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Environmental security in the Czech Republic: An analysis of the energy mix

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Abstrakt:

Tato diplomová práce se zabývá pojmem environmentální bezpečnosti a pomocí hlavních ukazatelů tohoto konceptu analyzuje energetický mix České republiky. Koncept environmentální bezpečnosti a jeho zařazení do oboru bezpečnostních studií je podrobně popsáno v první kapitole této práce společně s metodologickým uchopením následné analýzy. Hodnocení energetického mixu České republiky je poté porovnáno s referenčním stavem v roce 2040 popsaného v *Aktualizaci Státní Energetické Koncepce* z roku 2013. Evaluace jednotlivých změn energetických zdrojů v budoucím návrhu energetického mixu odkrývá dopad na úroveň environmentální bezpečnosti v ČR podle vybraných hodnotících ukazatelů. Práce dále rozebírá ostatní faktory důležité pro posuzování podoby energetického mixu a tvoření energetické strategie ČR. Na závěr je vyhodnocen dopad změny ve složení energetického mixu na úroveň environmentální bezpečnosti k danému referenčnímu datu a vliv konceptu environmentální bezpečnosti na tvoření energetické politiky v České republice.

Abstract:

This thesis examines the concept of environmental security in regards to its historical development and current classification in the security studies discourse. It analyzes its relationship to the concept of energy security and explains some other relevant concepts used in this study. It then carefully chooses four determinants of environmental security which are most relevant for assessing the energy mix of the Czech Republic. The evaluation of the current energy mix is then compared to the state and composition of the country's energy mix in 2040 as outlined in the New State Energy Concept (NSEC) of 2013. Reflecting on the changes of the energy mix presented in NSEC reveals the actual impact of the future version of the energy mix on the environmental security in the Czech Republic. The thesis further identifies other important factors to consider when making strategic decisions about the composition of the energy mix and energy policy in general. To conclude, a reflection on the implications of this study both on the concept of environmental security and the Czech energy decision-making is offered.

Keywords

environmental security, energy security, energy mix, State Energy Concept

Klíčová slova

environmentální bezpečnost, energetická bezpečnost, energetický mix, Státní energetická koncepce

Word count: 24 280 words, 131 389 characters

Declaration

Hereby I declare that I wrote this master's thesis on my own and have marked all the citations and sources in the text. All works and literature cited are stated in the attached bibliography. I also declare that I have not used this thesis to obtain any other academic degree and I give my consent for this thesis to be published and used for academic or research purposes.

……. …….

Prague Ondřej Šumavský

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List of acronyms

BAT	best available technology
Btu	British thermal unit
CNG	compressed natural gas
CZK	Czech Crowns
EEX	European Energy Exchange
EIA	Energy Information Administration
EPA	Environmental Protection Agency (The United States)
EROEI	energy return on energy invested
ETS	Emissions Trading System
EU	European Union
GDP	gross domestic product
IEA	International Energy Agency
IPCC	International Panel on Climate Change
LNG	liquefied natural gas
MIT	Ministry of Industry and Trade
Mtce	mega ton of coal equivalent
NGOs	non-governmental agencies
NO_x	nitrogen oxides
NSEC	New State Energy Concept
PV	photo-voltaics
RES	renewable energy sources
SEA	strategic environmental assessment
SEC	state energy concept
SO_x	sulfur oxides
WCED	United Nations World Commission on Environment and Development

Introduction

Economic growth and the management of natural resources put increasingly more pressure on the environment. Anthropogenic impact on the environment has been labelled as the leading cause of climate change and environmental degradation in the latest assessment report published by the Intergovernmental Panel on Climate Change.[1] Current efforts to generate and distribute safe and affordable energy to the ever-growing world population in a sustainable and environmental friendly way are coming to a head. This is being further exacerbated by the fact that most of world energy comes from fossil fuels. Despite having high energy density they are non-renewable, finite and therefore unsustainable in their nature. It is partly for these reasons that the transformation from fossil derived energy sources to renewable sources of energy poses one of the greatest political and economic challenges of this century. Albeit such a transformation might prove very ambitious and challenging it would inarguably enhance energy security of many individual states and contribute to the global effort to curb carbon emissions which are believed to play a major role in climate change. The link between energy and environment has become a very contentious matter of our time where humanity strives to find a means to meet the world energy demand in an effective, sustainable and the least harmful way.

Environmental security as a concept is relatively young and has not yet been firmly embedded in the security studies discourse. The traditional framework for the concept of security did not include environmental problems and was strictly limited to military and political issues. Nevertheless, the important role of the environment in the security discourse was underlined by the Copenhagen school of security studies which back in 1997 admitted in their book *Security: A New Framework for Analysis* that the concept was actually being securitized. In the last two decades the concept has been slowly introduced into the security studies discourse and is now relevant more than ever with omnipresent environmental degradation and natural disasters occurring at an alarming rate. It is important to note that environmental security is a broad concept with several components and dimensions such as resource security, energy security, biological security and the traditional security dimension.[2]

[1] (Intergovernmental Panel on Climate Change 2013)
[2] (Allenby 2000, 15)

Therefore, this thesis will mainly work within the energy security and resource security dimensions. However, the concept of environmental security and its historical development will be discussed in more detail in the theoretical part of this thesis.

The nexus between environmental security and energy procurement is very obvious and both are very much interwoven. The way humans obtain energy has both direct and indirect impacts on the environment. The emerging concept of environmental security can help people better understand long existing environmental problems and eliminate some of the weaknesses societies display when dealing with these problems. This alludes mainly to the fact that environmental issues have been militarized in the past which does not help in solving problems of such character. Alternatively, it suggests that preventive measures and early intervention be applied.

This thesis examines the link between environmental security and the procurement and management of natural resources with a specific focus on the Czech Republic. Multiple studies have examined the economic and political benefits of utilising domestic natural resources for energy generation. These studies have shown that the vast domestic coal reserves coupled with the moderate use of nuclear energy for electricity generation and stable imports of oil and natural gas ensure a relatively high level of energy security in the Czech Republic.[3] Though consistent with the definition of energy security these findings have neglected the aspect of environmental security in the Czech energy mix. Therefore, this thesis will aim to address the environmental impact of the Czech energy mix and thus hopefully create value-added to the contemporary list of studies on this topic. This thesis will analyze the current energy mix of the Czech Republic and draw a comparison of a currently drafted NSEC and its impact on environmental security in the Czech Republic. In order to offer an alternative perspective on the environmental impact of domestic energy resources this study will focus predominantly on the environmental security aspects of NSEC which delineates the composition of the energy mix and serves as a strategic guideline for the Czech energy sector in the foreseeable future.

[3] This thesis works with the energy security definition by the International Energy Agency which states that energy security stands for adequate, affordable and reliable access to energy fuels and services.

The first chapter will introduce the concept of environmental security and form the theoretical backbone of this thesis. It will comment on the development of this evolving concept within the security studies discourse and discuss various approaches to its understanding. It is also important to assess the role of this notion and the way it is perceived in the Czech Republic for its understanding varies around the world. The first chapter will thus elucidate the way this concept fits into the discussion about security and to what extent it affects the security situation in the Czech Republic. An emphasis will be put on the fact that Czech decision makers have paid scant attention to the environmental side of energy procurement and have been mainly concerned with non-environmental attributes of energy security. This is important to underscore because unchecked environmental problems can go a long way in destabilizing national security and potentially causing a spill over effect into neighbouring states.

The next sub-chapter will then elaborate on the theoretical part by setting methodological parameters for this thesis. A list of important terms like energy security, sustainability, and self-sufficiency together with more technical terms such as CO_2 emissions, fine particles emissions or import dependency will be outlined to provide the reader with a clear understanding of the terminology used in this work. Furthermore, a list of selected conceptual determinants of environmental security will be introduced which will later serve to measure the level of environmental security in relation to different energy resources outlined in NSEC.

The thesis will then characterise the role of the State Energy Concept and define the impact of this strategic political document on environmental security in the Czech Republic. For the purposes of this work an emphasis will be put on the composition of the energy mix which will be later scrutinized through the eye of environmental security parameters in following chapters. The drafting of this document proved to be extremely difficult as it had to carefully consider the ideas and findings of pundits from various scientific fields. Once finished, a process called strategic environmental assessment (SEA) took place where a private company was contracted by the Ministry of Industry and Trade to conduct an independent study on the actual environmental impacts of the concept. This was followed by a mandatory public presentation and hearing where people, companies and NGOs would submit

their objections and comments pertaining to the concept proposed by the government. The last step before a final revision of the whole document is where the neighbouring countries can submit their comments and objections to the concept. As a result of that one can still observe a certain level of discontent with this document especially on the part of ecological organizations that claim their submissions were not adequately examined. For this reason it is also appropriate to consider alternatives to the newly proposed composition of the energy mix and their potential impact on the level of environmental security.

The next chapter will account for a brief historical development of the energy mix in the Czech Republic to put things into perspective for it is crucial to understand the background of the Czech energy supply when considering the future path of its energy sector. There are several important factors at play when designing an effective and economically viable energy mix. One thing that must be borne in mind in the case of the Czech Republic is its geography and the availability of natural resources. Coal has always been available and thus supplied most of the demand for electricity and heat. Nuclear energy has joined the mix with two nuclear power plants operational at the moment that make up about one-third of total electricity generation in the country. Reserves of oil and natural gas are practically non-existent in the country with the exception of a few high quality oil wells in Moravia where the extracted oil is used mostly for industrial purposes. Natural gas is an imported commodity and is used primarily for heating. Renewable sources of energy now make up more than ten percent of total energy generation but their future looks rather bleak due to feeble public and governmental support.

Fossil fuels represent 90 % of total CO_2 emissions in the country with the amount of greenhouse gases being twice as much as the world average per person and 33 % above the EU average[4]. It should be noted that these numbers are strongly influenced by the character and disposition of the Czech industrial sector which accounts for approximately 36 % of the total country's GDP.[5] Given the country's industrial transformation after the Velvet Revolution and the level global CO_2 emissions benchmarks set in 1990, the Czech Republic

[4] (Eurostat 2011)

[5] Data taken from <http://www.quandl.com/czech-republic> and <http://data.worldbank.org/indicator/NV.IND.TOTL.ZS>, accessed on March 10, 2014.

still emits far less than it pledged to.[6] The total external cost of energy in 2011 was 80 billion Czech Crowns with fossil fuels being responsible for 88 % of the total amount.[7] Similarly, the amount of energy per one unit of GDP is much higher (1.7x higher than the average of the EU 15 states) than in other developed European states.[8] It is evident that status quo in this situation would be both costly and unsustainable, hence a proper discussion and deep analysis is timely.

In order to fully encompass the benefits and inconveniences of different energy resources through the lens of environmental security it is crucial to include energy externalities. In order to do so it is important to factor in positive and negative values of energy resources in order to estimate how these costs can impact the level of environmental security. The most common mention of externalities in the energy debate is related to the negative effects resulting from fossil fuel combustion but they also include other forms of hidden costs which if not internalized can be seen as a form of subsidy. Another crucial aspect of an energy resource in respect to its total cost is net energy. In simple words, it takes energy to make energy. This externality is calculated by a technique called Energy Return on Energy Invested (EROEI). Other characteristics such as density, portability or intermittency are also very important but EROEI should give us a clear idea about the economic viability of any given energy resource. For these reasons all essential factors will be carefully considered when determining a resource's impact on environmental security.

The last part of the thesis will closely analyze the proposed composition of the Czech energy mix as drafted in NSEC and estimate the impact of this document's conclusions on environmental security in the Czech Republic. Qualifying and quantifying selected determinants of environmental security in respect to individual components of the Czech energy mix will provide for the rigour and validity of this research. The overall aim of this thesis is to address and elaborate on the hypothesis that the currently proposed energy mix (as it stands in NSEC) may ultimately diminish the environmental security of the Czech Republic. Therefore, this study will offer a new approach to the selection and use of energy resources

[6] (United Nations Framework Convention on Climate Change 2008)
[7] This translates to about 4 billion USD or 2.9 billion EUR in 2014 numbers. (Hnutí DUHA 2012)
[8] (Eurostat 2011)

through the lens of environmental security which is set to become increasingly more prevalent in the foreseeable future.

1. Theoretical and Methodological Framework

1.1. Theoretical Framework

This part will introduce the theoretical and methodological framework of this thesis starting with the emergence and development of the concept of environmental security. It will explain how this concept fits in the discourse of security studies and comment on the ideas of its proponents and critics. This will be followed by an evaluation of the influence of environmental security within the current discourse and how its position might develop in the future. Literature on environmental security is abundant and therefore a wide range of scholars from different streams of thought has been selected to offer an objective and comprehensive summary of the on-going discussion.

In the methodological part of this section, the concept is broken down into several dimensions and, for the purposes of this thesis; the energy aspect of environmental security is closely examined. Various determinants are chosen based on how well they relate to the energy mix of the Czech Republic. The selection of these determinants is key for determining the outcome of the thesis as it establishes what the individual energy resources in the Czech energy mix will be evaluated upon. This section will also introduce and explain concepts like energy security and sustainability which are essential for a thorough conceptualization of this work. After this section, it should be clear why the selected determinants were chosen and how effectively they are going to determine the impact of the individual energy resources on environmental security in the Czech Republic.

Environmental security as a concept started to form in the 1980s with some authors pointing to the origins of environmental issues posing a threat to national security as early as in the 1960s.[9] In terms of its classification and relevance to security studies, it became part of

[9] One of the fundamental books pointing out to a rising environmental degradation was *Silent Spring (1962)* by Rachel Carson; a seminal report commissioned by the Club of Rome entitled *The Limits to Growth*

the securitization process of various topics like the environment, economy, human rights etc. which were supposed to broaden the security spectrum to make it more comprehensive. This is closely related to the shift from focusing solely on military threats to encompassing threats of a non-military character. The main wave of literature concerned with environmental issues and national security came in the 1980s followed by a series of scientific reports and political remarks recognizing environmental issues as a real threat to peace and security. To name just a few, the 1992 UN Security Council summit meeting with its *Agenda for Peace*, the 1999 NATO's Strategic Concept, NATO's Environment and Security Committee's remarks, the 2000 UN *Millennium Report* and many others that followed.[10]

Definitions of environmental security vary as each author brings his own definition to the table but they all revolve around a sustainable relationship between society and the environment where humans have safe and stable access to earth's natural resources while not causing environmental degradation as a result of their actions. Barry Buzan, a professor at the University of Economics in London and one of the authors of The Copenhagen School, offered the following definition in his book from 1991: "Environmental security concerns the maintenance of the local and planetary biosphere as the essential support system on which all other human enterprises depend".[11]Another definition which focuses more on the human vulnerability to environmental issues is offered by a leading expert on this topic Rita Floyd who in her book *Environmental Security: Approaches and Issues* defines it as: "The process of peacefully reducing human vulnerability to human-induced environmental degradation by addressing the root causes of environmental degradation and human insecurity".[12]

It is important to note that Rita Floyd does not consider environmental security a concept but rather an on-going debate. In the Czech Republic which is the referent country for this study there has been little attention to the concept itself but the Institute of Strategic Studies at the Military Academy in Brno stated in one of their reports that environmental security could be defined as a situation where the society and our ecological system interact

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which first tried to emphasize the limits of planetary resources on economic growth, or later *The Twenty-Ninth Day (1978)* by Lester R. Brown.

[10] (Elliot 2004, 210-211)

[11] (Buzan, People, States & Fear: The National Security Problem in International Relations 1991, 433)

[12] (Floyd, Matthew and eds. 2013)

with each other in a sustainable way.[13] It is also relevant to note that environmental security is not synonymous with ecological security even thought it is often used in the same context. In the case of environmental security, the environment represents the source of insecurity where societies, states, economies and other man-made institutions are the refferent objects of this insecurity. With ecological security, the situation is reversed in the sense that human activities are the source of insecurity and the referent object to be protected is the environment.[14]

To pick up on Floyd's argument that environmental security is an on-going debate, it is critical to identify some of the key aspects of this debate. Firstly, it has been argued that environmental issues are not present in the current security debate. Maria Trombetta has argued that environmental issues belong to the so called 'low politics' and have not been elevated to the so called 'high politics' where more attention is given to creating measures in order to tackle legitimate problems.[15] In addition, Trombetta states that *"not only are environmental problems often silenced by more urgent threats but the very opportunity of considering the environment as a security issue is also challenged"*.[16] The fact that the concept has not been included in the traditional concept of security was also underlined by the Copenhagen School which had already noted that threats to national security might appear in ecological forms and resonate in the environment.[17] The period when a number of authors called attention to the incapability of the traditional concept of security to include environmental issues was followed by a wave of research calling for a redefinition of the concept of security and suggesting a greater focus more on the relationship between natural (renewable) resources and conflict.[18]

The debate about environmental degradation and security has reached a point where many think it will not be possible to effectively tackle problems pertaining to environmental changes without elevating (securitizing) the issue or redefining the concept of security

[13] The whole definition can be found in their study titled *Perspektivy vývoje bezpečnostní situace, vojenství a obranných systémů do roku 2015 s výhledem do roku 2025*. (Ústav Strategických Studií Vojenské Akademie v Brně 2001, 23)

[14] (Barnett 2001, 108-109)

[15] (Trombetta 2008)

[16] Ibid.

