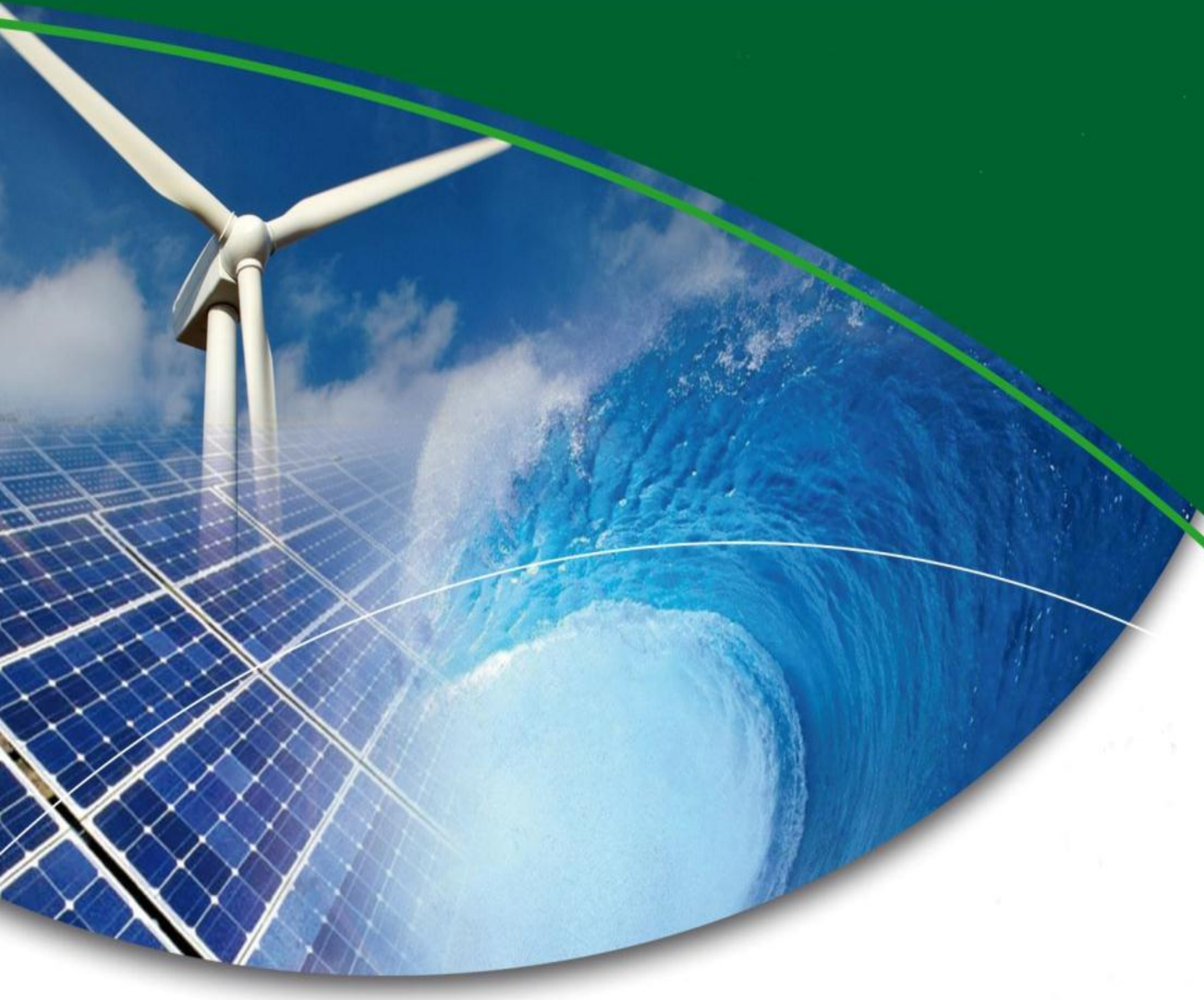

Renewable Energies in European Innovative Regions

Bachelor Thesis

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I. Abstract

The aim of this thesis is to analyse and compare three European regions, which develop renewable energy technologies, in terms of their organization and functioning. The study is furthermore designed to develop policy recommendations to enhance the performance of regional innovation systems. The focus lies on regional collaboration in the form of networks and formal institutions. The leading research question is: *To what extent do the organization and functioning of renewable energy innovation alliances in European regions explain differences in innovation performance?*

To answer this question, a cross-sectional study is conducted. The collected data is concentrated on the existing cooperation initiatives in the regions' renewable energy sector, such as knowledge and institutional infrastructure, stimuli for innovation, or the influence of regional collaborators on each other. The comparison shows significant differences within the regions' internal organization and functioning in terms of regional cooperation. It is concluded that the functioning of the triple helix has an impact on the innovation performance of an regional innovation system, while the organization of the region is not found to directly affect renewable energy innovation performance. Policy recommendations are made according to the research results, which underline the importance of the entrepreneurial university and the government's stimulation of bilateral networks. These findings are in line with many scholars, that have identified collaboration as crucial within the regional innovation system.

