MSc Program
Environmental Technology & International Affairs

# The Implementation of Climate Change into Environmental Impact Assessment - Theoretical and Practical Approaches of Adaptation and Mitigation Strategies

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
Dipl.-Ing. Dr. Klaus Rapp

Martin Schönberg

0714310

Vienna, 12 June 2015

# Affidavit

I, **Martin SCHÖNBERG**, hereby declare

1. that I am the sole author of the present Master's Thesis, "THE IMPLEMENTATION OF CLIMATE CHANGE INTO ENVIRONMENTAL IMPACT ASSESSMENT - THEORETICAL AND PRACTICAL APPROACHES OF ADAPTATION AND MITIGATION STRATEGIES", 70 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 12.06.2015

Signature

## Abstract

For more than four decades, various regulatory frameworks for environmental impact assessment (EIA) have been established on the international, supranational (European) and national levels. As far as EIA procedure is concerned, climate change has been taken into consideration only recently. This master's thesis aims at synthesizing possible ways of addressing climatic effects by means of EIA. An extensive literature research and analysis point out that these approaches are not just theoretical but also include practical aspects. This is demonstrated by the comparison of the respective legal foundations and practice in Austria, Denmark, Germany and Italy. In addition, the interdisciplinary master's thesis adds a crucial part to the current scientific discussion as all approaches can be categorized as either mitigation or adaptation measures. Further, energy efficiency is identified as a successful proxy to include climate change into EIAs, as it has already been realised by the unique Climate and Energy Concept in Austria.

**Table of Contents**

## List of Abbreviations

| | |
|---|---|
| § | "Paragraph"; article of a law |
| BGBl | "Bundesgesetzblatt"; Federal Law Gazette of the Republic of Austria |
| CAEC | Climate And Energy Concept |
| CHP | Combined Heat and Power Generation Plant |
| $CO_2$ | Carbon dioxide |
| ECJ | European Court of Justice |
| EEffG | "Energieeffizienzgesetz"; Austrian federal energy efficiency law |
| EIA | Environmental Impact Assessment |
| EIS | Environmental Impact Statement |
| GHG | Greenhouse Gas |
| ICJ | International Court of Justice |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPC | Integrated Pollution Prevention and Control |
| lit. | "littera"; letter |
| no. | Number |
| OECD | Organisation for Economic Co-operation and Development |
| Petajoule | 1 Petajoule (PJ) = $10^{15}$ Joule; Joule = SI (Système International) unit for energy, whereas 3.600.000 J = 1 kWh |
| para | paragraph |
| SEA | Strategic Environmental Assessment |
| SME | Small and Medium Enterprises |
| SUP | "Strategische Umweltprüfung"; German expression for SEA |
| UNECE | United Nations Economic Commission for Europe |
| UVE | "Umweltverträglichkeitserklärung"; German expression for EIS |
| UVP | "Umweltverträglichkeitsprüfung"; German expression for EIA |

**Acknowledgement**

First and foremost, I would like to thank my parents for the support they have provided me over the years and especially during my studies. Without their assistance, I would not have been able to finance neither my undergraduate studies nor the postgraduate master's programme „*Environmental Technology and International Affairs*".

I would also like to express my gratitude to my supervisor, Dr. Klaus Rapp, for his suggestions and support in writing this master's thesis.

# 1 Introduction

Human-induced negative effects on the environment were widely ignored until the late 1960s (Iemmi, 2010). The United States (US) was among the first countries that established a legally binding assessment of environmental impacts, namely with the so-called "*National Environmental Policy Act of 1969*" (Wood, 2003). In the European Union (EU), the public concern about the local environment culminated only in the 1980s, mainly caused by the death of the forests (Farmer and Stadler, 2005). This newly developed environmental awareness led to the introduction of a legally binding assessment of infrastructure projects. In the European Union, the *Environmental Impact Assessment (EIA) Directive of the year 1985* ("*Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment"*) constitutes the normative basis (Schnedl, 2012; European Commission - DG ENV, 2009). According to Schnedl (2012), this assessment method deals with all environmental media and comprises an identification, description, and assessment of direct and indirect impacts of public and private projects, which *are likely to have significant effects* on the environment. In addition, the EIA procedure even includes the participation of the public. The results of an EIA play a decisive role whether a project will be approved or not by the competent authorities. To cut the matter short, various legal acts have been passed that deal with the assessment of environmental impacts of projects in the US and in the EU as well.

Moreover, respective national legal foundations dealing with EIAs can be found throughout all European member countries, though with slight variations. Since EU directives are just binding as to their aim - as laid down in Article 288, paragraph 3 (Consolidated Version of the Treaty on the Functioning of the European Union [TFEU], 2012) - the EIA directive has to be transposed into national law. For instance, the EIA directive is transposed by the "*Umweltverträglichkeitsprüfungsgesetz*" (UVP-Gesetz) in Austria (Schnedl, 2012). Due to the transposition and national interpretation, the extent to which several topics are covered by EIAs differs among EU countries. In this context, two hot topics have to be highlighted that are only partly covered by the national EIA regulations. Namely, it is at issue how climate change and energy efficiency can be incorporated into the assessment methods.

First, climate change is just partly covered by EIAs, even though it is amongst the most widely discussed topics today. Climate change is mainly attributed to the tremendous increase of the concentration of atmospheric carbon since the Industrial Revolution (Houghton et al., 1983; Houghton, 2010; Houghton, 2003). It is undisputed that this rise in greenhouse gas (GHG) emissions is to a large extent human-induced (Pérez de las Heras, 2013; OECD, 2008). The burning of fossil fuels and certain forms of land-use have been causing an increase in carbon emissions since the mid of the 19th century, globally and in Austria as well (Erb et al., 2008). For several decades, more carbon - mainly in the form of $CO_2$ - has been released to the atmosphere than vegetation or oceans are able to take up. However, climate change has not been fully taken into consideration within EIAs. This is due to its features that include its trans-boundary character, time delays, the interconnectivity of various fields and uncertainties (European Commission, 2013a).

One solution to implement climate considerations into EIAs might be to include the concept of energy efficiency instead. Energy efficiency is seen as a method to reduce the total demand for energy by simultaneously becoming more climate-friendly. From a thermodynamic point of view, this means that the degree of effectiveness is altered (Erdmann and Zweifel, 2010). According to the same authors, this can be realized by a higher output of energy that is usable, or by lowering the energy input.

For several years, it has already been state-of-the-art to address climate change by means of energy efficiency. This is reflected in the *"Climate and Energy Package"* that is based on the communication "*An energy policy for Europe*" of the year 2007 (Böhringer and Keller, 2011). The same authors point out that this package includes the famous "*20-20-20 targets*", stating the objectives of the EU for the year 2020: 20 % less GHG emissions, a 20 % higher share of renewable energy sources and a 20 % increase in energy efficiency. As demonstrated by Loffredo (2011) and the European Commission (2009b), the European Union puts a special emphasis on the elaboration of guidelines dealing with the integration of climate aspects into EIAs. Another case in point is that the EIA directive has been amended recently referring implicitly to energy efficiency, as in annex IV § 1 lit. c *„energy demand and energy used"* are stated (Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, 2014). Furthermore, climate change and energy efficiency are already taken into consideration within EIAs in Austria by the mandatory *Climate- and Energy Concept* (*"Klima- und Energiekonzept"*) introduced with the UVP-Gesetz 2000 (BMLFUW, 2010).

However, this master's thesis aims at providing an overview of how climate change and energy efficiency can theoretically be implemented into environmental impact assessments.

The subsequent research questions have been generated after an examination of the literature:

- What possibilities exist to implement climate change and energy efficiency into EIAs? Do these theoretical approaches - as partly suggested by Agrawala et al. (2011), Bell et al. (2002), Byer and Yeomas (2007) and the Canadian International Development Agency (n.d.) - differ from "climate proofing" (Birkmann and Fleischhauer, 2009)?

- What is the standard in other European member states? Do legal foundations or similar instruments like the Austrian Climate- and Energy Concept for EIAs exist (BMLFUW, 2010)?

## 1.1 Methodology

In this master's thesis the qualitative method of literature research and analysis is applied. In order to reach a potentially complete illustration of the state-of-the-art, the main ideas for this thesis are excerpted from specialist journals, monographs, newspapers, and scientific online sources that are available in German, English and Italian. The scientific added value is that the findings of various disciplines are merged. The scientific field taken into consideration ranges from natural sciences, technology, law, politics, to environmental economics. Since the Climate- and Energy Concept (CAEC) is just mandatory in Austria, the practice and legal foundations of other EU member countries (Italy, Denmark and Germany) are scrutinized as well. This thesis aims at re-combining all these findings leading to policy recommendations for the implementation of climate change into environmental impact assessments.

## 1.2 Outline

This master's thesis presents a general description of environmental impact assessments in the first section. Subsequently, the legal background of EIAs is elucidated attributing the central legal foundations to international, supranational, and national law. Next, the concepts of climate change and energy efficiency are defined and brought together. Following this, various theoretical and practical approaches are outlined. All these approaches constitute possible options for the implementation of climate change into EIAs. A résumé concludes the discussion with final remarks and a critical reflection.

## 2 Environmental Impact Assessments

In general, four main types of environmental assessment exist. They include *Nature Impact Assessments*, *Territorial Impact Assessments*, *Environmental Impact Assessments* and *Strategic Impact Assessments*. Not included in this classification are *Climate Assessment Impacts,* which are foreseen by Austrian law, as they just constitute a mere legal analysis. (Schnedl, 2012)

*Nature Impact Assessments* comprise an analysis of the compatibility of plans and projects with the Natura 2000 protection areas that are based on the *Habitats Directive (92/43/EEC on the Conservation of natural habitats and of wild fauna and flora*) and on the *Birds Directive (2009/147/EC on the conservation of wild birds*). *Territorial Impact Assessments* are performed for projects that have spatial-related impacts on the economy, on the labour market, on the development of settlement and traffic, or on the environment. This type of assessment is not based on European Union law. In contrast, *Environmental Impact Assessments (EIA)* and *Strategic Impact Assessments* (or *Strategic Environmental Assessments, SEA*) are based on European Union law. The basic idea of an EIA is to examine the environmental impact of construction and infrastructure projects before their realisation, whereas SEAs deal with impacts of public plans and programmes. (Schnedl, 2012)

The Austrian law defines the main tasks of an EIA by the identification, description and assessment of a project on the environment - §1 para 1 UVP-G (BGBl. 1993/697 changed by BGBl. I 2000/89, consolidated version: 14/05/2015). These analyses comprise all environmental media (air, water and land), and therefore regard the environment as a whole. Owing to these features, Perman et al. (2003) refer to the EIA as an alternative to a cost-benefit analysis. In an EIA, possible adverse effects of a project on the environment are examined. These effects mainly occur due to emissions into the air, various forms of waste and wastewater, noise, vibration, electro-magnetic fields/ radiation, heat and light. These impacts affect various subjects of protection including human beings, animals, plants, water, air, climate, landscape, ground, material assets, and cultural heritage (Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, 2014).

After the initial idea, technical and economic feasibility studies, and (pre-)planning stages; the developer applies for the authorization of a public or private project at the competent authority (see Figure 1). In the first stages of a project, two processes are central: screening and scoping. Screening refers to the analysis whether a project is subject to an EIA or not. If an EIA has to be performed, the relevant information and documents that have to be provided to the competent authority are determined in the scoping phase. In general, this information includes a description of the expected adverse impacts on the environment excluding social and economic issues.

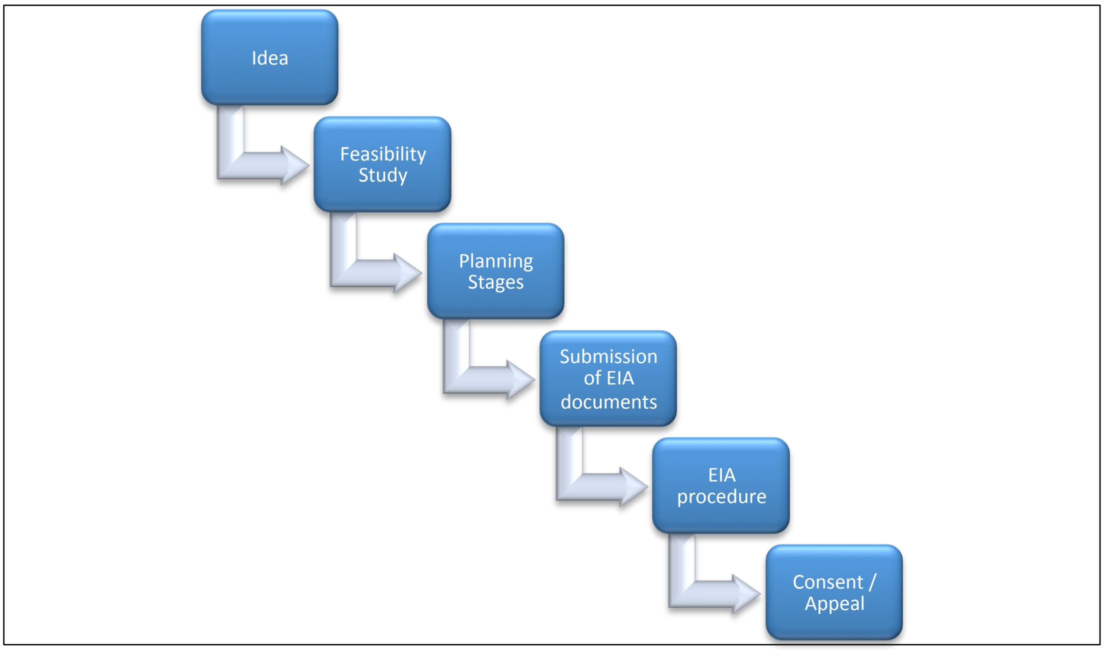


**Figure 1: Main Process Stages of a Project Subject to an Environmental Impact Assessment.**

According to § 19 UVP-Gesetz (BGBl. 1993/697 changed by BGBl. I 2000/89, consolidated version: 14/05/2015), multiple actors have a legal standing in the regular EIA procedure and have to be informed and consulted: neighbours, parties as per other legislative provisions dealing with specific environmental media (as for instance laid down in the provisions of waste management), the Ombudsman for Environmental Protection („Umweltanwalt“), the institution in charge of the planning of the water management (head of a provincial government), communities, citizen’s initiatives and environmental organisations. The competent authority takes a decision – a positive or negative consent to the project – that can be appealed at the next higher authority.

Additionally, the SEA is seen as a supplement or a preparation for an EIA. The basic idea is to consider environmental aspects already on an early stage. The legal basis for a SEA in Austria is found in numerous national and regional legal acts, even in building and waste management regulations. Short, the legal foundations of SEAs in Austria have a comprehensive, horizontal character. In German the technical legal term „*Querschnittsmaterie*" refers to this aspect. (Schnedl, 2012)

In this context, one might argue that no differences exist between SEA and EIA procedures. However, various examples can be highlighted that SEAs and EIAs differ. First, during the screening process of a SEA, the competent authority has to be contacted, in contrast to the EIA procedure. Furthermore, there is an obligation that reasonable alternatives have to be assessed and environmental effects are monitored within a SEA. In contrast, the EIA directive does not foresee a mandatory monitoring process, though a few EU member states have implemented it into their national legal foundations (European Commission, 2013a).

The previous paragraphs have highlighted the distinct types of environmental assessments. As EIA and SEA are originally not based on national law, the following section scrutinizes the various legal foundations.

## 2.1 Legal Foundations

As indicated in Figure 2, the legal foundations for EIA procedures can be identified at multiple levels. Whereas the international law constitutes the superstructure, the main source for legal acts in this field is the supranational European Union law. The legal foundations of the EU are of uttermost importance for the EIA procedure in all EU member states, symbolized by the central triangle. As the EIA directive has to be transposed to national law, respective legal foundations can be found in every member state. Though, in some countries, the European directives are not transposed by national law but by regional legislative acts.