[17] (Buzan, Waever and De Wilde, Security: A New Framework for Analysis 1997)

[18] An expert on this topic is Thomas Homer Dixon and his team from the University of Toronto (Dabelko, Lonergan and Matthew) who did extensive research on environmental scarcity and global security.

itself.[19,20,21,22] What these authors find problematic with the traditional concept of security is that it is too narrow and only concerned with the absence of conflict. According to Rita Floyd it should be broader and include the absence of other harmful things and issues. In this regard, she also calls for more academic focus on environmental security as it does not receive enough attention.[23] Over the years this issue has been politicized to a great extent but its securitization has so far been limited to the local level where actual environmental disasters take place.[24] There is wide consensus that environmental changes can result in serious threats to national security. This notion was embraced back in 1994 when the United Nations Development Programme emphasized that environmental security should be part of a comprehensive approach to security.[25] Nevertheless, the academic field stands divided on whether the traditional concept of security should be redefined to include environmental issues or not.

Environmental security has been getting increasingly closer to its securitization in recent years due to several environmental disasters which spurred large political and public debate about the extent to which humans are responsible for environmental disasters and how we can adapt to it.[26] This did not securitize the concept itself but it did elevate the concept of climate security which is closely linked to environmental security. According to Brauch Gunter Hans, it was the United Nations World Commission on Environment and Development (WCED) with its report titled *Our Common Future (*also known as the Brundtland Report) published in 1987 that marked the entry of environmental security into the security agenda.[27] It is important to note that public perceptions of the potential damage from environmental stress form a critical aspect of environmental security.[28] Another strong securitizing actor of climate security was the International Panel on Climate Change (IPCC) which was established in 1988 and made its biggest impact on climate security in 2007 with the release of its *Fourth*

[19] (Floyd, Matthew and eds. 2013)
[20] (Dalby, Environmental Security: Ecology or International Relations 2002)
[21] (Dyer 2001)
[22] (Trombetta 2008)
[23] (Floyd, Matthew and eds. 2013, 27)
[24] (Buzan, Waever and De Wilde, Security: A New Framework for Analysis 1997, 91)
[25] It further underlined that it should move away from the narrow military and defensive meaning to an all-encompassing and integrative concept that focuses more on human security. (Elliot 2004, 221)
[26] Just to name a few: the hurricane Cathrina in 2005, a series of earthquakes around the world with catastrophic impacts especially in Japan in 2011or more recently a storm that hit the Philippines in the middle of UNFCCC's COP meeting in Warsaw in November of 2013.
[27] (Brauch 2008, 29)
[28] (McNelis and Schweitzer 2001)

Assessment Report.[29] It may appear as if there was a relatively long period of silence and inactivity on the side of the environmental movement between the late 1990s and 2007. Trombetta argues that the environment was marginalized in these years due to the war on terror which made other threats appear more urgent and serious than the environmental ones.[30]

The war on terror brings us to the next contentious point that experts underscore when assessing environmental security, which is its militarization. The process of securitization of this concept has led to looking at it in the traditional way which is by means of taking measures using the military apparatus. Many environmentalists have criticized this approach as highly inadequate and ineffective and called for the demilitarization of environmental problems.[31,32,33] It has been highlighted that military responses to non-military threats are not effective and that demilitarizing environmental issues can actually lead to higher security for the environment. It is the different nature of the threats at hand that makes it ineffective to employ military measures. This argument can be supported by looking at various countries in Africa that suffer from food insecurity and lack of potable water. These areas are often highly militarized and volatile because local communities and armed groups try to protect their remaining food and water supplies by means of violence instead of taking a more collaborative non-military approach to solving this common problem.

One of the defining distinctions between a traditional threat and an environmental threat is that it is difficult to identify an enemy in the case of the latter.[34] Therefore, non-traditional approaches to security must be taken in order to attain environmental security.[35] Simon Dalby builds on this argument by saying that "this being the case there is no good reason to assume that conventional international relations thinking will provide the necessary intellectual toolkit for addressing these new formulations of security. Neither, and this is the most important point, is there any good reason to think that ecological matters can be usefully understood in terms of security from some external threat at all."[36] To offer an alternative to

[29] Ibid.
[30] (Trombetta 2008)
[31] (Dyer 2001)
[32] (Dalby, Environmental Security: Ecology or International Relations 2002)
[33] (Elliot 2004)
[34] (Trombetta 2008)
[35] (Elliot 2004)
[36] (Dalby, Environmental Security: Ecology or International Relations 2002, 3)

the military responses of the traditional approach to security, other measures have been suggested as more effective. Those include preventive measures, risk management, resilience and adaptability which threaten the logic of securitization theory itself.[37] Another stream of criticism comes from inside the field of security studies and targets the concept of environmental security itself. Monica Tennberg states that "critics of the concept claim that environmental problems are so different in nature from the threats to traditional security that it would be a 'risky business' in itself to start using the concept of environmental security."[38] Another point that has been criticized is the very broad meaning of the term itself that can include a wide range of topics. Nina Graeger compares it to the term sustainable development which is also often used to lobby for a great variety of goals.[39] Michael Thompson claims that environmental security is all about solidarity and that it is solely concerned with the security of northern countries, their access to resources and the protection of their pattern of consumption.[40] A fundamental wave of criticism also comes from the traditional school of security studies which argues that the concept of security shall remain unchanged and thus should not include the concept of environmental security for it would undermine the original meaning and understanding of security with the state as its referent object.

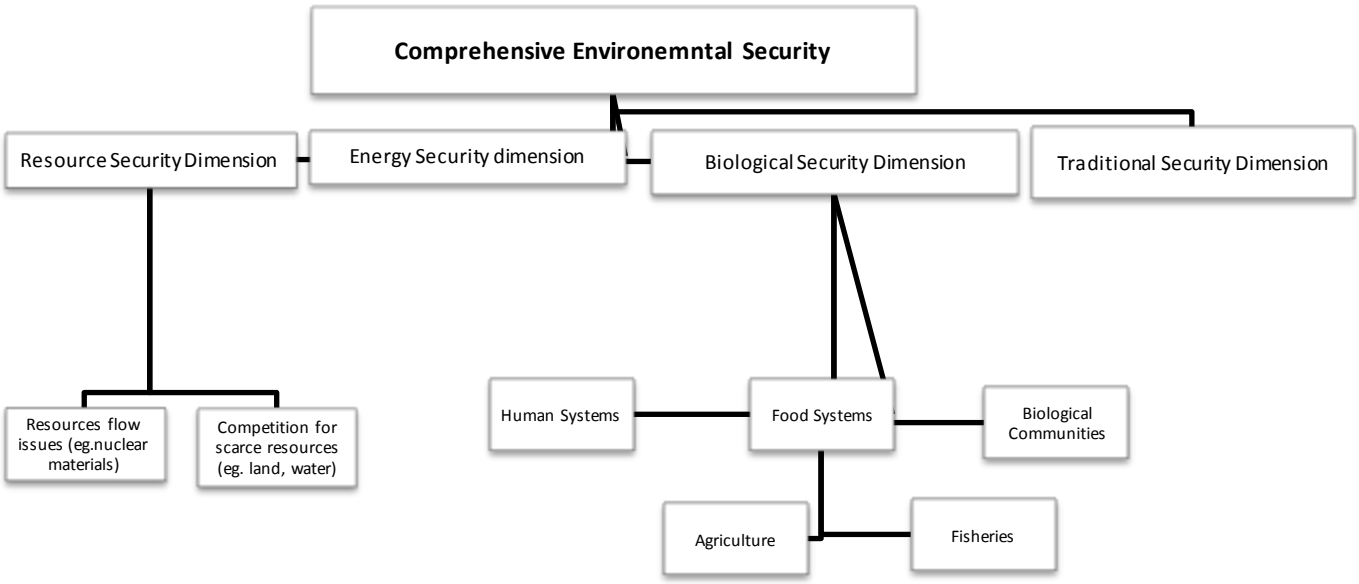
Another analysis of this debate was offered by Braden R. Allenby who suggests that global environmental stability is the broadest form of security which embodies all the other forms such as human security, foreign policy or national security. In other words, national security is a subset of global environmental stability and thus should be subordinate to it.[41] He goes on defining a comprehensive environmental security by saying it should consist of a resource security dimension, an energy security dimension, a biological security dimension and the traditional security dimension.[42]

Allenby does not stand alone in trying to define environmental security as an overarching concept. The Copenhagen School offers a similar analysis in their seminal book *Security: A New Framework for Analysis* where they outline a list of security concerns such as

[37] (Floyd, Matthew and eds. 2013)
[38] (Tennberg 1995, 242)
[39] (Graeger 1996, 113)
[40] (Thompson 1998)
[41] (Allenby 2000)
[42] (Allenby 2000, 15)

ecosystem instability, energy problems, population problems, food insecurity, economic problems and civilian conflicts.[43,44] The Copenhagen School also emphasizes that a crucial factor for environmental security is whether states, major economic actors and local communities embrace the scientific agenda because even though the concern is global, its political relevance is decided at the local level.[45] This brings the debate to the conclusion that environmental security has been successfully tackled only at the local level for a regional approach has proved more effective. This argument is further developed by Arthur. H. Westing who in his article *Environmental Approaches to Regional Security* offers compelling arguments as to why environmental regional security is the most effective way to tackle environmental problems.[46]

Figure 1. Dimensions of Environmental Security by Allenby.



(Allenby 2000)

[43] (Buzan, Waever and De Wilde, Security: A New Framework for Analysis 1997, 71-95)
[44] Also in (Fojtíková 2008, 2)
[45] (Buzan, Waever and De Wilde, Security: A New Framework for Analysis 1997, 91)
[46] (Westing 1986, 11)

According to an article by Petr Martinovský from the Masaryk University in Brno, apart from the traditional school of thought there are two other groups which he calls deepeners and wideners of the concept of environmental security.[47] He illustrates that the concept is being widened (from the military character to the political, economic, environmental and social) and deepened (from the referent object of a state to the human kind, an individual and the environment) thanks to the work of scholars like Allenby, Barnett, Floyd and others.[48] It is therefore obvious that environmental security itself has not been conceptually embedded in the traditional security studies field and still takes form of an on-going debate rather than a firmly established concept.

1.2. Methodological Framework

Before elaborating on the methodology of this thesis it is important to list and define some of the key terms used in this work in order to provide the reader with a rigorous conceptual background. First of one of these terms is 'sustainable development' which was defined back in 1987 in the Brundtland Report as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* [49] In the broad sense of the concept it stands upon three defining pillars which are social progress, economic growth and environmental protection. This work will be mainly concerned with the pillar of environmental protection (environmental sustainability) which is based on protecting the environment from pollution, degradation of ecosystems, unsustainable exploitation of natural resource, production of waste and climate change. This concept will therefore be used to evaluate the level of sustainability of energy procurement from the energy resources outlined in the Strategic Energy Concept of 2013.

Another concept that deserves clarification is energy security which has been defined in countless ways but the broad definition which most agree upon is the one provided by the European Commission which states that "energy security refers to the uninterrupted physical availability of energy products on the market at an affordable price for all consumers." This definition shows that only very broad and relatively vague definitions of energy security can

[47] (Martinovský 2011)
[48] Ibid.
[49] (Bruntland Commission 1987)

be recognized by many.[50] However, such a definition does not account for the environmental side of energy procurement which has gained importance in recent decades. It is therefore appropriate to explore a more complex definition of energy security, one which involves the environmental factor of energy procurement. Such a definition would rely on four basic elements which are availability, reliability, affordability and sustainability.[51] The main focus of sustainability in this matter is the effort to minimize greenhouse gas emissions, limit contribution to local, regional, and global forms of environmental pollution, and to protect energy systems from climate change.[52] Sustainability is also one of the structural pillars outlined in the governmental document but only comments on the environmental character of it in one short sentence.[53]

It is therefore essential this thesis scrutinizes this pillar and elaborates on the matter thoroughly. In regards to environmental security this definition serves as a more comprehensive definition of energy security and was elaborated on by Benjamin K. Sovacool in the book titled *The Routledge Handbook of Energy Security*.[54] It is interesting to see how varied the definitions are across the spectrum of different entities and organizations. One can also observe progress over time where for example the International Energy Agency went from a very short and broad definition to a more progressive and comprehensive one stating that: "Energy security means adequate, affordable, and reliable access to energy fuels and services, it includes availability of resources, decreasing dependence on imports, decreasing pressure on the environment, competition and market efficiency, reliance on indigenous resources that are environmentally clean, and energy services that are affordable and equitably shared."[55]

This thesis will also work with the term 'energy self-sufficiency' which in this case represents the level of self-sufficiency in generating energy without support or help from others. Absolute energy self-sufficiency would mean that the total bulk of energy produced in a country comes from domestic resources which can sustain the basic functioning of the

[50] For a comprehensive list of definitions of energy security see (Sovacool and ed. 2010)
[51] (Sovacool and ed. 2010, 10)
[52] (Sovacool and ed. 2010, 10)
[53] (Ministry of Industry and Trade 2013, 25)
[54] (Sovacool and ed. 2010)
[55] (Sovacool and ed. 2010, 4)

country and its society. It is virtually impossible to reach absolute energy self-sufficiency given the conditions of a country like the Czech Republic and for that reason this paper will work with this concept in terms of either the strengthening or weakening of self-sufficiency. A very important aspect of a country's energy strategy is the level of economic competitiveness which holds great significance in the European Union. The OECD defines economic competitiveness as "a measure of a country's advantage or disadvantage in selling its products in international markets." It is imperative to include this factor when analyzing the energy mix of the Czech Republic for effective generation and supply of energy to the industrial sector puts it in a competitive position in the international market.

In terms of methodology the thesis will take the form of a single-case study applying both quantitative and qualitative methods for the various determinants of environmental security. These determinants are carefully selected to reflect the relationship between the concept's main indicators and the newly proposed energy mix as outlined in NSEC. Environmental security has many important indicators but it is also a very overarching concept with factors that are not all relevant to the composition of energy sources in a given country. For that reason this thesis will work with four selected determinants that closely pertain to the energy mix of the Czech Republic and reflect the main concerns about energy procurement in the country. These four determinants are the following: emissions [CO_2, fine particles, sulfur oxides (SOx) and nitrogen oxides (NOx)], land resource use (landscape fragmentation and transformation, area needed/energy generated), sustainability (reserves to production ratio, import dependency vs. domestic self-sufficiency), and economic factors (total cost of the resources including externalities).

These four main determinants will be tested on the newly proposed energy mix and consequently receive an evaluation as to how much impact they have on the level of environmental security in the country. For the purposes of this assessment, this evaluation method will be called the environmental security index with values ranging from 1 (positive) to 5 (negative). The median value 3 will be considered as neutral hence making the total neutral value of an energy source 12.[56] If an energy source receives a value below the neutral value and its share increases in relation to the reference year 2040 it will be evaluated as

[56] Each energy source will be evaluated upon 4 determinants thus 4 multiplied by the neutral value of 3.

having a positive impact on environmental security. Similarly, if the value is above the neutral value with a projected increase for the reference year it will be considered as having a negative impact. In addition to this evaluation there will be a separate chapter to comment on and consider the significance of other relevant factors that will help assess the overall environmental impact of each energy source. These factors will include: energy return on energy invested (EROEI), energy efficiency, energy security factors or the findings of the strategic environmental assessment report on NSEC.

All four determinants of environmental security used in this thesis will bear the same factor of significance in relation to the total value of the environmental security index. This is because they all represent a pivotal strategic factor in assessing the viability of an energy source. The importance of emissions as one of the determinants have been repeatedly underlined in previous state energy concepts and the relevance of fine particles, sulfur and nitrogen oxides was only enhanced during heavy localized pollution periods in the industrial parts of the country. The sustainability factor will elaborate on the reserves-to-production index which is the amount of proven reserves of an energy resource relative to its production rate expressed in years. This should shed some light on the actual availability of an energy resource in terms of future planning. Economic factors are also crucial for decision-making as some resources have been getting increasingly more expensive and others have proved to be extremely financially volatile. Analyzing each source's cost development, current pricing trends and future projections can prove very valuable in determining its impact on environmental security. Finally, land resource use will evaluate each source's energy yield performance per area. This is particularly helpful in smaller countries like the Czech Republic where large scale installations with small energy yield could take over large areas of arable soil which could be used for agriculture or other useful and valuable purposes.

Chapter four will also comment on the relevance of each selected determinant and other important factors in relation to this study in order to provide the reader with compelling arguments as to why these determinants are so decisive for the case of the Czech Republic. It will identify the criterions for evaluation and list the most important data sources of each of the determinants. It will then comment on the changes in each energy source's share in the energy mix and extrapolate their future value of the environmental security index.