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IV. List of Abbreviations

CCC	Copenhagen Cleantech Cluster
CEEH	Centre for Energy, Environment and Health, University of Copenhagen
DV	Dependent Variable
EU	European Union
GCCA	Global Cleantech Cluster Network
ICN	International Cleantech Cluster
IO	Innovation Organizer
IV	Independent Variable
NSI	National Innovation Systems
OECD	Organization for Economic Co-operation and Development
PPR	Multi-annual research programs, region Trento
RIM	Regional Innovation Monitor 2011
RIS	Regional Innovation System
RTDI	Research, Technical Development and Innovation policies
SFG	Steirische Wirstschaftförderungsgesellschaft mbH
SRI	Research- Company Front Office, University of Trento
TU	Technical University (Graz)

1. Introduction

The topic of renewable energy sources is very current at the moment. In the light of Fukushima, for instance, Germany took a turn away from nuclear energy and is restructuring the national energy infrastructure. However, the demand for energy remains and a substitute for nuclear energy to fill the supply gap will be needed in the future. Since filling it with coal energy would be regressive considering environmental consequences, renewable energies could be the answer to this problem. Further, the EU gross inland oil consumption is expected to decrease in accordance with EU energy roadmaps (Appendix 1) and renewable energy sources are expected to increase their proportion. Each member state has a binding target of the renewable energy portion in the particular energy consumption. Up until now, the demand for renewable energy is predicted to grow three times its size, the EU being one of the largest global markets (Appendix 2). These forecasts open up the market for further deepening research on how to best exploit, use and integrate the new energy sources in our society.

With 'Roadmap 2050' and 'Energy 2020', the EU has started initiatives to further the use of renewable energies in all EU member states (European Commission, 2011). These initiatives get implemented on the regional level, where research and innovation mainly takes place. Lundvall and Borras (1997) argue within this reasoning by stating that the tendency of regions being the level at which innovation is produced, increases due to regional networks of innovators. The regional activities are at the end of the innovation chain and close to the market, therefore they are a fitting level for 'stimulating innovation and competitiveness in the globalizing economy' (Asheim & Coenen, 2005, p. 1174). Consequently, regional innovation systems have moved into the focus of attention of policy makers at any governance level. Due to their small size and homogeneity, regions can easily develop their own autonomous innovation systems. The Regional Innovation Monitor 2011 (RIM), which is an initiative of the European Commission's Directorate General for Enterprise and Industry with the aim to monitor regional innovation policy trends, found out that many regional innovation strategies have been developed recently. Four in five of all European regions implemented such renewed strategies since 2005. Such strategies are most effective if all regional actors are involved. It is argued that established knowledge infrastructures and knowledge transfer systems can act as important stimulators in promoting local innovation activities, not just good performing local firms (Doloreux & Parto, 2004).

1.1 Research Question

This study aims at empirically testing the relationship between renewable energy innovation performance and the organization and functioning of renewable energy innovation alliances by using three innovative European regions as empirical illustrations. In the last five years, many regions started creating new governance structures to produce significant Research, Technical Development and Innovation (RTDI) policies. However, the RIM also monitored the importance of national policy when developing regional policy, even in member states where the regional autonomy is high. This shows that European regions are still not being organized in a sufficient manner or do not function as efficiently as they actually could. Furthermore, the RIM discovered that the RTDI of two thirds of European regions still do not reach its full potential (Walendowski et al., 2011). In this paper, it is assumed that the reason for this can be found in the way the different regions function and how they are internally organized. This study intends to answer the following explanatory research question:

To what extent do the organization and functioning of renewable energy innovation alliances in European regions explain differences in innovation performance?

Existing literature has identified networks as a driving force of regional innovation and puts an emphasize on industry collaboration, as captured by cluster concepts, but also on bi- and trilateral networks. The university is often conceptualized as the most important actor in a regional innovation system, next to the industry and governmental institutions. This study however focuses on all three actors, which will be elaborated in terms of the triple helix, which is a way of organizing innovation, tailored around the cooperation between the three actors. The triple helix approach is adequate for this research because it contributes to a theoretical framework that fits the research interest and mostly concentrates on regional collaboration.

1.2 Sub-questions

On the basis of the main research question, three sub-questions have been developed, which structure the process of answering the main research question:

1. *In what ways can the organization and functioning of a renewable energy innovation alliance be structured?*
2. *How do selected regions in Europe perform in renewable energy production?*
3. *What differences and similarities exist between the selected European regions concerning the organization and functioning of the renewable energy innovation alliances?*

In order to answer the above mentioned research questions, three regions in different EU countries have been chosen, which are all members of the 'Global Cleantech Cluster Network '(GCCA) that was launched in 2010 and consists of 33 global cluster members and 4.000 cleantech companies worldwide. The network is independent and headquartered in Atlanta as a Nonprofit Organization that aims at establishing international networks and collaborations for all actors within the renewable energy sector. GCCA claims to further the renewable energy market by advising cleantech companies and assist in translating the newest sustainable technology to feasible business models, which increases the share of employees in the cleantech sector.

The regions are considered suitable for the research since all three of them are organized according to the triple helix structure. It is expected that they differ in their functioning and organization, since the aim is a sample that differs on the independent variables. This provides a good setting for comparing the regions on their differences on the triple helix.

This study has a cross-sectional design that is conducted with three case studies as empirical illustrations. These cases were selected with a purposive sampling method, which allows the researcher to pick the cases that seem the most appropriate in answering the research question. Three variables have been operationalized in accordance with a previously outlined theoretical framework. The operationalization enables the researcher to measure the outcomes of the cases with the unobtrusive data set that was collected, and draw conclusions on that basis.