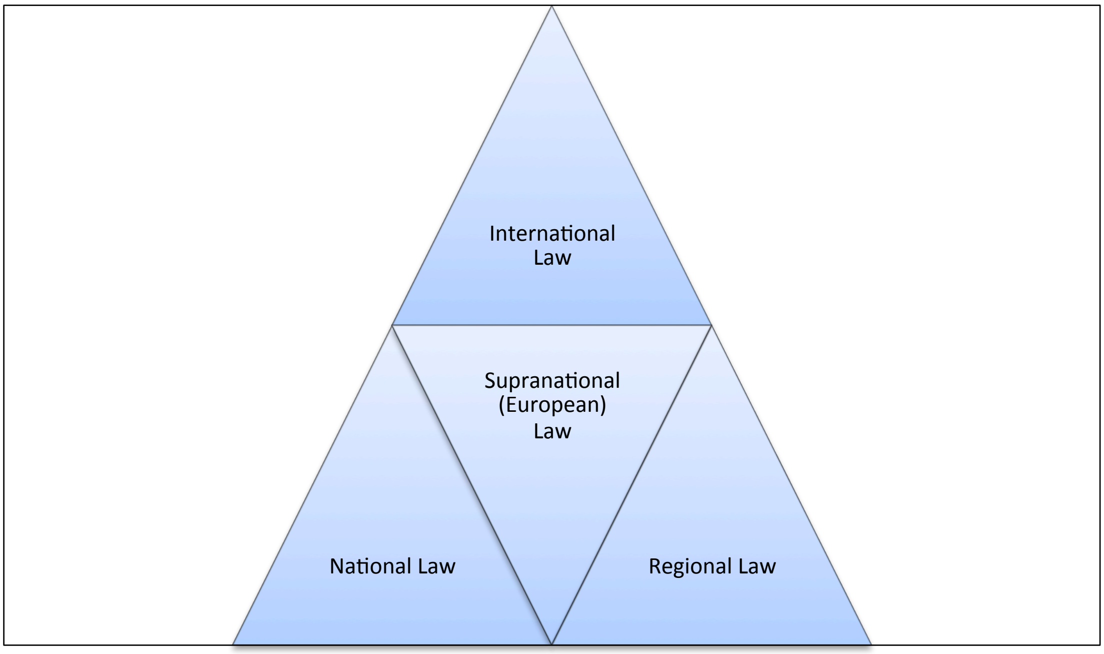


**Figure 2: The Main Sources of EIA Law.**

### 2.1.1 International Law

Various sources of international law exist. According to Herdegen (2011), the sources are listed in art. 38 para 1 lit. a to d of the *Statute of the International Court of Justice (ICJ)*: Lit. a refers to the international treaties, lit. b to the international customs, lit. c to the general principles of international law and lit. d. to the sources of the understanding of law (judicial decisions and teachings of the most highly qualified publicists). According to the same author, international environmental law is rather a new matter. Whereas two general milestones for environmental protection are the *Declaration of the United Nations Conference on the Human Environment of 1972* and the *Rio Declaration on Environment and Development of 1992*, environmental impact assessments have only recently gained more attention on the international level. So far, the EIA has found its way into the guiding principles of international law, and is reflected in the Aarhus Convention, the Espoo Convention, and in the ruling of the ICJ (*Pulp Mill Case*).

On the international level, several different guiding principles have been established for the protection of the environment. According to Schnedl (2012) these principles include the *precautionary principle, the polluter pays principle, the sustainability principle, the integration principle and the cooperation principle*. Amann and Maas (2015) list slightly different principles. The principles mentioned by them comprise the precautionary principle, the polluter pays principle, the common but differentiated responsibilities, the inter- and intra-generational equity and environmental procedural rights. However, Amann and Maas (2015) underline the importance of EIA, as they add the requirement to conduct a comprehensive environmental impact assessment to the six main organising principles for international environmental agreements.

Beside these generic principles, many international frameworks exist that constitute a normative basis for the EIA procedure. Without providing an exhaustive list of all of the legal texts, just the two main ones are outlined. These are the *Aarhus Convention* and the *Espoo Convention*.

First, the *Aarhus (also: Århus) Convention* deals with public participation and information. The original title of this legal text of 1998 is "*Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in*

*Environmental Matters*" (UNECE, 2001). This framework comprises three main pillars. The first pillar addresses the access to environmental information (art. 4), which equals the legal right to access information about the environment, human health and related aspects. There is reactive access to information when people have the right to access information without proving an interest, and the proactive access to information including the collection, transparent management, and dissemination of necessary information. The second pillar deals with public participation (art. 6-8). It includes the information of the public about the process of approval of a project and the possibility to give comments that have to be considered by the competent authorities. The third pillar refers to the access to justice (art 9). It introduces investigation procedures and the possibility to appeal against the decision of the authority (in case it is not a judgement of the Court of Final Appeal). (UNECE, 2001)

Second, another central normative basis is the *Espoo Convention*, also known as the "*UNECE Convention on Environmental Impact Assessment in a Transboundary Context"* (Schnedl, 2012). It was signed in 1991 and entered into force in 1997. The Espoo Convention deals with the notification and consultation of states and of the public on projects with trans-boundary environmental impacts. The Kyiv Protocol to the Espoo Convention is also noteworthy in this context because it obliges its signatories to assess the environmental impacts of plans and programmes. In other words, with the Kyiv Protocol the Strategic Environmental Assessment has been established on an international level. (UNECE, 2010)

Additionally, the *Pulp Mill Case* ("*Pulp Mills on the River Uruguay - Argentina versus Uruguay*") (Herdegen, 2011) constitutes a decisive ruling of the ICJ. The ICJ decided that an EIA is necessary for a project at the border river Uruguay, which is located between the countries of Argentina and Uruguay. The EIA has to be performed prior to realisation of the industrial plant due to the risk of activity with a significant adverse effect on the river that is used of both countries. The ICJ based its decision not only on the existing treaty between the countries but also on the international customs. Short, the ruling of the ICJ in the Pulp Mill Case is the first one on the international level dealing explicitly with a necessary trans-boundary EIA procedure based on customs. (International Court of Justice, 2010; Herdegen, 2011)

To cut the matter short, the EIA has recently gained more attention from an international perspective. The EIA procedure is reflected in the guiding principles of international law and in a number of international treaties. Moreover, it has already received attention in the jurisdiction of the ICJ.

### 2.1.2 EU Law

All the international legal matter is reflected in supra-national (European) and national legal sources. Although resource-nationalistic thinking still dominates in most member states of the European Union, many steps have been taken to harmonize environmental policies since the 1990s. This means that the member states have assigned many competences to the EU; so today many environmental issues are a matter of the Union, or even more specific, of the "*institutional triangle*" of the EU comprising *the Commission, the European Parliament*, and *the Council*. In general, the legislative acts of the European Union in the field of the environment have a specific character. The environmental law of the European Union is neither international law, nor national law, but constitutes an independent legal system (Schnedl, 2012). The environmental law of the European Union comprises all legal rules of the Union for the protection of the environment, whereas both an extended definition of the environment and an ecological understanding are incorporated. Moreover, the environmental legal provisions of the European Union are part of the so-called *acquis unionaire* (former *acquis communautaire*), which refers to the sum of all the legal foundations of the EU – such as treaties, acts and decisions – that require harmonisation within the Union. As all legal matter, also the concrete policies and legal foundations of the EU in the field of the environment – especially dealing with EIA, climate change and energy efficiency – can be categorized into primary law, secondary law, supplementary law, as well as policy documents and instruments.

First, the primary law of the European Union comprises the *Treaty on the European Union* (Consolidated Version of the Treaty on European Union [TEU], 2012)*, the Treaty on the Functioning of the European Union* (Consolidated Version of the Treaty on the Functioning of the European Union [TFEU], 2012) and the *Charter of Fundamental Rights* (Charter of Fundamental Rights of the European Union [CFREU], 2000). The two founding treaties and the Charter of Fundamental Rights of the European Union are of equal ranks. All three of them have a special reference to the environment. In concrete, the preservation of the environment is defined as one of the objectives of the European Union in Art 3 paragraph 3 (TEU, 2012), in Art 11 (TFEU, 2012) and in Art 37 (CFREU, 2000). With the *Treaty of Lisbon* 2007 (signed)/ 2009 (entry into force), special emphasis is put on climate change and energy efficiency in the Treaties, and new competences of law-making are granted to the EU. This is also highlighted by Schnedl (2012) and De Jong et al. (2010) who refer to the Union's new competences in the field of energy policy. The legal foundations are laid down in Article 194 paragraph 1 (TFEU, 2012) and include a common energy market, the security of energy supply, energy efficiency, development of new technologies, an emphasis on renewable sources and the interconnection of energy networks (Pérez de las Heras, 2013). Additionally, the combat of climate change is explicitly listed among the aims of the EU in Article 191 paragraph 1 (TFEU, 2012). However, even if various environmental aspects are addressed, EIAs are not explicitly mentioned in any source of primary law.

In contrast to primary law, secondary and supplementary law are more specific. Secondary law of the European Union comprises regulations, directives, decisions, recommendations, and opinions (Hartley, 2010). Regulations have a direct and immediate effect - Art 288, paragraph 2 (TFEU, 2012) -, whereas directives have to be implemented into national law. The latter are just binding as to their aim - Art 288, paragraph 3 (TFEU, 2012). However, a further categorization can be made according to general and specific law (Schnedl, 2012). General law has - in contrast to specific law - a comprehensive character. Especially in the field of the environment this categorization is crucial because most environmental issues can just be analysed from a comprehensive, horizontal angle. The term "comprehensive" or "general" refers to the fact that the law addresses various environmental media or compartments, such as the atmosphere, the hydrosphere and the lithosphere. Examples are the IPPC directive (Integrated Pollution Prevention and Control) that aims to prevent emissions from industries, and the EIA directive. On the other hand, (media-) specific law deals with a certain field of environmental law; for instance, environmental regulations in the area of the lithosphere. (Arndt, 2006; Schnedl, 2012)

In the European Union, the *EIA Directive of the year 1985 (85/337/EC on the assessment of the effects of certain public and private projects on the environment*) constitutes the normative basis for environmental impact assessments (Schnedl, 2012; European Commission - DG ENV, 2009; Directive 2011/92/EU of the European Parliament and of the Council on the assessment of the effects of certain public and private projetcs on the environment [EIA directive], 2012). The two annexes (I and II) of the Directive provide a categorisation of projects for which an EIA is necessary. For all projects listed in Annex I – no matter whether they are public or private – an EIA has to be performed, Art. 4, para 1 (EIA directive, 2012): Examples are crude-oil refineries, thermal power stations, iron and steel smelters, construction of motorways, waste incineration plants, pipelines, dams; all exceeding a certain given threshold of dimensioning or output (usable or not). In contrast, for all the projects that are listed in the Annex II, member states have to decide whether a project is subject to an EIA or not. This can be done by a case-by-case examination or by setting thresholds and criteria - art 4, para 2, lit a and b (EIA directive, 2012). The projects in Annex II are in the fields of agriculture, energy industry, extractive industry, metals production and processing, chemical industry, food industry, textile industry, paper industry, tourism and others - Annex II (EIA directive, 2012). The field of application of EU member states in the screening process is constrained by Annex III because the listed criteria are decisive whether Annex II- projects are subject to an EIA or not.

There are three major amendments of the Directive 1985/337/EC (European Commission, 2015a): First, the Directive 97/11 constitutes the transposition of the Espoo Convention dealing with EIA in a trans-boundary context. In addition, the list for which EIA projects are mandatory is expanded by the same amendment. Second, in 2003 the Aarhus Convention (with the main pillars *public participation, information* and *justice*) was incorporated into the EIA legislation by the Directive 2003/35/EC. Finally, with the Directive 2009/31/EC the first two Annexes were expanded including new technologies, such as Carbon Capture and Storage (CCS). The final codification of all the three mentioned Directives took place in 2011, right after the „*Conference for the 25th anniversary of the EIA Directive*“ which took place in Leuven, Belgium, in November 2010. This Directive (211/92/EU) was amended again in 2014 (2014/52/EU). (European Commission, 2015a)

According to the European Commission (2015b), the latest amendment aims at the simplification of the screening procedure and of the assessment of negative impacts on the environment. The same source points out that EIA reports and development consent decisions should be written more clearly and be transparent. Additionally, also time limits for the screening decision (90 days) and for public consultations (30 days) are stipulated (European Commission, 2015b). According to art 8a para 5 (EIA directive, 2012), final decisions of the competent authority have to occur within a "*reasonable period of time*. Though, unlike other legislative sources – such as Art 21 para 3 of the Annex 2 of the *WTO Agreement* (World Trade Organization, 2015), the EIA directive (2012), does not provide any definition what a reasonable period of time is.

Additionally, the preface of the consolidated version of the EIA directive (2011) gives an overview of the central legal sources on which the directive is based: Article 191 (TFEU, 2012) is mentioned as it recalls the precautionary principle of international law. Moreover, the preface highlights the significance of various documents for the legal foundations of the EIA directive, such as „*The mid-term review of the sixth Community Environment Action Programme*", '*Roadmap to a Resource Efficient Europe', "The United Nations Convention on Biological Diversity", "Europe 2020 – A strategy for smart, sustainable and inclusive growth"* or *the "UN Hyogo („Disaster Reduction") Framework for Action Programme"* (EIA directive, 2011).

In contrary, not only primary and secondary law are the only part of legal provisions dealing with EIAs. However, at least case-law has to be added to the picture. Case-law is categorized as "supplementary law" that usually includes the case-law of the European Court of Justice, international law and the general principles of law (Schnedl, 2012). In this context, just the European case-law is taken into consideration. The European Union (2013) provides an overview of the main rulings of the Court of Justice concerning the EIA of projects, categorised into *general statements of the Court of Justice (principals), statements of the Court in particular cases, judgements including cases of infringement of Union law* and *preliminary rulings*. An example of supplementary law is the case *Umweltanwalt von Kärnten (C-205/08)*, where the Court ruled that even if the size of the national part of a transboundary project is below the legal threshold values, the project is subject to an EIA if the total size of the project requires an EIA (European Union, 2013).

To cut a long matter short, various legal provisions that can be categorized in primary, secondary and supplementary law, deal with environmental impact assessments on the European level. Secondary law complements primary law, whereas both are specified by case-law of the European Court of Justice (ECJ).

Throughout the previous chapters, it has been clearly shown that various legal provisions of the EU address EIAs comprehensively. Additional to these legislative acts, the EU sets goals and priorities by publishing policy documents and by applying certain instruments. Green *Papers, White Papers, and Communications; Environment Action Programmes and Plans;* and *Public Private Partnerships (PPPs)* can be differentiated, especially in the fields of energy efficiency and climate change.

First, in the field of energy efficiency and climate change several green papers have been published. In this context, "*green paper*" refers to a report that deals with a specific topic and simultaneously constitutes the basis for policies and further strategies. Two examples are "*Towards a European Strategy for the Security of Energy Supply*" (European Commission, 2000) and "*A European Strategy for Sustainable, Competitive and Secure Energy*" of the year 2006 (Böhringer and Keller, 2011; Adelle et al., 2009). Furthermore, "*white papers*" of the European Union are mostly based on green papers. A case in point for this type of policy document is the "*White Paper on Adapting to Climate Change*“ (European Commission, 2013a). White papers can also be the starting point for action programmes (European Union, 1995-2015). Additionally, *communications* are used as an instrument to implement new policies. "*An energy policy for Europe*" of the year 2007 is a widely known communication (De Jong et al., 2010). On basis of the latter the "*Climate and Energy Package*" has been started. This Package includes the famous "20-20-20 targets", stating the objectives of the EU for the year 2020: 20 % less greenhouse gas (GHG) emissions, a 20 % higher share of renewable energy sources and a 20 % increase in energy efficiency (Böhringer and Keller, 2011; De Jong et al., 2010).

Secondly, *Environment Action Programmes and Plans* have been introduced to implement the Union's policies and strategies (Bahgat, 2011). The first Environment Action Programme was already published in 1973. The 7th Programme is in action since January 2014 and will act as guidance for environmental policies till the year 2020. The current programme includes a vision for the year 2050 and focuses on the key objectives natural capital, a resource-efficient low-carbon economy, and environmental safety, as it is highlighted and specified by the "*Energy Roadmap 2050*" (Riley et al., 2012). In addition to these programmes so-called *Action Plans* address single subjects and specify policies and strategies. The most famous one is the "*EU Energy Security and Solidarity Action Plan*" of the year 2008: It comprises the five elements *infrastructure, external energy relations, oil and gas stocks and crisis response mechanisms, energy efficiency* and *the use of indigenous energy resources* (Adelle et al., 2009; De Jong et al., 2010; Umbach, 2010).

A completely different policy instrument and approach is the participation in Public Private Partnerships (PPPs). With PPPs, projects of the government and private enterprises are realized together. A case in point is the European Energy Efficiency Fund that has been introduced to finance energy projects. (European Energy Efficiency Fund, n.d.)

All these elements clearly highlight that the EU's commitment in the sphere of EIA, climate change and energy efficiency does not stop with legislative acts, but even includes policy documents and instruments.

### 2.1.3 National Law – Austria

The current Austrian UVP-Gesetz goes back to the year 1993, where the EIA and the citizen's participation were introduced by the Federal Law Gazette no. 697 (BGBl, 1993/697). Since the European EIA directive does not have a direct and immediate effect and is just binding as to its aim - Art 288, para 2 and 3 (TFEU, 2012)-, it has to be transposed into national law. The European EIA directive is implemented into the Austrian UVP-Gesetz. This law is constantly updated, but has recently undergone only minor changes. The main amendments in Austria were necessary due to changes in the European EIA-directive, in 1997, in 2000 (therefore the law in Austria is known as the „UVP-Gesetz 2000") and in 2003, the latter adding the legal standing of environmental organizations in the EIA procedure. However, beside the UVP-Gesetz and its amendments, help for the single process steps, the implementation and the application of the EIA-law is provided by manuals, such as the *guide for environmental impact statements (EIS)* (Umweltbundesamt GmbH, 2008), and the guide for the climate and energy concept (BMLFUW, 2010). Additionally, help for the application of the law is provided by guidelines for certain branches and above all, by the circular „Rundschreiben UVP-G 2000" (BMLFUW, 2011).