When considering the life cycle of energy resources from procurement to utilization, having all economic and environmental aspects in mind, the selected determinants and additional factors this thesis will elaborate on should offer a very rigorous analysis of the actual impact of the newly proposed energy mix on environmental security. It is important to note that these determinants and indicators are very case specific and therefore might not be as effective in assessing the environmental impact in other countries.

2. State Energy Concept

This chapter will introduce and comment on the importance of the State Energy Concept (SEC) in relation to the Czech energy mix, environmental security and its overall impact on the formation of energy policy in the Czech Republic. First and foremost, it is important to note that SEC is a vital strategic political document as stated by the Ministry of Industry and Trade (MIT). It should outline a vision of the future functions of the Czech energy sector in regards to several of its essential factors such as electricity and heat generation, distribution, the composition of the energy mix, environmental impact, economic viability and many more important aspects.[57] The actual management of natural resources and their use is further analyzed in another strategic document titled *Natural Resource Concept of the Czech Republic*.[58]

MIT also draws on several other strategic documents such as the *Strategic Framework for Sustainable Development, National Action Plan for Renewable Sources of Energy, Export Strategy of the Czech Republic, Strategy of International Competitiveness or the Security Strategy of the Czech Republic*.[59] All these documents are intertwined to a certain extent and should be updated on a regular basis (usually every five years). The timeframe of updating SEC is rather inconsistent with the last one being released in 2010 to bring the 2004 version up to date.[60] The idea was to release an update of SEC every five years which has nevertheless

[57] SEC also deals with waste management, transportation, research and development or with different scenarios of future development in both the Czech and European energy sector. For more see: (Ministry of Industry and Trade 2013)
[58] Currently under revision. Latest version: (Ministry of Industry and Trade 2012)
[59] For the full list of strategic documents concerning SEC see (Ministry of Industry and Trade 2013, 8)
[60] The 2010 version was never officially ratified which makes the 2004 version still the most recent valid document.

proved unfeasible in the last ten years due to unstable political situation and disagreements over the goals and specifics of the document. The first problem might now seem obvious given the vibrant character of the energy sector with frequent technological advancements taking place all the time.

On one hand the state aspires to have stable and predictable development in the energy sector for decades to come but on the other hand it should also endeavour to be flexible and adaptable to new technologies and trends on the energy market. This is what makes the goals of SEC so problematic and somewhat contradictory. Therefore, the true purpose of this document should rather be to set goals and limits in the energy sector and leave the means of achieving these goals to the market and new emerging trends and technologies. This is because it is virtually impossible to predict the direction and circumstances of such a dynamic sector for decades to come.

2.1. State Energy Concept of 2004

This document was officially approved and published in March of 2004 which came two months before the accession of the Czech Republic into the European Union. Its strategic importance at the time of its release was undeniable as the Czech Republic was in need of a comprehensive strategy for its energy sector when joining the EU. The goals stated in this concept included the maximization of import independency and independence from energy sources coming from politically volatile areas.[61] It also mentions the importance of utilizing energy efficiency and developing the domestic potential of renewable sources of energy which at the time was still relatively undeveloped technological and economic sector.[62] It also emphasized the importance of coal (brown coal) for the Czech energy sector was as the leading fossil fuel for electricity and heat generation.[63] The strategic importance of this document in relation to the Czech accession to the EU was clear as throughout the document there are multiple references to the fundamental characteristics of the EU market such as the liberalization of the electricity markets, the need for unbundling, more integrated energy

[61] (Ministry of Industry and Trade 2004, 3)
[62] Ibid.
[63] Ibid. p.5

markets, stronger customer's rights.[64] This document is still valid today as no updated version of SEC has been ratified up to date.[65]

2.2. State Energy Concept of 2010

This document has never been officially approved and will most likely only serve as a bridging draft for the new document expected to be ratified in 2014. This could be argued with a high degree of certainty because the new strategic energy concept (originally from 2012) is now being considered as the official document to replace the 2004 version. All in all, the overarching strategic goals did not really change with the introduction of this document. The only apparent changes were the means of accomplishing these goals. The document puts emphasis on coordinated approach and underlines the importance of environmental issues in relation to the structure of the energy mix. It is therefore on par with the development of the EU energy strategy and climate policy which has been evolving into a strongly climate protection oriented policy over the past years.

2.3. Continuing Efforts to Draft a New Energy Strategy

The so called New Strategic Energy Concept (in this thesis referred to as NSEC) has been under scrutiny for the last couple of years and its final version has proved very difficult to agree upon. There are several reasons why consensus has not been reached in regards to the ratification of NSEC. First of all, the energy sector in the European Union has been very vibrant in the last decade which has brought numerous important legislative and practical changes for the energy sector in the Czech Republic. Moreover, vexed topics such as the breaching of the territorial ecological limits on mining or the construction of two additional nuclear reactors in the Temelín nuclear power plant have made the government rather reluctant to make the final vote on this matter.[66] In addition to that, the whole process of

[64] Ibid. p. 17,18,22,23.
[65] As of the time of writing this thesis.
[66] Territorial ecological limits on mining are geological boundaries beyond which further mining is prohibited by law. This was agreed in 1991 and it is expected that such limits will be reached in some areas as soon as 2018. Source: (Sivek Martin 2012, 653) For more see: http://www.greenpeace.org/czech/cz/Kampan/klima_a_energetika/zit-nebo-tezit/Limity-tezby/ , (accessed March 23, 2014)

ratification of such a vital document is rather lengthy for it must go through numerous revisions, public hearings, environmental assessment impact and other processes.

Another crucial factor that is to be considered by the MIT whilst drafting this document is the synchronization with the current European energy and climate policy. Because the Czech Republic is a member of the EU it has to adhere to the greater European strategy and make its future trajectory go alongside the European one. This might be yet another reason for constant delays in introducing the final version of the new SEC because the new 2030 climate and energy policy package is still to be ratified sometime this year.[67] Even though the main pillars of the European energy strategy (security of supply, competitiveness and sustainability) correspond with the Czech ones, the specific numbers of CO_2 emissions reduction and the share of renewable sources of energy in total EU's energy consumption remain a contentious topic.[68]

In summary, the new Strategic Energy Concept is proving to be an extremely complicated piece of policy document for its interconnectedness with numerous other strategic documents both in the domestic and European level. It almost seems that there is not going to be an appropriate time to ratify this document as there will always be a part of it in need of updating. It should therefore be a matter of prioritizing certain aspects over others and subordinating the document's goals to the European energy policy which sets the course for the entire union.

2.4. The Need for a New Energy Strategy

Even though SEC presents itself as a seminal strategic document when it comes to energy policy of the country, it may not be as essential for deciding the direction of the Czech energy sector for decades to come as one may believe. Although the still valid version of SEC from 2004 is a strategic document for the government and policy makers, it does not hold such strategic importance in the eyes of investors and energy companies that operate with large

[67] The 2030 climate framework package is expected to come in effect before October 2014 in order for the EU to show commitment before the UNFCCC COP 21 in Paris, 2015. For more on the package see: http://ec.europa.eu/clima/policies/2030/index_en.htm (accessed March 24, 2014).

[68] According to the latest negotiations, the EU Commission is trying to push for a 40 % reduction of CO_2 emissions (using 1990 as the reference year) and an increase of the share of renewables to 27 % by 2030.

amounts of capital on the energy market. Investors are mostly concerned with stock value and actual market development whereas SEC only offers different scenarios for development and a list of predictions. Most predictions in the energy sector usually prove to be wrong which tends to be one of the major critiques of SEC in the first place. Moreover, the last decade of investments in the energy sector has not been shaped by the actions of the Czech Republic but rather by the actions of stronger actors in Europe and overseas. The most prominent example of this is Germany that decided to phase out all of its nuclear power plants by the year 2022 in consequence to the Fukushima nuclear disaster of 2010.[69] This political move together with the launch of the so-called Energiewende have essentially distorted the energy market in Europe since a great number of countries in this region trade on the same energy spot market (EEX).[70]

Czech Republic finds itself in both a precarious and an opportunistic situation. The price of electricity is at its all-time low which does not incentivize any investment in the energy sector. This was predominantly caused by the rapid increase of renewable energy sources in Germany and consequently created an environment where traditional fossil fuels have become uneconomic to burn. It is vital to understand that the Czech Republic has limited options as to how to deal with this recent turn of events for its interconnection (both physical and economic) with the German energy sector. On the other hand this opportunity could create a very advantageous position for the Czech Republic as it is almost certain that Germany's Energiewende will go on which makes it a relatively stable scenario for the Czech policy makers at times when other countries find themselves in unfavourable and unpredictable situations. In other words, the Czech Republic may want to consider looking at the energy predicament through the European perspective rather than the domestic one given the dynamics and functioning of the European market and its influence on the country.

[69] The timetable for the nuclear power plants shutdown indicates that the first reactor will close in 2015 followed by one reactor shutdown in 2017 and 2019 with the final stage to come in 2021 and 2022 with 3 reactor shutdowns each year. Source: Robert Wilson, "Germany's Nuclear Energy Phaseout: The Timetable," (The Energy Collective, 2013), http://theenergycollective.com/robertwilson190/218636/germany-s-nuclear-phaseout-timetable (accessed April 29, 2014).

[70] Energiewende is German for energy transition which a plan proposed by the German government to transition to a more sustainable energy system by means of renewable energy, sustainability and energy efficiency with the coal of ultimately phasing out all fossil fuel energy sources. EEX stands for European Energy Exchange, an energy spot market located in Leipzig, Germany.

The fact that the Czech Republic has not updated its energy strategy for many years might now suggest that this document does not have such pivotal role in determining the course of the energy sector. Nevertheless, it has been argued that both domestic and foreign investors might perceive the absence of a new energy concept as a sign of an unstable business environment with no guarantees of economic returns resulting in their reluctance to invest in the domestic energy sector.

If NSEC is not capable of acting as a guideline document for investors on account of its inability to reflect current energy trends and price mechanisms, it should lay out the most important strategic goals of the energy sector as well as crisis management mechanisms. It should be concerned with the management of crisis scenarios such as sudden mine closures, power grid instability or energy storage and strategic energy reserves. It would be recommendable if it also put more emphasis on dealing with the environmental security of the country along with considering all of its critical factors.

3. The Energy Mix of the Czech Republic

This chapter will briefly comment on the Czech energy mix and its role in creating a stable and secure supply of energy for the country. It is crucial to accentuate that the energy mix of any country should first and foremost reflect available technological options, geographic location and the current state of its energy sector. One must acknowledge that these conditions vary significantly throughout the world thus making the composition of any country's energy mix a very case-specific matter.

Before discussing the specifics of the Czech energy mix, one must distinguish between total primary energy and electricity generation. The energy mix composes of more than just electricity generation as it encompasses all the primary energy used within a country's territory. In other words, total primary energy is the total amount of energy produces within a country's territory minus energy exports. Nevertheless, electricity generation forms a big part of the primary energy use because most of the energy sources the Czech Republic uses are

utilized for electricity generation.[71] Moreover, electricity consumption in Western countries has followed an increasing trend in recent years, mostly due to the abandonment of traditional fossil fuel sources and the transition to renewable energy sources (RES) for electricity generation.[72]

To better illustrate the magnitude of the Czech energy mix using numbers, the total primary energy used in the Czech Republic in 2012 was 1028 Petajoules (PJ) where liquid fuels (mainly oil) contributed about 285 PJ.[73] Therefore, when considering the composition of the energy mix, the main factors become electricity generation, heat generation and the use of oil (mainly for transportation). The significance of securing stable electricity generation is also obvious when one looks at the preparations of the new SEC where electricity generation receives a lot of attention. This is mainly because the Czech Republic is a leading exporter of electricity in Central Europe and most of the electrical capacity obtained from fossil fuels (mainly coal) that is expected to be lost will and can only be substituted by increased electricity generation output from other sources.

In order to properly analyze the environmental impact of the newly proposed composition of the Czech energy mix in the new Strategic Concept, it is important to put things into perspective in terms of the country's historical development and its actual possibilities in utilizing domestic natural resources. Geological characteristics are not particularly favourable when it comes to oil and natural gas as these commodities are very rare in this geographic region and the Czech Republic only produces about 3-5 % of its total oil consumption domestically.[74] The role of coal has been indispensable both in the electricity and heat generation sectors for its domestic abundance and relatively easily accessible reserves.[75] Hydroelectricity is the predominant source of electricity obtained from RES but has practically already reached its full potential. Micro-hydro projects are still on rise and very popular in the

[71] The single biggest exception to this is oil which is not used for electricity generation but yet makes up for more than one quarter of total energy consumption.

[72] Traditional fossil fuels like coal are used both to produce electricity and heat but renewable sources of energy like wind or solar (with the exception of biomass and geothermal energy) are only used to produce electricity.

[73] Czech Statistical Office data taken from: http://issar.cenia.cz/issar/page.php?id=1557 (accessed on 9 April, 2014)

[74] The only area where oil extraction takes place in the Czech Republic is in Southern Moravia and the surroundings of the city Ostrava. Source: (Kavina Pavel 2009).

[75] Coal currently represents more than half of the country's electricity supply and almost half of the heat supply.

country but are not expected to significantly enhance the country's hydro potential. The utilization of other RES in not particularly favourable as the Czech Republic does not receive as much sun and wind as for instance Spain or Germany.[76]

Historically, the use of coal has formed the backbone for both electricity and heat generation until the first nuclear power plant Dukovany came online in 1985. Since then the role of coal in electricity generation has been slowly diminishing due to a considerable increase in nuclear capacity with the construction of another nuclear power plant Temelín in 2002 and more recently with the introduction of RES (mainly photovoltaics and biomass) into the Czech electrical power grid. Therefore, when analysing the Czech energy mix in regards to the SEC, the main focus is usually on the sources which contribute to electricity generation (coal, nuclear and RES). Oil and natural gas are both finite commodities which must be imported into the country making their procurement and management dependant on their current price rendering them less desirable in terms of future strategic planning. In other words, the predominant focus of NSEC is utilizing the previously mentioned energy sources which can be obtained domestically and to be less dependent on volatile sources that are not at the country's disposal.[77]

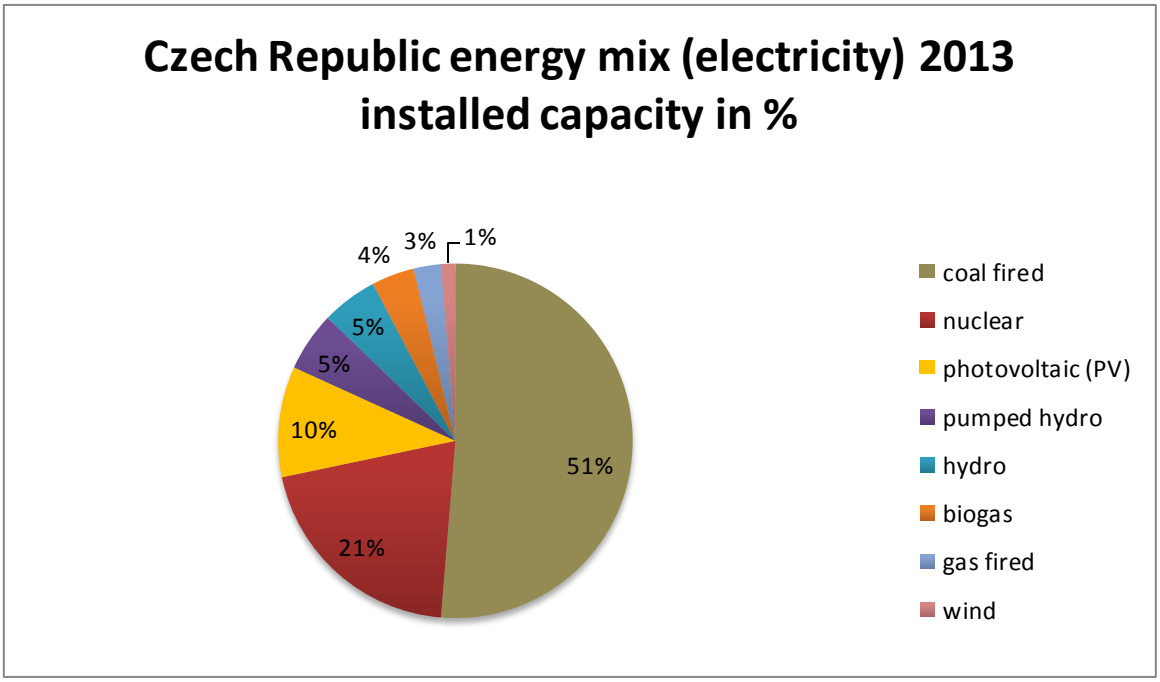
NSEC states that it aspires to create a balanced energy mix based on effective utilization of all domestic energy resources in order to secure a safe supply of electricity with a reserve capacity of 10-15 %. It also emphasizes energy efficiency as a contributing factor to the strengthening of energy security and the maximization of energy conservation in businesses and households.[78]

[76] Several reports have been published on the viability of RES in the Czech Republic. For more see: (Ministry of Industry and Trade 2010) (Skupina ČEZ 2007) (Greenpeace Czech Republic 2012)

[77] It is important to note that the Czech Republic also imports uranium from Russia but its procurement is far easier and more diversifiable than with other fossil fuels. Moreover, there is one active nuclear mine in the country and another is being considered for opening in the next couple of years.