1.3 Relevance of the research

Effective and autonomous European regions that are able to develop their own adequate regional policies, are said to have more productive output than regions that are depended on national policies. Therefore a study on the functioning of regional innovation systems can contribute to make regions more effective in terms of renewable energy innovation. Merely 18,3% of European regions have implemented demand-side innovation policies, the rest is still strongly supply-side oriented in spite of the promotion of knowledge transfer and collaboration activities between knowledge and industrial organizations (Walendowski, 2011). Consequently, the focus is not on supporting, but on radical innovation, which entails the development of new technologies. This is not beneficial for the development of leading innovative ideas, as produced under demand- side innovation policies, which increase the demand for innovations and therefore foster the uptake and demand for these (Edler, 2009). This study focuses on the collaboration for radical innovation and can therefore provide helpful insights when stimulating demand-side innovation development.

Chapter 2 of the thesis introduces the main concepts and theories. Chapter 3 presents the methodology such as the research design and data collection. In Chapter 4 the analysis of the cases and the comparison will take place. Conclusions and policy recommendations will be given in Chapter 5 and limitations of this research found its place in Chapter 6.

2. Theoretical Framework

In this theoretical part of the study, the concepts of regional innovation systems (RIS), which are the units of analysis, and innovation alliances will be conceptualized with the help of several definitions. This forms the basis for answering the main research question:

To what extent do the organization and functioning of renewable energy innovation alliances in European regions explain differences in innovation performance?

The analytical scheme of the theoretical framework is divided into three parts, namely organization, functioning and renewable energy innovation performance, which is in accordance with the variables of this study. Asheim (1998, 2002, 2005) is used for evaluating the organization of the selected regions. The four criteria by Etzkowitz (2003) will be the basis for the conceptualization of the RIS in terms of functioning. The broad innovation system approach by Gregersen and Johnson (2005) provides the basis for the dependent variable renewable energy innovation performance. After that, the first sub-question will be answered with the assistance of the two independent variables.

2.1 Defining the Concepts

2.1.1 Concept of Regional Innovation Systems

The basis of this study's theoretical framework is the concept of regional innovation systems. A RIS is a region where organizations interact to promote the use of knowledge (Doloreux & Parto, 2004), which is produced within the region, while serving various interests of all actors at the same time. The surrounding theories are aimed at studying innovation and cooperation that takes place at the regional level. An important aspect is that policy makers aim at giving incentives to cooperate. Cooperation can take the form of interactive learning, networking of the regional actors or specific collaborative projects. These actors are usually considered to be a member of one of the following three categories: knowledge organization, industry or government. Since interaction is an essential part of the concept of RIS it is suited for this study because the triple helix theory, on which this thesis focuses on, concentrates on interaction of different actors.

The triple helix approach has been identified by previous empirical studies by Asheim et al. (2003), Isaksen (2002) and Cooke et al. (2002) as 'a promising analytical framework for advancing our understanding of the innovation process in the regional economy' (Doloreux & Parto, 2004, p. 3). There are many different concepts used, therefore the study will move from its general definition to a more specific one. This is done by starting with definitions by Doloreux and Parto (2004) and ending with the conceptualization of RIS by Asheim (1998, 2002, 2005).

The concept of regional innovation systems is often defined as 'a set of interacting private and public interests, formal institutions and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge' (Doloreux & Parto, 2004, p. 3). Another definition is 'the regional innovation system can be thought of as the institutional infrastructure supporting innovation within the production structure of a region' (Asheim & Coenen, 2005, p. 1177). For firms to stay competitive, proximity in a region alone is not sufficient. They need to engage in interactive learning networks (Isaksen, 1999).

The RIS approach deals with the features of regional innovation capabilities, aimed at identifying the characteristics of regional innovation systems. These include the aspects of all regional actors and the innovation performance, that has been assigned indicators such as education, regional R&D intensities, technological bases or technological outputs (Doloreux & Parto, 2004). The RIS approach is furthermore exploring what makes a region an innovative region, usually by comparing different regions to one another, just like this thesis does. A vivid point of the RIS approach is that there are different forms of RIS, ranging from peripheral regions to regions in transition. A RIS is recognized to have several key indicators on 'various aspects of organizational and infrastructural capacity, competence, and capability'(Doloreux & Parto, 2004, p. 10).

Doloreux and Parto (2004) criticize that there is no unified framework or clear definition in the existing literature on regional innovation systems. They state that the reason for this is the lack of conceptualization of key terms such as 'region', 'innovation system' and 'institutions'. Therefore in the following paragraphs definitions for these terms, that are applicable to this research, will be provided.

According to Cooke (2001) region is 'a geographically- defined, administratively-supported arrangement of innovative networks and institutions that interact heavily with the innovative outputs of regional firms (Doloreux & Parto, 2004, p. 14). It is the space, where the interaction of the involved actors takes place. A region may be politically defined as an entity, but inherently a region is built upon internal cohesion.

Asheim and Coenen (2005) give the concept of innovation systems a broad and a narrow conception. The former comprises the economic structure with all its features and the set-up of institutions, which influence searching and exploring (Lundvall, 1992, p. 12). This definition adheres to a bottom-up, interactive innovation model (Asheim, 2001; Asheim & Coenen, 2005), which is the opposite of the narrow concept, that employs a top-down innovation model. The narrow concept integrates corporations and R&D facilities of public and private research institutions and universities. This is exemplified in the triple helix approach (Etzkowitz, 2003).

