1.3%	3.3%	4.0%	15%
EU	8.5%	12.7%	10.7%	20%

Table 7

Overview of Member States' progress

Source: European Commission, 27.03.2013, Renewable energy progress report, Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions

Legend:

> 2% above interim target
< 1% from or <2% above interim target
> 1% below interim target

In the National Renewable Action Plan, as stated in the Bulgarian Energy from Renewable Sources Act, there are several incentives and obligations for participants in the renewable energy market, including:

- prioritising the connection of producers of electricity from renewable sources to the transmission and/or distribution network;
- obligatory purchase of electricity produced from renewable sources, except for hydropower plants (HPPs) of over 10 MW installed capacity;
- preferential purchase prices for the electricity produced, except for electricity produced by HPPs of over 10 MW installed capacity;
- obligations to keep within time limits stated by producers for putting energy facilities into operation;
- allocation of funds by owners of transmission and distribution networks in their

investment programmes for network development in relation to the promotion of electricity produced from renewable sources (National Renewable Action Plan, Bulgarian Ministry of Economy and Energy, State Gazette No. 35/3.05.2011).

According to the latest Renewable Energy Progress report of the European Commission from March 2013, Bulgaria is exceeding its interim target for RES by 3% (**Table 7**).

Feed-in tariffs

The main supporting instrument for the promotion of RES in Bulgaria is the feed-in-tariff (FiT) for electricity produced from RES, or from high-efficiency co-generation plants feeding into the public grid, which are regulated by the State Energy and Water Regulatory Commission (SEWRC). The adoption of the new Renewable Energy Act in May 2011 meant that FiT rates were no longer regulated by law and could be reduced at any time. According to a 2012 report prepared for DG Climate Action of the European Commission, the Bulgarian regulatory authority SEWRC introduced a retroactive grid usage fee for any renewable energy plant connected to the grid since 2010. According to the report, these fees cut the tariff rates retroactively by as much as 39% for certain technologies, leading to uncertainty concerning Bulgaria's renewable energy investment climate (Ecologic Institute, 2013).

Conflicts

A variety of conflicts have emerged in relation to the production of RES in Bulgaria. Some are related to preferential prices for energy from RES sources, and others to the construction of RES parks in NATURA 2000 areas (on international bird migration routes, namely *Via Pontica*).

According to the National Renewable Action Plan published in 2011, incentives for the RES sector have led to an increased investor appetite for the production of renewable energy. However, they have also created obstacles to the development of the sector, some of which are outlined below:

- the number of investors that have come forth to construct wind and solar farms is so great that the capacity of the energy system would be exceeded;
- renewable energy projects have been implemented in sensitive areas with environmental restrictions, breaching environmental assessment procedures;
- requests have been submitted for the conversion of agricultural land to non-agricultural purposes in connection with the implementation of projects for the construction of wind and photovoltaic plants. Some of these investors however have not secured the necessary financial resources for these projects. The result is that the status and designation of fertile land is altered, precluding its further use for agricultural purposes (National Renewable Action Plan, Republic of Bulgaria, 2011).

Fig. 25

Protest on the streets of Sofia against high electricity bills and energy monopolies, February 2013

There were protests in more than 30 towns in Bulgaria.

Source: Railroadwiki

A 70-year-old man at the protests says:
"I protest against the misery that we have suffered from all of governments so far. They turned the country into our enemy"
His latest electricity bill was 350 BGN, while his pension is 350 BGN monthly

Source: Dnevnik.bg, February 24th, 2013

In April 2013, the Bulgarian Electricity System Operator (ESO) announced a plan to restrict the production from all RES connected to the grid, namely PV and wind, by 40% in order balance production and consumption. Similar cuts were implemented for conventional power plants. In May and June 2013, similar steps were taken in hydro power production to avoid the possible overflows of dams (Bulgarian Electricity System Operator, 2013). This happened following a period of citizen protests across Bulgaria in reaction to the high price of electricity bill (**Fig. 25**). The media led a persistent, targeted campaign against the preferential prices of energy from RES, despite the fact that the ratio of RES in their bills was below 10%. This situation has led to debates over whether there should be a new formula for calculating prices that include 'duties towards society'.

There are other environmental conflicts from RES. The wind and PV power plants of world's biggest consortia such as Mitsubishi, AES, and Lukoil in the north-eastern part of Bulgaria are situated on agricultural land, with a changed statute. **Fig. 26** shows a wind park in the proximity of the Black Sea, situated on the Via Pontica international bird migration route. According to experts from Birdlife Bulgaria, the migration route of the birds has changed as a result of the windmills. This causes difficulties to their migration. Plant managers have attempted to solve the problem by deactivating the windmills during the migration period.

Fig. 26

Wind mills in an international bird migration route

Source: T. Slavov

2.4.2.2 Assessment of the potential and costs of electricity production from RES by type

In the following sections we analyse the potential and costs of four different renewable energies; biomass, biogas, wind and solar. In the final section we analyse the potential for using this renewable energy for heating and cooling.

a) Biomass and biogas

In Bulgaria biomass as a source of energy comes in the form of wood and agricultural waste, such as straw, often processed in the form of pellets and briquettes.

Biogas production from agricultural waste biomass is a secondary process by which anaerobic disintegration produces gas with high concentration (up to 75%) of methane. In assessing the potential of biomass, we include the biofuels produced through its processing.

Potential and technologies

In assessing the potential for energy production from biomass, it is necessary to y differentiate between types of biomass and technologies for its use, namely its transformation into energy. There are mainly two types of biomass – wood and wood waste with a high concentration of tissue and organic raw material, which are then classified as follows:

- organic waste from agriculture, livestock breeding and maintenance of parks and gardens (excluding shrubs and branches);
- biogenic or industrial waste from food processing, including slaughterhouses, gastronomy and organic domestic waste

Available technologies for processing biomass include:

- direct incineration with and without cogeneration;
- thermal gasification;
- anaerobic digestion – biogas installations.

The assessment in this report considers the potential for energy from biomass from organic waste, considering it uses the most environmentally friendly technology for its treatment. In most cases, the treatment of organic waste uses large quantities of external energy. The technology of *anaerobic digestion* produces energy for electricity, heating and cooling from the *biomethane*, safely treating the organic waste. In addition, the residue from fermentation is harmless and provides an excellent biological fertilizer widely usable in agriculture.

Biomass

According to the National Long Term Programme to Encourage the Use of Biomass for the Period 2008-2020, the technical potential of biomass is as follows:

Wood biomass - yielded 5,662,472 m^3 in 2005, about 40% of the annual growth, including 3,073,059 m^3 of firewood.

Twigs and branches - waste products from wood processing. Currently, only a small portion of this is used as The collection of small-size wood is viewed as economically ineffective and only 9.6 % of planned quantities (348,339 m^3) are being utilized. Unutilized branches and twigs for 2005 amounted to a 65,164 toe/year energy equivalent. This represents a large amount of potential energy.

Solid agricultural waste - available unused quantities vary between 20 and 80% depending on the by-product (straw, vine pruning, fruit tree pruning, maize, sunflower, tobacco stems) totalling 593,800 toe/yr.

According to the same Programme, results indicate a significant energy potential from unused quantities of solid agricultural by-products. If the by-products for which well-developed technologies of energy transformation exist (straw, vine pruning, fruit tree pruning) were to be used, their energy equivalent would amount to 2.9 % of gross domestic consumption in Bulgaria (Bulgarian Ministry of Economy and Energy, 2011). The Programme concludes that the maximum possible electric generation is about 58 GWh/year.

Agricultural land is defined as the arable land, perennials, permanent grasslands for agricultural purposes (including high mountain pastures and grasslands with low production potential), family gardens and agricultural lands not cultivated for over three years.

Category	2011		2010		2009		2008	
	ha	%	ha	%	ha	%	ha	%
Area for agricultural purposes	5 486 572	49.4	5 492 891	49.5	5 490 113	49.5	5 648 206	50.9
Used agricultural area	5 087 948	45.8	5 051 866	45.5	5 029 585	45.3	5 100 825	46
Unused agricultural area	398 624	3.6	441 025	4.0	460 528	4.1	547 381	4.9

Table 8. Use of the territory for agriculture in Bulgaria 2011, total area (ha) and percentage of country area

Source: Ministry of Agriculture and Food Republic Bulgaria, BANSIC. Biogas Energy EOOD

In 2011, arable land made up 3 227 237 ha, which is 63.4% of used arable land in the country and to 29.1% of the total area of the country. According to Dr.Svetla Bytchvarova, professor and director of the Academy of Agriculture (Interview to S. Bytchvarova, 2013), of 4.6 million ha of land that was returned to its previous owners, 3.4 million ha are in use (during peak cultivation time), leaving 12 million ha of arable land abandoned. There is a thus a significant amount of land that is not being exploited for agricultural production, which could be used for production of biomass for energy.

Biogas

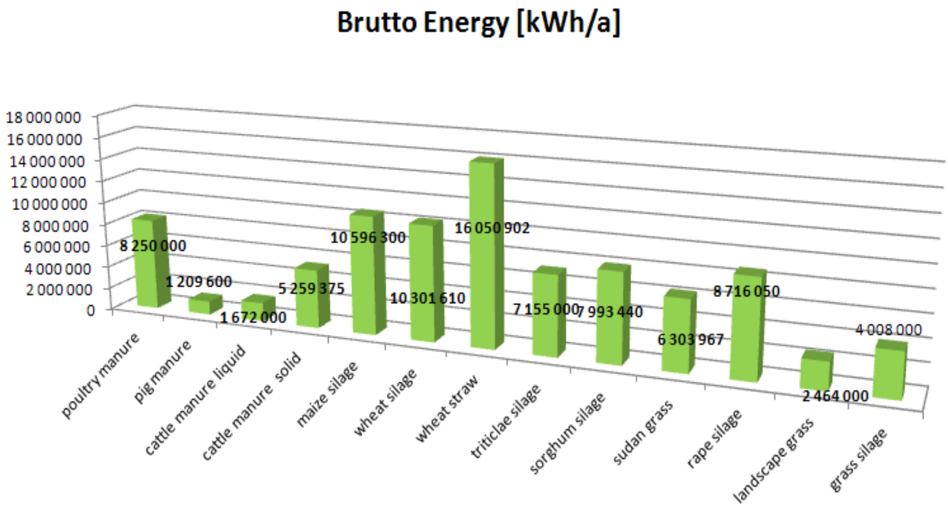
Brutto energy includes potential from heat and electric energy. **Figure 27** shows the total annual energy potential in KWh from various organic agricultural products. The figure shows that the potential from straw is the highest, followed by silage. Manure from livestock has the third most potential.

Fig. 27

Total energy, including electrical and heat energy

The chart is based on the production of biogas from the relevant substrates, provided in **Appendix 4**

Source: © Biogas Energy, data KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft)



Following this classification, we can attempt to make an assessment of the potential for energy production from biomass and biogas installations. This can be done by using data on the theoretical potential of different types of sources, and statistical data on agricultural lands, raw material production and animal breeding, and on criteria for selecting and building biogas installations.

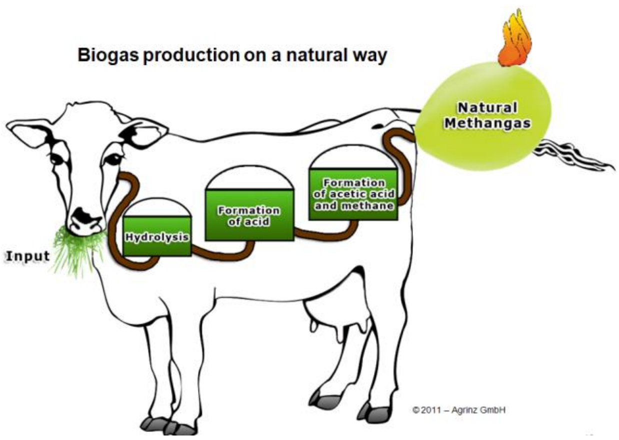
Biogas can be produced from all organic raw materials (e.g., **Fig. 66**) that have low lignin content, for example:

- Biogenic wastes from the food-processing industry and households
- Wastes from stock-breeding (liquid and solid manure)
- Energy crops, silage, etc.

Fig. 28

Biogas production

Source: AGRINZ GmbH 2011



Biogas can be used by several technologies, for example:

- Direct combustion and heat utilization:
- Combined heat and power generation (CHP) - gas-otto-engines, pilot-injection gas motors, Stirling-motors, biogas micro-turbines, fuel cells;
- Biogas upgrading - vehicle fuel;
- Biogas upgrading (bio-methane production), fed into the public natural gas grid.

Biogas production is a sustainable solution for the safe treatment and utilisation of animal manure, which can facilitate the application of the EU Nitrates Directive to which Bulgaria is bound. **Figure 29** illustrates livestock production rates in Bulgaria as of 2011.

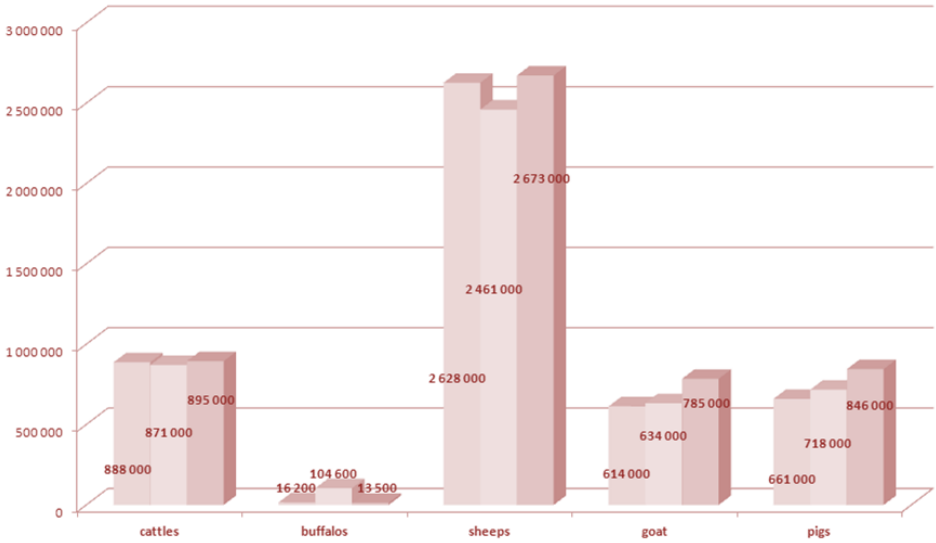


Fig. 29

Livestock production in Bulgaria as of 1st November 2011

Source: Ministry of Agriculture and Food Republic Bulgaria, Department 'Agrostatistic' – Inquiry "Numbers of stock bred in Bulgaria, until 1-st of November 2011", chart: © Biogas Energy EOOD

Types of biogas installations

Depending on the input material, there are four types of biogas installations. Two of these are regarded as significant sources of energy (see **Fig. 30**):

Agricultural biogas plants (manure and dung from cattle, pigs, poultry, and agricultural products and by-products)

Co-fermentation biogas plants (mainly agricultural waste and products combined with biogenic waste)

Fig. 30

Types of biogas installation

Source ©Agrinz GmbH

The other two biogas plants are:

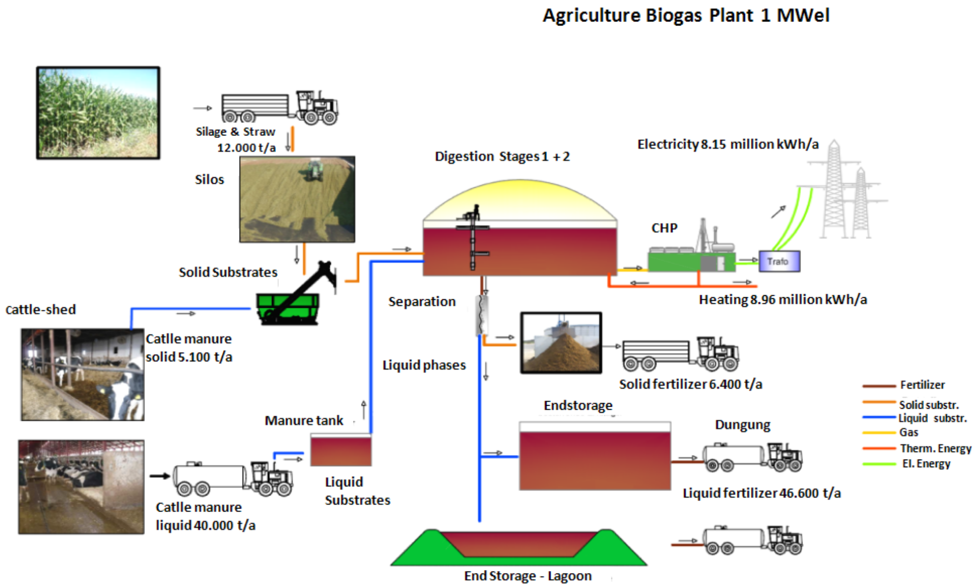
- Waste biogas plants (biogenic waste from gastronomy, slaughterhouses, animal feed, organic waste from households, etc.)
- Industry biogas plants (industry waste – bioethanol, biodiesel residues, etc.)

A principle layout of a biogas plant is presented in **Fig. 31** demonstrating the production cycle using different input material, such as silage and straw, cattle manure (solid and liquid) with the end products – thermal and electric energy, and fertilizers.

Fig. 31

Principle layout of biogas plants

Source: © Agrinz GmbH

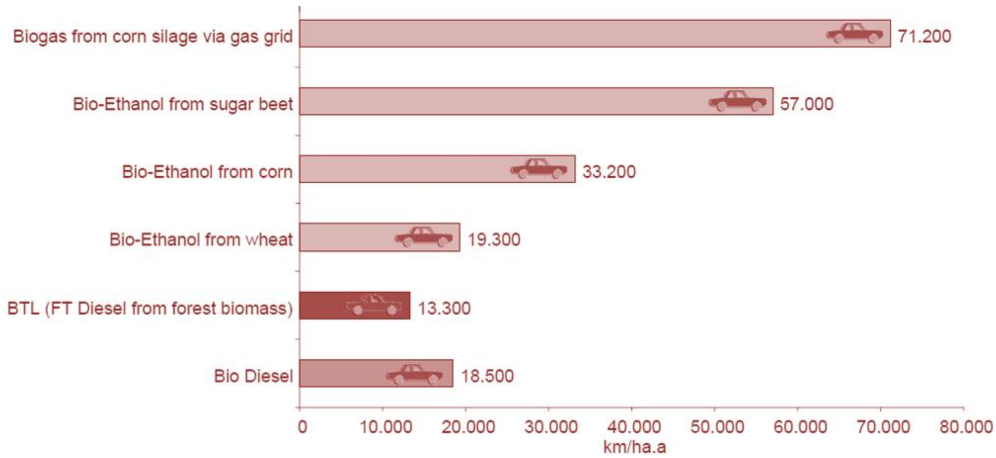


The graph below (**Fig. 32**) presents the advantages of biogas from waste biomass or silage as a second harvest. It is not only more sustainable compared to fuels from energy crops, but also it is more efficient.