Not all European directives are directly transposed into national law. One case in point is the *Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment* (Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment [SEA Directive], 2001). The SEA can be understood as a supplement to the EIA with the aim of taking environmental issues of a project as soon as possible - already in the planning phase - into consideration. In Austria, no special "SEA- law" exists. In concrete, the legal basis for a SEA in Austria is found in numerous national and regional legal acts, such as the law relating to water (*Wasserrechtsgesetz, WRG*), the law relating to waste management (*Abfallwirtschaftsgesetz, AWG*), the law relating to noise (*Bundes-Lärmgesetz*), the law relating to traffic (*Bundesgesetz über die strategische Prüfung im Verkehrsbereich*), the law relating to immission into the air (*Immissionsschutzgesetz Luft, IG-L*) and various regional provisions dealing with environmental planning and examination (*Umweltplanungsgesetz und Umweltprüfungsgesetz*). (Schnedl, 2012)

The Arhus Convention was not only implemented via the *European Directive 2003/4/EC on Public Access to Environmental Information* into the EIA provisions, but also found its way directly into the Austrian federal law establishing the law about public access to environmental information ("Umweltinformationsgesetz, UIG").

Similar as the European EIA Directive, the Austrian "UVP-Gesetz" also lists the projects that have to be subject to an EIA. The Annex 1 of the UVP-Gesetz (BGBl. 1993/697 changed by BGBl. I 2000/89, consolidated version: 14/05/2015) classifies 88 types of projects in the categories waste management, energy industry, handling of radioactive substances, infrastructure, mining, water management, agriculture and forest management, and other facilities (Schnedl, 2012). For all projects in one of these categories, a threshold value or a certain capacity is decisive whether an EIA has to be performed or not. The Annex 1 consists of three columns; projects that fall under column 1 and 2 are subject to an EIA, whereas for column-1-projects a regular EIA procedure has to be performed. For Column-2-projects, just a simplified EIA procedure is necessary. A simplified procedure refrains from a expert's report on the environmental compatibility ("*Umweltverträglichkeitsgutachten"*) but demands a summarising assessment of the impacts on the environment written by the competent authority. In contrary to the regular EIA procedure, the simplified one does not foresee a legal standing of citizen's initiatives. Though, these initiatives are seen as concerned parties who are allowed to inspect the records. In addition, a follow up-check after three or five years – as part of a regular EIA – is not included in the simplified procedure. Furthermore, column-3-projects are for projects in area meriting protection, such as bird protection areas and Natura-2000 reservoirs, alpine regions, water protection areas, air-polluted areas, and areas of settlement. *De lege lata*, an EIA is not immediately mandatory for column-3-projects, but each individual project has to be examined by the competent authority. (Schnedl, 2012)

Short, the national legislations dealing with the EIA and the SEA reflect the legislative foundations of the European and the international level. As the social, economic, technical, and natural environments cannot be considered as static, new challenges are constantly emerging. These have to be considered in the respective legislative acts for environmental assessments.

## 2.2 Justification of legal bodies to take action in the field of the environment

After having discussed the various legal foundations on the international, supranational and national level that deal with Environmental Impact Assessments in a broader sense; the question arises as to whether interventions by states or similar legal bodies can be justified in the field of the environment. For decades, it has been highly debated in science and public as well, *if*, *when* and *how* a state should intervene into the market and private activities. Moreover, it is a fundamental discussion in political philosophy. Libertarians and free-market capitalists may argue that the state should abstain from market regulations, whereas advocates of neoclassic economic and institutional theories justify interventions - as long the economic efficiency can be improved -, especially in the case of market failures, such as information asymmetries, monopolies and external effects.

In the case of Environmental Impact Assessments and Climate Change, the various legal foundations and regulations – as discussed above – mainly aim at internalising so-called external effects. In general, externalities or external effects are side effects that occur on non-participants due to decisions and activities. From an economic point of view, negative effects occur if the social costs are higher than the benefit, whereas a positive effect is present if the benefits exceed the costs. A classic example for a negative externality is bad air quality (in concrete, malodour/ irritation of the respiratory tract/ poor visibility) due to the emissions of a factory in the neighbourhood. In contrast, a positive externality might be to live in an area with well-tended front gardens in the neighbourhood.

Most people would agree that the state has to take action in order to regulate negative externalities or to prevent „public bads", such as bad air quality. In economics, public bads are the antonym to public goods, whereas both are defined by their non-rival and non-excludable use. In general, multiple (theoretical) ways and possibilities exist to internalise negative externalities and overcome the caused (economic) inefficiencies, for example *Pigou taxes* or discussions of the parties about the allocation – as stated by the *Coase- Theorem*.

To put it briefly, the human induced climate change can be regarded as an externality including positive and negative aspects. As negative aspects certainly prevail (as specified in Chapter 3.1 „The Effects of Climate Change“), from a mere neoclassical economic point of view, legal bodies have the right to intervene into the market and to pass respective legal acts in the field of the environment.

# 3 Challenges of Environmental Impact Assessments

Due to climate change, various new challenges occur in different fields and disciplines. Beside legal, economic and social challenges, the management of environmental effects is crucial for the success of a project. Therefore it is of uttermost importance to include considerations about the changing natural environment at an early stage of the project. To put it differently, climate considerations have to be included within EIAs as not only a project influences climate change, but also climatic effects are decisive for the (economic) success of the project. As it is difficult to include climatic effects directly into EIAs, an appropriate means has to be found. One solution to implement climate change into EIAs is to include the concept of energy efficiency. Energy efficiency can be defined as a method to reduce the total demand for energy by simultaneously becoming more climate-friendly.

In the following subchapters, the main effects of climate change are described leading to a characterisation of the reasons why climatic issues are difficult to tackle within EIAs. Subsequently, the concept of energy efficiency is presented, as a possible means to implement climate change considerations into EIAs.

## 3.1 The Effects of Climate Change

Due to the wide range of serious effects, climate change is amongst the most widely discussed topics today. The term *climate change* refers to the "*warming of the climate system [that] is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased*" (IPCC, 2013: 4).

These developments are attributed to the tremendous increase of the concentration of the greenhouse gases since the Industrial Revolution (Houghton et al., 1983; Houghton, 2010; Houghton, 2003). Today it is clear that the observed effects are anthropogenic or human-induced (Pérez de las Heras, 2013; OECD, 2008). Especially the burning of fossil fuels, cement industry and certain forms of land-use are responsible for the increase in carbon emissions since the mid of the 19th century (Erb et al., 2008). For several decades, more carbon (mainly in the form of $CO_2$) has been released to the atmosphere than vegetation or oceans have been able to take up.

The effects of climate change are tremendous and can be observed across all compartments of the earth. In the atmosphere, the air quality, the water cycle, and the mean temperature are affected. Oceanic ecosystems suffer from warming, acidification, rising sea levels, and a change in the thermohaline circulation. The cryosphere - comprising polar ice covers and glaciers - has constantly been diminishing. In addition, carbon cycles and biogeochemical cycles, that connect all spheres (atmosphere, biosphere, cryosphere, geosphere and hydrosphere), have been altered due to GHG concentrations and a higher positive radiative forcing on earth. (IPCC, 2013)

However, if the interaction between human activities and climate change is scrutinized, a two-way relationship can be detected (see Figure 3). This means that projects that are subject to an EIA are influenced by the consequences of climate change and can likewise affect the climate change and global warming.

First, projects have an impact on climate change through emissions that are generated during the construction, production or demolition phase or due to related activities. Another example is a change in water regimes due to one of these activities resulting in an adverse impact on the local climate.

Vice versa, multiple impacts have to be expected from a changing climate or from new climatic conditions on the project. This is especially true for projects with a long period of use, such as bridges and hydro power plants that both have a lifetime of about 100 years. In the past, climate considerations did not find their way into projects with a short lifetime: *"In the EIA climate change was considered to not to be a factor to the impacts of the project over its projected life of 25 years"* (Bell et al., 2002: 69). In addition, the Canadian International Development Agency (n.d.) identifies possible risks for projects that result out of changing climatic conditions. The same source classifies these risks into *atmospheric, hydrologic, hydro-meteorological* ones, and the *sea-level rise*, whereas the biggest hazards for projects will result out of "*…increased surface temperatures, decreased precipitation, more frequent and intense storms, changing weather patterns, sea level rise and changes in UV-light penetration levels"* (Canadian International Development Agency, n.d.: 25). Additionally, in Annex 2, *climate change* *induced hazards* are listed comprising *landslides, coastal flooding* and *river flooding, desertification, erosion, sedimentation* and *salinization* (Canadian International Development Agency, n.d.). Similarly, the European Commission (2013a) identifies the main adaptation and mitigation concerns due to *heat waves, droughts, extreme precipitation events, flooding, storms, landslides, rising sea levels, cold spells and snow, freeze-thaw damages,* and *wildlife fires*.

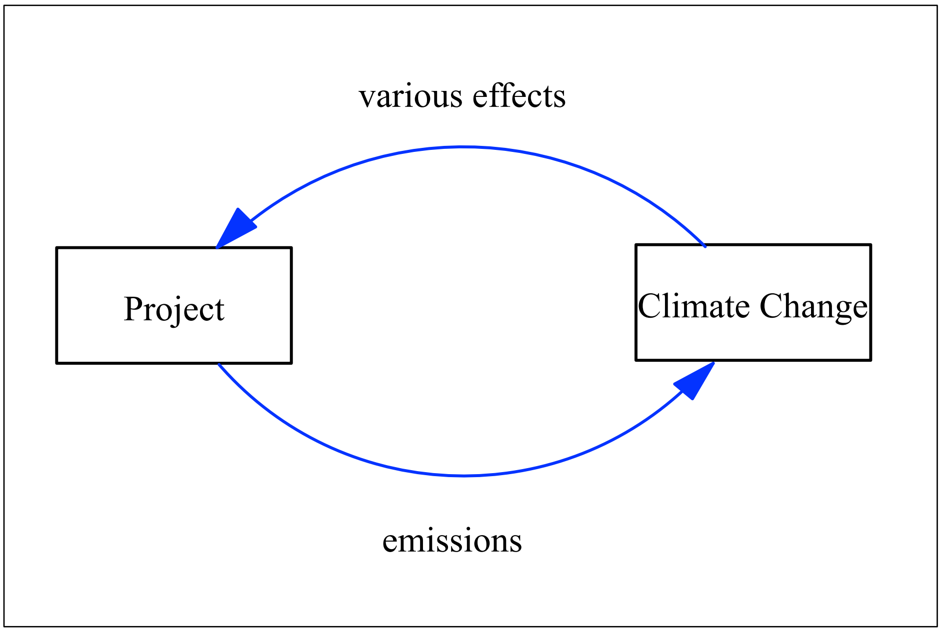


**Figure 3: Two-way Interactions between a Project and Climate Change.**

Moreover, different characterizations of (climate) effects exist. They include direct/indirect effects, cumulative effects, short-term effects, residual effects, and significant effects.

Firstly, *direct and indirect effects* of climate change on projects subject to an EIA can be distinguished. For example, direct or primary effects constitute a change in temperature or precipitation, whereas indirect or secondary effects occur when the output of a hydropower plant is lowered due to too much or too little water or a higher water temperature of rivers and lakes making the water use for cooling purposes especially during warmer periods difficult. In contrast, also direct and indirect effects of a project or a related activity on the subjects of protection exist.

Second, the terms "*cumulative effects" or "synergistic effects"* addresses both, *direct* and *indirect effects* (Canadian International Development Agency, n.d.; European

Commission, 2013a): These effects refer to the fact that climatic conditions and changing weather patterns are not an effect of actual activities, but are aggregated effects that have been influenced by human action and positive (reinforcing) and negative (moderating) feedback mechanisms over decades and even centuries. A case in point is an altered water regime (usually a reduction in the water flow) due to a decrease in precipitation, higher evaporation, and a lowering of the groundwater level (because more water is used for irrigation of agricultural lands).

Additionally, the European Comission (2013a) differentiates between *short-term*, *residual*, and *significant effects*. A short-term effect is for instance the induced traffic during the construction phase of a project. In contrast, residual effects are effects that persist after mitigation measures. Especially in the context of an EIA it is central to define what significant effects are. The European Comission (2013a: 8) explains them as "*effects that are significant in the context of the project, i.e. a function not just of magnitude or size of effect, but of the nature, sensitivity and scale of the receptor*." To put it differently, whether an effect is significant or not, depends on the intensity of the perturbation itself as well as the system or environment on which the effect acts.

To conclude, climate change is one of the biggest problems with tremendous and far-reaching consequences. Human activities influence global warming mainly by emissions, whereas the effects from climate change on the subjects of protection vary in place, time, orientation, and form.

### 3.1.1 Obstacles in Implementing Climate Change Effects into EIAs

Although climate change is one of the biggest challenges today, it has not gained sufficient attention within planning procedures and project management. The same is also true for environmental impact assessments. However, four main reasons exist why climate change is not fully taken into consideration within EIAs. They include its trans-boundary character, time delays, the interconnectivity of various fields, and uncertainties. Due to these features, it is difficult to incorporate climate change into EIAs.

Firstly, climate change has just been considered partly within EIAs due to its trans-boundary or even global character. Especially the quality and effect of greenhouse gases (GHGs) make it difficult to incorporate them into EIAs. However, the current climate research focuses mainly on carbon dioxide ($CO_2$) being the most common form of carbon in the atmosphere. Although this atmospheric trace gas has a relative smaller global warming potential than methane ($CH_4$), it has the largest share of all greenhouse gas emissions (Farmer and Stadler, 2005). Additionally, $CO_2$ is the most important link between various carbon reservoirs (Puhe et al., 2001). $CO_2$ is emitted globally and can even cause indirect effects in regions where it has not been released excessively. Therefore, there is no use in tackling GHG emissions only locally, as it is the case for other local and regional environmental problems and pollutants. For instance, the latter can be fought by the mere installation of end-of-pipe technologies, such as baghouse collectors or electro-static precipitators that filter particles in order to ameliorate the air quality of flue gases.

Second, climate change is a phenomenon that is characterized by time delays. Generally, $CO_2$ emissions remain in several reservoirs or compartments for a certain period of time. As a consequence, emitted carbon does not have a direct impact, but is accumulated in the atmosphere, where it can stay for more than a century (Erdmann and Zweifel, 2010). Extreme climate events - e.g. heavy precipitation - can occur decades later as an effect of former $CO_2$ emissions, but are independent on space and time from the former emission. To put it differently, since there is no direct link between release and immission, a time lag of many years exists.

Thirdly, the predictability of climate change effects is limited due to various interconnected fields. Although many scenarios of various organizations (like the Intergovernmental Panel on Climate Change; IPCC) exist, it is still difficult to assess the impact of climate change on projects and vice versa. The reason for this is that climate change and its impacts are not mono-causal events; hence interdependencies between various dimensions are obvious. Especially, energy production and climate effects are mutually influential. A case in point is that energy production and consumption have an environmental impact. For instance, $CO_2$ is emitted due to energy production and energy transformation leading to an increase of carbon in the atmosphere. On the other hand, climate change effects can have an influence on energy production and energy supply, as extreme weather events make the energy supply mainly out of renewable sources insecure. This is true for heavy rainfalls that force operators to open the sluice gates of hydro power plants, or for storms that cause a shut-down of wind parks. (Ebinger et al., 2011)

Finally, there are also uncertainties due to the complexity of natural phenomena. This means that limits of the computation and understanding of a process exist owing to multiple interrelated factors. Cases in point are feedback-mechanisms, such as cloud-albedo feedbacks. Especially the precise forecast of climate effects is impossible due to various reasons, such as the unpredictability of volcanic eruptions or future human behaviour. Therefore, climate scientist use a “calibrated language” to express uncertainties. A case in point is the IPCC report for policy makers (IPCC, 2013), where working groups have agreed on definitions for a certain probability; such as virtually certain (>99%), likely (>66%) or very unlikely (<10%).

Short, it is difficult to implement climate change aspects into the EIA procedure due to the trans-boundary character, time delays, interconnectivities, and uncertainties. However, various approaches have already been introduced to tackle the four main obstacles of taking climate change effects into consideration.

As already discussed, the Espoo Convention and the respective European and national amendments of the EIA directive and Court rulings have made it easier to include transboundary effects into the EIA procedure. In addition, the European Commission (2013a) suggests tackling long-term effects by using trend analysis and the consideration of environmental boundaries, as adaptive capacities. According to the same source, complexity can be addressed considering scenarios and investigating trends and drivers.