Institutions collectively function as an 'integrated web' that traverses different systems, levels of governance and interrelations (Doloreux & Parto, 2004, p.16). Institutions are the bodies that run regional innovation alliances with their inherent web structure. They connect all relevant actors in the system to a network through which knowledge flows. Institutional characteristics of a region include, next to the performance of the individual firm, knowledge infrastructures and knowledge transfer systems.

2.1.2 Concept of Innovation Alliance

The triple helix has undergone a long transition to the current model, triple helix III (Etzkowitz, 2008). Such transitions are part of the evolutionary feature of an innovation system (Edquist, 2004). This is in line with Etzkowitz (2008) who states that innovation is an never-ending transition. The triple helix III model evenly divides the power and stakes between the three groups of actors: academia, industry and government. Etzkowitz & Leydesdorff (2000) claim in their paper that most countries and regions aim at establishing such a construct of interaction. The outcome of such cooperation can be university spin-off firms, trilateral initiatives for knowledge based economic development, government laboratories and so forth. Isaksen (1999) states that research showed that simply the regional level is not sufficient for companies to stay innovative and competitive, however the learning processes are integrated into various forms of networks and regional innovation systems. The concept of innovation alliance builds on these interactive networks, collaborations or cooperations between the three actors. These formalized collaborations are the innovation alliances that cut across traditional boundaries between the actors within the space of the regional innovation system. Asheim and Coenen (2005) concluded on the basis of a European comparative cluster survey (Isaksen, 2005) that 'regional resources and collaboration are of major importance in stimulating economic activity' (Asheim & Coenen, 2005, p. 1179). The formalized procedures of innovation alliances can take shape in firms that diffuse knowledge, university spin-offs that exploit new knowledge or public research outcomes that become commercialized.

After this description of the relevant concepts, the applicable theories will be discussed in the forthcoming paragraphs.

2.2 Organization

Asheim and Coenen (2005) criticize that the effectiveness of RIS are mostly justified by single success stories like Silicon Valley and that there is no receipt for an effective RIS. Therefore Asheim (1998, 2002, 2005) developed a distinction between three kinds of regional innovation systems. This theory adds to the theoretical framework by providing an analytical basis for the evaluation of the organization of the three selected regions.

The distinction of Asheim (1998, 2002, 2005) is based on the division of two industrial knowledge bases, which is either 'analytical' or 'synthetic' (Laestadius, 1998). One of the main distinctions between the two is that analytical knowledge bases concern the creating of new knowledge, while the synthetic knowledge base aims at its application. The main differences can be found in table 1.

Tabel 1: Asheim and Gertler (2005)

Synthetic vs. analytic knowledge base

Synthetic	Analytic
Innovation by application or novel combination of existing knowledge	Innovation by creation of new knowledge
Importance of applied, problem related knowledge (engineering) often through inductive processes	Importance of scientific knowledge often based on deductive processes and formal models
Interactive learning with clients and suppliers	Research collaboration between firms (R&D department) and research organisations
Dominance of tacit knowledge due to more concrete know-how, craft and practical skill	Dominance of codified knowledge due to documentation in patents and publications
Mainly incremental innovation	More radical innovation

The selected innovative regions in this research are assumed to have an analytical knowledge base, but each region will be tested in accordance with the criteria in table 1. That way possible irregularities can be documented. The distinction between three kinds of regional innovation systems anticipates that the framework of a RIS accounts for fundamental differences between regional innovation systems.

The first type of RIS is called 'territorial embedded regional innovation system', which entails that synthetic knowledge employing firms, focus their innovation activity mostly on inter-firm collaboration within their region. Knowledge generating actors like universities do not count to the prevalent collaboration partners and the broad definition of innovation system come closest to this kind of RIS. Similar to this definition, Cooke (1998) refers to this kind of system as 'grassroots RIS'.

The second type is the 'regionally networked innovation system', where not only firms, but also other organizations are involved in an interactive learning process. The institutional infrastructure of the region receives support by the planned involvement of public as well as private organizations and is subject to policy interventions fostering collaboration and innovational activity. It entails a combination of a synthetic and analytical knowledge base. This type is considered ideal and comes close to Cooke's (1998) 'network RIS'.

The third and main type of RIS is the 'regionalized national innovation system', or 'dirigiste RIS' as Cooke (1998) referred to it. It features an institutional framework that is more integrated in national or international innovation systems, based on analytical knowledge bases. It mirrors the narrow definition of an innovation system, with networks based on specific radical innovation in a more linear model of cooperation.

It is estimated that the three selected regions are either 'regional networked' or 'regionalized national' innovation systems, since they build on analytical knowledge bases for renewable energy innovation, which excludes the first kind of RIS. However, the RIS characteristics will be applied to the three regions to identify not only the kind of RIS, but also to detect possible characteristics towards the 'territorial embedded regional innovation system'. Table 2 shows the characteristics of the RIS with their values.