Fig. 32

Distance (in km) a car can run with fuel produced on 1 ha

Source: © Agrinz GmbH



Potential for agricultural biogas installations

Agricultural installations

The construction of biogas installations solely based on agricultural products is not recommended. This is from the point of view of sustainability of the processes in the biogas installations, but also in the interests of protecting arable agricultural terrains from uncontrolled sowing of energy rich crops.

For the purposes of the current analysis, we can use the following approximations:

- Average estimation of yields from straw per 1 hectare land: the average harvest of straw from 1 ha is an average of 3 - 4 tonnes, which amounts to 536,181 kW(e) (energy values of 0.07 kW/tonne). This gives an overall potential of over 500 MW(e) of constructed biogas installations. Of course here we should note that the energy utilization of the total quantity of straw is not possible, which is why for the purposes of this analysis we accept a conservative scenario of 200 MW(e).

- Average estimation of yields from silage per 1 hectare land: Of the 2 553 242 ha sown with cereals, only 1 327 009 ha come from wheat, barley, rye, oats, colza and other crops, which allow for a more intensive agriculture and the sowing of a second yield. However there are barriers to intensive agriculture, such as a lack of markets for second yield crops - silage for the biogas installations

From 1 ton of silage from second yield crops (corn, Sudan grass, sorghum) producing an average of 390 kW(e), and with the average yield of 1 ha equalling 15 to 30 tons, the total energy potential is estimated at over 1,000 MW(e), with a more conservative scenario of 300 MW(e).

Installations using co-fermentation

The second yield of energy crops is recommended from the point of view of sustainable agriculture and for natural regeneration of the soil. Biogenic wastes are strong polluters of the environment and are a source of acute infections, which can lead to health epidemics. So far there no measures have been taken for the safe treatment of such wastes in Bulgaria, due to a lack of appropriate legislation and an absence of specialised installations for their treatment.

Co-digestion biogas installations are directly linked to the animal husbandry in the country. In Bulgaria there are mainly *three types of farms* – large, small farms and domestic farming.

For the purposes of the current analysis, we consider only the number of animals on large and small farms, assuming a ratio of 60% to 40% of cattle and dairy cattle and 90% to 10% of birds. The rest of the animals such as sheep, goats, and others are not considered since they are bred in open areas.

We calculate that the conservative scenario for energy potential from small and large farms, excluding the number of animals from family farms for own use, is a minimum of 70MW/el.

The energy potential of small farms (between 80 and 200 animals) is between 50 and 100 KW(e) and is fully sufficient for satisfying the needs of the farm for both electricity and heating.

The energy potential of small farms (between 80 and 200 animals) is fully sufficient for satisfying the needs of the farm for both electricity and heating

The construction of *co-digestion biogas installations* using animal manure, green mass (agricultural residues such as straw, silage and forage), as well as a secondary yield of energy crops and combination of biogenic wastes from gastronomy, food store chains, and the canning and food processing industry, is highly recommended. This is a way towards *energy independence.*

Estimation of the capacity and costs of a biogas plant

Next, we estimate the capacity and costs for the production of electricity and heating energy from agriculture and waste biomass products within Biogas plants.

Table 9

Calculations of energy potential from biomass annually

Source: Calculations by Mag. Eng. Yana Jekova, CEO of Biogas Energy Ltd. Bulgaria

Input materials:		
Cattle manure:	5,500 t/a	
Poultry manure:	10,600 t/a	
Corn silage:	10,000 t/a	
Straw Colza /wheat:	4,000 t/a	
Total	**30,100 t/a**	
Total produced power		
Electric power:	1,400 kW	
Heating power:	1,450 kW	
Energy:		
1.400 kW energy	(1,400 kW x 8 150 h = 11,410.000 kW/a)	
1.450 kW heating energy	(1,450 kW x 8 150 h = 11,817.500 kW/a)	
Energy for own needs	200 kW	1,630,000 kWh/a
Energy for sale	1,200 kW	9,780,000 kWh/a
Biofertilizer:		
42,000 tonnes high quality organic fertiliser annually from which:		
10,000 t/a solid manure		
32,200 t/a liquid manure		

As shown in **Table 9**, we consider the investment costs for an installation with 1.4MW installed capacity for electricity and 1.45 MW for heating. In the table below we provided the costs for the installations by type, upon which we make an approximation of the total capacity.

Types of costs	Estimated costs (EUR)
Engineering, management and introduction in exploitation of an installation	€ 450,000
Construction of an installation for exploitation: • Excavation activities • Construction of the fermenters – 2 fermenters of 4.200 m^3 each • Storehouse for the residue after the fermentation – for 6 months – 16.000 m^3 • Storehouse for raw materials – silo – 5.500 m^3 • Fundaments and buildings	€ 1,205,000
Biogas installation • including all necessary equipment and installation works	€ 2,397,000
Co-generation unit	€ 1,165,000
Additional equipment • including installation water supply, equipment for straw collection and its preparation for use, etc.	€ 318,000
Total for the construction of a biogas installation - 1,4 MWel (electrical energy) + 1,45MW heat energy	€ 5,535,000

Table 10: Calculation of estimated investment costs for biogas installation Source: Calculations by Mag. Eng. Yana Jekova, CEO of Biogas Energy Ltd. Bulgaria

Summary and Conclusion

There is a great potential for the use of biomass electricity and heating in Bulgaria. Za Zemiata foresees this potential to grow, with biomass comprising a significant percentage (see **Section 2.4.1** on Energy Scenarios) by 2050. Currently the main use of biomass is for heating by direct combustion. The potential of biogas, which

Biomass and animal manure for the production of biogas are the most efficient and sustainable use of waste for producing electricity and heating

is currently estimated to be between 570 and 1,600 MW, is not fully utilised due to the fact that this technology is new to the Bulgarian market. Investment costs are relatively higher than for other technologies and vary depending on whether heat energy is used. Such costs are lower than those of nuclear capacities, but the lack of biogas plants poses an obstacle to monitoring operational costs.

In order to stimulate the production of electricity from biomass in 2013, the government introduced preferential prices. These are the highest of other renewable energy sources, however, there are numerous environmental conflicts associated with the sustainable use of biomass. These include illegal logging, inefficient technologies such as direct burning which also cause air pollution. It is furthermore problematic that there preferential pricing is not applied to high-technology burning. Nor are there incentives for co-generation of heat and energy. In our view, combustion for electricity production solely, without utilisation of heat energy output is entirely unacceptable from an environmental point of view and should not be subsidised.

We therefore recommend that biomass and animal manure for the production of biogas are the most efficient and sustainable use of waste for producing electricity and heating.

According to official data from BAS from 2011, 60% of electrical energy generated in the country is used for the production of heat (for households and production needs). Biogas installations are the only RES that offer an effective means of disposing of organic waste safely, at the same time generating energy for electricity and heating, and producing organic fertiliser. The generation of energy for heating can save on the production of large quantities of energy for electricity.

The availability of inexpensive energy for heating can also facilitate a revival of greenhouse production, for which Bulgaria has a long tradition. The utilisation of available organic fertilisers, as well as the introduction of modern technologies for the use of CO_2 for direct nutrition of the plants, can close the natural cycle, and at the same time provide for inexpensive ecological products grown in an environmentally friendly manner.

b) Wind energy[17]

Present use and potential for the development of the wind energy in Bulgaria

As of the end of April 2013, there was an installed capacity of 670 MW, owned by 178 companies. According to experts from the Bulgarian Wind Energy Association, with existing technologies there could be an additional installed capacity of 600-800 MW over the next 10 years, which could double in following decade. This comes close to the projected scenario of EA Za Zemiata, as presented in **Section 2.4.1** on Energy Scenarios.

With technological development, the potential for development grows as well. For

[17] The chapter is based on information from Mariyana Yaneva, Executive Director of the Bulgarian Wind Energy Association (*BGWEA*) and on data from BGWEA.

example, modern wind turbine installed on higher altitudes where the wind is more powerful allows for greater production. While until recently, turbines had a capacity of 1 - 1.5 MW, they can now produce between 2 - 3 MW. This in practice means that higher capacity can be produced with fewer turbines.

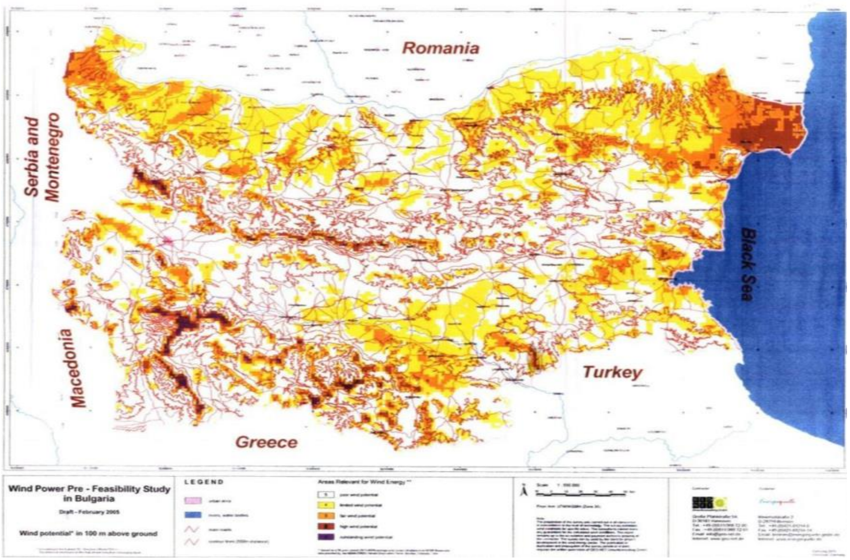


Fig. 33
Map of the winds in Bulgaria, modelled at 100 m altitude. The darker the colour, the better the conditions for project realisation

Source: 2009 GEO-NET Umweltconsulting GmbH, www.geo-net.de

Benefits from wind energy

From the outset of project development, investors in wind energy have relatively certain knowledge of the lifetime cost of a plant (**Fig. 34**). This is due to the facts that information for installation costs is available, the average wind speed is known in advance, and wind generation generally has low variable costs, zero fuel cost, and considerably lower carbon emission costs.

The investment and income that wind energy brings to Bulgaria are an important source of revenue for local municipalities and for the Bulgarian economy as a whole. It should be noted however that a large portion of investment in wind energy in Bulgaria comes from foreign sources.

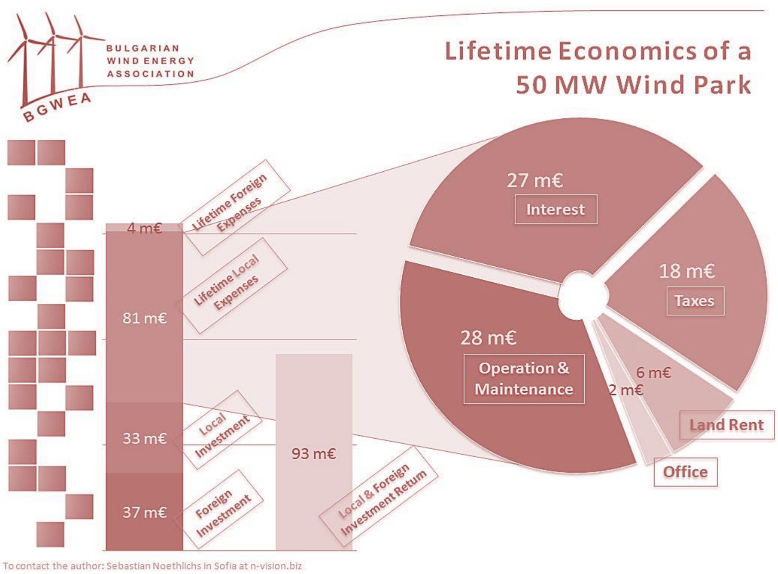


Fig. 34

Lifetime economics of a 50 MW wind park

Source: BWEA, 2013

Estimation of costs of wind energy in Bulgaria

Wind energy brings new jobs almost exclusively to the countryside and many structurally weak and economically underdeveloped areas

The principal components of the cost of wind energy include capital investment, operation and maintenance, and finance. The following represents an approximation for the lifetime economics of a 50 MW wind park, consisting of 25 turbines of 2 MW each installed in Bulgaria in early 2011.

In the model presented, initial capital expenses are split into two main categories – *foreign* and *local*. Foreign investments include mainly the cost of importing wind turbines and associated components and services that cannot be sourced locally. The local portion of investments includes the costs related to engineering and development, obtaining permits and construction.

Lifetime spending includes operation and maintenance expenses, office or administrative costs, rent paid to land owners for the land on which the plant is installed, insurance and interest payments, and local taxes.

Investment return is calculated on the assumption that the plant receives a feed-in tariff of BGN 190 (EUR 95) for the first 2,250 full load hours of operation in a year, for a term of 15 years. Since both the tariff and the term of the power purchase agreement are currently lower in Bulgaria, the return on investment will tend to be lower for future projects.

When we consider employment we should mention that the types of jobs created vary. High and low qualified jobs are created for workers such as technicians, managers, engineers, security staff, etc. Of particularly importance for Bulgaria is the location of these jobs. Wind energy brings new jobs almost exclusively to the countryside and many structurally weak and economically underdeveloped areas. If we add to the picture the ecological benefits of a 50 MW wind park, the overall benefits can be seen in **Figure 35**.

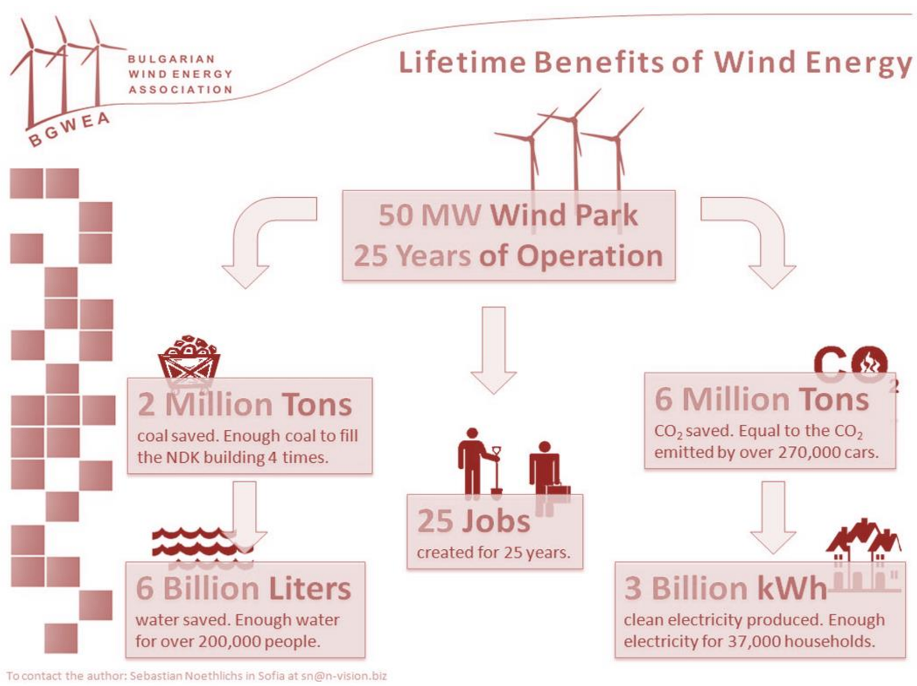


Fig. 35

Lifetime benefits of wind energy

Source: BGWEA

Main stages of the investment process for development of wind energy

- **Prices and markets**

The preferential buy-off price for wind energy is defined for a guaranteed period of time with the purpose of decreasing the investment risk of return of the initial capital investment. Its value depends mainly on the price of the wind turbines. However, other factors include the stability and predictability of the regulatory framework, the length of the procedures and the administrative expenditures for project development and the financial conditions, and later, the expenditures for exploitation.

After the obligation to buy-off wind energy at preferential rates expires, which for current operating capacities will happen in the period 2020 – 2024, plants will sell energy at market prices. Considering the more efficient wind turbines and hence lower production costs, it would not be incorrect to assume that the price of wind energy will become competitive in the following decade.

According to BGWEA, the question of the market and preferential rates depends significantly on when Bulgaria has a functioning energy market. The association considers that the creation of an auctioning market for the trade of electrical energy and regional connection of the markets is crucial. Prices on the free market should be formed reflecting externalities such as environmental pollution and deteriorating livelihood conditions as well.

- **Economic and social impacts**

Trends for the development of price levels for conventional and renewable sources move in two opposite directions. The price of the energy from conventional sources is increasing while that of the RES, and in particular from wind, is decreasing.

At the moment, sale prices for new wind capacities are compared with prices for the sale of energy from conventional plants, whose initial investments have been long been paid off. This is an incorrect approach. In principle, when a price assessment is made, it should take into account the whole lifecycle of the new plant. The preferential buy-off price of energy from wind should secure investors a return on their initial investment. The preferential price, however, is based on a period of 12 years, when in fact the lifecycle of a wind power plant is 25 years.

- **Priority of costs**

Wind energy is among the cheapest sources of energy on the market, compared to both conventional and other RES sources. In Bulgaria, it costs between EUR 0.066 and 0.077 per kWh, lower than the price of energy from modernised conventional plants, and close to the price of energy sold from plants that have paid off their initial investment.