Byer and Yeomas (2007) highlight that one of the main theoretical issues in the implementation of climate change considerations into EIA is how to address uncertainties of climate change. In order to deal with this problem, the authors suggest three methods, namely scenario analysis, sensitivity analysis, and probabilistic analysis. Since these methods are widely used across many disciplines, they are just outlined roughly.

First, *scenario analysis* or technique refers to the extrapolation or projection of possible future development paths (Byer and Yeomas, 2007). These paths are estimated according to assumptions, whereas the field of possible paths is restricted by two extreme scenarios; in fact, by the highest and the lowest scenario, making up a "scenario funnel" (as it is illustrated for different energy policy scenarios in Figure 5, later in this thesis).

Another recommended method is the *sensitivity analysis* (Byer and Yeomas, 2007). Sensitivity tests are applied in all types of modelling as well as in economic and financial analysis. Usually, these models consist of parameters and variables. While the values of the variables are calculated or generated by the model itself, the parameters are constant and given externally. A sensitivity test investigates how the model results will be altered by slightly changing the input data of the parameters.

Possible questions of a sensitivity analysis can be:

- In technical/economic feasibility studies: How does the (hydro) power output change, if the upstream flow decreases by five per cent?
- In Cash-flow analysis: How does the cash-flow change, if the interest rate is 2 per cent higher, due to an increasing inflation rate?

The third and last method suggested by Byer and Yeomas (2007) is a *probabilistic analysis*. This analysis adds the probabilities to certain options, paths, or scenarios. In this context, probabilities are values that give information about the likelihood of occurrence of a certain event.

To cut a long matter short, the previous paragraphs have demonstrated that various obstacles of the implementation of climate effects into EIAs exist. Nonetheless, various approaches have been developed to deal with these challenges.

## 3.2 Energy Efficiency

Having highlighted the challenges of the implementation of climate change into EIAs, the question arises what possibilities for the integration of climate change exist. One option to implement climate considerations into EIAs might be to include the concept of energy efficiency.

### 3.2.1 Different Types of Efficiency

However, having a look into various scientific disciplines, even the term "efficiency" can be heavily discussed. In this master's thesis two main types of efficiency are distinguished: *economic efficiency* and *technical efficiency*. The explanations of technical efficiency in this chapter are mainly based on Fischer et al. (2008) and Sen (2010):

First, *economic efficiency* expresses the relationship between benefits and costs. For instance, the concept of efficiency can even be used for the assessment for a certain distribution of goods. In this case, scientists speak of Pareto-efficiency, named after the Italian neo-classicist *Vilfredo Pareto*. In economics, efficiency hast to be clearly distinguished from justice; a distribution can be Pareto-efficient - meaning that no individual can ameliorate its position without deteriorating another's - but equally considered unjust.

In contrast, *technical efficiency* ($\eta$) refers to the input-output ratio of a (black-box) process. Energy efficiency or conversion efficiency is defined by the ratio of the (desired) output of a process (such as electrical energy and/or heat; P) divided by the input (the fuel; Q):

$$\eta = \frac{P}{Q}$$

In other words, an increase in efficiency means keeping the same output by lowering the input; doubling the input and get more than a doubled output; or, keeping the same input and augmenting the output. Daily life examples for an increase in energy efficiency are a better façade and window insulations, better industrial processes (such as a more efficient engine system for the combustion of hydrocarbons, or the adaptation of blade-angles of gas turbines), and switching to a more efficient fuel (with an increased lower heating value, LHV, or net calorific value, NCV).

However, also from a technical point of view various types of efficiencies can be distinguished. The *Carnot efficiency*, the *isentropic efficiency*, and the *polytropic efficiency* have a high importance in thermodynamics, especially in the steam cycle. The Carnot efficiency ($\eta$) can be understood as a measure for the quality of a process or a cycle and is defined:

$$\eta = \frac{1 - Tc}{Th}$$

where Tc is the average temperature for the heat that is transferred from the cycle (e.g. cooling) and Th is the average temperature for the heat that is transferred to the cycle (e.g. the combustion in a furnace).

*Isentropic efficiency* instead is the efficiency for a vertical expansion in a turbine without any losses. It is determined by three different kinds of enthalpies. The enthalpy (h) is by definition the measure for the total energy of a thermodynamic system. The isentropic efficiency is defined:

$$\eta = \frac{h1 - h2}{h1 - h2s}$$

where h1 is the enthalpy from the out-coming gas, h2 the specific enthalpy of the gas at the end of the real process and h2s (unknown) the specific enthalpy of the gas at the end of the ideal, isentropic process. The values for this formula can easily be determined out of the so-called h-s-diagram or out of the h-t-diagram, that both go back to the work and suggestions of the scientist *Richard Mollier*.

The *polytropic efficiency* is estimated similarly as the isentropic one. Usually, the polytropic efficiency for the expansion within a turbine is lower than the isentropic one because losses are taken into consideration.

In this context, many experts claim that not energy efficiency is the most important value, but in fact it is *exergy efficiency* that has to be optimized. The main reason for this is that energy efficiency does not include the usability of the converted energy. Exergy is defined as the energy that can be used, or as the potential between two different states. Energy consists of exergy and anergy, whereas anergy does not have any potential to do work. The exergy or exergetic efficiency is a measure for the quality of the converted energy.

To illustrate the theoretical examples of various approaches of technical efficiency, an industrial combined heat and power generation plant (CHP) with a gas turbine and a steam boiler is assumed. The values are taken out from Table 1 for a CHP heat led cycle. A Sankey representation of the flows of the system (the widths of the arrows correspond with the amounts of flow) is depicted in Figure 4.

**Table 1: Energy and Exergy Output of Different Natural Gas Fired Combustion Plants, fuel energy supplied (= 100%), Source: Fischer et al. (2008: 12).**

| Technology | Electricity Output (%) | Heat Output (%) | Temperature (Heat Output) (K) | Energy Efficiency (%) | Exergy Efficiency (%) |
|---|---|---|---|---|---|
| Heat Plant | *0* | *90* | *343* | *90* | *18* |
| Power Plant | *55* | *0* | - | *55* | *55* |
| CHP (heat led) | *20* | *60* | *473* | *80* | *45* |
| CHP (power led) | *50* | *12* | *473* | *62* | *55* |

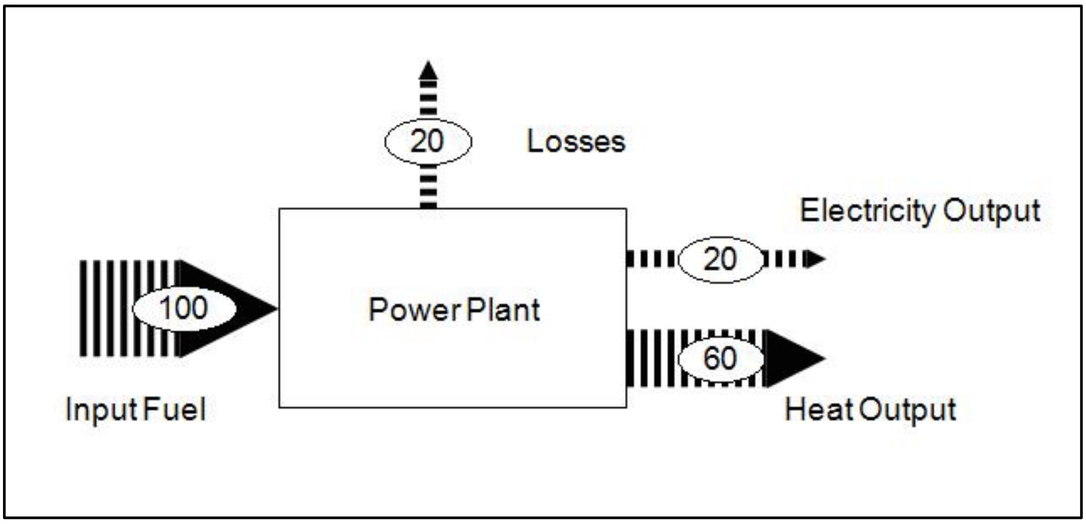


**Figure 4: Idealized flows in and out of a CHP; all values in dimensionless units.**

According to the 1st Law of Thermodynamics, no energy is lost in a closed system; the total amount of energy remains the same. The energy efficiency, expressed as output-input relationship, can be calculated:

$$\eta_{en} = \frac{(20 + 60)}{100} = 80\%$$

According to the 2nd Law of Thermodynamics, the entropy within a closed system increases. Equally, different qualities of energy exist. In this context, instead of the energy efficiency, the exergy efficiency can be determined by the calculation of quality factors. A quality factor (QF) is defined by the exergy-energy ratio. The quality factor for electricity (QF (E)) equals 1, whereas the quality - or Carnot factor for heat (QF(H)) has to be estimated:

$$QF(H) = 1 - \frac{T0}{Tw}$$

where T0 is the ambient temperature (273 K) and Tw is the temperature of the supplied heat (473 K). Putting all the parameters into the formula, the QF(H) equals to 0,42. Then, the exergy efficiency is determined:

$$\eta_{ex} = \text{E} * \text{QF(E)} + \text{H} * \text{QF (H)} = 20 * 1 + 60 * 0{,}42 = 45{,}2\%$$

Furthermore, the focus on the lifecycle of technologies has been more and more expanded in current scientific research. This means that already during the planning phase of a project, broader lifetime and lifecycle aspects have to be taken into account for a complete assessment of energy efficiency. In this context, the concepts of grey energy and the harvesting factor can be very helpful:

*"**Grey Energy:** Total energy needed for manufacturing, maintenance and recycling of electrical systems, devices and appliances over their life cycle.*

***Harvesting factor of active devices (energy converters):** Total energy generated over the lifetime of a converter related to the grey energy needed for manufacturing of a converter.*

***Harvesting factor of passive devices (consumer):** Total energy saved over the life time of an efficient device in relation to a inefficient device compared to, related to the grey energy of the efficient device"* (Brauner, 2014: 22).

To sum up, the consideration of the first two laws of thermodynamics leads to a closer analysis of energy efficiency and the introduction of the concept of exergy efficiency.

Only the latter includes aspects of energy quality and usability. For a comprehensive analysis it is recommended to take lifecycle aspects into consideration.

### 3.2.2 The Austrian Energy Efficiency Law

The importance of the concept of energy efficiency is underlined as a federal law dealing with energy efficiency ("*Bundes-Energieeffizienzgesetz*") was issued in Austria in 2014 (BGBl I (2014/72), consolidated version 5.5.2015 [EEffG], 2014), consolidated version 5.5.2015). In concrete, this law is a transposition of the *European Energy Efficiency Directive* (Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, 2012) and additionally reflects the Union targets of the *Climate and Energy Package* (Böhringer and Keller, 2011). A few sections of the EEffG (such as §1, §6, §7, §9, §10, §31 and §33) are of uttermost importance, as they were elevated to constitutional status. This means that the Austrian National Assembly passed the relevant parts with a two-third majority.

According to § 2 of the EEffG (2014), the aim of this federal law is to promote energy efficiency and can according to the same source be realised by:

- increasing the efficiency of use,
- reducing the total energy use,
- cutting down energy imports in order to increase the security of supply,
- decreasing the demand of nuclear energy,
- bringing down the emissions that are harmful to the climate,
- fostering the transition to an energy-efficient economy, and by
- lowering the energy costs for households.

Moreover, the law establishes a national commitment system and a national monitoring authority. Management plans, targets, audits and their contents have to be notified to this authority, whereas the law imposes measures and objectives not only on entrepreneurs and energy suppliers but also on the state itself. A yearly increase in energy efficiency is mandatory and is fixed as 1.5 % of the annual Austrian final energy consumption, which should not exceed the amount of 1050 Petajoule by the year 2020 -

§ 4 and § 8. (EEffG, 2014)

The EEffG (2014) obliges big enterprises (usually above 250 employees); small and medium enterprises (SME; with less than 250 employees); and energy suppliers to increase their energy efficiency in the period from 2015 till 2020.

First, big enterprises have to carry out an external energy audit every fourth year. In place of this audit, they can introduce an energy management system according to EN 16001 or to ISO 50001. Another possibility would be to realise an environmental management system according to ISO 14001; or to the Eco-Management and Audit Scheme (EMAS); or to implement a national recognised management system that includes a periodical energy audit. Second, SMUs don't have to realise a management system but just have to perform a periodical (every fourth year) energy counselling - §9 (EEffG, 2014).

According to §10 (EEffG, 2014), energy suppliers have to prove even measures at their own or other final energy consumers, in addition to their own energy efficiency improvement. Special emphasis should be put on the increase in energy efficiency in housing and mobility. Additionally, the suppliers have to prove that these energy efficiency measures amount to 0.6 % of the annual sales to their final customers of the preceding year. Moreover, the minister for economic affairs may conclude self-commitments about energy efficiency for smaller energy suppliers (<150 GWh) or for their associations (§11). (EEffG, 2014)

To sum up, the Austrian energy efficiency law foresees various measures for big companies, SME and the state itself in order to promote energy efficiency until 2020. In the European Union, the importance of energy efficiency is highlighted by passing the European Energy Efficiency Directive and consequently, by the mandatory transpositions to the respective national legal foundations.

### 3.3 Linking Energy Efficiency and Climate Change

Energy Efficiency has not only gained much attention on the national and European levels, but also within the international sphere. A case in point is the *World Energy Investment Outlook* of the year 2014 (OECD/IEA, 2014). This source estimates that the actual world-wide yearly investments in order to increase energy efficiency are approximately $ 130 billion, a sum that equals a share of about 50% of the global investments in renewable energy sources. For the calculation of these numbers the (OECD/IEA, 2014) interprets an energy efficiency investment as "…*the additional expenditure made by households, firms and governments to improve the performance of their energy-using equipment above the average efficiency level of that equipment in 2012*" (OECD/IEA, 2014: 137). The range of the estimated market share of energy efficiency varies among sources and methodologies, and is in the range between $ 130 billion and $ 410 billion (OECD/IEA, 2014).

In the world energy (investment) outlooks of the last years (OECD/IEA, 2014; OECD/IEA, 2010), various policy scenarios are taken into consideration. Figure 5 shows the main analysed policy paths, whereas in the "scenario funnel", the upper extreme scenario is represented by the current policy scenario and the lower extreme scenario is the "450 scenario", which refers to the GHG limit of 450 ppm $CO_2$ equivalents in the atmosphere (OECD/IEA, 2010).

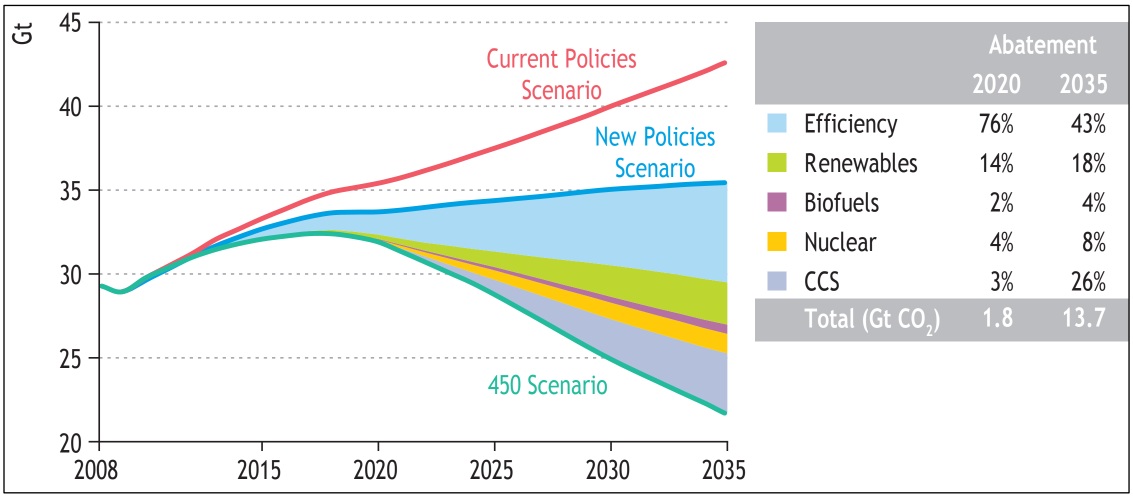


**Figure 5: World energy-related $CO_2$ emission savings by policy measure in the 450 Scenario compared with the New Policies Scenario; Source: OECD/IEA (2010: 409).**

Without getting into further detail, the graph above clearly shows that measures in the field of efficiency are central for the abatement of future GHG emissions. Energy efficiency has by far the largest significance in reaching policy targets and will contribute to the abatement of total $CO_2$ emissions, more than renewable energy sources, biofuels, nuclear energy, and CCS (OECD/IEA, 2010). As also pointed out in the same report, the reason for the importance of energy efficiency in decreasing GHG emissions can mainly be attributed to the comparatively low abatement costs.