Tabel 2: with help of Asheim (1998, 2002, 2005)

The organization of different types of RIS in the renewable energy sector

	Territorially embedded regional innovation system (type I)	**Regional networked innovation system (type II)**	**Regionalized national innovation system (type III)**
Location of knowledge organizations	Locally, but few relevant knowledge organizations	Locally, strengthening of (the cooperation with) knowledge organizations	Mostly outside the region
Collaborators	- Inter-firm learning processes on local level - Few knowledge organizations	- Firms - Knowledge organizations - Regional institutions - Public- private coordination	- National and international actors from knowledge and governmental organizations - Inter-firm cooperation for specific projects - Limited linkages to local industry
Knowledge base	Synthetic knowledge base	Combination of synthetic and analytical knowledge	Analytic knowledge base
Knowledge infrastructure	- Mature industries - Industry specific - Hands-on services, short term problem solving with ex-post support	- Growth phase of industry - Market-driven - Dynamic ensemble of ex-post support for incremental problem solving and ex-ante support for new technologies	- Emergent industries - Science driven - Commercializing science with ex ante support - Weak integration of knowledge and institutional infrastructure
Knowledge flow	interactive	interactive	more linear
Important stimulus of cooperation	Geographical, social and cultural proximity	Planned, systemic networking	Individuals with the same education and common experiences
Institutional infrastructure	- less developed	- Supports regions, is intentionally strengthened - Results from policy interventions	- Functionally integrated into national or international innovation systems
Typical locations and examples	Networks of SMEs in industrial districts	Germany, Austria and Nordic countries	Science parks

The values of each type of regional innovation system give insights on how the actors in the RIS are organized and related. Innovative networks of cooperation have been established by the regions to further the development of regional innovation systems, which once more shows the importance of integrating collaboration into the set-up of an regional innovation system when aiming at a high innovation performance.

2.3 Functioning

The four stages of a well-functioning system of triple helix networks (Etzkowitz, 2003, p. 301) will be applied to the three regions, as derived from the triple helix theory (Etzkowitz, 2003, 2008) in order to determine how they function. This section concludes that according to the triple helix model, networks and their functioning are crucial for the development of regional innovation in the field of renewable energies.

This study elaborates with the triple helix approach (Etzkowitz, 2003, 2008), because it is focused on the roles of the three actors, which suits the research interest. In the triple helix approach, the actors are not separated, but intertwined, influencing each other. The triple helix III model, where all three actors participate equally, is furthermore widespread in European countries (Viale & Campodall'Orto, 2002) and many nations aim at fulfilling its criteria. 'The triple helix is a platform for institution formation' (Etzkowitz, 2008, p. 8). The roles of the intertwined actors and the relationships amongst them change. Each actor represents a spiral in the helix, which are hardly ever equal players. In the statist model, the government drives the university and the industry further, in the laissez-faire model the driving force is the industry. In a laissez-faire society, the university has the central role, but is far away from the industry, where collaboration is unusual and competition prevails. These driving actors are called innovation organizer (IO). The IO is the center, around which the other actors rotate (Etzkowitz, 2008), since roles may change over time, another actor can take the lead.

The selected regions are presumed to be not build according to the statist model, since examples of such an organization of innovation include the former Soviet Union, France and many Latin American countries, where the university is very distant from the industry, and both are very depended on the government. That seems not applicable to Italy, Denmark and Austria, where the three regions under study are located. The laissez- fair society is mostly found in the USA, and therefore also does not apply to Europe.

In the beginning of the development of a triple helix, the actors enact their traditional roles in the collaboration (Etzkowitz, 2008). If all actors want to participate in the advance of the region in a particular sector, a regional growth agreement is made. Consequently, the knowledge organizations start producing knowledge about renewable energies and try to train more students in that area. The regional government could initiate permits, which allow the usage of funds or grounds for new buildings, while the industry might start to build up networks with suppliers for producing renewable energy technologies. Over time, when the university has produced plenty of knowledge, its position in the regional innovation system gets more central. The research outcomes form the basis for new spin-off firms and the university replaces the institutions as the IO of the energy innovation system. However, the three actors stay equal participants in a triple helix III model. This is where this study starts examining the selected cases.

The next step in this innovation alliance model is that the actors take the role of the other (Etzkowitz, 2008) while still maintaining their key characteristics and tasks. The transition might take shape in the industry not only producing renewable energy technologies, but also developing an in-house university, where their employees receive training in the particular industrial area, such as sustainable energy production. The regional university may take some business functions, like commercializing their produced knowledge and the government, next to its key task in providing societal rules, also offers venture capital for new renewable energy enterprises.

After that, trilateral networks are created, which 'operate in the space between institutions of higher education, industrial firms and government agencies' (Metcalfe, 2010, p. 504). Such organizations arise out of the interactions among the triple helix. Subsequently, these transitions have an impact on the actors within the RIS themselves and the larger society. An example could be that the university is no longer viewed as a scientific, but as a knowledge commercializing institution. These four stages of a well-functioning system of triple helix networks can be summarized in the following scheme. The effects of the triple helix transformation indicate how advanced the RIS are in their transition.

Tabel 3: Etzkowitz (2003)

Stages of triple helix transformation in the renewable energy sector	Effects of triple helix transformation
1. Internal transformation in each of the helices	a. Strategic alliances for R&D between companies b. Governments taking the role of venture capitalists c. Technology transfer offices between academia and industry d. Grant programs for the support of research is organized between academia and government
2. Influence of one helix upon the other	a. Government made university-industry cooperation easier through law b. Secure rules for commercialization of government sponsored research, good for technology transfer
3. Creation of a new overlay of trilateral networks and organizations from the interactions among the triple helix	a. An organization that includes all three actors, for example the New England Council
4. Recursive effect of the triple helix networks on the spirals from which they emerged and the larger society	a. The capitalization of knowledge transforms the role of the university, as well as how research results are viewed by scientists

2.4 Renewable Energy Innovation Performance

The theory by Gregersen and Johnson (2005) provides the theoretical framework of the dependent variable 'renewable energy innovation performance' to which hereafter will be referred to as 'innovation performance'. The units of analysis will be compared on the basis of these values.