Prices on the free market should be formed reflecting externalities such as environmental pollution and deteriorating livelihood conditions as well

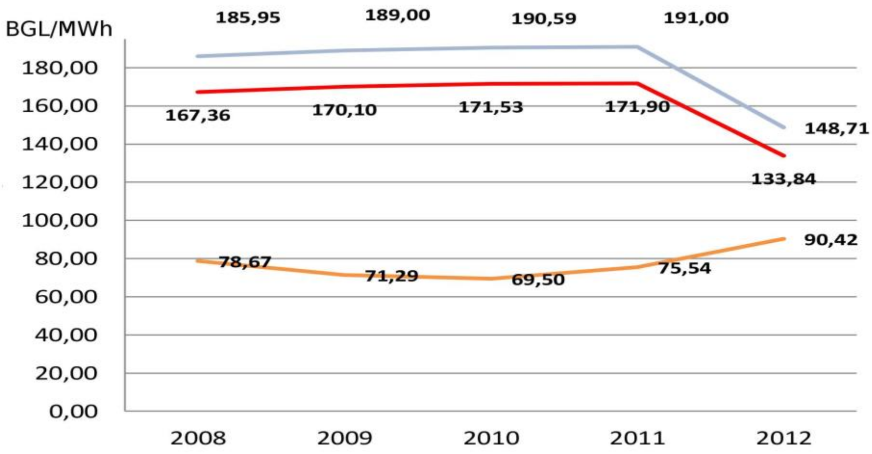


Fig. 36

Comparison of the market 'base price' of the electricity from conventional sources and wind energy (new methodology)

Orange – market 'base price' of electricity from conventional sources

Grey – market price of wind energy

Red – market price of wind energy including access fee

Source: BGWEA, 2012

The graph shows that since 2011, financial support for energy from wind (the regulated price) has decreased by 50%. For the same period the base price of the energy has increased by 20%. We can conclude that even without subsidies the economic potential of 800 MW for the next ten years will be realised and wind energy will be competitive on the market.

c) Solar energy

Tendencies and return of investment for a photovoltaic power plant

In Bulgaria there was a boom of the PV sector after the feed-in-tariff Law was accepted in 2007, leading to an installed capacity of 879 MW in 2013 (see **Section 2.4.1**).

The high buy-off prices for RES stimulated high interest among producers. The authors of this report recommend the connection of small PV installations under 5KW in order to avoid losses from transformation to low voltage and transmission. In cases of network failures, such installations can secure energy to the end consumer. In (state the year, not how long ago), the Bulgarian association Public Environmental Centre for Sustainable Development, Varna, carried out a pilot project to monitor the process of connection of micro producers of PV energy to the network. Unfortunately this pilot showed a poor return on investment over the project cycle of 25 years. This was due to unforeseen expenditures for synchronizing the operation of the system to sine-wave alternating current in the network, despite the high buy-off prices. In addition, the project leader Illiev noted that without state incentives for small scale solar energy production, and a lack of legislative coordination to regulate investments costs and fees, small scale solar production would likely not appeal to the average Bulgarian home owner (Iliev, 2013).

As a result, the authors of this report recommend energy production from small-scale PV integrated roof installations, which allow for the end consumer to be the actual producer of the energy. This could be possible with the introduction of new technologies especially in the construction of new generation photovoltaic panels, as current installations are not sustainable in terms of embodied energy and materials.

From 2011, the procedures for small producers have been eased, but new problems continue to make investment unprofitable, such as the 'Access tax to RES', of 0.07 EUR/kWh. This tax is logical for large producers for whom it is necessary to build new networks for connection to the grid, but not for small ones that connect directly to low voltage grids. Thus, the payback period of the investment increases to 30 years, which is longer than the timeline of the installation.

Cost of small-scale solar power installation in Bulgaria

According to ENPROM, the investment cost for a PV plant is between 3500 and 3800 EUR/kW for plants with monocrystalline and polycrystalline modules built on static platforms. For plants with thin-film solar cells the price can be higher, reaching 3900 EUR/kW. For plants with solar tracking panels the price range is 4500-5000 EUR/kW, but the quantity of energy produced is 35% greater compared to static constructions.

Assessment of the potential for energy for heating and cooling from RES

In this report we aim to develop a scenario for sustainable energy use. Thus we underline the advantages for producing energy for heating and cooling from RES with efficiency over 50%. Compared to the transformation of electricity into energy for heating and cooling using conventional sources of energy (such as Thermal Power Plants (TPPs), NPPs) RES is 30% more efficient without sending the energy for heating into installations for District heating. In contrast, highly efficient installations for burning biomass and for solar and thermal generation can have a transformation coefficient of over 90%. The other advantage of these installations is that the loss of transferred transfer is considerably lower. Due to the small dimensions of these installations, they can be located near consumers, something that is not possible for energy from TPP and NPP.

For the reasons listed above, the EC introduced changes to targets for the final energy consumption balance from RES by 2020, including a 20% target for heating and cooling.

On a national level the incentives are higher buy-off prices for co-generation installations, which stimulate the production of energy for heating and cooling from biogas and biomass. This also stimulates the decentralization and placement of energy production of at the place of consumption.

As noted in the Bulgarian National Energy Strategy 2020 "*almost 40% of energy used in Bulgarian households (including for heating and housekeeping) is for electricity, while for Europe this percentage is 11%. The excessive use of electricity in households results in costs that are three times higher than those of primary energy production. This is despite the fact that more ecological and less expensive alternatives exist, such as the direct use of natural gas*."

Solar energy for heating and cooling

Solar energy for hot water can help overcome energy poverty at household level. It is a paradox that in a country where 80% of the population is classified as living in energy poverty, 25% of electricity consumed in households is used for heating water in a country with one of the highest potentials for solar energy in Europe. Interestingly, from 1977 to 1990 Bulgaria ran a programme to promote the use of solar energy for heating, making Bulgaria a leader with a total installed capacity of solar panels of over 50,000 m^2, more than in countries like Spain. The installed capacities were mainly on rooftops of public buildings, enterprises and hotels, with households excluded from the programme. The fall of the communist government and a subsequent wave of privatisation, as well as the use of inefficient equipment and short-term inexpensive technologies however, meant the cessation of further installations within a decade. Such examples demonstrate how strategies and programmes can fail by not taking key factors into account.

In the last years Bulgaria has adopted a series of positive measures for stimulating the production of energy for heating from RES. These included introducing a tax-free regime for buildings with installed RES, obligatory connection to the heating distribution system, and credit lines with a 20% grant from the European Bank for Reconstruction and Development. After the year 2000, the market grew to 5,000 m^2 installed solar collectors annually. However it is difficult to provide a precise assessment due to a lack of centralized official data, and the segregation of the sector into small companies.

The concentration of the population of the country continues to be in towns and mainly in apartment blocks, which, according to the expert assessment of A. Atanasov from the Technical University in Varna, reduces the technical potential for the use of solar energy for heating and cooling to 5% of the total use of hot water. New buildings have had solar panel capacities installed in order to conform to EC targets for RES. What remains problematic however, is the existing building infrastructure and the high percentage of people living in energy poverty.

In Bulgaria, a good quality solar installation (between 1,300 and 1,700 MWh/m^2/a) for a four-member family home costs between EUR 1,000 and 2500, depending on the technology used, and based on a payback period of between 5 and 10 years for over a 20-year exploitation period.

Different authors foresee smaller investment costs when the capacity of the installations is increased: 377 EUR/m^2 (including VAT) for 6m^2 installations, 317 EUR/m^2 for 15m^2, and 488 EUR/m^2 for 132 m^2 (Pandelieva, 2009). For the purposes of the current analysis, we take a conservative average of the cost, updated for 2013 at 600 EUR/m^2, which includes maintenance and amortisation costs. With an average production rate of 600 MWh/m^2 for the different collectors, the cost is 1 EUR/KWh/a. For a 50 year exploitation period this works out to 0.02 EUR/KWh.

Energy for heating and cooling from biomass

According to the National Plan for Action for Energy from RES (2012), and based on the assessment of the Association for District Heating in Bulgaria, we estimate that by 2020 there will be new biomass installations with a total heating capacity of 99.2 MW. The total heating energy from these installations is estimated to produce 416.6 GWh/yr.

Energy for heating and cooling from geothermal energy[18]

Bulgaria is rich in geothermal waters with temperature between 20° and 100° Celsius, and for decades there has been a tradition in the use of this environmentally friendly source of energy for heating of buildings. According to data from MoEW as of 2010, from existing wells it is possible to produce 1979 litres/sec or 82.9 MW of heating capacity (when cooled down with 10° C) and 165.8 MW when cooled with 20° (on average at a 2000 m depth).

Bulgaria is rich in geothermal waters. For decades there has been a tradition in the use of this environmentally friendly source of energy for heating of buildings

Only 28% of this potential has been utilised in the last 5 years in Bulgaria. According to leading experts such as Professor K. Shterev, at depths of 4000m in the aquifers, there are large quantities of hot water, some of which are salinated at a temperature of 140° C. Their energy potential is estimated to be around 2300 MW.

When calculating the costs of energy for heating, the concession tax, of 0.25 EUR/m^3 must be included. There is also a minimum pollution tax if the water is released into soil or sewerage, because of its higher temperature and mineralization. When re-injected back to the geothermal reservoir, this tax can be avoided, utilizing a closed loop system.

Thus, for a 1-stage usage of a water source of 55° C and with a production rate of 40KWh from 1m^3 the cost is 0.006 EUR/KWh (0.0125 BGN/KWh). Then there are the investment costs for the construction of infrastructure from the source to the consumer to consider, as well as operational costs. For example, in the case of the largest hydrothermal source in the country, the Malmovazhanski aquifers located 1800m underground, the water springs on its own with a 3.5 bar pressure and 56° C. The use of communicating heat pumps could enable a 5-stage usage of the water, which could allow its use for drinking purposes.

For deep thermal aquifers, the initial investment costs and technical requirements for the consumer to be close to the source pose obstacles to the full exploitation of their potential, the usage of geothermal energy from surface layers (at depths up to several tens of meters) is increasingly. In the last several years hundreds of sequentially connected ground heat pumps have been installed, providing heating for separate buildings. The advantage of this type of system is that in the summer months they can be used for cooling.

These heat pump installations are well suited to Bulgarian sub-zero winter temperatures, especially compared to air to water heat pump installations, which are inefficient under such conditions.

[18] The chapter is based on data from Associated professor A.M. Mirtchev, Technical University Varna, 2013.

2.4.3 Discussion of the alternatives

The table below compares the price of energy from new and operating nuclear power plants, with energy from RES per KWh in eurocents. The buy-off prices of energy from the operating Kozloduy NPP and the different types of RES are taken from the State Energy and Waters Regulatory Commission (SEWRC) (new RES prices were introduced from 1st July 2013).

Costs by source (without VAT)	Minimum in eurocent/kWh	Maximum in eurocent/kWh	Other in eurocent/kWh	Comment
ELECTRICAL				
Nuclear (Belene NPP)	3.7 (at 5 % interest and 3 yr construction)	16.1 (at 10 % interest, 7 yr construction)	7.49 (HSBC at 8.23% discount rate)	Projections (LEC)
Nuclear (Kozloduy 5-6 NPP)	2.16 (to NEK)	3.78 (on the market)	0.78 (1.38) social prise and for availability	As of Feb 2013
Wind	5.38	8.99 (up to 30 kW)	5.71 (HSBC, LEC)	Fixed tariffs from July 2013
Biomass	8.41 (waste biomass from agriculture)	14.18 (up to 5 MW co-generation)		Fixed tariffs from July 2013
Biogas	4.56 (from waste water)	24.52 (up to 150 kW from biomass)	4.49 (landfill gas, LEC, HSBC)	Fixed tariffs from July 2013
Photovoltaics	8.19 (above 10 MW)	18.1 (up to 5 kW)		Fixed tariffs from July 2013
Hydro	5.02 (micro with pumps)	10.09 (up to 200 kW)		Up to 10 MW Fixed tariffs, 2013
THERMAL				
Thermal co-generation	1.97 (from Kozloduy NPP)	6.6 (from Lukoil)		Upper limits for price from 2013
Biomass		Same as for co-generation thermal station (see above)		
Geothermal	0.6			
Solar	Below 1 (DIY systems)	Same as for co-generation thermal station (see above)	2 (average)	

Table 11: Cost estimation of energy by type and source, minimum, maximum scenario, and scenarios

Source: Slavov, 2013

If we analyse the data, the lowest prices are for heating energy from RES. This provides evidence for our claim that the full potential of primary energy resources should be sustainably transformed into energy for electricity.

According to the new approach to energy price formulation presented by the Ministry of Economy and Energy, the least expensive is the regulated price of energy from Kozloduy NPP, the so-called ‘price for duties towards the society’. Kozloduy NPP sells about 60% of its production to NEK for households for 2.16 eurocents. This price is extremely low and in practice means that the power plant operates at a loss, subsidising cheap electricity for the population. These losses could lead to the bankruptcy of the station according to P. Dimitrov, the president of the KNSB, a major union. Ultimately, energy from Kozloduy NPP compensates for the more expensive energy from other power plants, including RES.

A comparison between projected energy prices from Belene NPP with current buy-off prices for energy from RES, shows that there are both cheaper and more expensive alternatives. Due to the rapid growth of PV power plants, the SEWRC has drastically reduced buy-off process for energy from PV. Currently, the most highly subsidized plants are small installations for the direct use of biomass (biogas) and for thermal gasification of biomass, especially co-generation.

In practice, these new conditions will halt the future development of new PV capacities in the country, including small-scale PV for buildings, until new PV technologies arrive on the market with low primary costs.

Prices for wind energy, on the other hand are gradually falling, ready for the liberalized market. Currently, and especially in the long-term, this is an obvious alternative to new nuclear capacities. However, in order to avoid social conflicts the building of new capacities will need to be in line with regional specificities and needs. The same would be the case with energy from water sources. Such energy is competitive, but faces obstacles in terms of developing new capacities due to the high levels of interest in investment interest, which threatens to create numerous environmental conflicts resulting from the cumulative effect of building numerous micro-hydro power plants along the same river.

What is crucial is to stimulate the development of RES projects using new technologies that do not cause environmental damage. In all cases, in the context of a reticence to develop smart grids, the development of new capacities from RES will only lead to new challenges related to the synchronization of energy consumption and production. For this reason, the role of the hydro power plants (especially of pumped-storage and cascade HPPs) as compensating capacities will probably continue to grow gradually.

For end consumers, the most affordable and efficient energy mix in an energy independent scenario would be solar energy for heating, as well as high-efficiency heating from waste biomass (replacing electricity for heating), since energy for heating is cheaper than electric energy

In conclusion, we argue that the development of RES offers an alternative to the development of nuclear energy in Bulgaria. RES we have shown, can satisfy the energy needs of the country in terms of potential and price, and guarantee its energy independence. Only through sound energy management however, can Bulgaria overcome energy poverty for the long term. Unfortunately as this report has shown, this aim is not shared by the governments that have ruled the country over recent decades, as policies have served private interests and investors' circles, especially at the expense of the state budget.

Renewable energy sources can satisfy the energy needs of Bulgaria in terms of potential and price, and guarantee its energy independence

3 Expansion of nuclear energy in Europe

The case of Slovenia

3.1 Overview of the energy situation in Slovenia, perspectives and role of nuclear energy[19]

Slovenia is at an important crossroads when it comes to energy. Yet energy policy seems to be regressing by revisiting past decisions to build new thermal power plants and new nuclear reactors

Lacking a coherent vision for the development of the energy sector, in 2009 Slovenia initiated the revision of its National Energy Program (NEP) in order to shape the energy future of the country. As of November 2014 however, the process appeared to be nowhere near completion. Like the rest of Europe, Slovenia is at an important crossroads when it comes to energy, yet as practical experience shows, energy policy seems to be regressing by revisiting past decisions to build new thermal power plants and new nuclear reactors.

The key challenges, which need to be addressed in Slovenian energy sector, are:

- reduction of greenhouse gases and other negative impacts on environment
- exhaustion of fossil fuel supplies (both within Slovenia and abroad)
- inefficient use of energy
- meeting the energy needs of the country
- making the transition to renewable sources of energy
- democratizing energy the sector
- economic, environmental and social transition of the energy sector

A 'business as usual' approach to solving these issues will not enable Slovenia to address these challenges sufficiently. Energy sector planning in Slovenia has

[19] The chapter is based on IJS, 2011, unless stated otherwise.

traditionally been based on predictions about long-term growth in energy consumption, and efforts aimed at building the capacity to meet those needs.

Given the current exhausted state of natural resources, environmental pollution and climate change, this approach must be changed. For this reason this analysis is based on the consideration of three possible scenarios. Two of these are based on the mainstream approaches to the development of the energy sector, while one is designed around a new approach. To establish a common basis for the analysis of these scenarios, we use expert papers, prepared for the revision of the National Energy Policy. We also consider the objectives of GHG reduction, increased uptake of renewables and increased energy efficiency. These are objectives to which Slovenia is already, or will be, under European Roadmaps for 2050. The first scenario builds heavily on coal, the second on nuclear energy, and the third rejects the need for coal and nuclear by proposing a mixture of energy efficiency measures and investment in renewables.

Given the current exhausted state of natural resources, environmental pollution and climate change, the approach to planning energy sector in Slovenia must be changed

3.1.1 Energy situation in Slovenia

The total primary energy supply for Slovenia for 2010 was 7.18 Mtoe, an increase of over 12 % from 2000. Primary energy production in Slovenia was 3.75 Mtoe in 2010 and tiotal consumption for that year came to was 5.10 Mtoe. The structure of the primary energy supply, and of final consumption is presented respectively in **Figs. 37** and **38**.

Fig. 37

Total primary energy supply of Slovenia by source in 2010

Source: Statistic yearbook of Slovenia 2012

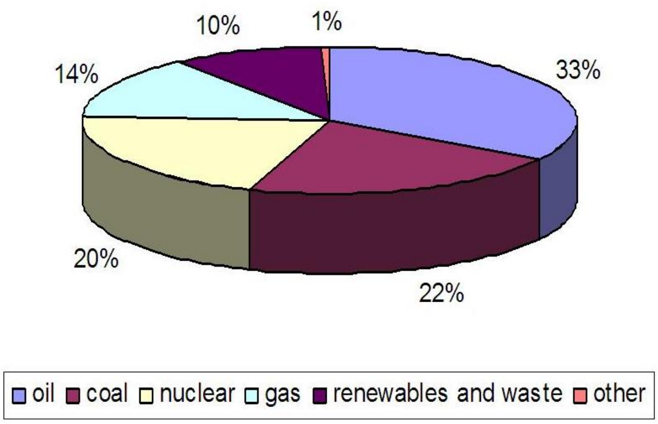
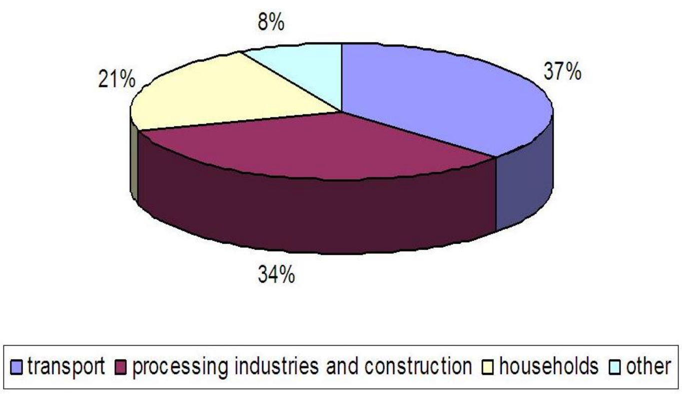


Fig. 38

End energy use by sector in Slovenia in 2010)

Source: Statistic yearbook of Slovenia 2012



In 2008, Slovenia was 55% energy dependent, meaning that over half of its energy needs had to be met by imported energy, mainly oil

In 2008, Slovenia was 55% energy dependent, meaning that over half of its energy needs had to be met by imported energy, mainly oil. The Slovenian economy is comprised of a large share of energy-intensive industry and a relatively small share of high-tech activities and services. Slovenia was overwhelmed by the economic and energy crisis. It severely impacted the structure of the energy supply, which has not changed significantly in the last 27 years. The energy intensity[20] of Slovenia is slowly decreasing, but is still far above the EU average. In 2008, the use of primary energy was still 54% higher than average EU-27 levels.