Cutting a long matter short, energy efficiency and energy efficiency investments are of uttermost importance to cut down future greenhouse emissions. To put it differently, the key for emission savings is to increase energy efficiency. In this context, it is obvious that the objectives of climate change and energy efficiency coincide. This can further be illustrated by three main points including the aspects of energy transformation, resource saving and energy security.

First, every form of energy transformation is related to effects on the natural environment. In this statement the $1^{st}$ and the $2^{nd}$ law of thermodynamics are reflected. As energy is transformed in thermal processes, mainly $CO_2$-emissions and waste heat are produced. Therefore, an increase in the efficiency of the process would lead to a decrease of these emissions. Simultaneously, this would constitute a measure for climate protection.

Second, increasing efficiency is a measure of resource saving. This means that within a more efficient process less input is necessary by keeping the output constant. In this context, the issue of decoupling has to be introduced. Generally, the term decoupling is linked to the idea of "eco-efficiency" (Haberl et al., 2011). The same authors state that decoupling refers to a development path that is marked by economic growth with a lower use of natural resources. In other words, the economic output can grow because of an increasing efficiency in the resource use. Additionally, according to Haberl et al. (2004), decoupling can also include the concepts of sufficiency and equity. This depends whether the proportional relationship between energy/material use and social well-being is removed (sufficiency), or the connection between social well-being and an increasing economic output is lifted (equity). Though a development that is characterized by growth and less resource use sounds quite unrealistic, Haberl et al. (2004) show various historic examples: "*Absolute decoupling*" – economic growth with less adverse impact on the environment and/or with a decreasing resource use – has recently been observed in Germany and in the Netherlands. However, since the year 2005 the phenomenon of "decoupling" can also be spotted in Austria. According to Anderl et al. (2012), the main reasons for this is a higher use of renewable resources, the shift from brown coal-fired to gas-fired powered plants and a decrease in the $CO_2$ emissions in the sectors "agriculture" and "waste".

Last, the issue of energy security has to be added. In the last decades, countries got more and more worried about the security of energy supply. Especially the aftermath of the nuclear catastrophe in Fukushima, Japan, in 2011, has induced a paradigm shift. In Germany, this is reflected in the definite turning point towards the so-called "energy transition" or „Energiewende" in German. This transition mainly refers to the decommissioning of nuclear power stations and to the shift to renewable energy sources and a more efficient use of energy as well.

Briefly, it is beneficial to address climate change by energy efficiency as their objectives coincide. This is particularly evident in the fields of climate protection, energy transformation, resource saving and energy security.

# 4 The Implementation of Climate Change into EIAs

The EIA is a suitable instrument to integrate climate change policies because EIAs are prevalent in most legal systems of the world and are highly accepted by the public. In addition, there are many *"...potential entry points for incorporating information on climate change impacts [within an EIA process]*" (Agrawala et al., 2011: 9).

In this context, further benefits of the integration of climate change into environmental impact have to be highlighted. The following advantages can be mainly inferred from European Commission (2013a) and from European Commission – DG ENV (2009):

- similar targets can be achieved in unison
- legal compliance in both fields
- marketing effects and reputation
- risk management, adaptive capacity and resilience taken into consideration
- reasons of transparency
- a more thorough integration of environmental issues into planning processes
- different temporal and spatial dimensions included into environmental planning.

In the following sections, various theoretical and practical possibilities of implementing climate change considerations into EIAs are presented.

## 4.1 Theoretical Approaches

In general, two main approaches exist to tackle and cope with long-term climate change effects. These approaches are adaptation and mitigation. In addition, geo-engineering and inaction can also be added as possible strategies.

First, adaptation refers to plans and programmes that "adapt" or adjust to climatic effects. In other words, it is tried to balance the negative impacts of climate change by modifying technologies, buildings, and lifestyles. Adaptation includes "*anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation"* (Canadian International Development Agency, n.d.: 9). If adaptation measures are not realised correctly or sufficiently, the term *maladaptation* is used (European Commission, 2013a).

In the context of adaptation measures, the term "*no-regret measures*" has to be introduced. These are adaptation measures that are realised without having specific climate effects in mind and prove to be financially beneficial over a certain period of time (European Climate Adaptation Platform, Climate - ADAPT, n.d.). The same source lists insulation of buildings as a possible example.

The discussion about adaptation measures and adaptation capacity is also connected to the issue of *resilience*. Resilience refers to the ability of a social, ecological or economic system to cope with external perturbations with the aim of maintaining the original structure and capabilities. The term is even mentioned in paragraph 15 of the preface of the EIA directive (2012). Resilience is zeitgeist of many disciplines today. To put it differently, resilience is discussed in a broad scientific field; from psychology, business, crisis management, systems sciences up to ecology.

In contrast, mitigation measures address the challenge of climate change on an earlier stage. In concrete, they aim at reducing the emissions of climate relevant greenhouse gases or at providing additional sinks for greenhouse gases.

For the sake of completeness, geo-engineering has to be mentioned as a possible climate strategy beside mitigation and adaptation. Geo-engineering refers to a planned alteration of the climate by various technologies. These technologies aim at reducing the atmospheric GHG levels or at influencing the solar radiation budget. In concrete, some theoretical approaches include the injection of aerosols into the stratosphere to increase the scattering; the artificial generation of seasalt aerosols (they will act as so-called cloud condensation nuclei, CCN) by special vessels in order to increase the cloud *albedo* (which is a measure for diffuse reflectivity); the installation of sunshades in outer space that will diminish the solar insolation; and the fertilization of oceans with mainly iron to stimulate algae growth which will lead to an increased carbon uptake.

However, Figure 6 illustrates the two-way relationship between a project and climate change, as it has been already done by Figure 3. Here, it is additionally depicted that adaptation measures deal with the effects of climate change and mitigation measures aim at reducing the adverse effects on the climate (GHG emissions).

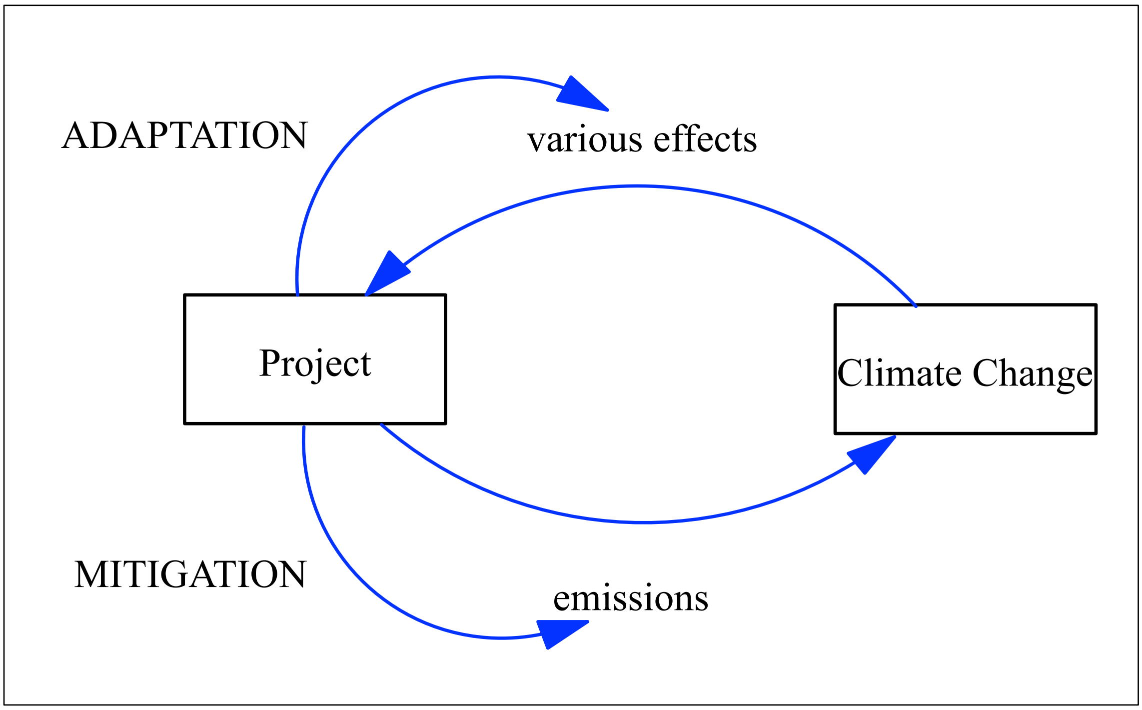


**Figure 6: Introduction of Adaptation and Mitigation Strategies to deal with Climatic Effects ON and with Emissions FROM the Project.**

The importance of adaptation and mitigation measures is emphasised by the last amendment of 2014 of the EIA directive (2012), as these strategies are implicitly and explicitly mentioned. In concrete, there are references to mitigation measures in paragraph 35 of the preface and in paragraph 8 of Annex IV of the EIA directive (2012). Though, these references have a rather general character and are not climate- specific.

In contrast, mitigation under the EIA directive (2012) aims at reducing, avoiding, minimizing, or substituting negative impacts on the environment by the project and project related activities. Additionally, paragraph 4 of Annex IV (EIA directive, 2012) includes mitigation and adaptation considerations exemplifying the subject of protection „climate“ by GHG emissions and „*impacts relevant to adaptation*“.

In brief, all theoretical and practical approaches of implementing climate considerations into EIAs can be attributed to one of the two main strategies of mitigation and adaptation.

### 4.1.1 Implementing Climate Change Considerations through Adaptation Measures

Various sources – published documents by the EU, the OECD, national agencies and scientists – suggest to implement climate change into EIAs by means of adaptation strategies.

In 2013, the European Union published an adaptation strategy that is mainly based on a white paper (*White Paper on Adapting to Climate Change*) and the *European Climate Adaptation Platform „Climate –ADAPT“* (European Commission, 2013a). This adaptation strategy has three main objectives. These objectives aim at enhancing the actions and measures taken by the member states, ameliorating decision-making, promoting the Climate – ADAPT Platform, and at expanding adaptation measures to sectors with a low resilience (European Commission, 2013b).

Secondly, the OECD (OECD, 2008) has published an advisory note on the integration of adaptation measures into the SEA, with a special focus on development cooperation. For the integration into the development cooperation context, policy measures have to be implemented into various national and trans-national strategies, plans and programmes by governments, agencies, as well as public and private organisations (OECD, 2008). In this trans-national context, institutional issues will be among the biggest challenges. In addition, from an institutional economic point of view, the high number of agents will cause high transaction costs.

Third, the Canadian International Development Agency (n.d.) provides a guide on the possibilities of climate change implementation into EIAs. The Agency suggests modifying the EIA process by adding a *climate change assessment, a vulnerability assessment and a risk assessment*. In these assessments, potential hazards are scrutinized for the project site and project activities. The hazards or risks are assessed qualitatively according to their relevance for the project, their rate of occurrence and severity (Canadian International Development Agency, n.d.). Bell et al. (2002) suggest the same type of assessment within an EIA. Moreover, the Canadian International Development Agency (n.d.: 17) proposes following questions to be answered in order to evaluate climate change impacts within an EIA:

- *"What are the projected climate change impacts?"*
- *"What may be impacted?"*
- *"What types of impacts can be expected?"*
- *"What specific impacts may occur at this location?"*
- *"What adaptation options can be used to address impacts?"*

Additionally, the introduction of a so-called *Environmental Management Plan* is recommended by the same source. This plan addresses possible adaptation measures by implementing certain policies and by pursuing different strategies. According to the Canadian International Development Agency (n.d.: 39), these strategies include *the prevention, the toleration and the sharing of loss*; *the adjustment of activities; resettlement; and restoration*.

Moreover, scientists have pointed out a number of possibilities to implement climate change into EIAs. However, they mainly focus on adaptation strategies and identify just three countries worldwide - namely the Netherlands, Canada and Australia - that consider climate change as part of their EIA (Agrawala et al., 2011). This is probably true for adaptation measures but certainly not for mitigation measures.

Developing countries - like Grenada, Kiribati, Trinidad and Tobago, and others - have already started to implement adaptation measures into the EIA process; Bangladesh, Dominica and other developing island states intend to do the same: „*In fact, some SIDS already recognise the need to use EIA as a tool to adapt to climate change in their National Communications to the United Nations Framework Convention on Climate*

*Change (UNFCCC) and/or National Adaptation Programmes of Action (NAPA)*“ (Agrawala et al., 2011: 15). According to the same authors, even important organisations - as the World Bank, the Asian Development Bank and the Inter-American Development Bank - plan to include adaptation measures in their standards about EIA. Beside the Netherlands that have fully implanted adaptation measures into their EIA legislation, other European countries are also on their way of doing the same, a case in point is Spain. (Agrawala et al., 2011)

Furthermore, Agrawala et al. (2011) identify possible entry points in every single step of an EIA:

The screening should be expanded to a “*climate change screening*” including issues whether the project is sensitive to climate change or not. Second, in the scoping process also climate variables should be included. Further, the EIA has to comprise a “*Climate Change Risk and Adaptation Options Assessment*”. This type of assessment can for instance be realised by means of a risk matrix. In such a matrix, the significance of certain risks is appraised by a certain probability or likelihood. In the final project realisation phase, adaptation measures can be implemented, monitored by certain indicators. (Agrawala et al., 2011)

A number of projects in Australia and Canada have already been realised incorporating climate change considerations (Agrawala et al., 2011), similarly as suggested in the paragraph above. Since these projects can be attributed to various sectors (electricity transmission, hydro power, construction, road infrastructure, landfill and residential development), it can be suggested that the examples for entry points listed above can be seen as general or generic elements for the implementation of climate change measures into an EIA.

The term *Climate Proofing* is related to adaptation measures. Climate Proofing comprises three dimensions and can be applied on planning and decision processes (dealing with infrastructure projects), on subjects (dealing with the actors) and objects (the focus is on buildings and infrastructure) (Birkmann and Fleischhauer, 2009). Since there is no common definition of Climate Proofing, the authors try to specify the term as methods, instruments and processes that are used as a means to secure the adaptability of plans, programmes and strategies towards actual and future impacts of climate change.

Birkmann and Fleischhauer (2009) compare EIA/SEA and Climate Proofing. Their main conclusion is that both objects of investigation have the same subjects of protection but the angles on the topic differ considerably. However, the focus of EIA/SEA is the compatibility with the environment, whereas Climate Proofing rather deals with the adaptation to the environment and climate. Therefore, as the authors clearly show, the perspectives are opposite. Some problems exist with depicting Climate Proofing because no unambiguous cause-effect relationship exists (Birkmann and Fleischhauer, 2009). This is due to the fact that climatic and natural phenomena interact in complex, non-linear ways. Hence, multiple insecurities and uncertainties exist. In contrast, assumptions made within EIA/SEA are rather based on causality thinking.

The main difficulty for the integration of adaptation measures into EIA, results out of the lack of specific climate data for a certain location. To put it differently, climate reports (as from the IPCC/WMO or from national organisations) just take global weather patterns into consideration and national reports mainly focus on national and economic welfare effects. Therefore it is hard to derive local trends and scenarios that can directly affect a project and site-related activities.

However, the mere implementation of adaptation measures into EIAs is not sufficient, as they do not deal with targets and strategies of climate protection. Therefore, mitigation policies have to be pursued as well.

### 4.1.2 Implementing Climate Change Considerations through Mitigation Measures

Not much attention has so far been drawn on mitigation strategies as a means to implement climate change into EIAs. Certainly, the most famous mitigation policy is the Kyoto Protocol. Whether the Protocol and its mechanisms have been successful remains to be seen. However, the legal framework of the *Kyoto Protocol* provides three mechanisms that can be classified as mitigation efforts; namely the *Clean Development Mechanism (CDM), Joint Implementation (JI)* and the *trading of Emission Certificates*.

First, the *CDM* is based on Art. 12 of the Kyoto Protocol. It is a mitigation measure because the emissions of climate-relevant GHG are lowered by specific projects. These projects are realised in developing countries by industrial states, whereas the latter get emission reduction certificates in return. The second mechanism is called *Joint Implementation* and counts as a mitigation measure as well. The legal foundations of the JI can be found in Art. 6 of the Kyoto Protocol. It differs from the CDM as under the JI both countries make commitments and have to decide on how to split the "emission bonus points" resulting out of a successfully realised emission reduction project in one of the two countries. The third mechanism, the *International Emission Trading (IET)* is based on Art. 17. Of the Kyoto Protocol and foresees that countries with reduction obligations trade certificates amongst them. For this purpose, the *Emission Trading Scheme (ETS)* was established in the European Union. (UNFCCC, 2007)

All the three mechanism of the Kyoto Protocol act as means for mitigation in order to reach the main goal which is the reduction of the human-caused emissions of green house gases (such as $CO_2$, $CH_4$, $N_2O$, $SF_6$, *HFCs and PFCs*) (European Commission, 2013a). Even though the Kyoto mechanisms constitute a good example for mitigation measures, they are not considered to complement or to be integrated within EIAs.