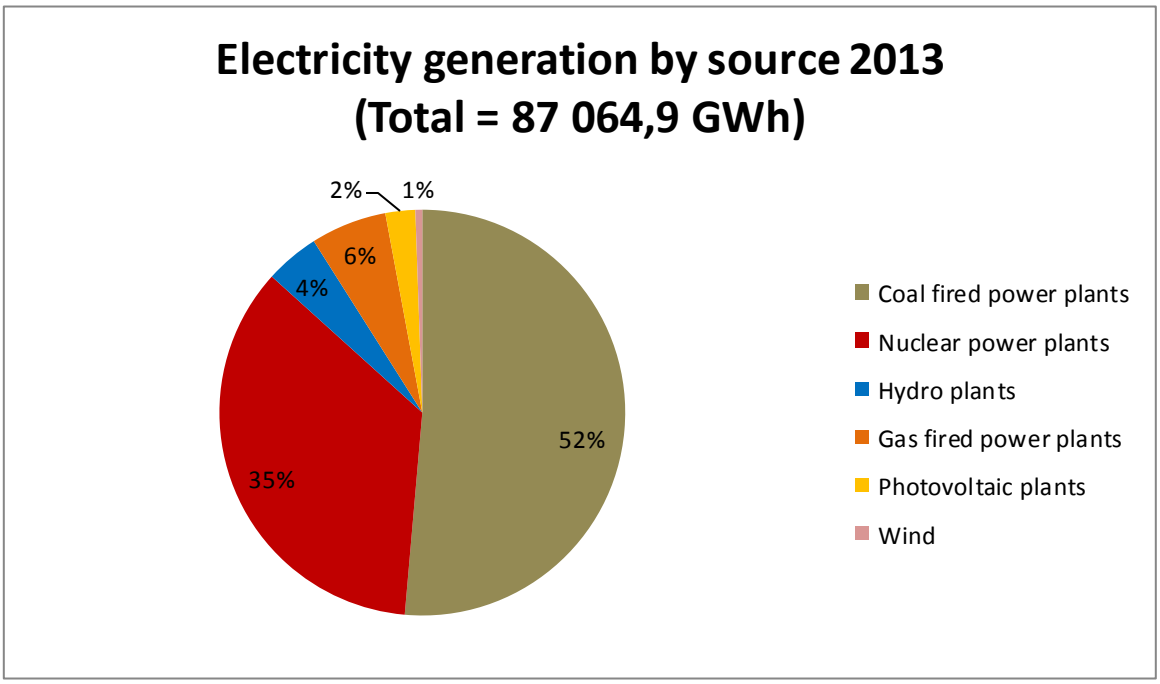
[78] (Ministry of Industry and Trade 2013, 26)

Table 1:



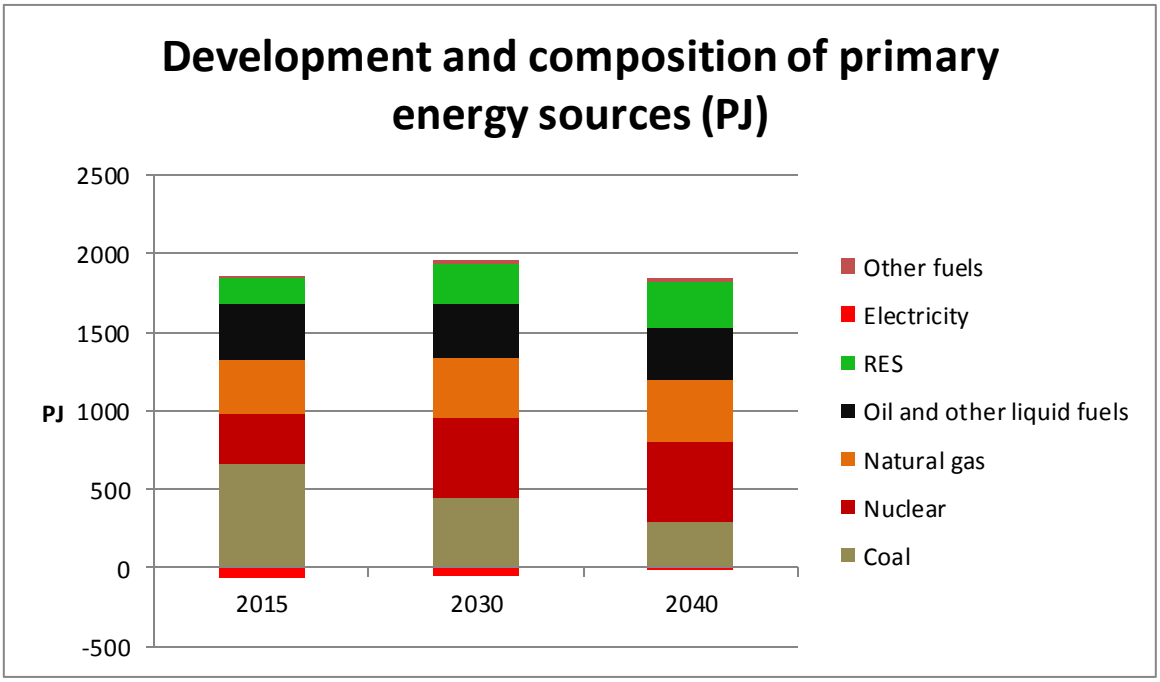
(Energy Regulatory Office 2013)

Table 2:



(Energy Regulatory Office 2013)

Table 3:



(New State Energy Concept 2013)

When it comes to the specific roles of the independent energy resources currently utilized in the Czech Republic, NSEC introduces significant changes all over the currently used energy portfolio. The role of brown coal which is currently burnt for both electricity and heat generation is projected to dwindle due to its ever diminishing reserves and negative environmental impact. The plan is to largely reduce the share of coal in electricity generation from the current 44 TWh to about 15-20 TWh by the year 2030.[79] According to NSEC its use shall shift to mainly heat generation or co-generation with high efficiency.

The single biggest resource utilization increase can be observed with nuclear energy which is supposed to replace the lost electrical generating capacity of coal. Nevertheless, this premise is based on a future successful construction of two additional nuclear reactors in the nuclear power plant Temelín which remains highly uncertain due to a very volatile energy market development in Europe in the last couple of years and the sub-sequential reluctance of

[79] (Ministry of Industry and Trade 2013, 28)

the Czech state to back this project financially through a so-called contract for difference.[80] The role of RES is set to increase but with no specific target other than their share in electricity generation is to surpass 15 %.[81] The consumption of liquid fuels is predicted to decrease mainly due to increases in efficiency, a transformation to cleaner liquefied natural gas (LNG) and compressed natural gas (CNG), and a partial electrification of transportation in the country. On the other hand, natural gas consumption is set to increase for its versatility and lower environmental impact as it is the cleanest of all fossil fuels to burn. This is projected to be coupled with increases in energy efficiency and more effective waste management including the construction of several waste incinerators to utilize up to 80 % of all waste after recycling.[82]

In summary, the future energy mix according to the New State Energy Concept is projected to consist of the following energy sources within their assigned ranges:

Total energy sources:

- Coal 11 – 17 %
- Nuclear 28 – 33 %
- Oil 14 – 17 %
- Natural gas 20 – 25 %
- RES 17 – 22 %

Electricity generation:

- Coal 11 – 21 %
- Nuclear 49 – 58 %
- RES 18 – 25 %
- Natural gas 6 – 15 %[83]

[80] Contract for difference is a form of business agreement in which one party (in this case the Czech state) commits itself to guarantee a financial payback on an investment (in this case two additional nuclear reactors) through subsidizing a certain part of the investment over a given period (in this case subsidizing electricity for many years to come).

[81] Ibid.

[82] Ibid.

[83] (Ministry of Industry and Trade 2013, 71)

The New State Energy Concept outlines a percentage range for all the energy sources which is understandable for it is almost impossible to predict the exact share of each energy source thirty years into the future. Nevertheless, in the next chapter the thesis will elaborate on the numbers behind these percentage ranges and set a median number in order to quantify the changes to be made in the future in regards to environmental security.

4. Assessing the Environmental Security of the Czech Republic Using the New State Energy Concept

This chapter will draw on the methodology discussed in chapter one and assess the impact of the newly proposed energy mix on the environmental security in the Czech Republic. It will carefully analyze all the components of the energy mix in relation to the determinants selected in the methodological part of the thesis. Each subchapter will thus open up with a general overview of the individual energy sources in regards to emissions, sustainability, economic factors and land resource use. It will then comment on the current situation of the individual energy sources in the Czech energy mix and assign each of them a value of environmental security. This value will be based on their actual performance in relation to the selected determinants and will be called the index of environmental security. The index will range from the value 1 to 5 with 1 having the lowest impact on environmental security (positive) and 5 having the largest impact (negative). The higher the total value of environmental (in)-security of an energy source the higher negative impact on the environment it has based on the determinants of this study.

This section will then proceed on to analyze the changes in each source's share in the energy mix and multiply the change factor by the given value of the index of environmental security. This will ultimately reveal whether the actual level of environmental security in the Czech Republic will increase or decrease with the adoption and implementation of the New Strategic Energy Concept (NSEC).

Emissions will be evaluated on the basis of openly accessible databases from International Energy Agency (IEA), Intergovernmental Panel on Climate Change (IPCC), The U.S. Energy Information Administration (EIA) and other reliable sources. In addition to

carbon dioxide values, emissions of fine particle, nitrogen oxides and sulfur oxides will also be considered and included in the evaluation. Sustainability will be evaluated upon the reserve-to-production index for resources obtained domestically whereas imported resources will be assessed on the basis of their overall situation in terms of reserves, accessibility and import diversification.[84] Economic factors will examine the total cost of all energy sources for the Czech Republic including externalities and try to determine the future financial development of their procurement and production. At last the land resource use factor will quantify the performance of the resources based on land transformation and land occupation. After each section a short paragraph will be devoted to the total change of each energy resource's share according to NSEC together with presenting a new value of the environmental security index for the reference year 2040.

To conclude, a table with values of all the individual energy sources will be provided in order to offer a comprehensive overview of each source's performance. The individual values prescribed to each source will try to reflect the databases, reports and other supporting material gathered during the research. This is to ensure this research proves rigorous and well-founded. Nevertheless, some factors require much deeper elaboration and analysis of the Czech energy environment and cannot be solely based on international data and analyzes from other countries. In such cases, the author will apply his own knowledge and perspective on the matter based on all available data to support his arguments. The data and numbers used in the following sections are as up-to-date as possible at the time of writing the thesis but given the fact dynamics of the energy sector it is possible some figures might not be consistent with current data.

Figure 2. Environmental security index

[84] Data for world reserves will be obtained from BP World Statistical Outlook.

4.1. Coal

Coal has always been a major energy source not only for the Czech Republic but for most of the planet as the world coal consumption in 2012 reached about 5328 million tonnes of coal equivalent (Mtce).[85] The Czech Republic consumed about 23.7 million tonnes of coal which represents roughly 0.4 % of total world consumption.[86] There are currently six operational coal mines in the country which produce about 42 million tonnes of coal annually with brown coal representing the main bulk of this number.[87] Coal currently supplies about two-thirds of heat generation for Czech households and businesses together with about half of electricity supply in the country.[88]

4.1.1. Emissions

Coal is the most polluting of all fossil fuels which took a toll on many areas in the Czech Republic that had suffered from frequent acid rains and local pollution of fine particles before most of them underwent a retrofit in 1990s. According to several peer-reviewed international studies, coal releases by far the greatest amount of CO_2 per unit of energy generated than any other energy resource.[89] According to a study by the Intergovernmental Panel on Climate Change (IPCC), the median value of CO_2 equivalent (CO_2 eq.) per 1 kWh of electricity generated is about 1000 grams of CO_2 eq. which is the highest value of all currently used energy sources for electricity generation.[90] The U.S. Energy Information Administration (EIA) on the other hand measures the total amount of CO_2 emitted by utilizing 1 million Btu (British thermal unit) (unit per volume factor). Coal gets the median value of about 100

[85] Mtce is a unit representing energy generated by burning one metric ton (1000 kilograms) of coal, equivalent to the energy obtained from burning 5.2 barrels (700 kilograms) of oil or 890 cubic meters of natural gas that is, 29.39 gigajoules (GJ), 27.78 million Btu (MMBtu), or 8.14 megawatt hours (MWh).

[86] Data taken from the BP Statistical Review of World Energy June 2013 (33) and the International Energy Agency's World Energy Outlook of 2013.

[87] Data taken from www.energostat.cz (accessed April 19, 2014).

[88] Ibid.

[89] (International Energy Agency 2012, 41), (International Panel on Climate Change 2012, 19), "Carbon Dioxide Emissions Coefficients", (U.S. Energy Information Administration), http://www.eia.gov/environment/emissions/co2_vol_mass.cfm (accessed April 15, 2014).

[90] Note that these figures are not completely accurate as the efficiency of heat generation is almost always higher than electricity generation. The Czech Republic uses coal for both heat and electricity generation. (International Panel on Climate Change 2012, 19).

kilograms of CO_2 per 1 million Btu which again places it at the top of their emission chart.[91] According to IEA's 2010 data the Czech Republic emitted on average 994 grams of CO_2/kWh generated from coal which amounted to 73.4 million tonnes of CO_2 ($MtCO_2$) making it responsible for more than half of the country's total emissions that year.[92]

Even though the overall emissions have been slowly declining, the share of coal in the total number has not decreased significantly. Furthermore, the single largest polluting entity in the country is the coal-fired power plant Prunéřov II owned by ČEZ which emits about 7 $MtCO_2$ annually.[93] Other emissions from coal combustion include emissions of fine particles (PM_{10} and $PM_{2.5}$) and SO_2 emissions which have the most detrimental effect on human health.[94] However, the amount of fine particles and sulfur oxides (SOx) released from coal combustion is directly proportionate to the quality of coal being burnt and the technology used. For that reason technological progress has been able to considerably reduce fine particles and SOx emissions from coal combustion but has not yet reached the point of being able to capture and store CO_2 which is still experimental technology.

As far as emissions from coal combustion in the Czech Republic go, it is safe to say that those most detrimental to human health have been significantly reduced over the last decades and more improvements and retrofits are taking place as the EU legislation obliges all coal-fired power plants to use the best technology available (BTA). What remains problematic is the number of people using inefficient furnaces at their homes which creates areas of increased local pollution. This problem is currently being tackled by a number of governmental programs designed to provide subsidies for those who want to switch to more ecological furnaces.[95]

In terms of emissions, coal gets assigned the highest value 5 of the environmental security index mainly because it is still the largest polluting energy source and any technology

[91] "Carbon Dioxide Emissions Coefficients", (U.S. Energy Information Administration), http://www.eia.gov/environment/emissions/co2_vol_mass.cfm (accessed April 15, 2014).

[92] (International Energy Agency 2012, 111-122)

[93] (Arnika 2012)

[94] HEAL study report on the impacts of coal on human health, http://coalhealthstudy.org/ and "Uhlí za vše nemůže", (Zdeněk Lyčka, TZB-info), http://www.tzb-info.cz/4499-uhli-za-vse-nemuze (accessed April 16, 2014).

[95] The biggest governmental program launched by the Ministry of the Environment is titled *Zelená Úsporám* and its budget for 2014 is 2 billion CZK.

that could possibly mitigate its emissions of greenhouse gases is still largely experimental. Moreover, the health impacts coal combustion has incurred in the Czech Republic in the last couple of decades cannot be discounted and rather add to the negative value prescribed to it.

4.1.2. Sustainability

Coal holds a special position in the country as it is the most abundant domestic natural resource. The majority of operational mines are open pit mines located in the area of the Ore Mountains (mostly brown coal) with some deposits of bituminous coal found in the Eastern part of the country and also west of the capital city Prague. The total proven domestic reserves in January 2013 according to Energostat were 826.8 million tonnes of brown coal.[96] With the current production rate at about 43 Mt/year these reserves would last approximately 18 years.