Despite some success, Slovenia has so far not succeeded in achieving its aim of de-coupling economic growth from the use of energy. The energy-intensive use of primary energy decreased rapidly in the second half of the 1990s. Since 2000 it levelled off, decreasing by 10.7% - 1.7% annually in the 2000–2008 period. In this period, two key factors were influential, the reduction of energy use intensity, (due to the cessation of some energy-intensive production) and an extreme increase in the use of energy for transport.

Changes in the final amount of energy consumption, and particularly of electricity, also show developments that are distinct from the EU average, and in particular the wealthiest EU countries. In 2012-2013, energy use decreased as large scale energy consumers have deliberately decreased production. However, in winter periods of high use and low availability of hydro power, Slovenia becomes increasingly dependent on the electrical power systems of neighbouring countries to meet its needs. Ensuring the maintenance of sufficient reserve capacities moreover depends on commercial contracts.

In the past, Slovenian energy policy called for the dynamic exploitation of water potential in large facilities. Since 2004, the generating capacities of hydro power plants (HPPs) have increased by 10%. The existing thermal power plants are technologically obsolete and facing the end of their prolonged operational life. The deadlines, set at the beginning of 2016, for their replacement in accordance with new environmental standards for emission concentration limits in the air, are approaching. All existing classic thermal energy facilities intended for electricity generation are planned for closure before 2027 (in total for 981 MW) the majority of them before 2016 (518 MW or 53%). This is why a 600 MW block of lignite powered plant block is currently being constructed, to become operational in 2014.

Nuclear energy looks set to persist in the energy map of Slovenia, as the operational life of Krško Nuclear Power Plant (NPP) will be extended until at least 2043 (instead of closing down in 2023, as originally planned and designed). The construction of an additional unit in Krško power plant of 1,100 to 1,700 MW is also planned.

The development and renovation of the electricity distribution network are lagging behind schedule. At the same time, Slovenia is facing new challenges with regards to planning and constructing smart networks to distribute production from

[20] Energy intensity is a measure of the energy efficiency of a nation's economy and is calculated as units of energy per unit of GDP.

renewable energy sources (RES), and in actively managing energy consumption, new technologies, and providing and monitoring electricity quality.

Special attention must be given to the use of energy in transport, which increased from 2004 to 2008 by 48%. This growth reflects the absence of a sustainable transport strategy, and threatens the fulfilment of the obligations under the Kyoto Protocol, notably the binding target regarding the share of RES in final energy consumption.

Slovenia supports the climate and energy objectives of the EU, in particular the objective that developed member states must reduce their greenhouse gas (GHG) emissions from 80% to 95% by 2050. In line with the EU Roadmap for 2050, this would mean a 54-65% reduction of greenhouse gases from the energy sector by 2030, and a 93-99% reduction by 2050 (as compared to 1990). In the field of energy efficiency, Slovenia is committed to reducing its end energy use by 9% in the period from 2008 to 2016. Slovenia is also committed to reaching a 20% share of renewables in end energy use by 2020.

In line with the EU Roadmap for 2050, a 54-65% reduction of greenhouse gases from the energy sector by 2030, and a 93-99% reduction by 2050 (as compared to 1990) would be endorsed by Slovenia

However, GHG emissions from the energy industry are increasing. In 2008, they increased by 6%, particularly due to an 18% increase in energy use by the transport sector in that year. To achieve the Kyoto objective, emissions outside the European Emissions Trading Scheme (ETS) must be kept under control, but emissions from transport are increasing too rapidly. In 2008, GHG emissions exceeded the target emissions of the Kyoto Protocol by 6%.

Energy use and supply contribute a considerable share to emissions of nitrogen oxides in Slovenia. In 2008, NOx emissions amounted to 47.2 million tonnes and again exceeded the target value of 45 million tonnes in 2010. In 2008, NOx emissions considerably increased (by 5.7%), in particular due to a greater use of diesel fuel in transport (in 2008, the increase in transport amounted to 2.4 million tonnes).

3.1.2 Stakeholders and players

Since 1990, Slovenia's energy arena has been dominated by large institutionalized actors. Non-institutionalized actors, such as civil society, are for the most part entirely excluded from entering energy sector decision-making processes. Decision makers (politicians) primarily play by the rules of powerful institutionalized energy producers and represent their interests. At the same time decision makers follow the logic of economic growth, making energy supply the primary objective of energy policy. This reinforces the prioritization of large energy producers.

The role of the EU in shaping energy policy is growing, as more and more law-making is made in Brussels. Decision makers at the EU level tend to have more progressive ideas about energy production. Thus, on a very limited scale, EU level decision-makers can be perceived as environmental advocates not to be ignored by Slovenian policy makers, who themselves largely ignore Slovenian civil society.

Traditionally, the energy sector perceives itself as superior to, rather than as a support mechanism of other sectors and subsystems, making it difficult for the

Slovenia's energy arena has been dominated by large institutionalized actors; civil society is for the most part entirely excluded

participation of other actors in the Slovenian policy making arena. As Tomšič and Klemenc (1996) point out, only exceptionally do end users participate directly in energy sector decision making. For this reason appeals to open the energy policy arena to the public are being increasingly issued by the general public, who are calling for open processes and appropriate communication forums (Lukšič 2010), as well as the inclusion of new expertise and technological solutions.

Yet the large energy actors are opposed to engaging the public in decision making processes (Lukšič, 2005; Lukšič, 2010). There are also significant power inequalities between the different actors in the energy arena. As the energy sector operates on a market basis, the role of authorities is limited to setting up the economic and environmental frameworks within which the actors must operate. With regard to consumption, concerned actors can only pressure the authorities,

Their limited influence does not extend to affect producers, or production, directly. Kitschelt (1996), observes that access to decision-making is denied to the general public, while at the same time decisions are centralized and made by decision makers who cooperate directly with the energy producers. This state of affairs is common, particularly in the energy sector, where decisions are aligned with certain interests (Jordan and Schubert, 1992).

The key stakeholders of the nuclear arena are listed in **Table 12**. The general positions of the key political players are outlined below[21]:

Stakeholder	Description	Reference group
Local Community	local residents	Krško and close surroundings
Local Authorities	local government	Krško municipality
Company (ies)	investor, operator, owner	GEN, NEK
Government	national government	Governments and parliaments, period 2003-2013
Economy Sector	national economy sector	Companies in Slovenia
National Society	society on national level	Slovene society
Neighbour countries	Austria, Italy, Croatia, Hungary	Austrians, Italians, Croatians, Hungarians
Global society	global population	global population
Nature	local or global environment	environment

Table 12

Key stakeholders in the energy sector of Slovenia

Source: Own elaboration

Government of Slovenia

Irrelevant of which political party governs Slovenia, it must, under the EU mandate support the transition to a low-carbon society, priority measures for energy efficiency and the expansion of the use of renewables. This is however rarely reflected in official government positions, and even less so in adopted policies and measures. The government does not deal with matters related to the transition to more sustainable energy in a comprehensive or systematic manner. Instead it leaves questions of energy efficiency and renewables to the ministries responsible. Such questions are mostly dealt with in the framework of demands

[21] Based on Focus, 2011.

that arrive from Brussels and not out of concern on the part of Slovene governments.

One of the key challenges of the energy sector is the use of energy in transport, as this is the fastest growing sector of consumption (and fastest growing emissions), but the government traditionally does not address this issue head-on, merely transposing regulations from the EU onto Slovene legislation. Nor are sustainable energy policies coordinated with other policies. Generally, members of the government have a poor understanding of the connections between energy, environment, economic and social policies.

This is clearly reflected in its official positions, which at once support a low-carbon economy and the construction of new coal power plants. In practice, the government is most likely to pursue goals of energy supply security, keeping energy prices affordable, and ensuring inexpensive energy is available for the economic sector. In practice, the government is also prone to allowing energy lobbies to influence its positions and actions.

The role of the government is an important one, as the government has to make energy balance predictions for 2010-2030. It also has to adopt the NEP and send it to parliament.

Parliament

In December 2009, the Slovene Parliament almost unanimously voted for a Declaration on the active role of Slovenia in international climate change policy, in support of the long-term of objective of an 80-95%reduction of GHG by 2050. In spite of this, Parliament was actively backing the construction of a new coal power plant that would on its own absorb almost the entire carbon quota that the Parliamentary declaration would allow. There is speculation that this is possible because the Economic and Environmental Parliamentary committees that adopt decisions on energy projects and policy are also subject to the influence of the energy lobby.

3.1.3 Nuclear energy and long term visions of the energy sector

The draft NEP claims that because electricity generation in large units is subject to market competition, Slovenia plans to focus its efforts on stimulating development of electricity generated from RES, mainly hydro energy and high-efficiency combined heat and power (CHP). Electricity generation in large units has been prioritised, with the completion of a chain of HPPs on the lower Sava River and the construction of a chain of HPPs on the middle Sava River. Exploitation of other environmentally acceptable HPP and of other RES is also planned.

Renewables rhetoric aside, in practice Slovenia is forcefully supporting and promoting a new coal power plant with a EUR 440 million state guarantee with the support of the majority of political parties. The long-term exploitation of nuclear energy in Slovenia will be assured by extending the lifespan of Nuclear Power Plant Krško (NPPK) and with the construction of a new nuclear power plant in Krško (NPPK 2).

Renewables rhetoric aside, in practice Slovenia is forcefully supporting new coal capacities and long-term exploitation of nuclear energy

Nuclear energy is currently one of the three key sources (the other two being

Actual realisation of the new nuclear power plant will depend on a combination of market conditions, business decisions, and social acceptability of the project

hydro and lignite) of electricity supply. Slovenian authorities believe it to be a low-carbon, and very competitive source of electricity generation in the long term. Prices and security of enriched uranium are stable due to the diversity of supply routes, coming from the USA.

The most important objectives in nuclear energy as stated by the government are to safely maintain Slovenian nuclear facilities and the independence of the supervision authority (the Slovenian Nuclear Safety Administration). Construction of a permanent disposal facility for low and intermediate level waste (LILW) has been ensured to replace the current facility at the current NPP Krško. The extension of the operational life of Krško NPP until at least 2043 is believed to be of key importance for long-term competitive electricity supply.

Construction of a new NPP of 1,100 to 1,700 MW is also a foreseen possibility at the Krško site. The project is believed to be positive from the perspective of energy supply and has a life expectancy of 60 years. However doubts have been cast on the costs of the project and how the increased costs of system services will be distributed among producers and consumers of energy. The project will pose a great challenge to investors over the period of construction and loan repayment. Due to the size of the project, electricity generation will largely depend on the regional electricity market, especially in the initial period of operation.

Actual realisation of the new NPP however, will depend on a combination of market conditions, business decisions, and social acceptability of the project. Rounding up sufficient investment will be the greatest challenge. As the government believes that the project is an important element in the framework of Slovenia's development strategy, a large portion of Slovenia's resources for development will likely be mobilised. Slovenia will also take an active role in forming and adopting measures for the international community in the field of nuclear safety.

However, many of the governmental views are not shared by the environmental non-governmental organisation (NGO) community in Slovenia and neighbouring countries. Opponents firmly believe that nuclear energy is too dangerous, too costly and too unsustainable for continued use. These NGOs strongly prefer energy efficiency measures and renewable because these options are more favourable toward the environment, society and democracy.

3.2 The cases of Krško NPP and Krško NPP 2

3.2.1 Prolonging the lifespan of the existing Krško Nuclear Power Plant[22]

Overview and history of the Krško Nuclear Power Plant

The Krško NPP (Slovene: Nuklearna elektrarna Krško, NEK) is located in Vrbina in the Municipality of Krško, Slovenia. The plant was connected to the power grid

[22] The section is based on European Commission, 2011, Municipality Krško, 2013, Posavje info, 2012, URSJV, 2012 and URSJV, 2013, unless stated otherwise.

on October 2nd, 1981 and went into commercial operation on January 15, 1983. It was built as a joint venture by Slovenia and Croatia which were at the time both part of Yugoslavia. The plant is a 2-loop Westinghouse pressurized water reactor, with a rated thermal capacity of 1,994 thermal megawatts (MWth) and 696 megawatts-electric (MWe). It runs on enriched uranium (up to 5 weight-percent 235U), fuel mass 48.7 t, with 121 fuel elements, demineralized water as the moderator, and 36 bundles of 20 control rods each made of silver, indium and cadmium alloys to regulate power. The operating company Nuklearna elektrarna Krško (NEK) is co-owned by the Slovenian state-owned company Gen-Energija and the Croatian state-owned company Hrvatska elektroprivreda (HEP). The power plant provides more than one-quarter of Slovenian power and 15 percent of that of Croatia.

In the early 1970s, The Tito government of Yugoslavia recognized the need for additional electrical production in the constituent republics of Croatia and Slovenia. With a domestic source of uranium available from the Žirovski vrh mine, proposals were submitted by Siemens (Germany) and Westinghouse (USA) to build a single nuclear power of a practical size. With the support of the U.S. government, Westinghouse won the competition to supply a plant based upon the Angra power plant being constructed in Brazil at that time. As the design began, it became apparent that Westinghouse had a more modern design underway for the KORI-2 plant which is now the sister plant of Krsko. Indeed when the Krsko Plant began producing power in 1981, it preceded both the Angra and Kori-2 plants.

The Yugoslav management in 1975 consisted of personnel from both the Slovenian and Croatian power companies and a representative from the central government in Belgrade. Ownership of the plant was shared by Slovenia and Croatia because these then-constituent republics of Yugoslavia had planned to build two plants, one in each republic, according to an agreement originally made in 1970 and revised in1982. However, that plan was abandoned in 1987 by Slovenia as a result of a referendum held in 1986. From that point on, there arose issues with nuclear waste storage, as the only existing waste storage site was located in Slovenia.

In 1997, ELES and NEK decided to increase operational and decommissioning costs billed to both ELES and HEP, but the latter refused to pay. In 1998, the Government of Slovenia nationalized NEK, stopped supplying power from Krško to HEP, and sued HEP for unpaid bills. In 1999, HEP counter-sued for damages because of lack of supply. In January 2001, the leaders of the two countries agreed on equal ownership of the Krško plant, joint responsibility for the nuclear waste, and the compensation of mutual claims. The joint management of the plant was to begin on January 1st, 2002. The plant was expected to start supplying Croatia with electricity by July 1st, 2002 at the latest, but the connection was only established in 2003. Since then, HEP has launched an additional lawsuit against the Slovenian side for damages incurred during the final year in which Krško failed to supply power.

Fig. 39

Map of Krško NPP

Source: Own elaboration using http://en.wikipedia.org/wiki/File:Slovenia_location_map.svg

Proposed prolonging of the lifespan of Krško NPP

In 2008 Krško NPP expressed its intention to prepare for prolonged operation beyond 40 years. The operating license in effect at the time had no expiry date, but the plant would have to submit to a Periodic Safety Review (PSR) every ten years. The first review took place in 1993, and the second in 2003, with the third one due by the end of 2013. With a planned lifespan of 40 years, it was anticipated that the NPP would close in 2023. Plant Life Extension (PLEX) would prolong its lifetime for another 20 years, until 2043, extending its lifetime by 50%. In this scenario, the regulatory process must assure the safe operation of the plant with emphasis on the detrimental effects of ageing. The procedure for licensing must be also be maintained and carried forward into the extended period, and safety improvements must address any gaps between current safety levels additional feasible safety measures.

In 2008-2009 the Slovenian Nuclear Safety Administration (SNSA) reviewed and compared different approaches for PLEX and its approval. Meetings took place in which management expressed a preference for the American approach for Plant Life Extension. Management also stated that their programs, important to Plant Life Management, were in accordance with American NRC (US Administration for Nuclear Safety) requirements and that they intended to file a License Renewal application. In 2009 a new regulation with special provisions regarding PLEX was adopted. The reason for adopting the American NRC approach was a lack of European experience. While in America the reactor license renewal was frequently practiced, European NPPs were just beginning to use PLEX processes.

The Plant Life Extension would prolong the lifetime of the Krško nuclear power plant for another 20 years, until 2043, extending its lifetime by 50%

The legal requirements of Slovenia do not restrict NPP lifespan, and foresee PSR as a tool to determine the safety of further NPP operations. The SNSA has adopted the PLEX approach to approve USAR changes related to the lifetime extension of the Krško NPP. The plant has to demonstrate compliance with the US NRC 10 CFR 54 (license renewal rule). Under regulations from 2009, the NPP has to fulfil equivalent relevant requirements of US NRC 10 CFR 51 to be granted a lifespan extension, performing a detailed review of its preparedness for severe accidents, identifying possible improvement and implementing reasonable ones. Important safety improvements are focused primarily on a third emergency diesel generator, a reactor head and a turbine control system.

So far no information has been made available to the public on how much this extension could cost

For PLEX conditions to be met, the NPP has to redo an ageing-related analysis, modify relevant Safety Analysis Reports, and conclude its Ageing Management Program. Severe Accident preparedness also has to be re-verified. To be granted, PLEX would require successful PSRs in 2013 and 2023, with in depth inspections carried out between these two reviews.

NPP Krško has submitted an application for the approval a lifetime extension by 40 years. In June 2012 the SNSA issued a decision in which they approved the changes that would enable the long-term operation of the NPP. This completed an extensive process initiated after the PSR in 2003. At that time, Krško NPP began to prepare and introduce a specific program for monitoring the ageing of components and their resistance to environmental influences, one of the prerequisites for extending its service beyond 40 years. NPP operators had to justify changes to the NPP safety report referring to maximum operating restrictions of 40 years. Several local organizations and an international team of experts from ENCONET, an expert organisation on nuclear safety from Vienna, also examined Krško NPP's application for lifetime extension, issuing a positive opinion.