#### 4.1.3 Implementing Climate Change Considerations through Adaptation and Mitigation

In scientific sources, theoretical approaches to implement mitigation are just mentioned together with adaptation strategies. Especially the EU (European Commission, 2013a) and the OECD (2008) emphasise the importance of a combined effort of mitigation and adaptation measures and the resulting positive effects.

The European Union provides guidelines on implementing climate change into the EIA procedure (European Commission, 2013a). In these guidelines climate change and biodiversity loss are tackled simultaneously. The European Commission (2013a) suggests to address climate change considerations at an early stage of the EIA procedure, especially already during the processes of screening and scoping. However, the same source highlights that there is no panacea on how to implement climate change into an EIA, as EIAs differ from each other. In contrast to all other sources mentioned above, the European Commission (2013a) recommends to include stakeholders in the determination of climate change issues. Theoretically, theses stakeholders can be identified and categorised beforehand - as it is state-of-the-art - by means of a stakeholder-analysis involving the three main aspects power, urgency and legitimacy.

Figure 7 is adapted from the EU guideline (European Commission, 2013a) and provides an outline about the numerous possibilities of the implementation of climate change issues into the EIA procedure. The figure is simplified leaving biodiversity considerations out. The questions and points proposed for the single stages of an EIA just give a few examples on how climate change can be taken into consideration.

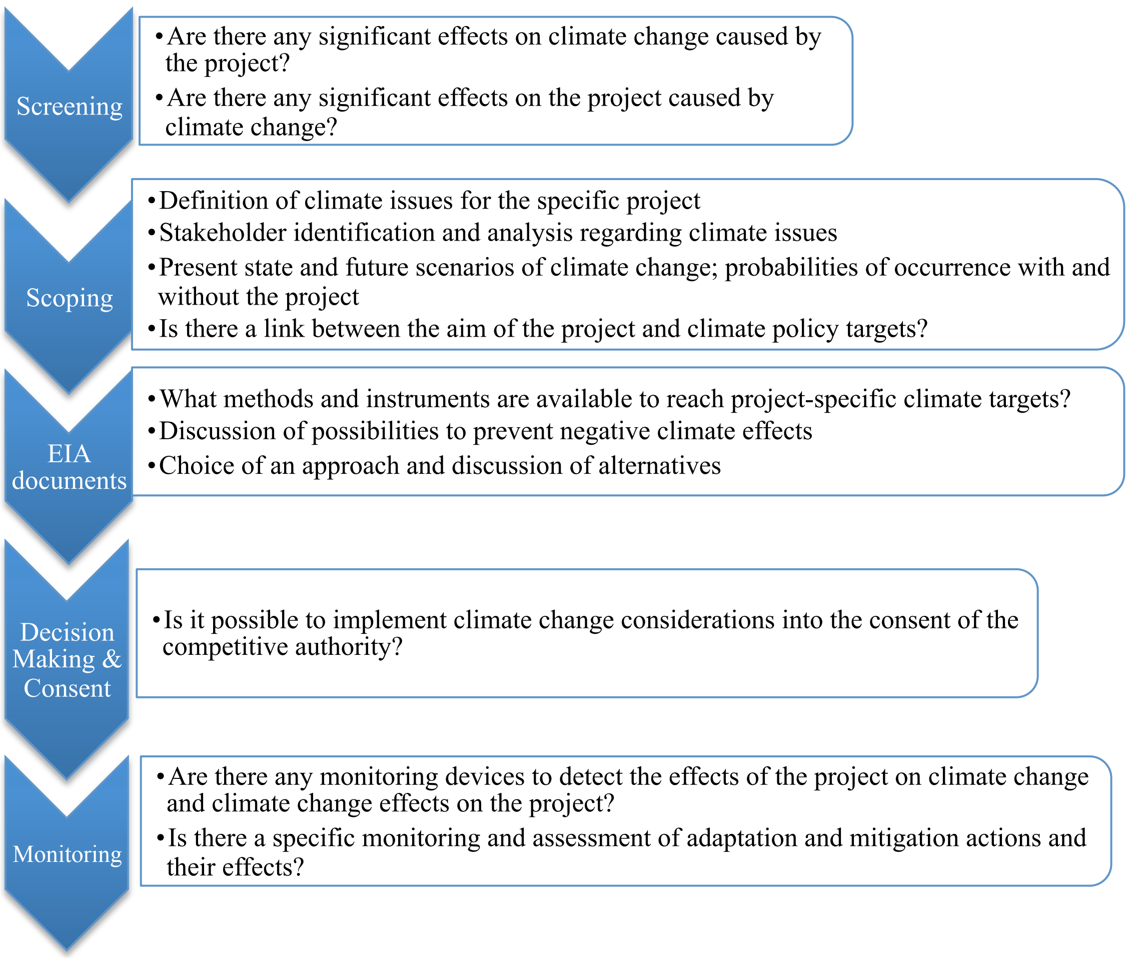


**Figure 7: Implementation of Climate Change Considerations into the EIA procedure; adapted from European Commission (2013a: 12 and 27).**

To cut a long matter short, the examples mentioned above have shown that the theoretical approaches - that deal with the implementation of climate considerations into EIA - can be characterized as mitigation or as adaptation measures. In this context, it has to be pointed out that the majority of the sources only addresses adaptation strategies.

### 4.1.4 The Conflict between Adaptation and Mitigation

A mere focus either on the implementation of mitigation or on the integration of adaptation entails many issues. One aspect that is not very often mentioned is that time and site-related aspects can also distinguish the two measures. This fact is only highlighted in the advisory note of the OECD (2008) and is recalled by the illustration in Figure 8.

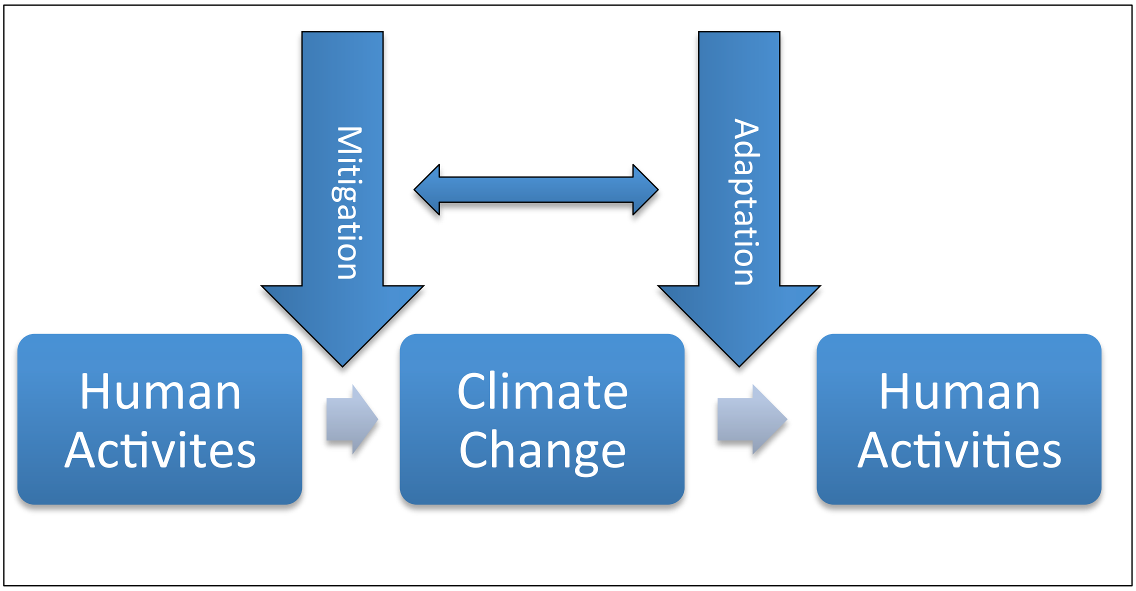


**Figure 8: Human Activities & Climate Change: Between the Priorities of Mitigation and Adaptation.**

The basic conflict between adaptation and mitigation strategies can further be illustrated by a simple economic analysis (see Figure 9). For this analysis, a one actor-economy has to be assumed. This actor can be a single state or the world as a whole. In this model, just two basic possibilities or „goods“ exist for the fight of climate change: adaptation and mitigation strategies. A fixed budget is given that can be deployed to realise a certain allocation of the two strategies or measures. The Budget Line 1 expresses the fixed budget. All combinations and allocations on and below this line are affordable, whereas all options above are not affordable.

If the actor decides to cut down the expenditures for mitigation measures, then Budget Line 1 rotates inwards (Budget Line 2’). This policy strategy can be linked to the idea that future generations will be richer and will probably have better possibilities to cope with and adapt to climate change. In fact, the budget line gets even steeper (budget line

2'') as more money is available for future adaptation measures. This thinking works the other way round as well. The more adaptation measures are shifted to the future, the less mitigation is realised today.

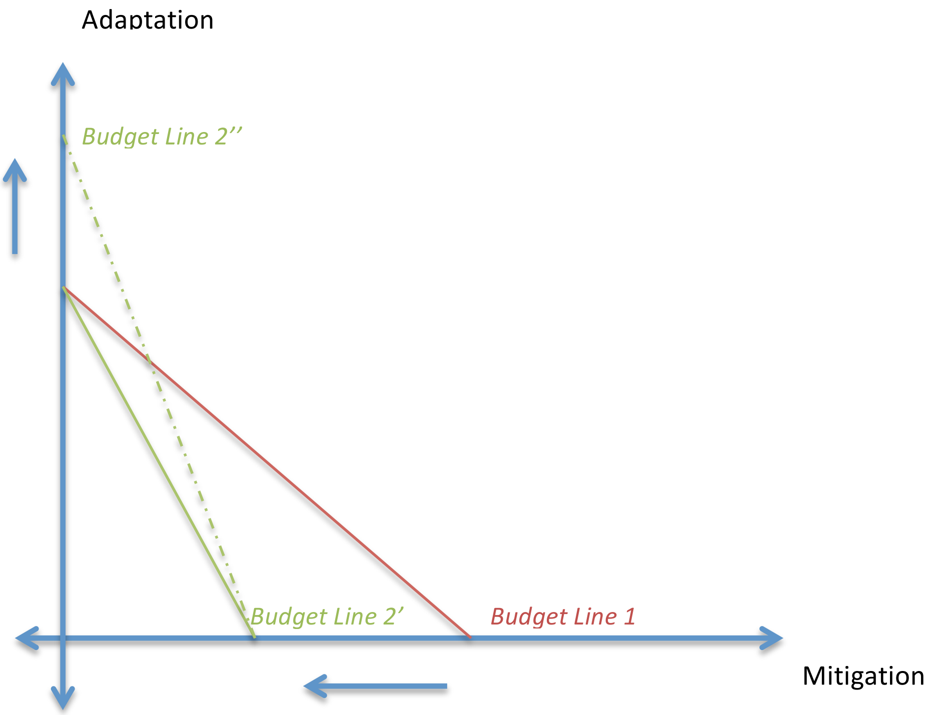


**Figure 9: The trade-off between Mitigation and Adaptation depicted by a Budget Line Analysis.**

A change in the total budget would cause a parallel shift of the line; inwards if the expenditures are reduced and outwards if the total investments are raised. Moreover, a change in the unit costs of adaptation or mitigation measures would also influence the rotation or shift of the budget line. As unit mitigation cost increase – *ceteris paribus* – the original budget line (Budget Line 1) will rotate inwards (Budget Line 2'). In contrast, a change in the price of adaptation measures that might be caused by improving technologies will cause the budget line to rotate outwards on the ordinate (for instance from Budget Line 2' to Budget Line 2'').

Even if this static model cannot depict multiple actors or discount considerations, it is quite powerful to make predictions and to illustrate the trade-offs and balancing out-effects of mitigation and adaptation measures.

However, it has to be pointed out that in reality more than the two options of mitigation and adaptation exist. At least the possibility of not taking any action has to be considered („inaction“). Therefore, Figure 10 also illustrates inaction as one of the three main climate policy strategies. Based on the 4th IPCC Assessment Report (AR4) a so-called triangle of tension has been chosen to scrutinize the relation between adaptation, mitigation and inaction (IPCC, 2007). From a mere economic point of view, inaction would be the most expensive option in the long term, as impact costs and the costs for adaptation and mitigation are considered. In the short term, the more adaptation measures are taken, the higher are the adaptation costs; and the more mitigation measures are realised, the higher is the increase in mitigation expenditures. Vice versa, strategies involving „inaction“ would lead to lower expenditures on a short-term basis.

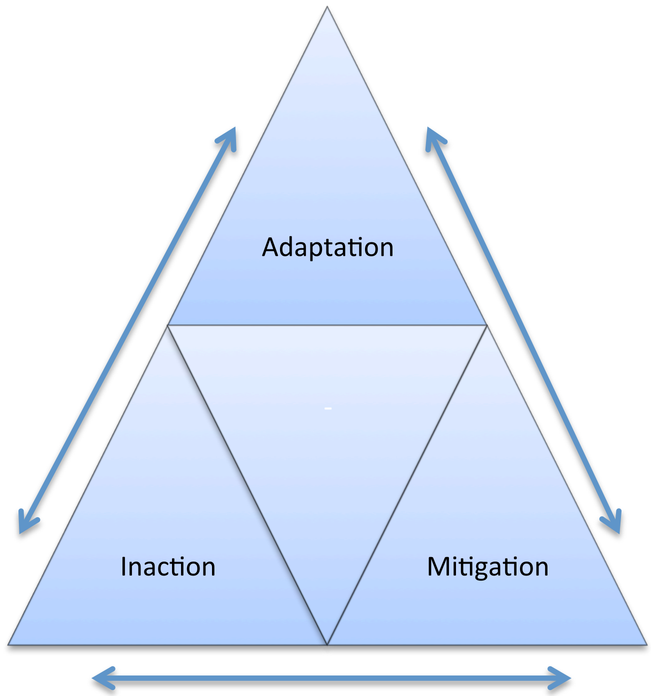


**Figure 10: Climate Policy Strategies Triangle of Tensions including Adaptation, Mitigation and Inaction, adapted from IPCC (2007).**

However, it is still highly debated as to whether it is cheaper to adapt to climate change than to prevent it. Whereas climate change sceptics as Bjørn Lomborg are in favour of adaptation strategies, other scientists would rather opt for mitigation measures or a combination of both (Sceptical Science, 2014). It seems obvious that if more preventive action is taken today, less future adaptation to climate change will be necessary. Though, who argues that more mitigation measures realised today are better and cheaper than adaptation measures in future, forgets that even adaptation measures have to be taken in advance. Whereas so-called reactive or ex-post adaptation deals with the effects of climate change as soon as they occur, proactive or ex-ante adaptation involves actions taken in advance (Aboriginal Affairs and Northern Development Canada, 2010). These ex-ante actions involve the same elements as has been identified before within the possibilities of implementing climate change considerations into EIAs. Concrete examples are climate change assessments, vulnerability assessments and risk assessments.

Briefly, adaptation and mitigation measures play a central role in dealing with climate change and its effects. Although the realisation of these measures is not the cheapest option in the short run, for the benefit of climate protection and for covering future risk, it is necessary to abstain from inaction while pursuing balanced strategies between adaptation and mitigation.

## 4.2 Case Studies

So far, the discussion in this master's thesis has just focused on theoretical approaches that deal with the implementation of climate change into environmental impact assessments. In contrast, the following subchapters will focus on practical realisations ("case studies") and will show examples of adaptation and mitigation strategies within EIA frameworks. As the national legal provisions dealing with EIAs are transpositions of the European EIA Directive and EU member states are always allowed to lay down stricter rules to protect the environment, various differences among Austria, Italy, Germany and Denmark can be identified.