Gregersen and Johnson (2005) originally used this approach to analyze National Innovation Systems (NSI). The theory builds on the concept of innovation systems and claims that innovation systems can be defined narrowly and broadly (Lundvall et al, 2002). This study applies the following model to regional innovation systems, since it can be applied to any governmental level of innovation activity. The innovation activity that is researched in this thesis, is the production of renewable energy sources in which all selected regions are specialized in. Gregersen and Johnson (2005) state that economic growth is not sufficient to evaluate the performance of innovation systems and the term 'performance of innovation systems' is not well defined. Gregersen and Johnson (2005) therefore conceptualize performance in terms of a broad and a narrow perspective.

The narrow NSI approach deals with research and development systems, which are arranged around technical product- and process innovations. High-tech and science based innovation have moved into the focus of attention. Performance indicators include the number of patents and scientific publications (Gregersen & Johnson, 2005, p.4). The broad NSI approach contains all features of interactive learning and innovation and recognizes all levels of innovation as well as different economic sectors. This model can be found in Appendix 3.

In this study, merely the broad performance of the narrow and broad innovation system will be empirically applied to the regions' renewable energy sector. The broad performance has been considered most suiting since it focuses on the aspects of interactive learning. The broad performance of a narrowly defined innovation system in the cleantech sector, includes amongst others renewable energy university- industry collaborations and the number of renewable energy high-tech spin-off companies. It also gives an indication of the share of renewable energies in the RIS, by taking the number of employees and companies in the sector into account. The 'double broad' perspective entails next to indicators of generation of new technology, also aspects of the organization and diffusion of new knowledge concerning renewable energies (Gregersen & Johnson, 2005, p.5). These aspects can be found in the next table.

Tabel 4: with help of Gregersen & Johnson (2005)

	Broad performance
Narrow innovation system approach	- Number of renewable energy spin-off companies - Renewable energy university-industry collaborations - Number of employees in renewable energy sector - Number of renewable energy companies
Broad innovation system approach	- Joint ventures in renewable energy sector - Amount of regional capital investments in renewable energy sector

All in all, this study fits in with the presented existing literature, since regional innovation systems will be the central point of the analysis. The concepts by Asheim and Coenen (2005), Cooke (2002), Etzkowitz (2003, 2008) and Lundvall (1992) provide the basis for this. The theoretical framework is therefore placed in the midst of the existing literature. The study will connect the concepts of innovation space and innovation alliances. This goes beyond the current status of the existing literature, since the connection between an RIS and its embedded networks is barely made. This study will fill the gap.

2.5 Answering the first sub-question

Taking into account the previous paragraphs, sufficient information is given to answer the first sub-question of this research: *In what ways can the organization and functioning of a renewable energy innovation alliance be structured?*

The answer was provided by the presented theories. All in all, organization can be structured according to the RIS classification by Asheim (1998, 2002, 2005) and the structure for functioning is derived from the four stages transistion by Etzkowitz (2003).

3. Methodology

This chapter describes how this study is constructed in order to apply the theoretical expectations previously outlined. This detailed description of the execution of this study is meant to enable other researchers to reproduce it in the same way. The chapter is organized as follows. The first part introduces the research design of this study, the second explains how the cases got selected and sampled. The third part illustrates how the variables were operationalized in order to measure the outcomes. This is followed by a description of the data collection and analysis.

3.1 Research design

The research design is a nonrandomized design, namely a cross-sectional study without any pre- or posttests, just one observation in one point in time. This design is similar to the post-test only experimental design, except the lack of the randomized treatment, which makes the cross-sectional design prone to the common confounders found in nonrandomized research designs (Gerring, 2012) that will be discussed later. When applied to small samples, the data needs to be analyzed qualitatively, which gives the first indicator for this study's data collection. This small-sample cross-sectional design will take shape in a most-similar case comparison across several cases, where the selected regions will be similar in many respects, except the independent variables. This has been exemplified in a study by Cornell (2002), who compared nine regions in the UdSSR for the effects of regional autonomy. He assumed that the regions were equivalent in all aspects that might be relevant to his hypothesis or that the remaining differences between the regions would not bias the outcomes.

The cross-sectional design in this study further aims to describe the relationship between renewable energy innovation performance and the organization and functioning of European regions. In order to do this, three case studies will be made and three sets of data collected. Gerring (2004) uses co-variation as a way of identifying research designs. The cause and effect must co-vary to be causally related. In a cross-sectional design, co-variation occurs synchronically across units. In this thesis it is thus expected that the effect of the independent variables is obvious across all units under study. An important part of the empirical analysis involves the comparison across the units, which will be done by comparing the three selected regions. A cross-unit analysis without a temporal variation, thus without a pre- or post- test, is according to Gerring (2004) a cross-sectional design (table 5). However, one characteristic of the cross-sectional design is that despite the lack of temporal variation, the independent variables are anticipated to precede the dependent variable. Gerring and McDermott (2007) also call this construct 'spatial comparison'. It has to be emphasized that this design is purely observational and not experimental since there is no manipulation of the treatment.