Nevertheless, as domestic coal consumption is expected to decrease over the next decades (due to increased efficiency, substitution using other sources etc.) the reserves to production ratio can realistically go up to 26 years which would secure abundant coal supply within the country until around 2038.[97] Furthermore, there is still some capacity in bituminous coal reserves and more potential capacity if the territorial ecological mining limits were to be breached sometime in the future.[98] This puts coal in a relatively secure position in terms of supplying the country with relatively inexpensive energy. In addition, according to the *BP World Statistical Outlook* the reserves to production ratio for Europe and Euroasia in 2012 was more than 200 years which would give the Czech Republic multiple options in regards to potential coal imports.[99] Coal is therefore not expected to be depleted in the near future which puts this resource in a good position in relation to the environmental security index. The value assigned to its reserves to production sustainability is 2.5.

[96] Data taken from http://energostat.cz/uhli.html (accessed April 20, 2014).
[97] Ibid.
[98] There is approximately an additional reserve capacity of 850 Mt of coal beyond the current territorial ecological limits which would significantly prolong the reserves to production ratio. For more see: http://byznys.ihned.cz/c1-54858870-cesko-ma-zasoby-hnedeho-uhli-uz-jen-na-18-let-dalsi-tezba-za-limity-bude-obtizna (accessed April 18, 2014).
[99] (British Petroleum 2013, 31)

4.1.3. Economic Factors

Coal still proves to be one of the cheapest sources of generating heat and electricity which applies especially to the Czech Republic because of its relatively abundant domestic coal reserves. The price of bituminous coal is set on the European market whereas brown coal is only traded domestically which allows it to have its own market.[100] Internationally, the price of most traded coal is currently somewhere between 40-60 USD/tonne and is expected to go up in the next decade as demand from China and India for more coal rises which keeps putting pressure on its price.[101] However, this conclusion might be a bit premature as demand for coal in the OECD countries is on decline which might make more coal available on the international market.[102,103]

The total price of using coal for energy is actually much higher than spot prices make it out to be for the incapability of the market to include total externalities of this energy resource. The Environment Centre of the Charles University in Prague released a study in 2012 in which it calculated the total external cost of using coal in the Czech Republic. It turns out that the country had to pay about 70 billion CZK for coal externalities resulting from its use for electricity generation in 2011.[104] Coal has by far the highest external cost which gets passed on health care costs and environmental reparation costs.[105,106] In addition to these external costs there is a strong possibility of an additional carbon tax in the future or even more likely a

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[100] The price of brown coal is dependent on long-term contracts for power plants and has been going up in recent years. For more see: http://www.topsrovnani.cz/aktuality/ceny-tepla-z-teplaren-2014-podrazi-energie-z-hnedeho-uhli (accessed April 20, 2014).

[101] (International Energy Agency 2013, 139-167). The price of bituminous coal on the European Energy Exchange market is about double of the internationally traded coal price. Source: www.eex.com (accessed April 21, 2014).

[102] This can be currently observed in The United States where natural gas has been replacing coal which is now diverted to export.

[103] NSEC projects that both bituminous and brown coal prices will plateau around 2020 and remain the same for the rest of the reference time frame. (Ministry of Industry and Trade 2013, 62)

[104] (Centrum pro otázky životního prostředí UK 2012)

[105] Another study by Ščasný and Melichar titled *External Cost of Fossil And Non-fossil Energy Systems: The Case of the Czech Republic* shows that the external cost of coal generation adds about 2.8 €c/kWh to the cost of bituminous coal, 3.2-4.6 €c/kWh of brown coal and 5.8 €c/kWh for lignite. (Milan Ščasný 2007).

[106] Another study on the health impacts of emissions from coal fired power plants was done by Philipp Preiss, Joachim Roose and Prof. Rainer Freidrich from the Stutgart university titled *Estimating Health Risks caused by Emissions of Air Pollutants from Coal Fired Power Plants in Europe - Documentation of Methods and Results*, available here:
http://www.greenpeace.org/czech/Global/czech/P3/dokumenty/Klima/Estimating_Health_Risks_IER.pdf
(accessed April 20, 2014).

reform of the European Trading System (ETS) which would ultimately increase the price of using coal. In terms of its economic performance coal is still able to generate electricity with profit and has been pushing out more expensive sources such as natural gas. However, its external costs and future prices or CO_2 make coal a much more undesirable energy source. This is why coal gets assigned the value 3.5 on the scale of environmental security index.

4.1.4. Land Resource Use

The life cycle of coal used for energy generation takes up large quantities of land. The Czech Republic is no exception to this as most coal is extracted from open pit mines (surface mining). The total land area of extractable reserves of brown coal in the country is about 1900 km^2.[107] According to a study by Center of Life Cycle Analysis at the Columbia University in New York, coal has affected the pattern of land both directly and indirectly during the stages of mining and electricity generation.[108] The study further notes that: "Coal mining transforms the existing landscape, destroys the soil, and removes ground vegetation, all direct effects of land use. Furthermore, the usage of materials and the energy for operating coal mines and building infrastructures requires additional land during the upstream processes—indirect land use. Further, there are secondary land disturbances (not quantified in this study) that are due to pollutants and effluents from the coal-fuel cycle, such as water contamination, land acidification, and deterioration of forests. They are caused primarily by acid or alkaline drainage, dust, and soil erosion from coal mines, and by pollutant emissions from coal power plants."[109]

On the other hand the embodied energy of coal is relatively high depending on its quality. A study by Martin Nicholson suggests that coal uses about 5700 m^2/kWh/year with electrical energy density of 1000 kWh/m^3 (brown coal) to 2300 kWh/m^3 (bituminous coal).[110]

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[107] Surface mining disturbs much larger areas than underground mining. (Ministry of Industry and Trade 2012, 11).

[108] This study considers both direct (land transformation) and indirect (land occupation metrics) uses of land for electricity generation for various sources. "The land occupation metric involves the duration over which the area of the transformed land returns to its original state, typically measured as a product of land area (m2) and time (year)." (Vasilis Fthenakis 2009)

[109] (Vasilis Fthenakis 2009, 1466)

[110] "Nuclear has one of the smallest footprints", (Martin Nicholson, The Breakthrough, 2013), http://thebreakthrough.org/index.php/programs/energy-and-climate/nuclear-has-one-of-the-smallest-footprints (accessed April 22, 2014).

This shows the relationship between the energy density of coal per area occupied. Underground coal mining shows much better results for the surface land above the mines remains almost intact.[111] Various studies have been considered for the land resource use factor of coal and the area/electricity generated factor alone gives coal the value of 2 in terms of its environmental security index. However, the study by Center of Life Cycle Analysis emphasizes that coal mines have relatively high land occupation rates (the land occupation metric involves the duration over which the area of the transformed land returns to its original state) with greater risks for long-term pollution.[112]

4.1.5. The Change of Coal Share According to NSEC

The future trajectory of coal outlined in NSEC states that its role will be diminishing over time down to 146.2 PJ (brown coal) and 143.0 PJ (black coal) of total annual primary energy share which is a large reduction given the 2010 figures which amounted to 564.3 PJ of brown coal and 194.3 PJ black (bituminous) coal. These figures coincide with the year 2035 when most domestic coal mines will have been exploited. In terms of electricity generation output, both bituminous and brown coal are expected to ebb and reach 2893.4 GWh and 13 712.4 GWh respectively.[113] Using the emission data provided by the International Energy Agency this change would result in a significant reduction in CO_2 emissions as well as other emissions resulting from burning coal. All in all, coal is still a major strategic energy resource for the Czech Republic and its future role will remain pivotal until other resources are able to replace its capacity both for heat and electricity generation. Coal's share in the total primary energy is projected to go from 41 % in 2013 to 15.7 % in 2040 making for a 25.3 % decrease.[114]

4.2. Natural Gas

The undeniable importance of natural gas in today's world is demonstrated by its wide usage for generating electricity, heating homes and businesses, and for a variety of industrial

[111] (Vasilis Fthenakis 2009, 1471)
[112] (Vasilis Fthenakis 2009, 1472)
[113] This represents a major decrease especially with brown coal that generated 42936.1 GWh of electricity in 2010. (Ministry of Industry and Trade 2013, 46)
[114] Data for 2013 taken from the Ministry of Industry and Trade.

and agricultural purposes.[115] The world natural gas consumption amounts to about 3314 billion metric meters with the Czech Republic representing about 0.2 % of the total number consuming between 8-9 billion metric meters annually.[116] World reserves are still very abundant and currently expected to last until the end of 21st century.[117] However, recent worldwide discoveries of unconventional natural gas coupled with advancements in drilling technology could only strengthen the role of natural gas as a bridge fuel from fossil fuels to RES. The most sought after form of unconventional gas at the moment is shale gas with the biggest market in the United States. Other countries like China, the United Kingdom and Poland also hold vast reserves of shale gas and only time will reveal whether they will make use of it at the same scale as the United States. Domestically natural gas is used mostly for heating as it is by far the most popular heating fuel in Czech households.[118] Using natural gas for electricity generation has so far been rather marginal mostly due to its low economic returns.[119] Import supply comes mainly from the Russian Federation (about 75 %) and Norway (about 25 %).

Future plans according to NSEC include more diversified supply and distribution networks of natural gas and the enlargement of domestic storage capacity up to 40 % of annual consumption numbers.

4.2.1. Emissions

Natural gas is proven to be the cleanest and the most versatile fossil fuel source being used at a high scale as burning it releases a little bit less than half of CO_2 emissions per kWh than coal.[120] In the case of the Czech Republic it is still a very low emission heating source for households and much preferred for its characteristics and ever improving quality of gas boilers on the market. Natural gas is also dubbed the bridge fuel as it is expected to facilitate the transition from fossil fuels to RES.

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[115] (Klare 2009, 45)
[116] (British Petroleum 2013, 23)
[117] Ibid.
[118] (Ministry of Industry and Trade 2013, 56)
[119] ČEZ has just recently finished the construction of a gas-fed power plant Počerady which has already proved unprofitable. More here http://www.cez.cz/en/power-plants-and-environment/ccgt-power-plants.html (accessed April 12, 2014).
[120] (International Panel on Climate Change 2012, 19)

The Unites States Environmental Protection Agency claims that: "Compared to the average air emissions from coal-fired generation, natural gas produces half as much carbon dioxide, less than a third as much nitrogen oxides, and one percent as much sulfur oxides at the power plant".[121] Problems can arise when natural gas is not transported safely as it can leak methane which is a far more potent greenhouse gas that carbon dioxide. Therefore, if leakages and manipulation of natural gas are handled properly the amount of emissions can be limited to about 53 kg of CO_2 per 1 million Btu.[122] In the case of the Czech Republic natural gas combustion contributed 17.4 $MtCO_2$ in 2010 out of the total 114.5 $MtCO_2$ from fuel combustion.[123] Having acknowledged that natural gas is currently the cleanest of all fossil fuels with high versatility, virtually no sulfur oxide and mercury emissions, and releases about half as much carbon dioxide as coal; it receives the value of 2.5 of the environmental security index.

4.2.2. Sustainability

Assigning the right value of the sustainability factor for natural gas and oil proves to be rather challenging as the Czech Republic does not possess any substantial reserves of these hydrocarbons.[124] In order to present a rigorous analysis this part will look at the import side of these commodities and their overall availability in the world. Other factors that should not be omitted from this analysis are import diversification options and financial factors pertaining to each resource which will be discussed under the *Economic factors* section of this chapter.

It is important to start off by making sense of various reserves statistics especially of oil and natural gas which often tend to substantially differ. Reserves are categorized by a confidence level, and beyond this there are further categories of *'potential additional reserves'* and *'undiscovered resources'* (both of which can be estimated to different confidence levels). The confidence level is divided into three groups: *1) proven reserves* - virtually certain to be technically and commercially producible, i.e. have a better than 90% chance of being

[121] http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html (accessed April 18, 2014).

[122] "Carbon Dioxide Emissions Coefficients", (U.S. Energy Information Administration), http://www.eia.gov/environment/emissions/co2_vol_mass.cfm (accessed April 15, 2014).

[123] (International Energy Agency 2012, 111-122)

[124] The Czech Republic has some reserves of shale gas but currently does not intend to exploit them as a moratorium on shale gas exploration was put in place in 2012. http://www.naturalgaseurope.com/czech-republic-plans-shale-gas-moratorium (accessed April 20, 2014).

produced. *2) Probable reserves*- not yet proven, but which are estimated to have a better than 50% chance of being technically and commercially producible. And *3) possible reserves* which at present cannot be regarded as probable, but which are estimated to have a significant but less than 50% chance of being technically and commercially producible.[125] This confusing division only adds to the inaccuracy of most estimates being published.

Let's accept this complex division of reserves as a disclaimer and use current data released by the International Energy Agency in its *World Energy Outlook for 2013*. In this document various charts of production vs. demand are offered together with valuable remarks on market trends, different pricing mechanisms and the current boom of unconventional natural gas (mostly shale gas).[126] The key message of the chapter about natural gas outlook is that "The world's remaining resources of natural gas are more than sufficient to meet any conceivable level of gas demand for the next several decades. Proven reserves of gas stood at 187 trillion cubic metres (tcm) at the end of 2012 (BP, 2013)."[127] This amount of natural gas can currently satisfy the world's demand for about 55 years and the fact that the Czech Republic's demand is expected to increase by only 61 PJ by 2040 does not present any immediate supply interruptions in near future in terms of the availability of natural gas.[128]

The country also has fairly well diversified pipeline infrastructure with the possibility of importing natural gas both from the east (Russia) and north (Norway). Long-term contracts with these countries should secure the demand for some time to come but possible supply interruptions mostly due to political instability in some of the transport countries still pose a threat for the future.[129] What could ameliorate this situation are possible exports of LNG from The United States in the next decade as the US has substantially benefited from its shale gas bonanza in recent years which has resulted in a surplus in production capacity available for export. The natural gas market is a very vibrant and complex environment which is currently experiencing a surplus of this commodity which could potentially drive its price down. However, its pricing varies throughout the world and is highly dependent on geography and

[125] (House of Commons Library 2007, 15)
[126] (International Energy Agency 2013, 99-136)
[127] Ibid.p.107
[128] (British Petroleum 2013, 21) (Ministry of Industry and Trade 2013, 40)
[129] The Czech Republic has long-term supply contracts with Norway (until 2017) and with the Russian Federation (until 2035). (Hnutí DUHA 2012, 19)

negotiating skills. Rest assured, the Czech Republic finds itself in a relatively secure position in terms of its future supply as long as the political environments of its supplying countries remain stable. The assigned value of environmental security for the sustainability factor of natural gas is therefore 3.

4.2.3. Economic Factors

The imports of natural gas cost the state more than 80 billion CZK annually which fluctuates by the year as natural gas is predominantly used for heating.[130] According to NSEC this price is set to go up to about 170 billion CZK annually in 2040.[131] Gas-fired power plants are already not profitable to run which made the biggest Czech energy company ČEZ mothball a brand new gas-fired power plant Počerady right after its completion. Even though the Počerady power plant was about six times cheaper to build that it would cost to construct the two additional nuclear reactors in Temelín (USD/kW), its profitability is determined by electricity prices which are currently very low on the European Energy Exchange market.[132] Natural gas externalities are on the other hand almost negligible with about 400 million CZK of indirect expenditures in 2011.[133]

The Czech Republic might benefit in the future from purchasing natural gas on the spot market as more natural gas is expected to become available especially from the US. The question is how the current European suppliers (mostly Russia) will react to an influx of relatively cheap gas into Europe and whether they will adjust their prices to it. The share of natural gas in the Czech energy mix is projected to increase according to NSEC which will most likely result in significantly higher annual expenditures. However, another factor which could significantly help reduce the demand for natural gas in the country is effective home weatherization which according to numerous studies offers substantial energy savings.[134,135]

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[130] Data taken from Czech Statistical Office. Colder winters require more heating hence more natural gas imports.

[131] (Ministry of Industry and Trade 2013, 64)

[132] The Počerady power plant cost about 17 billion CZK which translates to about 1036 USD/kW of installed capacity. The two additional nuclear reactors for Temelín are expected to cost about 250 billion CZK which translates to a little more than 6000 USD/kW. European electricity prices are currently at about 37 EUR/MWh. Source: www.eex.com (accessed April 21, 2014).

[133] (Hnutí DUHA 2012, 6)

[134] (Hnutí DUHA 2010, 39-49)

[135] (Greenpeace Czech Republic 2012, 18)

Due to its low externalities and a much greater potential for future consumption decrease, natural gas gets assigned the value 2.5 of the environmental security index.

4.2.4. Land Resource Use

It is difficult to measure a relevant value of land resource use for natural gas in the conditions of the Czech Republic as the majority of natural gas is imported into the country. Nevertheless, data suggests that transmission, storage and generation combined make up for about 180 m^2/GWh.[136] Overall the land resource use of natural gas does not significantly impact the environmental security in the country given that the Czech Republic only serves as a consumer oh this commodity. It is therefore only fair to assign the neutral value of 3 to this commodity.