So far no information has been made available to the public on how much this extension could cost.

Problems with prolonging the lifetime of Krško NPP

1. Public involvement

The process of the lifetime extension of the NPP should according to Slovene legislation, feature public discussion and involvement. Public involvement in discussion and decision making process in environmental matters should also be guaranteed according to the Environment Protection Act and the Aarhus Convention.

Slovenia is indeed a signatory of the Aarhus Convention. This convention speaks of the necessity for public participation in art. 6(1): "*1. Each Party: (a) Shall apply the provisions of this article with respect to decisions on whether to permit proposed activities listed in Annex I*". Annex I lists the operation of nuclear power stations as a ‘proposed activity’. As every 10 years PSR is conducted, this means that Slovenia is every 10 years 'permitting a proposed activity listed in Annex I.' Hence public participation should be ensured, yet this is not the case.

2. Environmental Impact Assessment[23]

According to the Environment Protection Act (Article 40), a comprehensive Environmental Impact Assessment (EIA) must be conducted as part of the processes of preparing a plan, program or other general act (as is the case of the

[23] Based on Haverkamp (2010) and Stritar (2010).

Under the Espoo convention, every 10-year safety review must include an EIA, which has not been the case

SNSA's formal decision), implementation of which may have significant effects on environment. In the case of the SNSA's formal decision to approve changes that would enable the long-term operation of the NPP, no EIA has been conducted.

Under the Espoo convention, every 10-year safety review (PSR) must include an EIA, which has also not been the case. In the Espoo Convention, art. 1(v): (v), ‘Proposed activity’ means any activity or any major change to an activity subject to a decision of a competent authority in accordance with an applicable national procedure. The SNSA review every 10 years represents a decision of a competent authority. Therefore there is an obligation to carry out a transboundary EIA at minimum. On the basis of the non-discrimination clause in the Aarhus Convention moreover, a national EIA is also required.

The technical lifetime of Krško NPP was foreseen as 40 years. Any extension beyond this period requires an EIA under Slovenian legislation, and the Espoo convention. Such an EIA would have to be comprehensive, fully comparing alternatives, with a complete overview of waste production and full clarity about plans for dealing with waste. With the transboundary implications for waste production, a transboundary EIA is required to show that the impacts on the environment are (socially, economically and environmentally) necessary and that there are no better ways of delivering services than with lifetime extension.

It is not clear how this process of extending the lifespan of the Krško NPP can be successfully completed, since this option is not discussed in any official documents. The currently valid National Energy Program does not plan for lifespan extension, while the revised National Energy Program includes this option in some of the analysed scenarios, but is not adopted and hence not valid.

3. Conflict of interests

It is important to note that connections between the SNSA and Enconet indicate a significant conflict of interest. Enconet is regarded by the SNSA as an independent expert institution, competent to provide opinions on the adequacy of engineering solutions. In other cases Enconet plays the role of a commercial partner to the SNSA. This can be problematic, as these decisions should be made by an independent actor.

4. Unfavourable geological conditions

IRSN, the French Institute for Radiological Protection and Nuclear Safety, was contracted by GEN (the owner of Krško NPP) to establish whether geological conditions at the intended site for Krško II were suitable for the future development of a second NPP. In particular, it had to identify the potential for surface rupture associated with the possible presence of faults within 5 km. In the beginning of 2013, the IRSN presented its opinion on this matter: *"this new and serious finding does not allow concluding in a favourable manner as regards the suitability of the Krško II site for the implantation of a new nuclear power plant. Acknowledging the fact that the feasibility of designing a reactor against fault surface displacement is questionable, and consistent with IAEA and NRC recommendations, IRSN believes that GEN should consider revising its strategy for the Krško II project and* *further examine the possibility to search for an alternative site*." The findings of this report apply to Krško II, but as Krško II would be located on the same site as the currently running NPP, the report basically warns that the current site may not be safe for NPP operations or for the storage facility of LILW. If the findings of the report are correct, the implication is that the Krško NPP reactor should be shut down. Furthermore, even if the reactor is deemed safe from earthquakes at a 'satisfactory' level, this does not preclude problems with accompanying facilities, such as control facilities, temporary storage for used fuel and for LILW.

A report advising a reconsideration of the site for the Krško II project basically warns that the current Krško NPP site may not be safe for operations or for the storage facility of radioactive waste

5. Security issues

The main security risks relate to the aging of NPP materials and components. The security of operations is the main precondition set out by the SNSA to permit the lifespan extension. Regular checks allow monitoring the security of the NPP. However, the risk remains and increases as the lifespan of the NPP is prolonged.

Engagement of the public in discussions

No public debates have been held regarding the issue of PLEX for Krško NPP. GEN, NEK and the SNSA conducted PLEX related activities, but excluded the public from these processes. As in many other cases in Slovenia, procedures were partly hidden from the public eye, ensuring ignorance of whatever the current phase was and whether participation was possible or any impact could be had on decision making processes. All too frequently the Slovenian public is faced with non-compliance to the Aarhus and Espoo conventions, in effect blocking public participation in discussions and decision making processes.

Some organizations are working on issues of public participation (Focus, Greenpeace, ZEG), informing the public about problems related to the project, conducting meetings with the SNSA and disseminating their arguments and views. Until now there have been no serious attempts to use legal procedures, although legal strategies have been discussed. Local residents (in Vrbina and Spodnji Stari grad) and ex-local partnerships Krško and Brežice have also been involved in some activities.

Arguments and comments from the general public have been excluded or discounted. Thus the future activities of NGOs will probably focus on insisting on a full EIA as justification for the environmental impacts for extending NPP service beyond 2023. The input from the EIA should be taken into account in making a decision on granting permission for the 'extension of service life' (Aarhus Convention, art. 6(8)).

3.2.2 Construction of Krško NPP II[24]

Overview and history of the proposed new block in Krško

Strategic Slovenian documents support the construction of a new NPP in Krško. Construction plans were first listed in a Resolution on National Development Projects for 2007-2023 in 2006 (SVRSR, 2006), as part of a project on

[24] Section is based on GEN 2010, GEN 2013, Municipality Krško 2013 and URSJV 2013, unless stated otherwise.

Sustainable Energy and Hydrogen Economy. The key arguments used by developers in favour of the project are based on achieving climate objectives, reducing import dependency and providing competitive electricity prices that ultimately increase the competitiveness of the Slovenian economy. However, data shown in Table 22 puts the arguments about climate objectives and price competitiveness under scrutiny. Moreover, import dependency is likely to increase with an additional nuclear block due to Slovenia's lack of uranium and its need to import nuclear fuel.

GEN (2010) analysis of the electricity production sector shows that even with increased energy efficiency, and use of renewables and thermal power plants it will not be possible to satisfy the growing needs for electricity without a new nuclear power block. This analysis is clearly refuted that of the National Energy Plan (IJS, 2011a), which shows that even without a new block, Slovenia can export electricity. In spite of this evidence, explorations for an additional nuclear block remain active.

A pre-investment analysis was done GEN (2010) for several different types of reactors. The focus was on pressurised water reactors (PWR), mainly due to the fact that it is a familiar and accepted technology in Slovenia (more than 60% of all reactors are based on PWR technology) accompanied by significant expertise and experience. Thus, parameters for this analysis were based on power segments of 1000 MW and 1600 MW or 2x1000 MW.

It is envisaged that a new block would produce about 12 TWh annually or, in double variant, 16 TWh. Although 12 TWh represents roughly the annual needs of Slovenia, the electricity is planned to be sold in foreign markets.

According to the pre-investment analysis, the investment cost is estimated to be between EUR 1.6 – 2.9 billion, depending on the size of the reactor. The price for a double block would increase to EUR 3.7 billion. The cost per installed capacity ranges from 1.860 – 1.790 EUR/kW or 1.690 EUR/kW for a double block. The analysis of economic indicators shows that a double block would be the best investment. However, in later estimations, the investor shows a price range of 3 – EUR 5 billion (GEN, 2013), which seems to be more realistic.

The investor company plans to finance construction with its own funds from sales of energy bonds and equity capital. It plans to invite partners and co-investors and hence establish an investment company that will manage the NPP after construction. The main risks for the profitability of investment are changes in the investment value and the sale price of electricity, and reduced production.

The timeline is based on a comparison with the construction of similar reactors and foresees a construction period of 60 – 66, or in the case of a double block, 84 months. The start of construction is planned for January 2015. One major public call for selecting the supplier is anticipated. The supplier would be requested not only to supply the technological equipment, but to implement the whole project, from planning and permission to construction. It is planned that the second block would employ more than 400 people. The LILW is to be stored on site, the precise location of which is still being explored.

An EIA was conducted as part of an expert evaluation, compiling all available data and evaluations from previous environmental studies, analyses and EIAs. The assessment showed that the planned construction was welcome and would have marginal impacts on environment, acceptable under all legislative standards.

This EIA was however, not an official report but a preliminary one. The process was not open to public scrutiny, representing more of a promotion document for the construction of a new NPP than an authentic EIA.

To date Slovenia has no long-term solution for the storage of the low and medium level radioactive waste, which is now temporarily stored under the existing reactor

Open issues of the proposed project

The proposed construction of the second block in Krško leaves several crucial issues open, the most relevant being the following:

- There has been a lack of public consensus about the necessity and will to proceed with construction. As described in the following section, there has so far been no clear public consensus about the construction of the second block.
- The project was not placed in strategic documents of Slovenia in a transparent and democratic manner. Although the project appears in a governmental Resolution on National Development, it was put there without prior public consultation, which opens a question about its eligibility as a strategic priority of Slovenia.
- With a planned transition to renewables and the ongoing construction of a lignite power plant, the question remains for whom the new nuclear block would produce electricity. All of the energy scenarios analysed in the NEP, including that of nuclear power, indicate plans to export energy. This opens the question of whether the new block is really meant to satisfy the needs of Slovenia, or the appetites for profit of investors. Under the energy scenario with new nuclear capacity, about 10 TWh of electricity are planned to be exported, amounting to almost the entire annual production of the planned nuclear block. Under such circumstances the necessity for the block is highly questionable, especially in terms of economic, environmental and social acceptance - begging the question: why Slovenia would carry the risks and costs of nuclear capacity if the electricity it produces is mainly meant for export?
- There is no planned storage for radioactive waste. To date Slovenia has no long-term solution for the storage of the low and medium level radioactive waste, which is now temporarily stored under the existing reactor. Solutions for dealing with low and medium level radioactive waste have been discussed in Slovenia since 2001, but so far no option has been fully accepted by the public. As a consequence the construction of a repository has not yet begun, while the current temporary facilities at the Krško NPP are being utilised almost to their full extent. This issue should be resolved before expanding nuclear capacities in Slovenia.
- Geologically, the site is not a suitable one. See **section 3.2.1** for more details on this issue.
- The economic, environmental and social feasibility of the project is questionable, especially when compared to measures for increasing energy

So far, there has been no public debate on the construction of the second NPP block in Krško

efficiency or uptake of RES. There has been no specific comparison of a nuclear vs a renewable option. Such an analysis has only partially been incorporated into the comparison of scenarios under NEP, but it has not been analysed. Such a comparison would be necessary for an informed public debate, as it would bring to light different decision making factors upon which the public can assess the acceptability of the project.

- Investment from private sources will not be sufficient. Although plans are to finance the project with private money, the experience of TEŠ6 as this report will show, tells us that eventually public money ends up financing it. At the moment only approximately one third of the necessary investment will be covered by the investor HSE. The other two thirds is foreseen to be covered by loans from public banks, namely, the European Investment Bank (EIB) – secured with a state guarantee – and the European Bank for Reconstruction and Development (EBRD). This leaves an open issue of whether Krško II could break new ground by bringing more public money into financing an economically, environmentally and socially questionable project.

These issues need to be thoroughly addressed in an open public debate, but so far not much they have received little mention, as discussions of whether to construct the second block remain closed.

Engagement of the public in discussions[25]

So far, there has been no public debate on the construction of the second NPP block in Krško. A public discussion was carried out for the draft NEP when the Ministry for Energy opened a public consultation in June 2011. Lasting four months, it was structured around two documents, the draft NEP and an Environmental Report for the Comprehensive Environmental Impact Assessment of the NEP. During the consultation period about twenty presentations were made on the NEP by the Ministry, but of those, only seven were made for the wider public. The response to these presentations was significant, with over fifty comments from a variety of organisations sent to the Ministry. Cross-border consultations were also implemented with neighbouring and other interested countries, parallel to the public consultations carried out in Slovenia.

The report from the public consultation shows that in regards to the different energy scenarios suggested in the NEP, the majority of NGOs that commented are against construction of a new block in Krško. They support instead a long-term transition to 100% renewable, and the phasing out of nuclear power by 2030. The public consultation report also suggests that the NEP must clearly define the prolonging of the lifespan of Krško I as a strategic decision because there are no reasons to stop the functioning of the existing NPP before 2043, unless safety issues arose. However, this is not a view that the majority of NGOs share. Another suggestion made in the report from the public consultation is that the NEP clearly takes a position on the second reactor in Krško, or freezes decision-making on the issue. In the process of adopting the NEP it has to be clearly decided, which of the following options is chosen:

[25] Based on IJS, 2011b.

- NPP Krško II is listed as the selected strategy for the development of the energy sector in Slovenia and construction activities continue. However, also a public debate on the social acceptance of the project is carried out.
- NPP Krško II is not listed in the NEP, and the NEP develops a strategy in which a new block is not necessary.
- The NEP adopts a moratorium on decision-making on the construction of NPP Krško II, and a new cycle of debate and decision-making is opened in the energy sector's next phase of strategic planning.

As recently as November 2008 a public survey on the issue of nuclear safety in Slovenia showed that 63% of respondents thought Slovenia was not well enough prepared for it (RTV Slovenija, 2010). Yet, public opinion in favour of the construction of a new NPP block is slowly growing.

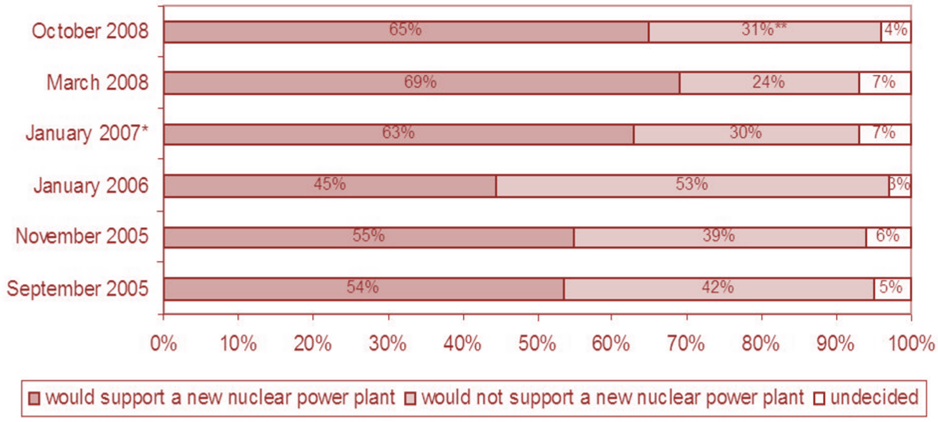
Fig. 40

Public support for nuclear energy in Slovenia

* Question asked: 'Do you think a new reactor in Krško would be environmentally justified?'

** 22% would not agree with a new nuclear power plant, and 9% would close the existing Krško nuclear power plant entirely

Source: Živčič, 2012



3.3 Impacts of uranium mining in Slovenia

Uranium mining in Slovenia has only taken place on one site, at Žirovski Vrh. Situated 45 km west of Ljubljana, The Rudnik Žirovski Vrh (RZV) facilities started producing ore in 1982, and yellow cake in 1984, until the Slovenian Government ordered the cessation of production in 1990.

Exploration for uranium ore began in 1960. When estimated supplies were deemed sufficient, the decision to open a mine was adopted in 1976. Of the 3,3 million tonnes of material excavated over the operational period, 633 000 tonnes were uranium ore. Also produced in the same period were 452 tonnes of yellow cake. The mine is located in an agricultural area on the north-eastern slopes of the Žirovski Vrh ridge in the Julian Alps, at an altitude 430 - 580 m. The mill was situated in the Brebovščica river valley.

The uranium mine extends across an area of 2000 m (north-south) by 150 m (east-west). The mine is divided into 4 horizons, which are further divided into 14 blocks. The mining of uranium ore was carried out by the 'room-and-pillar' method, connected to the surface by passages used for ventilation, material supply and transportation. The Zirovski Vrh deposit is one of numerous sites of uranium

The Zirovski Vrh deposit is one of numerous sites of uranium embedded in sandstone

As this type of rock is fragile, it is characterised by stability problems

embedded in sandstone. As this type of rock is fragile, it is characterised by stability problems, requiring extensive support. Water flows into the mine mainly through cracks in the sandstone and through conglomerates, which are more permeable than layers with ore deposits. The ground water that passes through ore-enriched zones becomes contaminated. Water in the flooded blind tunnels has been found to contain uranium concentrations of over 6 mg/l. According to measurements taken from 1992 to 2000, the water discharged through section P-10 had a yearly average uranium concentration of 250 - 350 µgU/l, and a radium concentration of 30 - 100 Bq/m^3.

In 1992 the Parliament of Slovenia adopted a law on the permanent closure of the mine, and restoration works slowly started. From 1996 – 2008 the sanitation works took place. The objectives included reduction of radon emissions, long-term stability and maintenance of facilities, and protection of underground and surface water. The rehabilitation work in the mine included the drilling of boreholes of approximately 150 m in the deepest section in order to collect inflowing groundwater more efficiently, and a complete renovation of section P-10. Facilities such as the crushing plant, chemical plant and transport bridges were either destroyed or handed over to users outside RZV.

According to official data, the radioactive impact of the mine is below 1 milliSievertv/year (0.3 - 0.4 mSv per year), but such an impact is not negligible and exceeds the impact calculated for authorised discharges from nuclear power plants. In the case of France for example, the official calculated impact for the people living near nuclear reactors is about 10 microSievert/a. Uranium and radium concentrations are elevated around nearby water flows.