Tabel 5: Gerring (2004, p. 343)

Research Designs: A Covariational Typology

		Temporal Variation	
		No	Yes
Spatial Variation	None (1 unit)	[Logically impossible]	(a) Case study I
	Within-unit	(b) Case study II	(c) Case study III
	Across-unit	(d) Cross-sectional	(e) Time-series cross-sectional
	Across- and within-unit	(f) Hierarchical	(g) Hierarchical time-series; Comparative-historical

The three case studies are also included in the research design, a case study is 'an intensive study of a single unit for the purpose of understanding a larger class of (similar) units' (Gerring 2004, p.342). Yin (1994) stated that a case study is qualitative with a small sample, which is in tune with this study. Campbell and Stanley (1963) defined a case study as a research that investigates the properties of a single case. In this thesis, three cases will be used and compared, which is called a comparative case study, that has the advantage over a single case study, that more cases will be studied and compared afterwards. This grants a greater generalizability across the cases. The findings of the regions will be interpreted in terms of the functioning and organization of the triple helix and will be evaluated against indicators of innovation performance.

The issue with case studies is that there are no pre- or post- tests and no control groups. Therefore alternative explanations cannot be ruled out. However, case studies still contribute to research, since they allow 'one to peer into the box of causality to the intermediate causes lying between some cause and its purported effect' (Gerring 2004, p. 348).

The most-similar case comparison helps eliminating many confounders that thread the research design. Any factor that correlates with the independent variables has the potential to falsify the outcomes. Many confounding variables are prevented by choosing units that are similar on these confounding variables and only differ on the independent variables that are tested for in this research. Therefore the following control variables are used in this study: per capita GDP, growth of regional per capital GDP, share of employment in industry, unemployment rate, innovative entrepreneurship, technological and public knowledge. The regions are similar in these respects and therefore the control variables will not falsify the outcomes since they have the same influence in every region.

The fact that the design is nonrandomized, gives room for a number of confounders, that are eliminated through randomization in experimental designs, like many aspects of internal and external validity. Other research designs might promise a higher validity, but next to the enormous costs of conducting such an extensive experiment in three different regions, it is unethnical to manipulate whole regions and their innovation systems just for the means of research. A cross-sectional analysis is ethnical responsible and easily applicable, and the effect of the independent variables on the dependent variables can still be observed.
This study aims at generalizing over the rest of the population of cases, for which the cross-sectional design is suited because the data often comes from representative samples, which makes it easy to generalize over units. Furthermore, a cross-sectional design can easily be replicated in different settings. The study will therefore concentrate on external validity, also because internal validity is generally very low in such designs.

3.2 Case selection and sampling

Since the research design has been explained, the cases for this study will be selected. The population of cases are all European regions within the EU member states. The units of analysis are regional innovation systems. A non-probability sampling technic is employed and the likelihood of this sample being representative is rather low. More specifically, a purposive sampling method with similar cases will be used, which is often exercised when dealing with case studies, and where the researcher uses the own judgment to decide which cases are the most suitable to answer the research question. The choice for similar cases implies that the units will be studied in-depth and are being compared where they are similar. In this study, the similarity is that all three regions are structured according to the triple helix model.

The three selected cases are Styria in Austria, Trento in Italy and the Copenhagen region in Denmark. The Regional Innovation Monitor has ranked regions in Denmark and Southeast Austria as ‘balanced innovating regions’. This means that they have similar patterns of innovation and performance in terms of ‘innovative entrepreneurship’, ’technological innovation’ and ‘public knowledge’. Trento has been ranked a ‘knowledge-absorbing innovating’ region, which implies that it has the highest scores on ‘innovative entrepreneurship’ and a low score on ‘technical innovation’, compared to other European regions. A table illustrating this can be found in Appendix 4.

The countries, in which the selected regions are located in, all employ a mixture of bottom-up and top-down policy making approaches. Furthermore, they all identified the regional policy level as the most important one (Appendix 5). The fact that the regions are on the same level in these respects, enables to focus the comparison on the implementation of the triple helix, without any confounders, like the level of innovative knowledge, status in the EU or low GDP, influencing the outcomes. That way these factors are controlled for. Phrasing it differently would be: other things being equal, how can differences in renewable energy innovation performance be explained by the organization and functioning of innovation alliances. This is in accordance with the most-similar approach, where the samples are similar in many respects, except the independent variables, as explained earlier.

However, the selected regions still differ on the independent variables: the networks within the region are the main focus of this study, which was not a criteria for the classification by the EU, the lack of demand-driven innovation in Austria, the lack of decentralization in Italy and Austria, or the limited autonomy of Danish regions regarding general issues. Moreover, all three countries joined the EU in different points in time, which means that the regions have been influenced differently by the EU and the country itself. Another major difference with extensive consequences is the devolution process in Europe, which has not been taken into consideration in the classification of the RIM. The devolution process has started in the 1980s and has not happened homogeneously across all Europe. Therefore all European regions are on different trajectories (Walendowski et al., 2011) depending on historical backgrounds, institutional transformation and path-dependency. Furthermore, according to Yoder (2007), different types of regionalization exist across the EU, especially concerning decentralization, functions and competences at the regional level.