4.2.5. The Change in Natural Gas Share According to NSEC

According to NSEC its share in total primary energy sources is projected to increase only by about 61 PJ annually from 2010 to 2040.[137] Nevertheless, its use for electricity generation is projected to more than triple from 2010 when it contributed about 1125 GWh to an estimated number of 3664.9 GWh in 2015. The final estimate for the reference year 2040 is 5311.2 GWh of electricity output generated.[138] Using the IEA study's *CO_2 from Fuel Combustion* data for natural gas in the Czech Republic for the increase from 2010 to 2040 numbers, the CO_2 increase solely due to electricity generation would be 1.7 $MtCO_2$ eq. annually.[139] If we plot the number provided by the U.S. Energy Information Administration for natural gas the total emissions increase representing the additional 61 PJ using current technology would be about 3 $MtCO_2$ of which about half would come from natural gas being used for electricity generation.[140] In 2013 natural gas made up for 289 PJ of total primary

[136] This excludes extraction which is not relevant for the Czech Republic. (Vasilis Fthenakis 2009, 1468)
[137] In 2010 natural gas represented 336.1PJ and is expected to reach 397.8PJ in 2040.
[138] (Ministry of Industry and Trade 2013, 46)
[139] Calculated by taking the difference in electricity output from natural gas in GWh and multiplying it by the amount of carbon dioxide equivalent emitted in order to yield 1kWh of electricity in the Czech Republic (405 kg CO_2/kWh).
[140] The average number of carbon dioxide released per 1 kWh of electricity generated between 2008-2010 was 426 g CO_2/kWh which is considerably more than natural gas releases when used for other purposes such as heating or transportation according to the numbers by the U.S. Energy Information Administration. For more see http://www.eia.gov/environment/emissions/co2_vol_mass.cfm (accessed April 19, 2014).

energy sources which was 16.3 % out of the total value of 1771.6 PJ.[141] This translates to an increase of 108.8 PJ in 2040 which will constitute 21.7 % share of natural gas in the total primary energy mix in 2040 according to NSEC.

4.3. Oil

The world's daily consumption of oil in 2012 reached almost 90 million barrels of which the Czech Republic used about 194 000 barrels/day representing approximately 0.2 % of world oil consumption.[142] Domestically oil is used predominately for transportation together with a small portion used in the chemical industry.[143] The main bulk of oil imports come from the Russian Federation (70 %) followed by Azerbaijan (20 %), Kazakhstan (7 %), Algeria and other Arab states (1 %) with the rest being produced domestically.[144] There is currently no appropriate or viable replacement for oil as it has very high energy density and supports nearly the entire transportation system of the country. Nevertheless, its use in the transportation sector has been slowly declining in recent years due to its volatile prices and technological advancements in fuel efficiency being constantly introduced in the modern car fleet. The prospect of a society not dependent on oil is currently still rather unthinkable which makes oil a very profitable and valuable commodity. Our economies will have to adapt to a reality without oil in the future and trying to reduce our dependency on this finite commodity will only make this transition smoother.

4.3.1. Emissions

As stated above oil is mostly used in the transportation sector which alone contributed about 18.2 $MtCO_2$ in 2010.[145] As an individual source of emissions oil amounted to 22.8 $MtCO_2$ in 2010.[146] Using oil for gasoline releases about 73.1 kg CO_2/MBtu which places oil

[141] Ministry of Industry and Trade 2013 data available at http://download.mpo.cz/get/50327/57069/611832/priloha001.pdf (accessed April 24, 2014).
[142] (British Petroleum 2013, 9)
[143] (Hnutí DUHA 2012, 20)
[144] Ibid.
[145] (International Energy Agency 2012, 111-122)
[146] Ibid.

somewhere between coal and natural gas.[147] In addition to its carbon dioxide emissions burning gasoline also releases carbon monoxide, various hydrocarbons and nitrogen oxides.[148] Even though oil is not used to produce electricity in the Czech Republic it still markedly adds to the total greenhouse gas emissions and thus receives the value of 3.5 on the scale of environmental security index.

4.3.2. Sustainability

Oil presents us with a very similar situation to that of natural gas in regards to supply and demand in the Czech Republic. One noticeable difference is the slightly decreasing trend of oil's future share in the energy mix of the country.[149] Unconventional forms of oil have been also on the rise due to increased explorations in the last couple of years preceded by high oil prices which incentivized exploration investments. The current world proven reserves amount to about 1700 billion barrels which are expected to last about 52 years at the current rate of consumption.[150] The Czech Republic imports about 70 % of its oil supply from the Russian Federation which is the second biggest oil producer with more than 10.5 million barrels per day only after Saudi Arabia.[151]

In terms of diversification the situation is a little bit more favourable than it is with natural gas seeing as oil is easier to transport and there is an additional pipeline capacity in the west (Ingolstadt) which enhances both the energy security and the diversification capability of the Czech Republic. The sustainability factor for oil in the Czech Republic receives the value of 2.5 for the decreasing trend of this commodity in the country's energy mix and a better capability for possible diversification.

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[147] "Carbon Dioxide Emissions Coefficients", (U.S. Energy Information Administration), http://www.eia.gov/environment/emissions/co2_vol_mass.cfm (accessed April 15, 2014).

[148] For a full list see http://www.ecooptimized.com/index.php/gasoline/76-gasoline-emissions-.html (accessed April 17, 2014).

[149] (Ministry of Industry and Trade 2013, 40)

[150] (British Petroleum 2013, 7) (International Energy Agency 2013, 421)

[151] Ibid.

4.3.3. Economic Factors

Not too long ago the price of oil hit its all-time high soaring to about 147 USD/barrel of the Brent crude oil spot price back in 2008. The reason why oil prices are so important is that oil is still an essential commodity for most world economies and its price is connected to various industries and not just to transportation. In 2013 the Czech Republic spent about 100 billion CZK on oil imports.[152] This number is according to NSEC expected to go up and reach 250 billion CZK a year in 2040.[153] This is a worrying trend especially because the share of oil in the Czech energy mix is projected to decrease but its procurement price is expected to more than double.[154] This puts the country in a precarious situation as there is currently no viable secondary commodity which could fully replace the role of oil in today's society.[155]

It is also important to acknowledge that apart from many negative indirect externalities of oil (the cost that emissions of carbon dioxide, carbon monoxide and others incur on the society and the environment), there are also positive externalities of using oil such as rapid economic development that has made now industrialized countries rich by delivering cheap energy in large quantities. Environmental damage in the form of oil spills and landscape destruction is another factor which is difficult to express in financial terms and often takes place in oil producing countries rather those that import it. For all the reasons mentioned in this section oil receives the value of 4 as it has undeniably locked the country into dependency for which there is no immediate remedy.

4.3.4. Land Resource Use

Similarly to natural gas oil is mostly imported into the country and thus deserves evaluation only on the consumer side of the supply chain. Moreover, oil is not used to produce electricity domestically and therefore there are no power plants that would require this commodity for their operation. Pipelines and storage facilities are the only two factors that contribute to its land resource use. In order to keep the overall evaluation fair, oil will be given the value of 3 which makes in neutral for this environmental security index determinant.

[152] Czech Statistical Office 2013
[153] (Ministry of Industry and Trade 2013, 64)
[154] Ibid.
[155] Electro-mobility and bio-fuels cannot fully substitute for oil at the current consumption rates.

4.3.5. The Change in Oil Share According to NSEC

Oil made up for 352.9 PJ of total primary energy in 2013 and is expected to ebb down to 326.2 PJ in 2040.[156] This change would roughly translate to an annual carbon dioxide decrease of 3.6 $MtCO_2$.[157] It is interesting to note that even though the role of oil will decrease in the next decades, according to NSEC its role will be replaced by increases in electro mobility, natural gas (CNG and LNG) and bio fuels with more favourable carbon dioxide emissions.[158] Its share in the energy mix was 19.9 % and is expected to go down to 17.8 % in 2040.

4.4. Nuclear Energy

Nuclear energy represents an important source of energy for the extremely high density of nuclear fuel and hence its ability to generate much more energy per mass. There were 434 nuclear reactors in the world in 2013 which had generated about 2346 TWh in 2012.[159] The fuel used in nuclear power plants is uranium which is a finite resource but currently still very abundant and accessible. There are two active nuclear power plants in the Czech Republic which together generated about 29 TWh in 2013 and thus contributed 1.2 % to the total share of world electricity generation from nuclear energy.[160] In the local distribution of electricity generation this represents a much bigger share of 35 %. Its share in heat generation is still insignificant but plans for a greater utilization of the residual heat are being considered.

Nuclear energy as it stands will most certainly form the backbone of Czech electricity supply in the future as NSEC suggests at least a 50% share in electricity generation for the reference year 2040.[161] Moreover, plans for the construction of two additional reactors at the nuclear power plant Temelín are still being considered even after a recent decision of the

[156] (Ministry of Industry and Trade 2013, 40)
[157] Calculated using EIA's numbers at http://www.eia.gov/environment/emissions/co2_vol_mass.cfm (accessed April 15, 2014).
[158] (Ministry of Industry and Trade 2013, 60)
[159] Vladimír Wagner, "Jaderná energetika na prahu roku 2014," (Objective Source E-Learning, 2014), http://www.osel.cz/index.php?clanek=7383 (accessed April 10, 2014).
[160] (British Petroleum 2013, 35)
[161] (Ministry of Industry and Trade 2013, 75)

majorly state-owned energy company ČEZ to cancel the expansion tender.[162] NSEC also states that its goal in the nuclear energy sector is to develop plans for an additional nuclear power plant together with trying to extend the lifespan of the Dukovany power plant up to 60 years.[163]

4.4.1. Emissions

The undeniable advantage of nuclear energy is its ability to generate almost zero carbon emissions. It also does not emit any fine particles, nitrogen oxides or sulfur oxides.[164,165] There are other problems connected to the procurement and storage of the nuclear fuel which will be discussed in another chapter of this thesis. Nuclear energy's capacity to generate large amounts of energy with virtually no emissions places this energy source on the low impact side of the environmental security index with the lowest impact value 1.

4.4.2. Sustainability

Nuclear power plants require uranium to generate energy which is still an abundant resource but just like other finite resources its quality tends to degrade as the easily extractable reserves are used up first which makes it more difficult and costly to extract over time. According to the World Energy Watch group the proved reserves (reasonably assured below 40 $/kgU extraction cost) and stocks will be exhausted within the next 30 years at the current annual demand.[166] The total uranium reserves will last longer than 30 years but might prove much more expensive to extract which could influence the financial profitability of nuclear projects in the future.

Once nuclear facilities are constructed they yield a high amount of energy per unit of fuel and have a long life span. The only concern in terms of sustainability for nuclear energy in the Czech Republic is the actual fuel. Its supply will most likely remain stable and secure as

[162] "CEZ cancels Temelín expansion tender," (World Nuclear News, 2014), http://www.world-nuclear-news.org/NN-CEZ-cancels-Temelin-expansion-tender-1004144.html (accessed April 19, 2014).
[163] (Ministry of Industry and Trade 2013, 75)
[164] http://www.epa.gov/cleanenergy/energy-and-you/affect/nuclear.html (accessed April 19, 2014)
[165] (International Panel on Climate Change 2012, 19)
[166] (Energy Watch Group 2006, 5)

it is currently imported from the Russian Federation only about once a year by plane. Moreover, there is potential for domestic uranium mining after the last active uranium mine will close down in a couple of years. If the Czech Republic managed to procure nuclear fuel domestically it would maximize its self-sufficiency in terms of generating nuclear energy. The only predicament left then would be the storage of burnt fuel which is currently stored on site but with no viable prospects for safe future storage. Nonetheless, the sustainability factor of nuclear energy ranks at the value of 3.5 which is higher that the values of coal, oil and natural gas.

4.4.3. Economic Factors

The cost of nuclear energy is often a vexed topic as investments in nuclear energy are in the order of billions of euros and construction times can take up to ten years.[167] As mentioned above the quality of nuclear fuel is decreasing making it increasingly more expensive to satisfy the growing demand for uranium. Uranium prices have been quite volatile in recent years but are not likely to hinder the development of new nuclear projects as the cost of nuclear fuel only represents a fraction of the total cost of running a nuclear facility.[168]

The Czech Republic is a great example of how price sensitive and conditional investments in nuclear energy are for the majority state-owned company ČEZ has been trying to build two additional reactors in one of its nuclear power plants for years. Once a nuclear facility is built it can generate electricity at a comparatively low cost but the actual investment proves to be financially too risky for investors. In the case of the Czech Republic it is mostly because of low electricity prices on the European Energy Exchange market which would not make any nuclear power plant investment profitable with the current electricity prices.[169] The investment cost of the two additional Temelín reactors would surpass 6000 USD/kW which is several-fold higher than the cost of any other conventionally used source.[170]

[167] Typical construction times range from 4 to 7 years according to OECD's Nuclear Energy Agency.
[168] (Energy Watch Group 2006)
[169] Current electricity prices on the European spot market are about 37 EUR/MWh. Any investment in nuclear power plant requires electricity prices of at least 70 EUR/MWh.
[170] The total installed capacity of the two additional reactors was supposed to be about 2400MW with a planned cost of 10-15 billion EUR.

That is why the majority state-owned company ČEZ said it would not make the required investment unless the Czech state offered to subsidize the electricity these two reactors would generate. However, a subsidy of such proportion in the form of a contract for difference or other pricing mechanism would oblige the state to subsidize every kWh generated for 35 years to come.[171] A contract for difference is essentially a fixed price contract designed to pay the difference between the contract price and market price.

The undeniable advantages of nuclear power (low generation cost of electricity, relatively inexpensive fuel, low externalities) seem to be irrelevant in the eyes of the market as the initial investment in nuclear power plants bears very high financial risks. Therefore, nuclear energy is only financially viable if consumers and/or taxpayers bear all the risks. For the reasons of high financial cost of nuclear projects and low electricity prices, nuclear energy currently does not present itself as a good investment choice and receives the value 4 of the environmental security index.

4.4.4. Land Resource Use

Both studies used for the evaluation of this factor show very low numbers for nuclear energy as it has several thousand times higher energy density than any other fuel in the Czech energy mix.[172] According to Martin Nicholson's study it occupies about 1200 m^2/GWh/year which corresponds to the Vasilis Fthenakis's study's values measured over the period of 30 years.[173] This value also includes mining and milling which are both conducted outside of the country and does not have to be included in the calculations. The study goes on commenting on the actual size of nuclear power plants by saying: "The land use of a nuclear-power plant itself is higher than that of a coal-fired plant probably because it adds an exclusion area and a barrier space reserved for a possible accident."[174]

This is true but not really substantial as the Czech Republic only has two nuclear power plants. The biggest issue pertaining to the land resource use of nuclear energy still

[171] (Calla and Hnutí Duha 2013)
[172] "Nuclear has one of the smallest footprints", (Martin Nicholson, The Breakthrough, 2013), http://thebreakthrough.org/index.php/programs/energy-and-climate/nuclear-has-one-of-the-smallest-footprints (accessed April 22, 2014).
[173] (Vasilis Fthenakis 2009, 1468)
[174] Ibid.

remains in the form of nuclear waste and its storage. Even though additional land for nuclear storage would not significantly alter nuclear energy's area/electricity generated performance, it does majorly affect its land occupation performance given that used nuclear fuel gives off radiation for as long as 10 000 years.[175] The extraction and storage of nuclear fuel currently pose the greatest risks and challenges to nuclear energy but do not affect its overall area/electricity generating capacity performance for which it is given the value 1 of the environmental security index.

4.4.5. The Change in Nuclear Energy Share According to NSEC

The New State Energy Concept outlines monumental changes for nuclear energy in the Czech energy mix as it intends to increase the nuclear capacity to 507.9 PJ in 2040 from the 318.6 PJ it is expected to reach next year.[176] This translates to an electrical output increase of more than 17 TWh which roughly the same amount generated by the nuclear power plant Temelín in a year.[177] This scenario would make nuclear energy the predominant source of electricity generation in the country and secure such a position for years to come as any additional nuclear capacity installed in the next decade will have a lifespan of at least 30 years.

4.5. Renewable Sources of Energy

Renewable sources of energy have been experiencing a powerful expansion all over the world especially in the last decade or so. The drivers for this unprecedented boom are numerous but some of the most influencing factors include global efforts to curb greenhouse gas emissions, create a sustainable system of energy supply, reduce the dependency on finite hydrocarbons, and become more energy self-sufficient. A significant increase in renewable sources of energy in the Czech Republic was heralded by the Czech accession to the EU in 2004. The year 2005 saw the country pass its first renewable energy legislation which due to several circumstances led to an unexpected boom in the solar business to be later strongly criticized by the general population.