3.3.1 Waste rock piles

Jazbec is the main waste rock pile of RZV (1.5 million tonnes), situated in the Jazbec valley. The supporting dam formed by mine waste is less permeable than the stored material, and no seepage of water has been observed on the pile face. The material was stored in alternate layers, with 20 cm of red mud on top of 80 cm of mine waste. A 5 m thick zone on the aerial side of the pile consists of coarse mine waste

According to official data, the concentrations of the radionuclides Ra-226 and uranium in the waste rock are about 0,5 Bq/g. The uranium content of the waste rock is the main source of contaminated seepage from the mine waste pile. Along the Brebovščica River, numerous springs exist which are fed by karstic groundwater. The groundwater is polluted because of the infiltration of meteoric water percolating through the uncovered waste pile and leaching into the red mud. The water at the bottom of the waste pile contains up to 5000 µg/l uranium. The water discharged from the drainage channel at the bottom of the waste pile has annual average uranium concentrations of 250 to 550 µg/l.

3.3.2 Boršt Mill tailings disposal

Over the course of its operation, RUZV produced 600,000 tonnes of hydro-metallurgical tailings, for deposit on the Boršt tailings pile. The volume of the deposited material is approximately 375,000 m^3. This storage site is about 2 km away from the former uranium processing plant. During their deposit, the following procedures were followed in terms of environment controls, and methods for water management and geotechnical stability:

- diversion of surface waters from the tailings pile to prevent contact with tailings;
- capture of ground water and springs for linkage to the drainage system;
- clay sealing of the bottom of the tailings pile;
- capture of (contaminated) surface and seepage water from tailings, and discharge into a retention pond.

Due to the high radium content in tailings, both the uncovered top surface area and the covered embankments are a considerable radon source. Emissions were evaluated at approximately 5 Bq/(m^2.s). Surface waters, water in tailings as well and those underneath the tailings are contaminated by uranium and soluble inorganic materials (NH4+, SO42-, Cl-). Ammonia and total inorganic materials are also above regulated discharge limits.

The government's objectives concerning the remediation of tailings storage are as follows:

- provision of permanent landslide stability by drainage channel, drainage screen and cover construction;
- design of a drainage curtain to facilitate tailings consolidation;
- provision of tailings stability and enhancement of erosion resistance by reshaping of tailings pile;
- prevention of radon emissions, of leakage of hazardous contaminants into water streams, and of erosion of tailings by covering;
- protection of the tailings pile from surface and ground water from the hinterland (erosion, increased infiltration through the cover and the tailings);
- prevention of cover and tailings erosion by construction of a drainage system;
- prevention of excessive dust formation.

To conclude, it must be noted that it is not possible to evaluate the cost of reclamation of the waste rock piles and tailings piles. Also the monitoring of the long term impact of sanitation measures is costly. At the moment the costs are the subject of active debate, as the government has announced that the State does not have sufficient funds to continue financing the sanitation of the mine.

At the moment the costs cost of reclamation of the waste rock piles and tailings piles are the subject of active debate, as the State does not have sufficient funds to continue financing the sanitation of the mine

3.4 Alternatives to nuclear power in Slovenia

3.4.1 Energy scenarios

The government's strategic guidelines for forming the energy strategy of Slovenia until 2030 are based on objectives and orientations of the energy policy, the Energy Act, the Treaty of Lisbon, and on the analysis of diverse scenarios of energy policy that meet these objectives. Two strategies for sustainable use and local supply of energy and three scenarios for electricity supply were analysed for the preparation of the NEP. The energy scenarios were assessed against one scenario of economic development and a uniform scenario of all external circumstances (developments in the world markets, discoveries of new supplies of gas or oil and any other developments that might happen outside of Slovenia) All scenarios were also assessed within the framework of a comprehensive environmental impact assessment.

The analyses of the energy sector, which were prepared for the National Energy Program, looked into a variety of scenarios for the development of the energy sector. In the comparative analysis of the effects of energy policy in Slovenia by 2030, six alternative energy policy scenarios were assessed. First, two strategies for sustainable use and local energy supply were analysed, based upon which three electricity supply scenarios were juxtaposed. The two RES and energy efficiency strategies analysed are the following:

- reference strategy (REF), which includes emergency measures for fulfilling adopted obligations; and
- intensive strategy (INT), which establishes a support environment for the implementation of all profitable energy efficiency projects, and ensures greater economic impacts and advantages for competing in the field of green energy technologies. The strategy is also more ambitious in stimulating RES exploitation, and developing local supply and CHP (combined heat and power) in all sectors.

The three electricity supply development scenarios that were assessed differ in terms of key investments in production units:

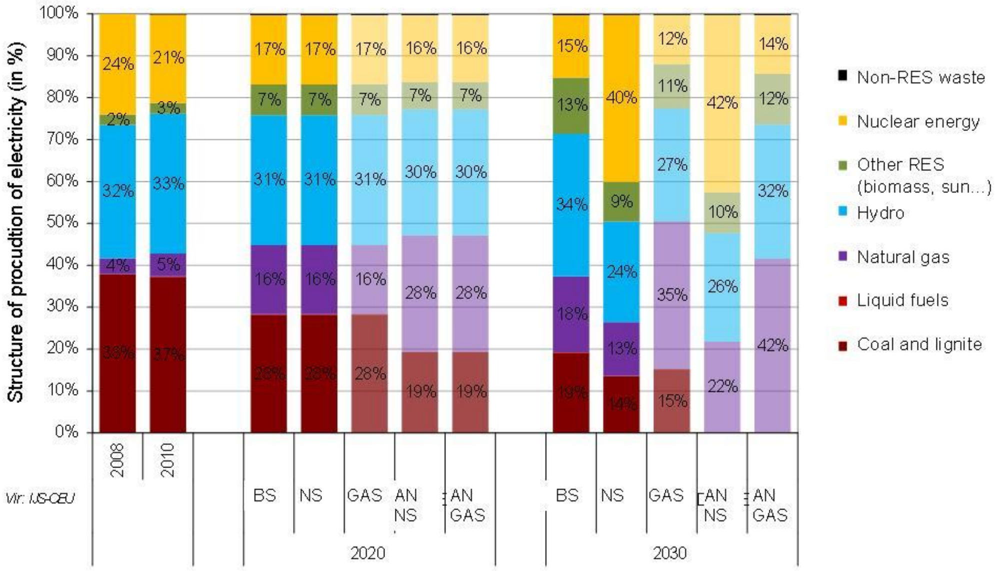
- the *basic scenario* (BS) presupposes continuation of ongoing investments, or implementation of measures for their completion (HPP on lower Sava, TEŠ6); increasing the operational period of the NEK acceleration of the construction of the planned and new hydroelectric power plants; modernisation of existing and construction of new high-efficiency units for CHP; and verifies the construction of new gas and steam power plants considering the conditions in international markets;
- the *nuclear scenario* (NS) involves an upgrade of the basic scenario, and presupposes measures that will provide for long-term exploitation of nuclear energy in Slovenia through construction of a new NPPK2 unit at the site next to the existing NPPK with a capacity of 1,000 MW. It would be in operation before 2030;
- the *gas scenario* (GAS) also implies an upgrade of the basic scenario in the direction of even greater diversification of energy-supply resources. It foresees increasing the share of the fourth energy product by 2030, through the construction of two gas and steam power plants (GSPP),using natural gas, with a total capacity of 800 MW.

The scenarios for the NEP, which were done initially, did not examine the strategic aspects of pending investments. Due to public dilemmas related to investment in TEŠ6, two additional electricity supply scenarios were analysed to enable assessment in the case that investment were terminated. An additional nuclear scenario (AS NS) without TEŠ6 considers construction of a gas and steam power plant with a 400 MW capacity and a nuclear power plant with a 1,000 MW capacity. An additional gas scenario (AS GAS) without TEŠ 6 considers the construction of two GSPP with a total capacity of 800 MW. All of the scenarios include nuclear power, as the lifespan of the currently running reactor is planned to be prolonged until 2043 (**Fig. 41**).

Fig. 41

Structure of electricity generation (%) according to different scenarios analysed in NEP

Source: IJS 2011.



Reference strategy and intensive strategy

The two energy policy strategies in the field of sustainable use and local supply of energy encompass measures of energy efficiency in all sectors, the use of RES for heat supply, and dispersed production of electricity, including wind farms, CHP and local supply of energy. The REF includes necessary measures for fulfilling adopted commitments. The INT establishes a support environment for implementation of all profitable projects of energy efficiency, which ensures greater economic impact and creates an advantage in the technological race for green energy technologies. The strategy is more ambitious with regard to promoting the exploitation of local RES development (hydro, solar, biomass, wind and geothermal) and CHP in all sectors.

The NEP contains an intensive strategy for promoting the sustainable use and local supply of energy. The advantages of this strategy in comparison to other reference strategies include: less emissions and more robust implementation of the objectives of Climate Action and the Renewable Energy Package. In practical terms this means a 25% share of RES in gross final energy consumption. With regard to the Kyoto Protocol, it means less energy consumption, a larger share of RES by 2030, a smaller net export of energy and less import dependency, greater improvement of energy intensity, an overall improvement to indicators of energy supply security, and significantly greater reduction of GHG emissions in comparison to the reference scenario. The weakness of the intensive strategy however, lies in slightly higher emissions of nitrogen oxides and dust particles due to the use of wood biomass. Yet the intensive strategy offers a better starting point for initiating a long-term transition to a low-carbon society.

Structuring the social choice problem in terms of scenarios

A scenario of increasing energy efficiency and use of renewables over reliance on gas power plants demonstrates that the development of a sustainable and democratic energy sector is possible in Slovenia

In response to the options presented from the governmental side, environmental NGOs called for the consideration of additional scenarios that did not include construction of TEŠ6. In response, two additional scenarios were prepared, however, neither of these fully responded to NGO concerns. The additional nuclear scenario is in complete contradiction with the views of NGOs. The additional gas scenario in comparison is relatively closer to NGO demands. However, it is seen as a disproportionate response, since NGOs advocate the use of gas only as a transition source, rather than as a long term strategy that involves its increased exploitation and the development of capacities exceeding the needs of Slovenia. If the additional gas scenario were to prioritise increasing energy efficiency and the use of renewables over reliance on gas power plants, it would be more compatible with the NGO vision, and able to demonstrate that the development of a sustainable and democratic energy sector is possible in Slovenia.

For this reason, this analysis builds on a slightly adjusted AN GAS scenario. The key adjustments are in increased efforts for energy efficiency gains, expansion in the use of renewable, and a decreased role of gas.

As it would be too complex to analyze the overall costs and benefits of all of the scenarios, our analysis focuses on three approaches to electricity production:

- Alternative 1: construction of a new coal power plant (TEŠ6)
- Alternative 2: construction of a new nuclear power plant (NEK2)
- Alternative 3: mix of energy efficiency measures and use of renewables and gas

It is also useful to focus on these three approaches because they are most representative of the practical options for the future development of the energy sector. It should be noted here that any analysis of the energy sector should also consider the demands of the transport sector, however as transport was excluded from the analysis of the draft National Energy Program, it will also be excluded here. The next section an provides overview of the key economic characteristics of the different options.

3.4.2 Overview of key economic aspects of electricity production scenarios

3.4.2.1 The coal scenario

The report looks at the economic picture of block 6 of the lignite power plant in

Šoštanj (TEŠ6). In spite of not being part of the energy plans of the country[26] and the massive opposition faced by the project on the basis of its environmental impacts, financial doubts and corruption allegations[27], this project is in the final phases of construction. This is despite the fact that many Slovenian economists have persistently and openly questioned whether it would not be better to abolish the project at this phase, rather than generating an economic loss from the beginning of its operations[28].

The TEŠ6 project is in the final phases of construction, despite not being part of the energy plans of the country and the massive opposition on the basis of environmental impacts, financial doubts and corruption allegations

Main assumptions

The main assumptions for TEŠ6 are the following:

- the power plant will be operational for 40 years;
- total installed capacity will be 600 MWe or 545.5 MW;
- the power plant plans 6650 hours of operation annually;
- about 3,5 TWh p.a. of electricity production is planned;
- CO_2 emissions are planned to be around 3 150 kt p.a.;
- 440 kg/h or 2926 tonnes of lignite will be used annually.

Investment costs: construction, equipment and financial costs

The controversies raised about the project by different actors ensured that most economic aspects of the project were made publicly accessible. Hence it is possible to have detailed insights into the economics of TEŠ6. **Table 13** presents investment costs based on different variants of the investment program for TEŠ6.

Table 13

Investment costs of TEŠ6 according to different investment programs (thousand euros)

Source: Investment program of TEŠ6, 5th revision from September 2012

Item	Investment program (April 2006)	REV1 (Nov. 2006)	REV2 (Mar. 2009)	REV3 (Oct. 2009)	REV4 (Aug. 2011)	REV5 (Sep. 2012)
Construction work	92,292.9	93,575.5	96,896.2	78,857.2	74,868.2	67.589.7
Equipment	444,622.9	775,800.0	1,010,062.3	908,240.9	964,273.6	1.126.738.5
Other	61,740.0	20,670.0	22,116.9	10,116.9	34,107.5	26.067.9
Financing expenses	38,305.0	63,874.6	213,662.7	106,579.8	122,678.7	82.096.2
Total	**636,960.0**	**953,920.1**	**1,342,738.2**	**1,103,794.8**	**1,195,928.1**	**1.302.492.3**

As **Table 13** shows, investment costs doubled over the period from 2006 – 2012. According to the investor (Šimac, 2013 a and 2013b), the last estimation is still not representative of the final price tag, as cost continue to rise as the construction progresses.

[26] TEŠ6 is not mentioned as a possible project in the last valid energy policy of Slovenia, Resolution on National Energy Program – ReNEP. Official Journal of Republic of Slovenia No. 57/2004.

[27] Some insights of the opposition to the project can be gained at http://www.sejecas.si/.

[28] See for example Cirman, 2013, or Šimac, 2013.

Operational costs

The operational costs of TEŠ6 are listed in **Table 14**.

Item	2015	2020	2025	2035	2045	2054
1. Coal	68,982.3	70,724.2	72,510.1	65,078.3	54,725.2	57,237.6
2. Limestone	3,563.1	3,653.1	3,745.3	3,361.5	2,826.7	2,956.5
3. Ammonia	577.2	591.8	606.7	544.6	457.9	478.9
4. DEMI water	353.8	353.8	353.8	302.1	241.7	241.7
5. Technological water	701.6	701.6	701.6	599.0	479.2	479.2
6. ELKO	420.0	441.4	463.9	512.5	566.1	619.1
7. Product disposal costs	1,306.4	1,306.4	1,306.4	1,115.5	892.4	892.4
8. Maintenance	3,300.0	6,600.0	6,600.0	5,956.9	6,506.9	6,506.9
9. Other expenses	5,500.0	5,638.9	5,781.3	6,330.1	6,387.7	6,681.0
10. Depreciation	42,722.5	42,722.5	42,722.5	42,722.5	2,107.2	2,107.2
11. Labour costs	7,100.0	7,462.2	7,842.8	9,024.3	9,569.7	10,466.3
12. Financing costs	41,600.8	27,576.8	16,487.5	2,485.3		
13. CO_2 emission credits	68,823.8	78,070.6	90,806.4	111,575.4	128,160.5	177,476.3
14. Heat generation costs	-5,639.2	-6,205.8	-6,829.4	-10,143.5	-12,284.4	-14,595.0
TOTAL all expenses	**244,951.5**	**245,843.3**	**249,928.4**	**249,608.0**	**212,921.1**	**266,143.0**
TOTAL electricity expenses	**239,312.3**	**239,637.4**	**243,098.9**	**239,464.5**	**200,636.7**	**251,548.0**
Production (GWh)	3,529.3	3,529.3	3,529.3	2,998.3	2,398.7	2,398.7

Table 14

Production costs and electricity production (thousand euros)

Source: Investment program of TEŠ6, 4th revision

Investment costs per unit of installed power, electricity production price and other economic indicators

The last revision of the investment plan, which provides estimation for the figure REV4, estimates the average investment cost per installed kW to be 1788,7 EUR/kW. The average electricity production price is not given in the last revision of the investment program, but production prices are estimated to range from 66,9 EUR/MWh in 2015 to 104,9 EUR/MWh in 2054. The other key economic indicators are presented in **Table 15**.

Concept	Invest. program (Apr. 2006)	REV1 (Nov. 2006)	REV2 (Mar. 2009)	REV3 (Oct. 2009)	REV4 (Aug. 2011)	REV5 (Sep. 2012)
Average generation cost (EUR/MWh)	34.25	39.6	41.7	55.83	NA	NA
Payback period (years)	16	14.7	16	17	15	15
Net present value with a 6 % discount rate (EUR million)	88.97	502.3	237.8	17.0 *	83.6	112.9
Internal rate of return (%)	7.5	11.1	9.11	7.17	7.59	7,75
Relative net present value	0.19	0.79	0.29	0.022	0.108	0.116

Table 15

Key economic indicators of TEŠ6 project

* At 7% discount rate.

Source: Investment program of TEŠ6, 4th and 5th revisions.

Estimates show that is it very likely that TEŠ6 will produce a EUR 120 million loss in its first three years of operation, while losses could rise in the future (Cirman, 2013). As about one third of the investment value is supported with a state guaranteed loan from the European Investment Bank (EUR 440 million), this estimate casts gloomy predictions on the necessity to cash in the state guarantee. This ultimately means that the taxpayers in Slovenia will have to pay for the project, one that has been managed poorly from the beginning.

3.4.2.2 The nuclear scenario

This report assesses the economic outcome of the planned construction of a second nuclear block in Krško. However, such an assessment can only be carried out based on Preinvestment figures commissioned by GEN (the investor), dating back to 2008. The Preinvestment figures largely underestimate investment costs (slightly under EUR 2,7 billion), a fact that has been recognised by the investor [29]. Instead, realistic investment costs are estimated in the region of EUR 3 – 5 billion. In the absence of better data and more realistic estimations, the figures from the Preinvestment basis are used. Where possible, these are compared with more realistic estimations provided by official documents or expert analyses.

Main assumptions

The analysis of options commissioned by GEN considers the following different types of reactors: AREVA (EPR, 1630 MW), Westinghouse (AP1000, EPP1000, 1 x 1117 MW or 2 x 1117 MW), MHI (Tomari3, 880 MW), ATMEA (ATMEA-1, 1130 MW) and MHI (EU-APWR, 1740 MW). Although the analysis views the double Westinghouse block as the best option economically, in governmental debates the single Westinghouse unit is considered as the more practical option because of the lower costs and capacity. The NEP also considers both the single and double block options. However, for the purpose of this report, the option of the single Westinghouse unit is examined in greater detail. The main assumptions for this option are the following (GEN, 2010):

- a 60 year period of plant operation;
- total installed capacity of 1117 MWe or 1085 MW;
- 7460 – 8760 hours of annual operation (about 91-92% usage);
- between 6,4 and 8,1 TWh of electricity produced annually;
- between 2319 and 7024 kt of CO2 emitted annually;
- between 21,1 and 26,7 t of uranium used as fuel annually

Defining expenditures for Krško II

In spite of the inclusion of Krško II in energy policy debates in the elaboration of the NEP, there have been no discussions about the specifics of the project, especially with regard to price. As the debate remains behind closed doors for the most part, it is extremely hard to obtain realistic data about the economics of the project. Figures are thus based on the application energy permit application for

[29] See GEN 2013.