### 4.2.1 Austria's Climate and Energy Concept

In Austria, the Climate and Energy Concept (CAEC) was introduced as a part of the Environmental Impact Statement (EIS) in 2009 (BMLFUW, 2010). According to Schnedl (2012), the main elements of an EIS are the description of the project; a description of the expected considerable environmental damage; the expected considerable environmental impacts; and measures to prevent, reduce and to compensate considerable adverse environmental impacts. In concrete, beside the description of the project, the EIS consists of a non-technical summary, alternative solutions and surveys about waste, energy, traffic, noise, potential accidents/ risks/ hazards, hydrology, water, air and climate, soil, agriculture, ecosystems, forests, land use and human medicine. The EIS has to be submitted to the competent authority, to the Ombudsman for Environmental Protection ("Umweltanwalt"), to the local community, and to the ministry of the environment (BMLFUW), which all are given the right to official statement. To put it simply, the project developer has to apply for the consent of the competitive authority by submitting technical documents and the environmental impact statement. This equals the first step of an EIA procedure. (Schnedl, 2012)

According to the same author, even the preliminary procedure ("Vorverfahren") that can be performed on a voluntary basis includes - beside basic plans - an EIS. The CAEC is part of the EIS, even if the EIS is just performed within a preliminary procedure. Further, the CAEC is mandatory for regular and simplified EIA procedures. Its main aim is that projects that are subject to an EIA implement climate-protection and energy efficient measures that correspond with the state of the art. The legal basis for the CAEC is the amendment of the UVP-Gesetz 2000 by §6 para 1, no. 1, lit. e, introduced by the Federal Law Gazette in 2009 (BGBl I, 2009/87). This amendment (BGBl I, 2009/87) comprises an exhaustive list of the elements of a CAEC:

- energy needs of the facilities, machines, and equipment according to the energy sources
- available energy indicators
- a depiction of the energy flows (energy balance)
- measures for energy efficiency
- information about the GHGs that are caused by the project and measures for their reduction. The GHGs that have to be included are listed in §3 no. 3 of the law on emission certificates, "Emissionszertifikategesetz" (BGBl I, 2011/118) and comprise carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrochlorofluorocarbon (HCFC), perfluorocarbons (PFCs), sulphur hexafluoride ($SF_6$) and other natural or anthropogenic gaseous constituents of the atmosphere that absorb and re-emit infrared radiation.
- a confirmation of an authorized civil engineer or technical office that the measures of the climate and energy concept correspond with the state of the art.

The CAEC has to be a single document, with meaningful data and statements about the energy use and the climate impacts of the project. Crucial are the borders of the system. According to the guidelines, just the emissions and the energy use directly related to the project can be counted. This means that the life cycle and various supply chain stages before and after are not included. Nevertheless, the emissions of the construction phase together with the induced traffic (at site and outside) have to be taken into account. The emissions of the relevant greenhouse gases (GHGs) should be balanced. In general, they can occur from running a plant (process-emissions and/or energy-related emissions), from the induced traffic during the construction phase, and from the construction phase itself. In the CAEC, the $CO_2$-emissions have to be listed together with the indicators for energy and the energy balances. If other GHGs exceed the emission limit of 500 t $CO_2$-equivalents per year, then they have to be added as well. The BMLFUW (2010) provides basic emission calculations, whereas emission factors and energy requirements can be found in the national inventories for airborne pollutants. (BMLFUW, 2010)

The UVP-Gesetz 2000 does not only provide the necessary elements of an EIA and an EIS but also indicates possible limitations of the necessary constituents of an Environmental Impact Statement and an CAEC as well - §6 paragraph 2 (BGBl I, 2009/87):

As the BMLFUW (2010) points out, for less energy-intensive and less climate-effective projects, the applicant just has to provide basic information including a description of the main energy and climate-influencing facility components, a basic energy balance, the calculated GHG emissions including the induced traffic, a depiction of the measures taken for an increase in energy efficiency and for a reduction in GHGs. A complete and detailed CAEC has to be provided in the case large amounts of GHG are emitted and if the project includes highly energy intensive processes, e.g. industries and thermal power plants.

It is recommended to incorporate energy efficiency considerations already at an early stage of planning (BMLFUW, 2010): This can be done by the means of an integrated planning process. The benefits of such a process are higher energy saving potentials and a comprehensive impression of the energy flows. This can be further specified for the four main sub-steps of planning:

- *Choice of location*: Is there a district-heating network? Are there private and/or industrial customers? Does the erection of the plant cause extensive LUCF - Land Use Change and Forestry - effects that lead to the release of further GHGs?
- *Site adaptation*: use of local renewable energy sources, connection to the electrical grid/ heating network/ infrastructure
- *Dimensioning & Optimization*: avoidance of over-dimensioning, insulations, minimization of losses; all measures taken to increase the technical efficiency
- *Kick-Off for the Implementation of an Energy-Management System:* possibly according to ISO50001 or to ÖNORM EN 16001:2009

Furthermore, the guide for the climate and energy concept (BMLFUW, 2010) focuses on the following six project types and provides calculation methods for the GHG emissions of the same sectors:

1) Waste incineration plants, thermal power plants and combustion plants
2) Industrial plants
3) Projects of industry, commerce and urban development
4) Shopping centres with car parks and tourist accommodation
5) Ski areas
6) Mining projects

In this context, one might ask whether mandatory reference documents exist and what specific measures can be taken to increase energy efficiency.

First, most of the projects listed in the Annex of the UVP-Gesetz 2000 are at the same time *IPPC (Integrated Pollution Prevention and Control*) plants. For these projects, the application of the *BAT (best available technology* or *technique)* is mandatory as much as an efficient use of energy – art 11 lit. f of the "*IPPC Directive*" (Richtlinie 2010/75/EU des Europäischen Parlaments und des Rates über Industrieemissionen - integrierte Vermeidung und Verminderung der Umweltverschmutzung, 2010). The definition of the state-of-the-art in Austria has been adapted to the definition of the BAT of the IPPC directive (BMLFUW, 2010) and various documents for reference have been established. Though, a European BAT reference document explicitly dealing with energy efficiency exists (European Commission, 2009a), energy efficiency is not treated separately within the Austrian EIA law, but can rather be understood as a horizontal matter.

Further sources for determining the state-of-the-art are national and international documents and norms. A number of documents exist for different industries and plants; though, there is just one specific document dealing with energy efficiency ("ENE" code used). It provides an overview of possible indicators for energy efficiency and presents "*techniques to achieve energy efficiency*" especially in the processes of *combustion; steam; heat recovery and cooling; cogeneration; electrical power supply; electric motor driven sub-systems; compressed air systems; pumping systems; heating, ventilation and air conditioning systems; lighting; drying, separation and concentration* (European Commission, 2009a).

Another comprehensive document dealing with measures to increase energy efficiency is provided by Berger et al. (2005).

In addition, various specific measures can be listed to increase energy efficiency within single systems. These are mainly based on BMLFUW (2010):

- *Combustion and vapour systems*: insulation of the pipe system, combined heat and power (CHP), preheating of the air that is burned (for instance by the waste heat), preheating of the boiler water by an economiser, reduction of excess air, maintenance of heat exchangers (free from residues to guarantee a maximum degree of effectiveness)
- *Building and house technologies*: heat pumps, free cooling, heat recovery, heat insulation of pipes
- *Engines*: dimensioning, optimisation of the transfer system
- *Airing systems*: optimization of engines and of filtering, automatic control systems, dimensioning
- *Pump and pressurized systems*: avoid over-dimensioning, minimize the number of bends and valves, avoid leakages
- *Lighting*: optimal adaptation of intensity and spectrum, increase in the use of daylight, introduction of an automatic control system (including motion sensors and time control)

Finally, further measures exist to reduce the climate relevant GHGs and to simultaneously increase energy efficiency. They can be attributed to the planning phase, the operation phase, the induced traffic, and the construction phase.

First, during the planning and operation phases the GHG emissions can be reduced by the use of renewable energy sources, the use of waste heat, the connection to a district heating system, heat recovery, and the implementation of an energy management system. Second, GHG emissions are belittled by imposing limitations to traffic, implementing traffic and logistic systems, by pushing ahead alternatives for car use (walk, bike, public transport) for employees, and buying more eco-friendly company cars (e.g. electric cars for short distances). Last, during the construction phase, trains and ships can be used for the material transport instead of lorries, and newer machinery and vehicles that even comply with the state-of-the-art. (BMLFUW, 2010; Berger et al., 2005)

The previous paragraphs have outlined the main elements of the *Climate and Energy Concept* that is mandatory in Austria. The CAEC is a fixed part of the EIA, in concrete of the environmental impact statement. The CAEC is a means of implementing climate change into EIAs, as it aims at implementing climate-protection and energy efficient measures into projects that are subject to an EIA. Since the CAEC deals with the effects of projects on the climate, it can be categorized as a mitigation measure.

### 4.2.2 Italy, Denmark, Germany

**Italy**

In Italy, documents and legal acts that deal with the implementation of climate effects into EIAs can be found at various administrative levels. In general, national, regional ("*regione*"), provincial ("*provincia*"), and municipal ("*comune*") levels can be distinguished. One main basis for legal acts and EIA/SEA procedures is the Italian translation of the European document "*Guidance on Integrating Climate Change and into Strategic Environmental Assessment*" (European Commission, 2013a). Though, respective documents have just been identified at the regional and the provincial level.

First, the region of Piemonte provides a central document that is the outcome of the project "*Regions for Sustainable Change*". This document presents guidelines on the implementation of climate change into strategic environmental assessments on a local level. In the second section, mitigation strategies (such as energy efficiency, the reduction of GHG, and reduction of air pollution) as well as adaptation policies (architectural and planning measures, management of natural resources) are addressed. (Loffredo, 2011)

Second, the legal acts of the autonomous *Provincia di Trento* have to be highlighted. In 2010, the law dealing with environmental impact assessments was supplemented by an additional article introducing an impact assessment of energy as well as a climate impact assessment ("*valutazione dell'impatto energetico e sul clima*"). (Repubblica Italiana - Provincia Autonoma di Trento, 2010)

To sum up, various examples show that at various administrative levels attention has been shifted on ways to incorporate climate change within EIA processes in Italy. These approaches pursue mitigation as well as adaptation strategies.

**Denmark**

Instead of legal texts or policy documents, a scientific study is used as a proxy to investigate the practice of implementing climate change into EIAs in Denmark.

The scientist Larsen (2012) investigated 19 EIA reports of projects in Denmark, mainly including the realisation of on-shore and off-shore wind-driven power stations. She came to the conclusion that mitigation measures were included in 18 of 19 reports and adaptation was not addressed in a single one. This fact is rather surprising, as in the scientific literature and several advisory notes adaptation measures are rather emphasised than mitigation policies. One reason for this specific outcome might be that Larsen (2012) focused on renewable energy projects. Especially for those projects, the operators want to highlight the low GHG emissions by confronting them with non-renewable energy projects. The same author suggests expanding the focus on adaptation measures, whereas it has to be stated in this context that - as demonstrated in the chapters above - adaptation has already been stressed to a great extent on various legislative and organisational levels.

Shortly, there is scientific evidence that - at least - mitigation measures are used as a means to consider climate change within EIAs in Denmark.

**Germany**

In order to scrutinize the current situation and practice in Germany, the consolidated version of the national EIA law and the results of a congress are examined.

First, the national law dealing with environmental impact assessments in Germany („*Gesetz über die Umweltverträglichkeitsprüfung, UVPG*“) does not foresee any explicit mitigation or adaptation measures. Just the impact of projects on the climate is mentioned as a mandatory part of the assessment (§ 2 para 1 no. 2 UVPG). (Gesetz über die Umweltverträglichkeitsprüfung (UVPG), 2013)

Secondly, the author Nagel (2014) outlines the main points of the $12^{th}$ EIA Congress in Bad Honnef, Germany: Due the amendment of the European EIA Directive in 2014, further aspects of climate change will have to be considered within EIAs in Germany. These include the extension of the current perspective to *global* climate change and the consideration of effects of a project on the climate and the effects of climate change – such as extreme weather events – on the project. In addition, Nagel (2014) predicts the introduction of a risk assessment and the concept of energy efficiency into EIAs in Germany.

Briefly, neither mitigation nor adaptation measures are foreseen by the EIA legislation in Germany at present. Nevertheless, at a conference it has been predicted that the new European EIA directive will lead to the implementation of energy efficiency and risk management approaches into the respective national EIA law until 2017.

### 4.2.3 Comparison of the Case Studies

From the analysis of the practice and the legal foundations of Austria, Italy, Denmark and Germany, it can be deduced that the Austrian *Climate and Energy Concept* is a unique concept. Among the investigated countries, the CAEC is the only mitigation measure that is enshrined in the national EIA law and therefore a mandatory constituent of EIA procedures.

In addition, examples from Denmark and Italy show that mitigation measures as well as adaptation measures have found its way into EIA, and in the case of Italy, even at various administrative levels.

Finally, it is expected that in other European member states, as in Germany, new climate change considerations will be introduced into the EIA legislations as the recent European EIA amendment has to be transposed by May 2017.

# 5 Conclusion and Reflection

In the introduction of this master's thesis two main research questions have been presented. As scientific literature and case studies have been scrutinized above, now it can be judged whether these research questions have been answered or not.

The *first research question* focuses on the possibilities of implementing climate change and energy efficiency into EIAs. The analysed theoretical examples show a wide range of possibilities to implement climate change into EIAs. All the presented approaches can be characterized either as mitigation or as adaptation measures, whereas the majority of the scientific sources only addresses adaptation strategies.

Further, the issue has been raised whether theoretical approaches - as partly suggested by Agrawala et al. (2011), Bell et al. (2002), Byer and Yeomas (2007) and the Canadian International Development Agency (n.d.) - differ from "climate proofing" (Birkmann and Fleischhauer, 2009) or not. As the discussion of the theoretical approaches has demonstrated, climate proofing is just related to adaptation measures and not to any type of mitigation strategy. However, the mere implementation of adaptation measures into EIAs is not sufficient, as they do not include targets and strategies of climate protection. In addition, countries that will be affected by climatic effects with a high probability are in favour of binding international agreements that establish a mandatory adaptation within EIAs. Cases in point are the developing island states Grenada, Kiribati, Trinidad and Tobago, and Dominica. In this context, it is recommended not to concentrate just on adaptation measures but to pursue balanced strategies between adaptation and mitigation, even though it is not the cheapest option in the short run. In the long run, this is probably the only cost-effective option as both climate protection and future risks are covered.

The *second research question* explores the standard in other European member states and asks whether legal foundations or similar instruments like the Austrian Climate- and Energy Concept for EIAs have been realised. The respective legal foundations and practice in Austria, Denmark, Germany and Italy has been scrutinized and compared. The main conclusion of this analysis is that the Austrian Climate and Energy Concept (CAEC) is a unique way to include climate change into EIAs by means of energy efficiency. It is beneficial to address climate change by energy efficiency as their objectives coincide. For instance, this is particularly evident in the fields of climate protection, energy transformation, resource saving and energy security.

Moreover, it is beneficial to implement an energy management system already with the CAEC at an early stage of planning, as such a system is also required for big enterprises by the Austrian energy efficiency law (EEffG). In fact, enterprises can introduce an energy management system according to EN 16001 or to ISO 50001 that replaces the external energy audit required by the EEffG.

In this context, the question arises why energy efficiency has been enshrined in various national legal acts (such as the UVP-Gesetz or the EEffG) but has not been used as a criterion for permits by the competent authorities. However, two main arguments exist against energy efficiency as a mandatory legal criterion. They include economic and institutional aspects. More stringent measures and additional legal obligations imposed by one country within the European Union can constitute a market discrimination and impediment to competition. As the *European Single Market* is already established in most spheres, more restraints can certainly lead to competitive disadvantages of companies in Austria and effectuate their movement to other European member states with less requirements and more "business-friendly" regulations. Further, energy efficiency as an additional legal criterion could lead to increased barriers that can have the same effect as institutional and bureaucratic impediments.

In addition, whether life-cycle aspects should be implemented into EIAs or not remains a contentious issue. As much scientific attention has been drawn on the lifecycle of technologies, one might suggest including similar aspects (as grey energy and harvesting factors) within EIAs. Certainly, this would require *enormous* temporal and spatial extensions of the boundaries of the system. Though, such extensions would conflict with the primal aim of EIAs addressing the assessment of *site-related* impacts.

Finally, an expansion of the concept of energy efficiency to EIAs of other countries is expected. In the near future, other European members will probably include the concept of energy efficiency as well as further mitigation and adaptation measures in their national laws, as the recent European EIA amendment has to be transposed by May 2017.

**Bibliography**


Aboriginal Affairs and Northern Development Canada (2010, September 15): Definition and Types of Adaptation. [Online] http://www.aadnc-aandc.gc.ca/eng/1100100034628/1100100034629 - accessed: May 16, 2015.

Adelle C., Pallemaerts M., and Chiavari J. (2009): Climate Change and Energy Security in Europe. Policy Integration and its Limits. SIEPS 2009:4. [Online] http://www.sieps.se/sites/default/files/549-20094.pdf - accessed: May 24, 2015.

Agrawala S., Kramer A. M., Prudent-Richard G., and Sainsbury M. (2011): Incorporating Climate Change Impacts and Adaptation in Environmental Impact Assessments: Opportunities and Challenges. OECD Environment Working Papers(24). DOI: 10.1787/5km959r3jcmw-en.

Amann M., and Maas R. (2015, February): International Environmental Conventions. Lecture on International Environmental Conventions, 7th MSc Program: Environmental Technology & International Affairs, TU Vienna.

Anderl M., Bednar W., Fischer D., Gössl M.. H.C., Jobstmann H., Ibesich N., Köther T., Kuschel V., Lampert C., Neubauer C., Pazdernik K., Perl D., Poupa S., Purzner M., Riegler M., Schenk C., Schieder W., Schneider J., Seuss K., Sporer M. et al. (2012): Klimaschutzbericht 2012. REP-0391. Umweltbundesamt GmbH, Wien. [Online] http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0391.pdf - accessed: May 15, 2015.