[175] (Vasilis Fthenakis 2009, 1472)
[176] (Ministry of Industry and Trade 2013, 40)
[177] Ibid.p.46

The country's renewable energy goal set by the EU is to have at least 13 % of RES in the primary energy consumption by 2020 with further emission reduction goals and new target for RES to be negotiated later in 2014. The aforementioned unprecedented expansion of RES was not anticipated even by the Ministry of Industry and Trade which is responsible for drafting the State Energy Concept. The evidence for this argument is clear when one takes a look at the energy statistics of RES from the year 2013. RES in total generated 10 198.7 GWh in 2013 which is only about 700 MWh short of what MIT predicted for the year 2020.[178] The biggest share of it was produced by hydro facilities (cca.37 %) followed by bio gas (cca.21 %) plants, solar PV plants (cca.21 %), biomass (cca.16 %) and wind (cca.5 %) and waste disposal (cca.1%).[179] To demonstrate how progressive this industry is one must only look at the share of RES in the total primary energy consumption where RES represented 14.53 % in 2013 thus having surpassed the 13 % goal for 2020 way ahead of time.[180]

NSEC calls for no future subsidies for RES in the form of feed-in-tariffs or any direct form of subsidy which could incur substantial financial burden on the businesses and consumers.[181] This will most likely not be necessary as RES are slowly becoming competitive in other countries and are expected to be fully competitive in most countries in the foreseeable future.

4.5.1. Emissions

Emissions associated with RES are either very low or negligible depending on the source for there is no fuel combustion present in the process of generating electricity from RES.[182] This is particularly true for hydroelectricity, wind energy and solar energy; all of which contribute to electricity generation in the country. Burning biomass, bio gas or landfill gas generates emissions but these processes tend to be either carbon neutral for the fuel supplied comes from a renewable process or emit a very small number of additional of carbon

[178] (Ministry of Industry and Trade 2013, 46). Energy data taken from www.energostat.cz (accessed April 19, 2014).
[179] Data taken from www.energostat.cz (accessed April 19, 2014).
[180] Ibid.
[181] (Ministry of Industry and Trade 2013, 74)
[182] (International Panel on Climate Change 2012, 19)

dioxide.[183] SOx and NOx emissions are also very negligible and pale in comparison to coal or natural gas emissions.[184] The overall emissions associated with RES are usually attributed to emissions generated during the construction of wind turbines, solar panels or hydro power plants. These fall into the category of energy externalities and will be examined in a separate chapter. Given the characteristics and data available on RES the decision to assign this group of energy sources the value 1 of environmental security index seems to be very sound.

4.5.2. Sustainability

Wind energy, hydro energy and solar photovoltaic energy all use natural resources to generate electricity. In the case of wind and solar these resources are virtually infinite and only limited to land use. Biomass, bio gas and landfill gas all burn resources that are naturally replenished and are only limited to how much organic waste the society produces. There is not much potential in increasing hydro capacity in the Czech Republic but all the other sources can still be substantially expanded in this geographic area. Solar panels do not have to occupy arable soil but can instead cover the roof-tops of buildings and houses. Wind energy, according to a report released by the Czech Academy of Science, can reach an electricity generating potential of 6 000 GWh but currently generates only about 478 GWh annually.[185,186] Even if a large expansion RES took place in the Czech Republic it would most likely only strengthen the country's self-sufficiency and enhance the sustainable character of its energy sector. RES are therefore assigned the value 1 of sustainability of the environmental security index.

4.5.3. Economic Factors

As relatively new sources of energy RES have had a hard time expanding due to their high cost, problematic legislature and incorporation into the power grid. Hydro energy and geothermal energy have long been competitive worldwide but other alternative RES such as

[183] Renewable process means that the nature will naturally replenish the sources used. Some emissions can be monitored in the case of burning biomass for electricity where organic matter is mixed with non-organic matter for better and more efficient combustion.

[184] http://www.epa.gov/cleanenergy/energy-and-you/affect/non-hydro.html (accessed April 19, 2014).

[185] (Academy of Sciences of the Czech Republic 2008)

[186] http://energostat.cz/obnovitelne-zdroje.html (accessed April 20, 2014)

wind, solar PV, biomass and bio gas have been only slowly gaining in importance and penetrating the Czech energy mix. Nevertheless, in order to stimulate growth of RES, some European governments implemented a system of economic subsidies for these sources. These subsidies now show the real cost of renewable energy which in the Czech Republic amounted to 38 billion CZK in 2013.[187] It is further estimated that future governmental subsidies (mostly in the form of feed-in-tariffs) will add up to about 814 billion CZK by 2030.[188]

On the other hand the ambitious system of financial subsidies which in the EU alone reached 57 billion USD in 2012 has also resulted in a rapid decline in RES technologies (mostly solar PV) which has made the technology much more accessible.[189] The International Energy Agency estimates that the levelized cost of RES electricity generating systems will see a 40 % decrease by 2035.[190] In addition, wind and solar PV are already price competitive in some countries even without governmental subsidies.[191] RES have resulted in tremendous costs in the Czech Republic (mainly due to bad legislation) but one must be reminded about the long-term advantages of RES which require virtually no investment in fuel (solar, wind, hydro) and have very negligible external costs due to their low emissions and lower environmental impact.[192,193] This analysis acknowledges the substantial financial burden connected with the development of RES and the higher cost of electricity from these sources. Nonetheless, these costs are expected to be compensated by their positive impact on human health and the environment in the long run. This is why the RES get assigned the value of 2 of the environmental security index.

[187] http://oze.tzb-info.cz/fotovoltaika/9591-bilion-za-fotovoltaiku (accessed April 22, 2014)

[188] Ibid., note: this number can increase if more RES are connected in the future which is becoming increasingly less likely due to extensive reductions in solar PV feed-in-tariffs in the last couple of years.

[189] (International Energy Agency 2013, 226)

[190] Ibid.p.221

[191] Ibid.p.217-229

[192] (International Panel on Climate Change 2012, 19)

[193] The external cost of RES in the Czech Republic in 2011 was 1 billion CZK which was about 70 times lower than from coal. Source: (Hnutí DUHA 2012, 6)

4.5.4. Land Resource Use

To adequately analyze the land resource use of RES would require an analysis of each and individual renewable source for their different performances. Nevertheless, for the purposes of this study wind energy, solar PV, hydro energy and biomass will be evaluated as one. The highest values of land area per electricity generating capacity were given to biomass (up to 460 000 m^2/GWh/year) and hydro (200 000 m^2/GWh/year) followed by wind and solar PV.[194]

Before assigning a cumulative value for all RES it is essential to mention some of the most seminal factors that determine the land resource use of RES. Biomass and hydro have overall low area/electricity generated performance for they occupy large areas which could be used for other purposes (mainly biomass).[195] In terms of solar PV one must distinguish between roof-top solar PV and large scale such as solar farms or concentrated solar farms. The area used for solar PV is virtually irrelevant as it does not occupy any additional space but only uses already existent structures. This is not the case for large solar farms that occupy vast areas. The comparison of different solar PV installations can be seen in the study by Fthenakis.[196] The performance of wind energy hinges largely on the size of the turbine, wind speed determined by location and whether the free lands are utilized for grazing, agriculture, and recreation.[197] The study concludes by stating: "Except for the fuel cycle, renewable technologies transform more land than does conventional electricity technologies under the conditions described. However, we caution that the matrix of land transformation alone cannot characterize the real land-use impacts since it does not convey the duration of land use and recovery, and any functional degradation."[198]

The overall performance of RES in regards to this determinant remains rather poor (though depending on the source) but with considerable capacity for improvement in the

[194] "Nuclear has one of the smallest footprints", (Martin Nicholson, The Breakthrough, 2013), http://thebreakthrough.org/index.php/programs/energy-and-climate/nuclear-has-one-of-the-smallest-footprints (accessed April 22, 2014).

[195] Hydro usually requires the presence of large reservoirs unless located in mountainous areas with large heads.

[196] (Vasilis Fthenakis 2009, 1471)

[197] Ibid.

[198] (Vasilis Fthenakis 2009, 1470)

future as solar and wind technology advances to generate more electricity per area occupied. For the reasons stated RES cumulatively receive the value of 3.5 of the environmental security index.

4.5.5. The Change in RES Share According to NSEC

As mentioned above the development of RES took place at an unprecedented pace rendering some of the NSEC projections incorrect even at the time of writing this thesis. The final prediction for 2040 is 18 607.5 GWh of electricity generated in a year which would put RES right behind nuclear energy in terms of electricity generation capacity.[199] The total primary energy share is expected to reach almost 300 PJ in 2040 which might prove to be a rather pessimistic number given the recent development in this field. If this number is correct RES would more than double in the next 27 years and their share in the total primary energy would jump from about 8.3 % in 2013 to more than 16 % in 2040.

[199] (Ministry of Industry and Trade 2013, 46)

4.6. The Overall Change of the Czech Energy Mix and Its Impact on Environmental Security

	Emissions	Sustainability	Economic factors	Land resource ratio	Total (2014)	Change in primary energy (NSEC 2040 in %)	Total (2040)	Impact (Positive/ Negative)
Coal	5	2.5	3.5	2	13	- 41.7 %	7.6	positive
Natural gas	2.5	3	2.5	3	11	+ 37.6 %	6.9	positive
Oil	3.5	2.5	4	3	13	- 7.3 %	12.1	negative
Nuclear	1	3.5	4	1	9.5	+ 50.3 %	4.7	positive
RES	1	1	2	3.5	7.5	+ 203.3 %	- 7.7	positive

The total value of the environmental security index of the current energy mix for the year 2014 is 54 with the mean value 10.8 per source. The overall impact is determined by the total value of the index of every energy source where values below 12 are considered as positive and values above 12 as negative. This is because the neutral value is 3 which when multiplied by the number of determinants gives us the value of 12 making it the overall neutral value on an energy source. Therefore, any future increase in the resources rated below 12 will result in a positive impact rating whereas those given values above 12 would have to show a decrease in their total amount in order to receive a positive overall rating. This is the case with coal which scored 13 and still received a positive rating as its future share is expected to decline bringing the total value down to 7.6. Oil is the only energy source to receive an overall negative value for the reference year 2040 because its projected consumption decrease is not sufficient to bring the value of environmental security index under the neutral value. If we add up all the values for the reference year 2040 we get the value of 23.6 of the environmental security index which shows a substantial improvement over the next 25 years. The values should be perceived as indicative of the overall improvement as there are several additional factors in play which go well beyond the scope of this thesis.

5. Additional Energy Factors Pertaining to the Environmental Security of the Czech Republic

Apart from the four main determinants of environmental security chosen for the evaluation of the Czech energy mix, there are other important factors to consider when assessing the environmental impact of utilizing various energy resources. This chapter will take a closer look at some of those factors most relevant to the energy mix of the Czech Republic which ought to be examined when creating the State Energy Concept. However, these factors are not only specific to the Czech Republic and should be considered when creating an energy strategy of any given country.

The factors this chapter will discuss are the following:

- Energy Return on Energy Investment (EROEI)
- Energy externalities
- Energy efficiency
- Energy security factors
- Environmental impact assessment

Each of these factors will bring an extra value to the overall assessment of the newly proposed composition of energy resources in the eyes of the concept of environmental security and weigh in on the final evaluation of the energy mix. Main critiques of NSEC have often included comments on some of these factors and their role in creating an energy strategy should not be discounted. This chapter is therefore intended to solidify the arguments and assessment from the previous chapter in order to make the overall evaluation more comprehensive and rigorous.

5.1. Energy Return on Energy Investment (EROEI)

"EROEI is the ratio of energy returned from an energy-gathering activity compared to the energy invested in that process."[200] It represents a crucial factor when evaluating individual energy sources because it reveals whether an energy source has a positive or

[200] (Post Carbon Institute 2013, 106)

negative energy balance. The general trend shows signs of a decline in energy returns for most energy sources over time and thus indicates growing rates of depletion. Making sense of EROEI and understanding it is critical when considering the composition of an energy mix and making strategic decisions that will affect the future trajectory of a country's energy policy.

The relationship is usually described as the energy returned to society divided by the energy required to get that energy. The numerator and denominator are assessed in the same units so that the ratio derived is dimensionless.[201] EROEI is usually measured at the point that the energy resource leaves the extraction of production facility (mine-mouth, well-head, farm gate, etc.).[202] Nevertheless, other measuring techniques include both direct energy involved (used at the production site) and indirect energy involved (energy used to manufacture the machinery used at the production site).[203] Different EROEI ratios have been measured for different energy sources over time but the general consensus is that the minimal value of energy return has to be about 3:1 for an energy source to have actual value for the society.[204]

When oil was first extracted its EROEI was in the order of 100:1 which has over time declined to about 10-20:1 with conventional oil and around 3-5:1 with unconventional oil.[205] One of the highest EROEI ratios can still be achieved with coal and newly with wind energy with up to 80:1 and 38:1 respectively.[206] EROEI is also closely tied to commodity prices. If the price of oil soars way above 130 USD/barrel it would most likely be still profitable to extract unconventional forms of oil even in remote locations just to get a profit on every barrel later sold on the market.

For countries like the Czech Republic it is more important to consider the EROEI for imported fuels (oil, natural gas, uranium) as the country does not produce these commodities and only imports them.[207] The value a country can then create with the fuels it imports should be superior to the value of the energy purchased for the production of goods it created. This is

[201] (Post Carbon Institute 2013, 109)
[202] Ibid.
[203] (Energy and the Wealth of Nations: Understanding the Biophysical Economy 2012, 312)
[204] Ibid.
[205] (Post Carbon Institute 2013, 46)
[206] Ibid.
[207] (Post Carbon Institute 2013, 110)

explained as EROEI of obtaining energy through trade: "An economy without enough domestic fuels of the type it needs must import the fuels and pay for them with some kind of surplus economic activity. Thus the economy's ability to purchase the required energy depends upon what it can generate to sell to the world, as well as upon the fuel required to grow or produce that material. The EROI for the imported fuel is the relation between the amount of fuel bought with a dollar relative to the amount of dollar profits gained by selling goods or services for export."[208] Applying this logic will help to predict economic vulnerability of a given economy and can therefore prove very helpful in deciding what energy sources and to what extent should be imported.

5.2. Energy Externalities

Energy externalities represent the total cost of using an energy source including costs that the market usually fails to incorporate into the current pricing system. Having the knowledge of external energy costs can significantly influence decision making in energy and economic policy. The EU has been trying to expose the real price of using various energy sources by implementing certain mechanisms such as CO_2 allowances (ETS) or plans to implement some sort of a carbon tax. Greenhouse gases have been proved to have a negative impact on the environment in a way that they contribute to climate change. Including the cost of greenhouse gas emissions in the current pricing system can pave the way to address this issue. Externalities are usually measured using the ExternE method (Externalities of Energy) which has been developing over the last two decades and frequently used for numerous research projects by the European Commission.[209]

Externalities (sometimes also called indirect subsidies) can be both short-term and long-term. Short term externalities can for example result in cheap and reliable electricity (positive short-term externality) when a coal-fired power plant is built but also in increased local pollution and health problems (negative short-term externality). People can then weigh

[208] (Post Carbon Institute 2013, 110)

[209] (Centrum pro otázky životního prostředí UK 2012, 6). For more see www.externe.info (accessed April 26, 2014).

these positives and negatives with reasonable accuracy.[210] Long-term externalities usually represent the negative impact on climate change and the transformation of the environment which are difficult to express in financial terms.

In the case of the Czech Republic studies have been done especially on the externalities resulting from using coal-fired power plants.[211] "The external costs of electricity generation are mainly caused by the acidifying substances, airborne particles and greenhouse gas emissions."[212] It has been estimated that the use of coal entails the largest indirect financial expenditures in the form of increased health care costs and damages to the environment.[213] The external cost of other energy sources which form the Czech energy mix was included under the *economic factors* determinant discussed in the assessment section of this thesis.

Including energy externalities in the total price of energy would most likely change the dynamics on the energy market as some energy sources would become uneconomic. Nevertheless, it is also important to bear in mind that externalities can also take form of positive consequences and it is then up to the society to weigh the pros and cons of each energy source to make an appropriate decision. The goal of exposing the real cost of using different energy sources is to bring attention to the fact that the impact of various pollutants on the environment and the society should not be overlooked.

5.3. Energy Efficiency

Energy efficiency is a sub-category of energy conservation which in simple terms translates to using less energy. This can be accomplished through curtailment (turning off the lights) or efficiency (replacing the old lights bulbs with energy efficient light bulbs).[214] However, these examples do not adequately capture the actual scope of energy savings opportunities through changing the way we use energy.

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[210] Schalk Cloete, "On Energy Subsidies and Externalities," (The Energy Collective, 2013), http://theenergycollective.com/schalk-cloete/264701/energy-subsidies-and-externalities (accessed April 25, 2014).

[211] (Centrum pro otázky životního prostředí UK 2012)

[212] (Consumption-based indicator of the external costs of electricity 2012)

[213] Ibid.