As the debate remains behind closed doors for the most part, it is extremely hard to obtain realistic data about the economics of the Krško II project

Krško II (GEN 2010). However, as comparisons to other planned or running nuclear projects show, these figures could be challenged. The project costs for Krško II are presented in the following equation:

Project expenditures = construction costs + costs for the investor + financial costs + operational costs + costs for the decommissioning and waste management + costs for the grid and replacement and compensatory capacities + costs for reconstruction and modernisation + costs for insurance against accidents

Investment costs: construction and financial costs

The costs presented in this report, as stated above, are based on those provided by GEN in its application for energy permit. The costs for the construction of the reactor and related facilities are given as 'overnight costs' for prices in April 2008. GEN assesses on a Preinvestment basis that the costs for construction of the power plant total EUR 2,687 billion (see **Table 16**), but admits that the latest estimates probably fall in a more realistic range of EUR 3 – 5 billion (GEN, 2013). The latter estimation is more in line with others, for example of 5339 USD/kW from the World Nuclear Association (2013b). NEP estimates the investment to be in the area of EUR 4 billion (IJS, 2011a).

The project is planned to be mainly financed through debt resources (GEN, 2013): 60 % of the investment would be covered through a loan and 20 % by the issuing of bonds. Only 20 % of the investment is planned to be covered by investor capital. According to IAEA (Barkatullah, 2011), capital costs can run up to 60% of the costs of electricity generation. The World Nuclear Association warns that: "*Long construction periods will push up financing costs, and in the past they have done so spectacularly*" (World Nuclear Association, 2013b). This means that the financial costs, which are currently estimated to be about EUR 235 million (GEN, 2010), are very likely underestimated. The example of the Belene NPP is instructive in this regard: costs were initially estimated at EUR 6,1 – 6,3 billion, half of which was to be covered by the NPP, but in the end costs had soared to EUR 1,76 – 1,8 billion. This seems to be more realistic scenario for Krško II. Assuming a cost of EUR 5 billion, 60 % of which is covered by loans, a borrowing figure of EUR 3 billion can be reasonable expected for Krško II.

Main investment costs	Preinvestment basis (EUR million)
Construction	
Construction works	710.711
Equipment and montage	1,020.507
Other services (testing, education, starting)	18.223
Engineering	72.893
Unplanned	182.233
Financial costs	
Financing of the investment	234.762
Other costs	
Value added tax	447.866
Total	**2,687.196**

Table 16

Investment costs of Krško II

Source: GEN, 2010

Operational costs

The Preinvestment basis lists the following as operational costs: fuel costs, labour costs, maintenance costs, amortisation, waste disposal costs (LILW), payment of tax on profits, modernisation investments and other costs. **Table 17** lists the estimated costs.

Table 17

Operational costs of Krško II
Source: GEN, 2010

Main operational costs	Preinvestment basis [in 000 EUR]
Fuel costs - first loading - per year	103 000 41 200
Labour costs	45,38 per employee p.a
Maintenance	33 591 p.a.
Amortisation	N/A
LILW disposal	6 093 p.a.
Decommissioning cost	178 720 in the last year
Tax on profits	20% p.a.
Other costs (water tax, land use tax…)	11 025 p.a.
Modernisation investments	597 179

a) Fuel costs: **Table 18** shows inflation rates that are assumed for rising fuel costs.

Table 18

Inflation rates for escalation of the fuel costs for Krško II

Source: GEN, 2010

Period	Inflation rate
2020-2029	+0.2% p.a.
2030-2039	+0.3% p.a.
2040-2049	+0.4% p.a.
2050-2081	+0.5% p.a.

b) Labour costs: **Table 19** shows the assumed inflation rates for rising labour costs.

Table 19

Inflation rates for escalation of the labour costs for Krško II
Source: GEN, 2010

Period	Inflation rate
2020-2029	+1,5% p.a.
2030-2039	+1% p.a.
2040-2049	+1% p.a.
2050-2081	+1% p.a.

c) Amortisation costs: For amortisation, the following rates are assumed:

- 1.667% for the construction works and
- 3.33% for the equipment and montage.

Other services, engineering and unplanned costs use an amortisation rate of 1.667% for 39% of those costs and rate of 3.33% for the remaining 61%. The average amortisation rate for modernisation investments is 3.89%. Due to variations in these rates, amortisation costs vary from year to year and the Preinvestment basis does not sufficiently provide for annual costs.

d) Waste management costs: There is still no site confirmed for the long-term storage of nuclear waste on Slovenian territory, in spite of lengthy discussions.

Regarding the short-term and long-term storage of the highly radioactive waste no estimation of costs has been made, but if we look at British estimates, the price tag is from GBP 46,000/m^3 to GBP 201,000/m^3 (Nuclear Engineering International, 2008).

e) Decommissioning costs: Traditionally, decommissioning costs are defined as 10 - 15% of total capital costs (Decommission, 2013; World Nuclear Association, 2013b), which in case of Krško II should be between EUR 300 and 750 million if we use the price estimate of EUR 3-5 billion. However, the official GEN estimation evaluates decommissioning costs at EUR 178.72 million. As experience with decommissioning is very limited, the costs are uncertain. E.D.F. estimates the cost to be 230 EUR/kW. Official French estimates suggest a decommissioning cost of 258.86 EUR/kW (1998). The costs of decommissioning the Ignalina NPP in Lithuania are expected to be EUR 1 billion in official documents. In France, the decommissioning of the Brennilis NPP (a small 70 MW power plant), has already cost EUR 480 million (20 times the estimated costs) and in Germany, the decommissioning of Niederaichbach nuclear power plant (a 100 MW power plant), amounted to more than EUR 143 million (Wikipedia, 2013). This indicates that the planned decommissioning costs for Krško II have very likely been significantly underestimated.

f) Modernisation investments: Modernisation investments are planned in years 31, 33, 35, 37 and 39 to improve and upgrade the equipment. These costs are estimated to be about 12% of the annual value of equipment and its montage.

g) Profit tax: Payment of profit tax is planned at the rate of 20% throughout the lifetime of the power plant.

h) Other costs: Other costs include: water use tax, land use tax, insurance of the plant, and other various costs.

Investment costs per unit of installed power, electricity production price and other economic indicators

The Preinvestment basis estimates the average investment cost per installed kW at 1,794.6 EUR/kW. The average electricity production price before tax on profit is estimated at 25.05 EUR/MWh. The levelized electricity generation costs are estimated to be 33,58 EUR/MWh in case of a 5% rate of profitability, 41 EUR/MWh in case of 7% and 54.77 EUR/MWh in case of a 10% profitability. The estimated internal rate of return is 15.39%, the net present value EUR 3.856 billion, the profitability index is 1.8 and the payback period is 8 years. However, the NEP estimates the price of generation to be in the area of 65 EUR/MWh, which is significantly higher that the estimation of the investor.

In Slovenia, investment costs are traditionally calculated as if the production unit can operate without its surrounding infrastructure

Nevertheless, it must be noted that the listed indicators of economic performance of the project omit several very relevant economic categories, such as storage of highly radioactive waste. In Slovenia, investment costs are traditionally calculated as if the production unit can operate without its surrounding infrastructure. It seems that this is the case with the Preinvestment basis of GEN also, as the investment estimation of GEN does not include the following other relevant cost categories: the construction of the connecting grid, securing of capacity for secondary and tertiary regulation, construction of additional infrastructure on site, unit for processing of the waste, storage of the highly radioactive waste and insurance against accidents. The listed costs are normally not accounted for by the investor, with the assumption that the state (i.e. taxpayers) will pay these. If the listed categories were included, the economic picture might look significantly different.

3.4.2.3 The renewables scenario

Although named the 'renewables scenario', this option builds heavily on energy efficiency measures and to some extent on using gas as a transition element. However, the key elements for analysis are renewables.

Energy efficiency orientations

Slovenia, as a Member State of the EU, has adopted the objective to achieve 1% of energy savings annually and 9% in the period from 2008 to 2016. In Slovenia, improvements in the field of energy efficiency have so far been too slow and limited in scope to implement objectives derived from Directive 2006/32/EC and the National Energy Efficiency Action Plan, 2008–2016. There are very few incentives for the efficient use of electricity. This does not come as a surprise if we look at recent history, in which ambitious energy efficiency objectives for 2004 were not been achieved under the National Energy Program mainly due to a lack of investment funds for energy efficiency.

The EU has set the objective of improving energy efficiency by 20% by 2020. To achieve this even more ambitious objective, the removal of obstacles to larger market breakthroughs for energy efficient measures will be necessary. The fact that implementation of energy efficiency measures depends on several tens of millions of investment decisions of end-consumers in the next twenty years, makes energy efficiency objectives much harder to achieve than to make decisions on investments in thermal power plants (TPP) or NPP. Thus, an adequate allocation of investment funds, and new technological knowledge and service providers will be needed. Also, the quality and availability of information on benefits and practical aspects of energy efficiency for the end-consumers will be crucial. As none of these improvements have ever been provided by the market, it is crucial that the new National Energy Program prioritises the drive for energy efficiency.

The efficient use of energy in the program is a priority for the stimulation of economic growth and development of jobs in Slovenia. The program sets ambitious objectives for the long-term reduction of final energy consumption without transport (a reduction of final energy consumption by 7% from 2008 to 2030) and the controlled growth of electricity use (controlling such use to limit the increase to no more than 7% from 2008 to 2030). The Energy Efficiency Action Plan for the period 2008–2016 will be fully implemented and upgraded with a more ambitious plan for the period until 2020 or 2030. Improving energy efficiency will only be possible if resources from end-consumers of electricity are invested in energy efficiency. The program therefore also plans incentives for providers of new services related to funding and implementation of measures for energy efficiency. It is planned that energy efficiency will be supported by 'green fiscal policy' measures. In parallel with increased taxes, a scheme supporting energy efficiency will be introduced for vulnerable population groups, along with a system of voluntary agreements for improved efficiency of energy use and exploitation of RES linked to tax relief for industry.

If the described plans regarding energy efficiency become a reality, and energy efficiency becomes a key priority of energy policy, Slovenia will benefit on multiple fronts: cutting greenhouse gas emissions, creating millions of new green jobs, and decreasing dependency on energy imports and reliance on nuclear and fossil fuels. In addition to the plans listed above, actions and measures must be put in place to ensure that energy efficiency gains are maximal and not subject to the rebound effect (when improvements in energy efficiency are soon overbalanced by the increased use or size of .e.g. car).

Renewable energy orientations

Under the EU renewables directive, Slovenia adopted the very ambitious objectives of achieving a 25% share of RES in gross domestic final energy consumption (today it stands at 15%), and a 10% share of RES in final energy consumption in transport. Previous efforts to develop RES failed to achieve the majority of objectives set out in the Resolution on the National Environmental Action Plan (ReNEP) for 2010. Slovenia was merely approaching its target of a 25% share of RES with regard to heat supply in 2010. In 2008, hydroelectric power plants contributed 93.3% of all electricity generated from RES[30]. In relation to the heat supply, wood biomass prevails among RES, contributing more than half of the total heat supply. In 2010, the target objective of 33.6% of RES with regard to the electricity supply was met, according to initial estimates, although this is partly a consequence of increased hydrology and lower energy use during the economic crisis. Therefore, it was only partially met as a result of government efforts. Furthermore, the objective from ReNEP of doubling CHP generation was not achieved, as by 2008, production by means of CHP had only increased by 38.5%. To increase the share of RES, final energy consumption will have to be reduced, while production from RES simultaneously increases.

Obstacles to greater breakthroughs in RES for heat generation are similar to those to achieving greater energy efficiency. However the obstacles to increased electricity generation from RES are slightly different. The development of solar and biogas power plants has been made possible through clear and harmonised regulations, but investors in wind power plants and small hydroelectric power plants face a lack of transparent procedures within spatial planning frameworks for solving conflicts between the interests of nature protection and those of reducing GHG emissions. The State is not active in directing investors, and investors do not integrate spatial and environmental planning in the early stages of project

[30] As the main part of the hydro power plants are large HPPs (>10 MW), their categorization as 'renewables' can be questioned. However, as the standard statistics and EU legislation classifies them as renewables, this categorization is used in the report.

planning. There is no social consensus achieved regarding to what extent – if any – damage to nature from electricity generation from RES is permissible. Greater breakthroughs in CHP from wood biomass will depend on the further development of district heating systems. Increased energy utilisation from wood biomass is also conditioned by the development of the scrap wood market and the entire chain of wood-processing industries. A general obstacle for electricity generation from RES, district heating and CHP projects is a lack of interest by investors with adequate capital. In addition, preparation of these projects demands additional knowledge that smaller investors don't possess. To enable the comprehensive introduction of sustainable energy technologies, new approaches to planning are required. This applies to the planning of networks, spatial planning and the planning of the energy industry in local communities and settlements.

There is no social consensus achieved regarding to what extent – if any – damage to nature from electricity generation from renewable energy sources is permissible

According to the draft of new National energy program, the objective is to prioritise the exploitation of all environmentally suitable RES, to achieve a long-term increase and attain target shares of RES in the gross final energy consumption, namely: heat – a 33% share by 2020 and a 37% share by 2030; electricity – 40% by 2020 and a 53% share by 2030. The NEP will also enable breakthroughs in the development of forms of RES that are currently less exploited. The aim is to achieve equal levels of hydro energy, wood biomass and other forms of RES exploitation by 2030. Plans for heat generation foresee stimulation of exploitation of wood biomass, solar and geothermal energy. For this, the exploitation of wood biomass in high efficiency CHP and district heating systems are prioritised. Plans for electricity generation foresee further exploitation of wind, solar and hydro energy, and wood biomass and biogas in high-efficiency CHP.

All sectors will contribute to providing the necessary conditions for optimum implementation of the Action plan for Renewable Energy Sources 2010–2020. A programme management system will be established, alongside measures for the systematic alleviation of obstacles for implementation (especially administrative obstacles), and for the active supervision of programme implementation. The achievement of the objective, namely a 25% share for RES, will greatly depend on implementation of the programme for improved energy efficiency and on the development and implementation of sustainable transport policy in Slovenia and the EU.

The key elements of the supporting environment will continue to be the support scheme for electricity generation from RES, the Rules on Energy Performance of Buildings, and incentives for energy-saving building restoration. Also foreseen are improvements at all levels project planning for RES exploitation, procedures of spatial planning, and targeted fiscal policy and incentive schemes for heat generation from RES. The long-term transition to a low-carbon society will require exploitation of RES to a considerably greater extent, and conditions for this must be provided for in spatial planning acts. Active networks will increase the flexibility, accessibility, security and economics of electricity supply and support greater efficiency and the dispersed generation of electricity from RES and high-efficiency CHP.

Renewables potentials and objectives

A variety of studies have looked into the potential for renewables in Slovenia. As their methodologies differ, it is hard to compare them, hence the potentials, assembled in **Table 20**, are assessed on against data from different studies. This data was collected for NEP preparation.

Renewable source	State in 2008	Potential till 2020	Technical potential	Suggested objective for 2020	Suggested objective for 2030	Frauenhofer ISE potential assessment for 2020 and 2030	
Small HPP	454	135	1100	86	135	621	676
Wood biomass	36	300	2875	72	153	566	596
Landfill gas	31	150	147	16	0	220	220
Biogas	40	206	222	262	267	583	833
Wind	0	1000	3055	217	747	447	645
Photovoltaic	2	155	961	345	912		N/A
Geothermal	0	121	300	150	150	42	240

Table 20

Renewables potentials for Slovenia (in GWh)

Source: IJS, 2011c; Frauenhofer ISE, 2005

In spite of the numerous studies, potentials for renewables are mainly estimated up until 2020. However, several estimations exist also for 2030. **Table 21** provides an overview of the accumulated renewables potentials for Slovenia as estimated in NEP and by Frauenhofer ISE.

Alternative source	2020 with large hydro	2020 without large hydro	2030 with large hydro	2030 without large hydro
NEP	6464	1883	8833	3210
Frauenhofer ISE*	6940	2479	8017	3211

Table 21

Renewables potentials for 2020 and 2030 (GWh p.a.)

* Photovoltaic production is not included because it was not estimated.

Source: IJS, 2011d; Frauenhofer ISE, 2005

Costs of renewables

As the costs of renewables are technology specific, only the overall assessments of the investments needed for renewables are brought together. The NEP estimates that investment costs for the renewables intensive strategy will be about EUR 2.4 billion in the period 2011-2030. Frauenhofer ISE predicts a EUR 1.8 billion investment for the period 2006-2030, but this excludes photovoltaic investments. As the major part of the estimated price tag of NEP is attached to photovoltaics, it is not possible to directly compare the two available assessments.

3.4.3 Discussion of the different scenarios

Deliberation and analysis from the draft NEP

According to analysis in the draft NEP, the scenarios differ with regard to the year 2030 as follows: the nuclear and gas scenarios point to advantages over the basic scenario with regard to energy indicators and indicators of operational security of supply. The gas scenario presents an acceptable alternative according to all aspects, but does not prove advantageous over the other two scenarios. Electricity generation is more expensive than in the other two scenarios, the GHG and NOx emissions are larger, and so is import dependency and sensitivity to changes in energy prices on international markets. Despite higher supply costs, the gas scenario is less demanding than the nuclear scenario in terms of investments.

For reasons of lower supply costs and less emissions the following scenarios of electricity supply, the basic and nuclear scenarios are particularly adequate for the NEP. The basic scenario satisfies the needs of Slovenia by 2020, while the nuclear scenario is more long-term oriented and provides further long-term exploitation of nuclear energy in Slovenia.

From the standpoint of security and competitiveness and due to the demanding nature of project implementation, the overlapping of the operation of NPPK 2 and NPPK is strictly necessary. Within the impact assessment, 2022 is taken into consideration as the first possible year of operation of the facility, but realistically, the year of construction of the facility will be subjected to entrepreneurial optimisation. In addition, this realisation depends on the social acceptability of the project. Up to the section on construction of NPPK 2, the basic scenario is the same as the nuclear scenario, and gives information on how the nuclear scenario will be implemented in the event of suspension of the construction on the NPPK 2.