Arndt H.-W. (2006): Europarecht. 8th edition, C.F. Müller, Heidelberg.

Böhringer C., and Keller A. (2011): Energy Security: An Impact Assessment of the EU Climate and Energy Package. Copenhagen Consensus Center. University of Oldenburg, Germany. [Online] http://www.copenhagenconsensus.com/sites/default/files/CCC_energy_surveyFINAL.pdf - accessed: July 7, 2014.

Bahgat G. (2011): Energy Security: An Interdisiplinary Approach. John Wiley & Sons, Hoboken. ISBN: 978-0-470-68904-2.

Bell A., Collins N., Ells C., de Romily G., Rossiter A., and Young R. (2002): Evaluation of the ClimAdapt Guide to Incorporating Climate Change into the Environmental Impact Assessment Process. Research and Development Monograph Series. [Online] http://www.cefconsultants.ns.ca/csr.pdf - accessed: July 14, 2014.

Berger H., Bachmann G., Cremer P., Dechant A., Eisenhut T., Kollegger A., Passath J., and Tagwerker C. (2005): Energieeffiziente Technologien und effizienzsteigernde Maßnahmen. [Online] http://www.umweltbundesamt.at/fileadmin/site/publikationen/M172.pdf - accessed: May 01, 2015.

BGBl (1993/697): Bundesgesetz über die Prüfung der Umweltverträglichkeit und die Bürgerbeteiligung.

BGBl I (2014/72), consolidated version 5.5.2015 [EEffG] (2014, August 12): Bundes-Energieeffiziengesetz.

BGBl I (2009/87): Änderung des Umweltverträglichkeitsprüfungsgesetzes 2000 - UVP-G-Novelle 2009.

BGBl I (2011/118): Emissionszertifikategesetz 2011.

BGBl. 1993/697 changed by BGBl. I 2000/89 (consolidated version: 14/05/2015): Bundesgesetz über die Prüfung der Umweltverträglichkeit (Umweltverträglichkeitsprüfungsgesetz 2000 - UVP-G 2000).

Birkmann J., and Fleischhauer M. (2009): Anpassungsstrategien der Raumentwicklung an den Klimawandel: "Climate Proofing" - Konturen eines neuen Instruments. Raumforschung und Raumordnung 67(2), 114-127.

BMLFUW (2010): Leitfaden für das Klima- und Energiekonzept im Rahmen von UVP-Verfahren. [Online] http://www.umweltbundesamt.at/fileadmin/site/umweltthemen/UVP_SUP_EMAS/uvp-leitfaeden/Basisleitfaden_KlimaEnergiekonzept.pdf - accessed: July 7, 2014.

BMLFUW (2011, February 16): Rundschreiben UVP-G 2000. [Online] http://www.umweltbundesamt.at/fileadmin/site/umweltthemen/UVP_SUP_EMAS/UVP-Gesetz/UVP_G_RUNDSCHREIBEN_2011.pdf - accessed: May 15, 2015.

Brauner G. (2014, December): Introduction to Energy Systems. Lecture on Energy and the Environment, 7th MSc Program: Environmental Technology & International Affairs, TU Vienna.

Byer P.H., and Yeomas J.S. (2007): Methods for addressing climate change uncertainties in project environmental impact assessments. Impact Assessment and Project Appraisal 25(2), 85-99.

Canadian International Development Agency (n.d.): GUIDE TO THE INTEGRATION OF CLIMATE CHANGE ADAPTATION INTO THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROCESS. Adapting to a Changing Climate in the Caribbean And South Pacific Regions. South Pacific Regional Environment Programme. Caricom. [Online] https://www.iaia.org/IAIA-Climate-Symposium-DC/documents/Caricom_Climate%20Change%20and%20EIA.pdf?AspxAutoDetectCookieSupport=1 - accessed: July 7, 2014.

Charter of Fundamental Rights of the European Union [CFREU] (2000, December 18): OJ C 364/01. [Online] http://www.europarl.europa.eu/charter/pdf/text_en.pdf - accessed: May 01, 2015.

Consolidated Version of the Treaty on European Union [TEU] (2012, October 26): OJ C 326/13. [Online] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012M/TXT&from=EN - accessed: May 01, 2015.

Consolidated Version of the Treaty on the Functioning of the European Union [TFEU] (2012, October 26): OJ C 326/1. [Online] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN - accessed: July 24, 2014.

De Jong S., Sterkx S., and Wouters J. (2010): The EU as a Regional Actor: Energy Security & Climate Change. Working Paper N.8, EU-GRASP. [Online] http://www.eugrasp.eu/wp8-the-eu-as-a-regional-actor-climate-change-and-energy-security-by-sijbren-de-jong-steven-sterkx-jan-wouters - accessed: February 26, 2014.

Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment [SEA Directive] (2001, June 27): OJ L 197. [Online] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32001L0042&from=EN - accessed: May 15, 2015.

Directive 2011/92/EU of the European Parliament and of the Council on the assessment of the effects of certain public and private projetcs on the environment [EIA directive] (2012, January 28): OJ L 26, amended by the Directive 2014/52/EU (OJ L 124, 25.4.2014). [Online] http://ec.europa.eu/environment/eia/pdf/EIA_Directive_informal.pdf - accessed: May 01, 2015.

Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (2012, November 14): OJ L 315/1. [Online] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32012L0027 - accessed: May 01, 2015.

Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (2014, April 25): OJ L 124. [Online] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0052&from=EN - accessed: July 7, 2014.

Ebinger J., Vergara W., and Leino I. (2011): Climate Impacts on Energy Systems: Key Issues for Energy Sector Adaptation. World Bank Publications. [Online] http://www.esmap.org/sites/esmap.org/files/DocumentLibrary/E-Book_Climate%20Impacts%20on%20Energy%20Systems_BOOK_resized.pdf - accessed: July 7, 2014.

Erb K.-H., Gingrich S., Krausmann F., and Haberl H. (2008): Industrialization, Fossil Fuels, and the Transformation of Land Use. An Integrated Analysis of Carbon Flows in Austria 1830– 2000. Journal of Industrial Ecology 12(5-6), 686-703.

Erdmann G., and Zweifel P. (2010): Energieökonomik. Theorie und Anwendungen. 2nd edition, Springer, Berlin/Heidelberg.

European Climate Adaptation Platform, Climate - ADAPT (n.d.): How to factor uncertainty into adaptation decision-making? [Online] http://climate-adapt.eea.europa.eu/uncertainty-guidance/topic2#What+are+no-regret+adaptation+measures%3F - accessed: May 05, 2015.

European Commission - DG ENV (2009, June 12): Study Concerning the Report on the Application and Effectiveness of the EIA Directive: Final Report. [Online] http://ec.europa.eu/environment/archives/eia/pdf/eia_study_june_09.pdf - accessed: May 1, 2015.

European Commission (2000): Green Paper - Towards a European strategy for the security of energy supply. COM/2000/0769 final. [Online] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52000DC0769 - accessed: May 24, 2015.

European Commission (2009a): Reference Document on Best Available Techniques for Energy Efficiency. [Online] http://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf - accessed: May 16, 2015.

European Commission (2009b): Adapting to Climate Change: Towards a European Framework for Action. White Paper. [Online] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:EN:PDF - accessed: July 7, 2014.

European Commission (2013a): Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment. [Online] http://ec.europa.eu/environment/eia/pdf/EIA%20Guidance.pdf - accessed: May 01, 2015.

European Commission (2013b): The EU Strategy on adaptation to climate change. Strengthening Europe's resilience to the impacts of climate change. [Online] http://ec.europa.eu/clima/publications/docs/eu_strategy_en.pdf - accessed: May 06, 2015.

European Commission (2015a): Environmental Impact Assessment - EIA. [Online] http://ec.europa.eu/environment/eia/eia-legalcontext.htm - accessed: May 01, 2015.

European Commission (2015b): Review of the Environmental Impact Assessment (EIA) Directive. [Online] http://ec.europa.eu/environment/eia/review.htm - accessed: May 01, 2015.

European Energy Efficiency Fund (n.d.): European Energy Efficiency Fund. Objective of the Fund. [Online] http://eeef.eu/objective-of-the-fund.html - accessed: May 24, 2015.

European Union (1995-2015): Glossary. White Paper. [Online] http://europa.eu/legislation_summaries/glossary/white_paper_en.htm - accessed: May 15, 2015.

European Union (2013, March 14): ENVIRONMENTAL IMPACT ASSESSMENT OF PROJECTS. RULINGS OF THE COURT OF JUSTICE. [Online] http://ec.europa.eu/environment/eia/pdf/eia_case_law.pdf - accessed: May 01, 2015.

Farmer K., and Stadler I. (2005): Marktdynamik und Umweltpolitik. Ein Beitrag zur gleichgewichts- und ordnungstheorethischen Fundierung umweltorientierter Volkswirtschaftslehre. LIT Verlag, Wien. ISBN: 3-8258-7417-6.

Fischer M., Schuller O., Albrecht S., and Faltenbacher M. (2008, 30/09 - 02/10): Exergy-Efficiency as Enhancement of Energy-Efficiency - an LCA Perspective. LCA8, Seattle. [Online] http://www.lcacenter.org/LCA8/presentations/323.pdf - accessed: May 05, 2015.

Gesetz über die Umweltverträglichkeitsprüfung (UVPG) (2013, July 25): Gesetz über die Umweltverträglichkeitsprüfung in der Fassung der Bekanntmachung vom 24. Februar 2010 (BGBl. I S. 94), das zuletzt durch Artikel 10 des Gesetzes vom 25. Juli 2013 (BGBl. I S. 2749) geändert worden ist. [Online] http://www.gesetze-im-internet.de/uvpg/BJNR102050990.html - accessed: May 17, 2015.

Haberl H., Fischer-Kowalski M., Krausmann F., Martinez-Alier J., and Winiwarter V. (2011): A socio-metabolic transition towards sustainability? Challenges for another Great Transformation. Sustainable Development 19(1), 1-14.

Haberl H., Fischer-Kowalski M., Krausmann F., Weisz H., and Winiwarter V. (2004): Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer. Land Use Policy 21(3), 199-213.

Hartley T. C. (2010): The Foundations of European Union Law; An Introduction to the Consitutional and Administrative Law of the European Union. 7th edition, Oxford University Press, New York.

Herdegen M. (2011): Völkerrecht. 10th edition, C.H. Beck oHG, München.

Houghton R.A. (2003): Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850–2000. Tellus 55B, 378-390.

Houghton R.A. (2010): How well do we know the flux of CO2 from land-use change?. Tellus 62B, 337-351.

Houghton R. A., Hobbie J. E., Melillo J. M., Moore B., Peterson B. J., Shaver G. R., and Woodwell G.M. (1983): Change in the Carbon Content of Terrestrial Biota and Soils between 1860 and 1980: A Net Release of CO2 to the Atmosphere. Ecological Monographs 53(3), 235-262.

Iemmi M. (2010): L'impatto ambientale della generazione elettrica. In: Acea SpA (Ed.) L'IMPRESA E L'ECOSISTEMA. CISU Centro d'Informazione e Stampa Universitaria, Roma, pp.223-284.

International Court of Justice (2010, April 20): Pulp Mills on the River Uruguay (Argentina v. Uruguay). [Online] http://www.icj-cij.org/docket/files/135/15873.pdf - accessed: May 05, 2015.

IPCC (2007): AR 4 WG II Figures Chapter 18, FIG 18.1. [Online] https://www.ipcc.ch/graphics/ar4-wg2/jpg/fig-18-1.jpg - accessed: May 15, 2015.

IPCC (2013): Summary for Policymakers. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)].

Larsen S. V. (2012): Climate Change in Environmental Impact Assessment of Renewable Energy Projects. IAIA12 Energy Future - The Role of Impact Assessment, Porto, Portugal. pp.1-6.

Loffredo S. (2011, June): CAMBIAMENTO CLIMATICO E VALUTAZIONE AMBIENTALE STRATEGICA GUIDA PER GLI ENTI LOCALI. [Online] http://www.lamoro.it/documents/CambiamentoClimaticoeValutazioneAmbientaleStrategica-guidaperglientilocali_000.pdf - accessed: May 17, 2015.

Nagel P.-B. (2014): Neuigkeiten zur Umweltverträglichkeitsprüfung (UVP). Ein Kurzbericht vom 12. UVP-Kongress in Bad Honnef. ANLIEGEN NATUR 36(2), 93-96. DOI: ISBN 978-3-944219-10-3.

OECD (2008, October 30): Strategic Environment Assessment and Adaptation to Climate Change. Endorsed by members of the DAC Network on Environment and Development Co-operation (Environet). [Online] http://www.oecd.org/dac/environment-development/42025733.pdf - accessed: July 7, 2014.

OECD/IEA (2010): World Energy Outlook, IEA Publishing. Licence: https://www.iea.org/t&c/termsandconditions/. [Online] http://www.worldenergyoutlook.org/media/weo2010.pdf - accessed: May 15, 2015.

OECD/IEA (2014): Worl Energy Investment Outlook, IEA Publishing. Licence: https://www.iea.org/t&c/termsandconditions/. [Online] https://www.iea.org/publications/freepublications/publication/WEIO2014.pdf - accessed: May 15, 2015.

Pérez de las Heras B. (2013): Climate change and energy in the EU: global challenges, colective responsibilities. European Global Strategy Project 4/2013- 17/4/2013. [Online] http://www.realinstitutoelcano.org/wps/wcm/connect/cbc604804f4b219a85a09f8c9edeb290/EGSMadrid-PerezDeLasHeras-climate-change-energy-EuropeanUnion.pdf?MOD=AJPERES&CACHEID=cbc604804f4b219a85a09f8c9edeb290 - accessed: July 7, 2014.

Perman R., Ma Y., McGilvray J., and Common M. (2003): Natural Resource and Enviromental Economics. 3rd edition, Pearson Education Limited, Harlow. ISBN: 978-0-273-65559-6.

Puhe J., Ulrich B., and Dohrenbusch A. (2001): Global Climate Change and Human Impacts on Forest Ecosystems: Postglacial Development, Present Situation and Future Trends in Central Europe. Springer, Ecological Studies 143, Berlin.

Repubblica Italiana - Provincia Autonoma di Trento (2010, March 09): Legge provinciale n.5. [Online] http://www.regione.taa.it/bur/pdf/I-II/2010/11/BO/BO11100156739.pdf - accessed: May 17, 2015.

Richtlinie 2010/75/EU des Europäischen Parlaments und des Rates über Industrieemissionen - integrierte Vermeidung und Verminderung der Umweltverschmutzung (2010, December 17): OJ L 334/17.

Riley A., Alex B., and Rauscher D. (2012): EU Energy Roadmap 2050: EU External Policies For Future Energy Security. Directorate-General For External Policies of the Union. [Online] http://www.iris-france.org/docs/kfm_docs/docs/observatoire-pol-etrangere-europe/2013-03-eu-energy-roadmap-2050-eu-external-policies-for-future-energy-security.pdf - accessed: April 15, 2015.

Sceptical Science (2014, April 24): Getting sceptical about global warming scepticism. What's cheaper, mitigation or adaptation? [Online] http://www.skepticalscience.com/mitigation-cheaper-than-adaptation-intermediate.htm - accessed: May 16, 2015.

Schnedl G. (2012): Umweltrecht im Überblick. Facultas AG, Wien. ISBN: 978-3-7089-0801-4.

Sen M. (2010, September 13): Energy Engineering. [Online] http://www3.nd.edu/~msen/Teaching/EnergySyst/Notes.pdf - accessed: May 12, 2015.

Umbach F. (2010): Global energy security and the implications for the EU. Energy Policy 38(3), 1229-1240.

Umweltbundesamt GmbH (2008): UVE-Leitfaden, Eine Information zur Umweltverträglichkeitserklärung, Überarbeitete Fassung 2008. REP-0184. [Online] http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0184.pdf - accessed: April 17, 2015.

UNECE (2001, October 30; entry into force): Aarhus Convention. Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters; 2161 UNTS 447; 38 ILM 517 (1999).

UNECE (2010, July 06): New international treaty to better integrate environmental and health concerns into political decision making. Geneva.

UNFCCC (2007): United Nations Framework Convention on Climate Change. The Kyoto Protocol Mechanims. [Online] http://unfccc.int/resource/docs/publications/mechanisms.pdf - accessed: May 16, 2015.

Wood C. (2003): Environmental impact assessment: a comparative review. 2nd edition, Taylor & Francis, New York.

World Trade Organization (2015): Understanding on rules and procedures governing the settlement of disputes. Annex 2 of the WTO Agreement. [Online] https://www.wto.org/english/tratop_e/dispu_e/dsu_e.htm#21 - accessed: May 01, 2015.

**List of Tables**

**List of Figures**