[214] (Post Carbon Institute 2013, 67)

The International Energy Agency devotes an entire chapter of its most recent *World Energy Outlook* to energy efficiency with the goal of bringing more attention to such a strategic sector of energy management.[215] Similarly the European Union underlined its commitment to energy efficiency by making it one of its targets in the 20/20/20 strategy, and more broadly of its energy policy in the long run.[216] Improvements can be seen all around the world as global energy intensity (the energy needed to produce one unit of GDP) declined worldwide by 1.5 % in 2012.[217] The initial gains in energy efficiency are usually the easiest and cheapest. Further increases prove to be increasingly more expensive and difficult as the law of diminishing returns comes into play.[218]

The potential for conservation and energy efficiency in the Czech Republic is still very large as various studies suggest.[219] According to the calculations made by several consulting companies the highest potential for efficiency increases can be achieved in the industry sector, building sector, transport sector and power generation and distribution sectors.[220] The studies show that the total potential for energy savings through increasing building efficiency (insulation, more efficient heating, using better materials etc.) can reach up to 175 PJ.[221] Passive house standards for new buildings could further augment the energy savings potential in the future. Another area for possible improvement is heat distribution infrastructure which is obsolete and about 20 % of generated heat gets lost in the transmission process.[222]

Possible savings in the industry sector are also vast as the Czech Republic's energy density factor is about 1.7 times higher than the European average.[223] Industry represents about 41 % of total energy consumption in the country with possible future savings of 141 PJ

[215] (International Energy Agency 2013, 231-260)

[216] The 20/20/20 strategy stands for a 20% reduction in EU greenhouse gas emissions from 1990 levels; 20% energy consumption produced from renewable sources of energy, and A 20% improvement in the EU's energy efficiency.

[217] (International Energy Agency 2013, 231)

[218] The law of diminishing returns states that after a certain level of efficiency has been established, further attempts will see decline in effectiveness.

[219] The two main studies used for this thesis that discuss the energy efficiency potential in the Czech Republic in great detail are *Energetická [R]evoluce* and *Chytrá Energie.* They base their analyses and calculations on specific reports by renowned energy consulting companies and non-governmental organizations.

[220] (Hnutí DUHA 2010)

[221] (Hnutí DUHA 2010, 39)

[222] Ibid.

[223] (Studie možností úspor energie v českém průmyslu 2008)

(31 %) in the next couple of decades.[224] The Czech Republic also ranks among the worst in domestic material consumption and waste management which could both see substantial improvements.[225] These are only some of the areas where large energy savings could take place but conservation can nonetheless be achieved through different behaviour in the way we use energy. Choosing energy efficient appliances over more wasteful alternatives should become standard practice where regulations that try to enforce better labelling or the discontinuations of the most wasteful appliances should be promoted.

The government acknowledged the importance of energy efficiency in NSEC by stating the most important areas for possible improvements. For the most part they overlap with the recommendations of other non-governmental entities and include: the promotion of energy efficient appliances and goods, increased energy efficiency in electricity and heat generation, dispatch efficiency and better consumption monitoring, increased standards for building energy efficiency, and the promotion of energy performance contracting.[226,227]

To conclude, energy efficiency has been growing in importance in the face of ever increasing energy prices and efforts to curb current consumption rates. If appropriate investments are made it is very likely that energy efficiency can considerably impact the rate of energy consumption in the Czech Republic which could result in lower energy supplies and significant financial savings.

5.4. Energy Security Factors

As discussed in the methodological part of the thesis energy security forms a big part of the environmental security concept with many of their determinants overlapping. Availability, reliability, affordability and sustainability are the four main factors of energy security where two of them (sustainability, affordability) were included in the evaluation of the Czech energy mix through the lens of environmental security. The other two factors

[224] According to a study done by an energy consulting company SEVEN. (Hnutí DUHA 2010, 45)
[225] (Hnutí DUHA 2010, 46)
[226] (Ministry of Industry and Trade 2013, 86-88)
[227] Energy performance contracting ensures the profitability of a certain project by passing the responsibility to deliver the desired savings on to the contractor.

(reliability, availability) also deserve attention as they deal with specific aspects of the supply side of energy.

The availability of energy resources varies with each energy source where those procured domestically (coal and RES) have the best future prospects for relatively abundant and reliable energy supply. The availability of nuclear fuel was discussed in the previous chapter and it is safe to assume that its future procurement will not be interrupted in any major way.[228] It would be prudent to reconsider the availability and affordability of the other fossil fuels (oil and natural gas) as the country is entirely dependent on their imports. Even though fossil fuel dependency is projected to decrease according to NSEC, the dependency on energy imports will increase regardless.[229]

In terms of making the current energy supply chain reliable, their energy exporting regions must remain politically stable and so do the transit countries. However, political negotiations can only achieve so much leaving the country largely reliant on other states and foreign entities. The risk of low reliability can be to a certain extent ameliorated by a more diversified supply chain where potential risks are distributed among more actors. Future diversification plans according to NSEC's diversification graph are not to see much change as the level of diversification remains flat for the next 10 years and then increases only by a small fraction before it plateaus again until the end of the reference timeline.[230]

5.5. Environmental Impact Assessment

Strategic environmental assessment (SEA) is a mandatory requirement process set by law of possible environmental impacts of various strategic concepts. In this case it was prepared for the purposes of assessing possible environmental impacts of the New State Energy Concept on the environment. This rather lengthy process leads to the publication of a comprehensive report where individual goals outlined in NSEC are analyzed and assessed in relation to the environment. In regards to this thesis it represents a very useful complementary

[228] The availability of uranium could be enhanced by opening an additional uranium mine in the country which is being considered at the time of writing this thesis.
[229] (Ministry of Industry and Trade 2013, 63)
[230] (Ministry of Industry and Trade 2013, 66)

study which was prepared by a renowned private company.[231] The result was a 234-page report with detailed analysis of the goals highlighted in NSEC for all energy sources and priorities of the Czech energy sector for the future.[232]

Some of its points of analysis overlap with the determinants of environmental security and include goals such as lowering greenhouse gas emissions, limit land transformation, use less water, improve biodiversity etc.[233] According to the report, the overall future impact of NSEC on the environment will be rather positive but the impact level varies with each of the two development scenarios offered in NSEC. The first scenario is called the referential scenario and the second one active/progressive scenario with slightly more ambitious numbers especially for nuclear energy and RES. The second scenario was evaluated as having significantly more positive impact on the environment as it offers greater reductions in coal use and a higher share of nuclear energy and RES. Some of the positive points outlined in SEA include: increased quality of forests due to decreased acidification from power plants, better waste management, decline in coal and oil consumption, energy efficiency, more renewable sources of energy in the energy mix, requirements to use the best available technology (BAT) in respect to energy generating facilities, and a significant reduction of CO_2 emissions down to 63 % of the current value.[234]

Nevertheless, it also highlights some possible negative effects connected with the implementation of NSEC such as: increased land transformation from RES, extensive use of water, electricity exports, soil erosion, and negative environmental impacts resulting from the development of infrastructure, storage capacity or the transport sector.[235] The assessment goes on mentioning that evaluating the environmental impact solely based on what is stated in NSEC cannot fully quantify the actual impact of individual projects and development plans without a detailed knowledge of these projects.[236]

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[231] The Ministry of Industry and Trade hired a company called *Amec – Environmental Solutions* to conduct the environmental assessment.

[232] (Aktualizace Státní energetické koncepce: Posousení vlivů na životní prostředí 2013)

[233] (Aktualizace Státní energetické koncepce: Posousení vlivů na životní prostředí 2013, 116-118)

[234] (Aktualizace Státní energetické koncepce: Posousení vlivů na životní prostředí 2013, 169,223)

[235] Ibid. p.170

[236] Ibid. p.225

The strategic environmental assessment report offers insightful information regarding the potential impact of the individual strategic goals outlined in NSEC. This assessment comes useful especially when looking at different scenarios for future development of the energy mix. Its importance in determining the change in environmental security of the country is undeniable and should not be discounted. The relationship between the future composition of Czech energy mix and its impact on the environment is inextricable and should thus reflect a mutual respect in terms of how we use our resources.

Conclusion

The thesis opens up with an introduction to the concept of environmental security and its evolution amidst the developing discourse of security studies. The importance this concept has gained in the last decades cannot be overlooked and has only been further amplified by multiple environmental disasters from which the environment emerged as an enormously powerful force. These tragedies have ranged from man-made oil spills, localized air pollution, or coal mine collapses to severe weather events like floods, fires or hurricanes. Traditionally, security studies have not been concerned with threats of non-military character. However, this has been changing as the concept of environmental security entered the process of securitization in the last decade or so. The increasing frequency and severity of environmental disasters challenges the traditional concept of security which does not consider environmental threats and thus in a way forces and drives the development of this concept. Another important point to emphasize is the call for a demilitarization of environmental issues where more effort is made towards employing risk management, preventive measures, resilience and adaptability.

The overarching focus of this thesis was to explore the nexus between the environment and energy procurement. It did so by analyzing the impact and consequences of the relationship between the Czech energy mix and the environment. More specifically it analyzes the environmental impact of energy procurement and management in the Czech Republic using the concept of environmental security. After rigorous research of the concept itself four main determinants of environmental security were selected for the study. These determinants reflect the main foundation of the concept in relation to the energy mix of the Czech Republic.

They therefore emerge as a combination of mutual characteristics pivotal both to the concept of environmental security as well as the Czech energy mix. These determinants are emissions, sustainability, economic factors and land resource use.

In order to put the actual evaluation of the selected determinants into perspective, the chapter on the State Energy Concept mix further explained the relevance and disposition of this strategic document within the policy environment of the Czech Republic. It emphasized the interconnection between domestic energy policy and the overarching European strategy and market. It also commented on the geographical situation of the country in terms of its relative dependence, namely on Germany, and the economic and decision-making consequences this relationship entails. The next chapter presents an overview of the Czech energy mix in order to illuminate the background of energy supply in the country. It also highlights certain supply and demand trends and offers a set of graphs designed to depict the local energy system in a more coherent way.

The empirical part of this thesis is presented in chapter four which evaluates individual energy sources represented in the Czech energy mix (coal, natural gas, oil, nuclear energy, renewable energy sources) using the selected determinants of environmental security. In other words, the theoretical basis of the thesis is tested on an actual case using the *New State Energy Concep*t (NSEC). Each source is then analyzed through all the determinants and an appropriate value of the environmental security index is assigned to each source. The evaluation is based on statistical and empirical data supported by independent studies from relevant sources. The final values of the environmental security index are then adjusted according to the changes in each source's share in the energy mix for the reference year 2040. This assessment ultimately reveals that the environmental security of the Czech Republic will see a substantial improvement if the current version of NSEC is ratified and all relevant circumstances and projections remain valid.

Nevertheless, it is essential to underline that the energy sector is an extremely vibrant environment where changes take place at an unprecedented rate, especially in the last decade. This is evident notably when looking at NSEC future predictions for renewable energy sources in the Czech Republic which are already proving wrong in just under a year since drafting the energy concept. Although some projections might prove wrong, it is likely they will result in

an additional improvement in environmental security for the country. This will particularly hold true for areas with dynamic technological progress such as energy efficiency, RES, electrical grid and BAT standards. Energy efficiency, for instance, is one of the most contentious points often highlighted by ecological organizations, NGOs and various experts as being largely underestimated in NSEC. Should more improvements in energy efficiency become available in the future, the country only stands to benefit as energy demand would decrease resulting in reduced heat and electricity generation. Less financial expenditures in one sector can incentivize investment in other sectors, potentially increasing environmental security through environmental friendly projects. Another factor to most likely influence electricity prices and to have a substantial impact on the European energy market is the price of CO_2 allowances on the European Energy Exchange. If high enough it could increase the level of environmental security in the country by reducing electricity generation from coal-fired power plants and adding more funds into the Ministry of the Environment's energy efficiency budget which focuses on energy savings and renewable energy sources in family houses.

Implications for the Concept of Environmental Security

Even though the concept of environmental security is still rather new and has not established a firm position in the current security studies discourse, it still offers valid insight into the matter of environmental issues. As Braden R. Allenby suggested, environmental security can act as a comprehensive overarching concept encompassing the resource security dimension, the energy security dimension, the biological security dimension as well as the traditional security dimension.

This thesis suggests that energy security has many similar characteristics with environmental security but needs to be considered outside of this concept as environmental security is not particularly concerned with the availability and reliability of energy supply.[237] It can be argued that by increasing the level of environmental security in the Czech Republic the subordinate dimensions will follow the same trend to a certain extent. This means that the

[237] This is why energy security factors were mentioned in a special chapter entitled *Additional energy factors pertaining to the environmental security of the Czech Republic*.

traditional security dimension might improve along with higher levels of environmental security but could be diminished by factors which are not included in the concept such as military threats.

Nonetheless, it will prove very effective in determining the security of a country solely based on non-military threats. In order to conduct a comprehensive analysis, specific cases must be selected where military threats do not enter the equation. Moreover, additional circumstances like political situation and geopolitics must be considered. This was demonstrated by examples of possible energy supply interruptions for the Czech Republic looming from the east. Overall, selecting emissions, sustainability, economic factors and land resource use has proved very conducive in analyzing the level of environmental security in the Czech Republic and has added to the relevance of this concept in the current security studies discourse.

Implications for the Environmental Security of the Czech Republic

The author acknowledges certain limits to testing the concept on the Czech energy mix as it is difficult to accurately quantify some of the determinants on imported energy commodities or other energy processes conducted outside of the country. Having established the value 12 as the neutral value of the environmental security index, only 2 energy sources in the current Czech energy mix were evaluated as having a negative impact on environmental security (coal and oil). Nevertheless, both sources are expected to see their use decline over the next decades and only oil was assessed as having a negative impact on environmental security in 2040 for its low projected rate of consumption decrease. The share of coal is projected to ebb significantly in the next ten years as its electricity generating capacity stands up to be replaced by nuclear energy and RES. Substantial increases in the share of nuclear energy and RES will both have a positive impact on the level of environmental security as their emissions are the lowest of all currently used energy sources. The inconvenience of using these sources is their financial cost where nuclear energy has the highest initial investment cost and RES still largely rely on hefty feed-in-tariffs. This is where assessing economic factors with individual energy sources proved very valuable as NSEC does not include any type of economic analysis of the energy mix.

The only finite hydrocarbon source to most likely follow an upward curve in regards to consumption is natural gas which is still abundant throughout the world. Moreover, new unconventional forms of natural gas are being explored with partial success in some regions (USA) which could further add to its availability on the world markets. However, its price remains relatively high to other resources, consequently weakening its role of a bridge fuel. The overall improvement in the level of environmental security based on the selected determinants is significant. According to NSEC the Czech Republic aspires to follow the trend of most progressive countries where coal and oil consumption is dwindling while being replaced by more environmentally friendly energy sources coupled with increased energy efficiency. However, numerous objections have been made criticizing NSEC for not being ambitious enough in regards to energy efficiency, renewable sources of energy and unfounded projections that do not correspond with the current European trend.

The chapter on other important aspects identified some important elements to consider when weighing the advantages and disadvantages of various energy sources. It discussed Energy Return on Energy Invested, energy efficiency, energy externalities, energy security factors and the Environmental Impact Assessment. These are all factors that bear great significance in choosing the appropriate energy source and it is therefore highly recommended that policy makers expose them to scrutiny in order to make prudent and sound decisions.

It is very likely that the current composition of the Czech energy mix outlined in the *New Strategic Energy Concept* will see several changes and adjustments in the future. However, this thesis will not lose its relevance should such changes occur as it provides the reader with a comprehensive methodology where the values of environmental security index can be adjusted to any alterations of future versions of the State Energy Concept. This thesis can also be used as a reference study for further research of environmental security and energy policy as more studies are needed to explore the nexus between these two areas.

Summary

This thesis introduces an evolving concept of environmental security which has been slowly penetrating the discourse of security studies in the last couple of decades. The concept has gained in significance due to deteriorating environmental conditions and frequent environmental disasters spurring academic and political debate about the causes and possible solutions. The theoretical part identifies the main arguments for elevating this concept in the international relations and security studies areas along with pointing out the most frequent criticism from the traditional stream of thinkers. Those who endorse the concept often call attention to the inability of the traditional concept of security to include environmental issues into its portfolio and criticizing its military approach used for dealing with threats. The proponents of the traditional concept of security advocate that including environmental issues would irreversibly alter the very foundations of the concept of security.

The concept is then applied on the energy mix of the Czech Republic in order to evaluate its impact on environmental security using four determinants most relevant to the case study. Emissions, sustainability, economic factors, and land resource use factors are employed to determine the environmental security index of the current energy mix where each energy source is assigned a numerical value. The main chapter then draws a comparison between the current energy mix and its future composition as outlined in the New State Energy Concept which is the most substantial strategic document concerning energy policy of the country. This analysis shows a significant improvement in the level of environmental security for the reference year 2040 based on the selected determinants. It also discusses other additional factors relevant to energy policy that should be considered when devising an appropriate energy mix.

The study offers a viable case study example for testing the main thesis of the concept of environmental security which could add to its growing importance in addressing environmental threats in the modern era. It evaluates the proposed energy mix as having a positive impact on the environmental security in the Czech Republic and elaborates on additional factors to consider in case the conditions on the energy market change in the future.

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