The advantages of scenarios without TEŠ6 are mainly environmental. With regard to investments, they are slightly less promising. The advantages of the scenario with TEŠ6 are in terms of greater strategic security of supply in 2030, lower expected energy price and less sensitivity to price changes on the international energy markets in 2020, and slightly lower electricity prices in 2020. An additional selection criterion is the fact that investment in TEŠ6 is pending and, consequently, the scenarios without TEŠ6 are burdened with costs of termination of contracts and of investment-related activities.

Deliberation and analysis on the basis of the analysed scenarios

As it not possible to compare all three options – coal, nuclear and renewable – side by side, this section aims at providing some thoughts on the pros and cons of the different options. Direct comparison is not possible because of the different installed capacities, different life spans, and different operational periods of the coal, nuclear and renewable scenarios.

Table 22 presents the key indicators of all analysed options. The table shows that the investment per installed capacity is very close for nuclear and coal. Yet it must be noted that the estimate is made at the overall investment cost of EUR 2.7 billion, which even the investor assesses to be too low. Apart from that, the estimated investment for the additional NPP block fails to include several very important cost categories, such as the cost of waste and insurance for risks, while many other costs are seriously underestimated (e.g., decommissioning costs).

Indicator	Coal	Nuclear	Renewables
Installed capacity (MWe)	600	1,117	149
Operation period (years)	40	60	25
Operation hours (h)	6,650	7,460-8,760	
Total output (TWh)	3,5	6.4-8.1	3,2
Total investment (EUR bln)	1.4	4	2,4
Investment per installed capacity (EUR/kW)	1,788,7	1,784.6 *	1,609.66***
Generation price (EUR/MWh)	66.9 – 104.9	65 **	65 – 165
CO2 emissions (kt p.a.)	3150	2,319-7,024	N/A

Table 22

Selected indicators from the analysed energy scenarios

* At investment of EUR 2,7 bln, which is on the low range of the price estimates. The realistic price is about EUR 3-4 bln.

** Estimate from NEP

*** Average cost of installed capacity, but depending on the renewables mix, this can vary. However, keep in mind that operation time of installed kW of renewables can be significantly shorter than the operation time of installed coal or nuclear capacity.

Sources: IJS, 2011a; GEN, 2010; Frauenhofer ISE, 2012

Moreover, another important issue has to be brought to attention in light of analysing the different energy scenarios. This is the question of what Slovenia actually needs in terms of electricity production. The most frequently heard argument used by key players in the energy sector against the further promotion of renewables is that renewables cannot satisfy the needs of the Slovene market. However, Table 23 puts this argument under question. The table lists the different scenarios from NEP and provides an overview of the multiple characteristics of the different scenarios, among them plans for electricity export.

Scenario	Dependence on imports in %	Share of electricity from domestic resources in %	Electricity export in TWh	CO_2 emissions in Mt CO2eq.	CO_2 emissions outside ETS in Mt CO2 eq.	NO_x emissions in kt	Emissions of dust particles in kt	Investments 2010- 2020 or 2030 in mln EUR2008	Specific cost for electricity generation in EUR2008/MWh
Situation in 2008	56.0		-1.4	16.9	9.1	58.8	6.3		
				2020 Scenario					
BS INT	46.2		1.5	14.3	7.2	27.5	5.2	2,360	72 (74)
NS INT								5,949	
GAS INT								2,640	
AS NS	49.6		2.1	14.5		27.9	5.2	5,562	81 (82)
AS GAS								1,974	
				2030 Scenario					
BS INT	45.2	71	2.6	12.7	7.1	20.9	4.4	3,396	78 (81)
NS INT	30.5	79	10.2	12.7		20.9	4.4	7,383	72 (77)
GAS INT	47.5	58	7.5	14.4		23.1	4.4	3,956	83 (85)
AS NS	37.4	64	8.3	10.2		19.34	4.3	6,997	72 (77)
AS GAS	55.2	49	3.8	11.3		20.7	4.3	3,290	84 (85)

Table 23

Overview of characteristics of scenarios analysed in NEP

Source: IJS, 2011a

As **Table 23** shows, even the additional gas scenario, which is the most ‘renewable’ choice among the scenarios analysed in the NEP, plans to export electricity. The export would amount to 2.1 TWh by 2020 and 3.8 TWh by 2030. This means that even some extent of gas generation capacities would be unnecessary from the perspective of covering Slovenia’s needs. In this case, planned CO_2, NO_x and PM emissions would be reduced, making this scenario the most environmentally responsible. Investment needs would also be reduced to some extent, meaning that from an investment perspective this scenario would also be the most beneficial. The generation price is the highest in the case of AS GAS, but this aspect would also be improved if less gas-based electricity were produced.

Even the additional gas scenario, the most ‘renewable’ choice, plans to export electricity. Some extent of gas generation capacities would be unnecessary from the perspective of covering Slovenia’s needs

Bearing these arguments in mind, Slovenia would be better off trying to satisfy its needs only, and not planning to produce electricity for export. Electricity might be a sought after product, but it is also a product which brings high societal and environmental costs.

As stated in the introduction to the Slovene section of the report, planning of the energy sector starts with predicting growth in energy consumption, and planning the construction (or renovation or lifetime prolonging) of capacities to produce that energy. The key policy recommendation arising from the report and analysis done for the NEP, is that this approach must be changed. The first steps should be to properly assess all the potentials for energy efficiency, to set political objectives and to plan measures for reduction in energy use and more efficient use of energy. Slovenia should plan to increase its use of renewables, not only for environmental reasons, but for many others. One reason is that with large projects there little transparency of decision-making and project management. Experience shows that with large scale energy projects in Slovenia, lack of transparency is more the rule than the exception, resulting in economically and environmentally disastrous solutions that present Slovenia with long-term burdens. Large energy projects tend to overrun significantly in terms of costs and time, mainly at the expense of taxpayers. They are monopolizing the energy sector, when dispersed production from renewables could put people more in control of the sector, resulting in more transparency and less corruption.

Another strong reason for orienting towards renewables and abandoning plans for fossil and nuclear power is that the regions in Slovenia where these sources are produced are not moving toward transition. Although coal and nuclear blocks bring additional income for local budgets there, these funds are not strategically directed into transitioning towards different development options.

A clear example of not making a transition to more sustainable development direction is found in the Zasavje region, where already in 2003[31] plans were underway to close down coal mining and burning facilities. State aid was provided, as was support for reorienting the region towards other industries. Now, a good

[31] Regulating the Gradual Closure of the Trbovlje-Hrastnik Mine and Development Restructuring of the Region Act (official consolidated text) /ZPZRTH-UPB1/, Official Journal of Republic of Slovenia No. 55/2003.

decade later, the region is still relying on coal based activities, because political and energy elites are pushing for this option.

There are several other reasons for the reorientation of the energy sector. One is that acting on climate change later will cost more than acting on it now. Another is that in spite of still having substantial environmental effects, renewables are by far the safer option for the environment. The health effects of renewables are also significantly less than those of coal and nuclear power. Moreover, the negative health impacts of coal usage and of nuclear accidents must be borne by taxpayers, which is in total contradiction to the 'polluter pays' principle. However, this fact is largely ignored when discussing the costs of the energy sector.

For these reasons, Slovenia would do better to orientate its energy policy towards efficiency and renewables. To do this, clear political will and leadership is needed, as well as knowledge transfer, and the commencement of initiatives to support infrastructure (smart grids, storage facilities…) development. It is critical that Slovenia recognise that action programs for energy efficiency and renewables are not simply unwelcome impositions by Brussels, but an opportunity to embark upon an alternative energy path.

4
Conclusions

As the cases of Bulgaria and Slovenia have shown in this report, the authorities in both countries seem to be increasingly interested in further developing their nuclear capacities, using arguments based on energy security, or cost effectiveness. However, our detailed analysis has shown that in making these cases, energy assessment needs have been exaggerated, and the full costs of new NPPs have been underestimated or poorly defined due to differences in opinion with regard to what costs should be included. In addition, the environmental risks are not fully accounted for, particularly in the cases of the Belene NPP in Bulgaria and the Krško NPP in Slovenia, the former of which is planned for, and the latter of which is presently sited on a highly seismic zone.

What is striking is that in Europe, unlike in the USA, no insurance provides for protection against losses in the region in the case of accidents - not for individuals, the environment, real estate, nor for long-term agriculture losses. Liability for nuclear damage covers less than 1% of the total costs of the damage in the case of an accident of the size of Chernobyl or Fukushima. Furthermore, problems with the long-term storage of radioactive waste in the cases described in the report remain open with no fixed solutions, as it is also the case with existing NPPs in Europe and all over the world. Such a state of affairs reflects gross irresponsibility on the part of authorities toward citizens and future generations, and creates in essence, a 'generation debt'. Forty years after the closure of the Kozloduy NPP, for instance, Bulgaria still hasn't dedicated a site to the long-term safe storage of its nuclear waste. The situation is similar in Slovenia, where the site of LILW storage has not yet been decided.

Environmental risks are not fully accounted for, particularly in the cases of the Belene NPP in Bulgaria and the Krško NPP in Slovenia.
Problems with the long-term storage of radioactive waste remain open

On the matter of whether sufficient potential for RES exists in Bulgaria and Slovenia to avoid the construction of new nuclear capacities, this report has shown not only that such potential is available, but economically justified. Claims that RES are more expensive than energy from existing fossil fuel capacities, are only valid if one disregards the ecological price of the pollution caused by the latter, and the fact that investments made in fossil fuel production with public money in socialist times remain unpaid. Furthermore, we have shown that in comparison to the cost of new nuclear capacities, RES can produce economically competitive energy with less risk capital. This is particularly true for energy for heating and cooling and co-generation, which should be prioritised for subsidies as a more efficient and sustainable source of energy. In the long-term, with the further technological development and increased production, RES installations,

More ecologically friendly energy future is not just possible, but already evolving as the RES share increases. However RES is no 'silver bullet', and sometimes leads to environmental conflicts

especially for wind, will result in a lower cost per KW/h, while the nuclear capacities on the contrary, will continue to become more expensive as costs for metals and management of radioactive waste increase. Moreover, the reality as this report has shown, is that the costs of building new NPPs often increase many times beyond initial estimates, as both the cases of the Belene NPP and the Krško II NPP illustrate.

What is clear is that a more ecologically friendly energy future is not just possible, but already evolving as the RES share increases. However, it is important to remember that RES is no 'silver bullet', and sometimes leads to environmental conflicts, especially when projects (such as hydropower) are situated in ecologically sensitive areas such as NATURA 2000 zones. In some cases, these conflicts may be exaggerated (perhaps when new technologies are involved for which social acceptance is low) compared to the scale and danger of pollution from conventional power plants, the lower prices of which are more attractive to consumers.

With regard to the environmental health impacts of uranium mining, our monitoring (mainly in Bulgaria) has shown that the rehabilitation of closed mines in many cases has not been successful. Measurements done by the EJOLT team confirmed the results of state authorities, proving that levels of radiation in groundwater coming from mines have not decreased as predicted by experts in the 1980s, and are no less radioactive four decades after mine closure. The funds planned for the proper rehabilitation of mines have largely been underestimated, raising the real question of whether nuclear energy really is a less expensive option, and who pays the real cost for the increasing reliance on it.

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Appendices

Appendix 1

Comparative data of Bulgaria with neighbouring and European countries

Country/ 2011 indicator	Austria	Den-mark	France	Germany	Italy	Greece	Bulgaria	Romania	Hungary	Turkey
Population (million)	8.404	5.561	65.048	81.752	60.626	11.310	7.369	21.414	9.986	73.723
GDP at current prices (EUR billion)	300.7	240.5	1996.6	2592.6	1579.7	208.5	38.5	131.3	100.14	557.73
GDP per capita, EUR/inhabitant	35,780	43,251	30,694	31,713	26,056	18,453	5,224	6,132	10,028	7,565
Relative economic consumption in PPS (%)	119	113	113	120	101	91	45	47	61	57
Primary energy consumption, million toe (2010)	32.75	19.06	256.58	306.36	165.96	27.73	17.39	33.99	24.00	99.71
Primary energy consumption per capita, toe/capita (2010)	3.911	3.443	3.966	3.745	2.750	2.453	2.299	1.583	2.397	1.374
Gross energy production, kWh	65,400	33,139	542,947	557,890	291,417	50,064	45,143	56,968	33,499	219,334
Gross energy production per capita, kWh/capita	7,782	5,960	8,347	6,824	4,807	4,427	6,126	2,660	3,355	2,975
Consumption of energy, kg of oil equivalent per EUR 1 000	131.82	93.74	151.60	141.89	123.65	147.46	671.10	395.54	295.49	233.1
Consumption of energy for Bulgaria/ consumption of energy of a country	5.09	7.16	4.43	4.73	5.43	4.55	1.0	1.70	2.27	2.88
Energy import dependence, % (2010)	61.82	-18.21	49.30	59.78	83.78	69.11	71.6	21.66	58.26	69.28
CO_2 emissions, (Mt CO2 eq)[32]	81.9	56.1	479.5	917.0	493.7	118.5	67.9	123.7	65.6	401.9
Climatic intensity of energy consumption (2009)	92.6	93.3	89.4	93.2	93.9	95.5	109	93.6	87.5	100.4

Source: Eurostat; data published in 2012 and refers to 2011, which is the last year of complete data for all countries.

[32] Megatonnes of carbon dioxide equivalent.

Appendix 2
Timeline of development of Krško NPP

1970: The reason why the plant is co-owned by two countries was that these then-constituent republics of Yugoslavia planned to build two plants, one in each republic, according to the original 1970 agreement and its revised version from 1982.

1975: The Yugoslav management in 1975 consisted of personnel from both the Slovenian and Croatian power companies and a representative from the central government in Belgrade.

1981: The Krsko Plant begins producing power in 1981, preceding both the Angra and Kori-2 plants. The plant is connected to the power grid on October 2, 1981 and goes into commercial operation on January 15, 1983. It is built as a joint venture by Slovenia and Croatia which are at the time both part of Yugoslavia.

1987: Plan is abandoned in 1987 by Slovenia due to a referendum held in 1986.

1997: ELES and NEK decide to increase the operational and decommissioning costs billed to both ELES and HEP, but the latter refuses to pay.

1998: The Government of Slovenia nationalizes NEK, stops supplying power from Krško to HEP, and sues HEP for the unpaid bills.

1999: HEP counter-sues for damages because of lack of supply.

2001: In January the leaders of the two countries agree on equal ownership of the Krško plant, joint responsibility for the nuclear waste, and the compensation of mutual claims.

2002: The joint management of the plant begins from January 1

2002: July 1: The plant is expected to start supplying Croatia with electricity by July 1, 2002 at the latest, but the connection is only established in 2003 because of protests by local population.

2008: June 4: After a coolant leak on June 4, 2008, the European Commission sets off an EU wide alarm through the European Community Urgent Radiological Information Exchange (ECURIE).

2023: The planned retirement date for the NPP is January 14.

2043: Lifetime of the NPP is extended by 20 years until January 14, 2043 has been made to the Slovenian regulatory body (URSJV).

Appendix 3
Costs and benefits of the proposed new NPP in Krško

The following costs and benefits should be considered in relation to the construction of the new NPP block in Krško:

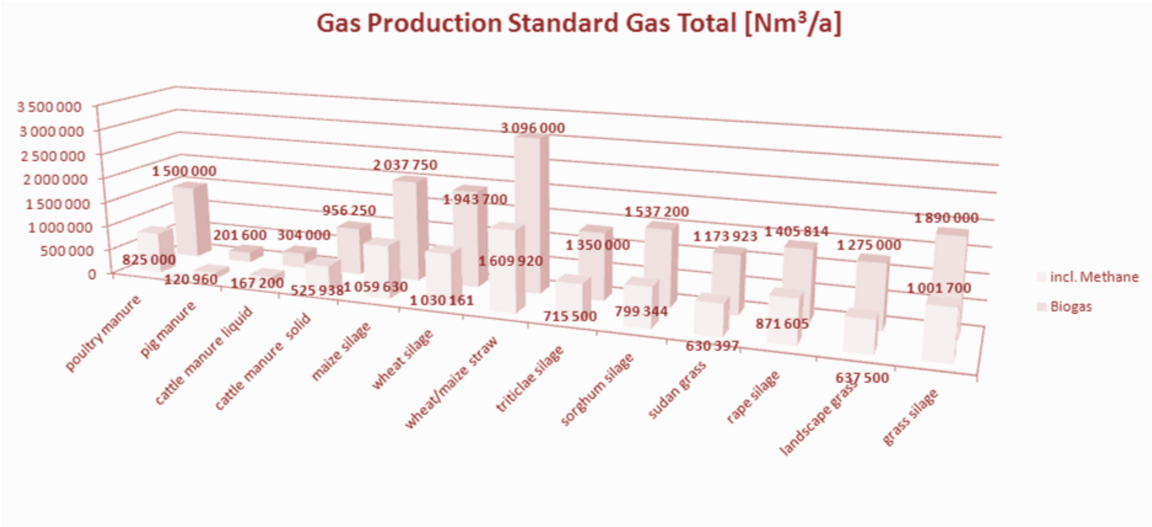
Stage/Phase	Actors / Stakeholders	Cost / Benefit	Activity
Planning / Preconstruction	Company	Cost	Project plan
	Company	Cost	Investment plan
	Company	Cost	EIA
	Company	Cost	Financial costs
	Government	Cost	Consultation process
Construction	Company	Cost	Land acquisition
	Company	Cost	Construction
	Company	Cost	Building the supporting grid
	Company	Cost	Building the supporting infrastructure
	Nature	Cost	Damage to the environment during construction
Operation	Operating firm	Cost	Nuclear fuel purchase and transport
	Operating firm	Cost	Operational costs
	Local Residents	Cost	Accidents
	Nature	Cost	Accidents
	Global society	Cost	Accidents
	Company	Cost	Short term storage and waste reprocessing plant
	Nature	Benefit	Reduction in Carbon emission
	Global society	Benefit	Reduction in Carbon emission
	Company	Benefit	Electricity production
	National society	Benefit	Electricity production
	National economy	Benefit	Electricity production
Phase out / Decommissioning	Company	Cost	Long term waste storage plant
	Company	Cost	Insurance in case of accident
	Company	Cost	Closing down and site restoration
	Government	Cost	Maintenance of waste

Appendix 4

Data of energy indicators of different substrates in Bulgaria. All data is on the basis of 10 000 t/a substrates

Estimated gas production potential for Bulgaria

Source: © Biogas Energy, data KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft)



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