3.3 Operationalization

After the case selection, the variables are operationalized. All of the variables and their theories have already been discussed in the theoretical framework chapter. Table 6 provides a short overview of the operationalized variables.

Tabel 6: Operationalization of Variables

Variables	Values	Measurement	Main Data Sources
Dependent Variable:			
DV_1: Renewable energy innovation performance			
	Number of renewable energy spin-off companies	Bad: 0- 10 Good: 10 +	Regional Innovation Monitor 2001
	Renewable energy university- industry collaborations	Bad: No Good: Yes	GCCA member reports
	Joined ventures in renewable energy sector	Bad: No Good: Yes	Regional Innovation Monitor 2011, GCCA member reports
	Amount of regional capital investments in renewable energy sector	Bad: 0-5 million Good: 5 million +	GCCA member reports
	Number of employees in renewable energy sector	Bad: 0- 15.000 Good: 15.000+	Regional Innovation Monitor 2011, International Cleantech Network
	Number of renewable energy companies	Bad: 0- 250 Good: 250+	Regional Innovation Monitor 2011, International Cleantech Network
Independent Variables:			
IV_1: Organization	**Three types of RIS:**		
	location of knowledge organizations	See table 7	Regional government reports
	collaborators		Regional government reports, GCCA member reports
	knowledge base and flow, infra-structure		Industry reports
	important stimulus of cooperation		GCCA member reports
	institutional infrastructure		Regional government reports
IV_2: Functioning	**Triple helix transformation in the renewable energy sector**		
	bilateral networks		GCCA member reports
	-Strategic alliances	Bad: No Good: Yes	
	-Venture Capitalists	Bad: No Good: Yes	
	-Tech. transfer offices	Bad: No Good: Yes	
	-Grant programs	Bad: No Good: Yes	
	influence upon each other	Bad: No Good: Yes	GCCA member reports
	creation of trilateral networks	Bad: No Good: Yes	GCCA member reports, Regional Innovation Monitor 2011
	effect on 3 actors and society at large	Bad: No Good: Yes	Regional Innovation Monitor 2011

The dependent variable has the values (for the narrow innovation system approach): number of spin-off companies, university-industry collaborations, number of employees and number of companies; and the values for the broad approach are joint ventures and capital investments. All of these values are specifically focused on the renewable energy sector. The measurement will be ratio, since it has a zero point. Each region will be ranked on an index from 0-6, on how many values of the variable they fulfilled, zero being the poorest and six being the best performance. Conclusions will be made as to how good each region scores. 6-5 values are considered 'good', 4-3 are 'mediocre' and 2-0 are 'poor'.

The first independent variable is organization. In order to examine the organization in each region, this study will differentiate between three kinds of RIS, which all have their own characteristics when evaluated against the values of this independent variable. The variable organization has seven values and 20 different measurements that will be applied to the regions' renewable energy sector. A table summarizing this operationalization can be found on the next page. The values are location of knowledge organizations, collaborators, knowledge base, - flow and infrastructure, important stimulus of cooperation and institutional infrastructure. The regulation ascertains that if a region scores 20- 13 measures on a particular RIS type, than it is considered to be an exemplar of such. It is often the case that two types have the same measurement for one value. In that case, the point is subsequently given to the type of RIS where the region already has the most points. The networked innovation system is generally seen as the ideal type of RIS (Asheim & Coenen, 2005), while the characteristics of the regionalized national system lack local embeddedness which lead Asheim and Coenen (2005) to put the innovation capabilities of the outcomes of a regionalized national innovation system into question, since the stimulation of local industries is one of the preconditions for the steady development of RIS. Therefore, the organization of the RIS is considered 'good' when the region scores the most points on regional networked innovation systems, 'mediocre' when it is classified as a regionalized national innovation system and 'poor' when it is territorially embedded. This does not imply that there is a rank order between these types in general. In this study however the emphasis is put on networks and their organization. Consequently is a regional networked innovation system a far better basis for such alliance organization than a territorial embedded system. Furthermore will each region be placed in a pyramid scheme amongst the three types, to capture the organization's nature.

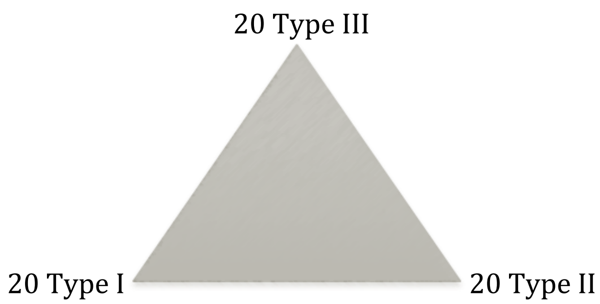

Figure 1: Positioning of RIS

Tabel 7: IV organization

The operationalization of different types of RIS in the renewable energy sector

Values:	*Measurement:*	**Territorially embedded regional innovation system *(Type I)***	**Regional networked innovation system *(Type II)***	**Regionalized national innovation system *(Type III)***
Location of knowledge organizations	Local or outside location	Local	Local	Outside the region
	Few or many knowledge organizations	Few	Many	Many
Collaborators	Inter-firm learning processes on local level	Yes	No	No
	National and international actors from knowledge and governmental organizations	No	No	Yes
	Linkages to local industry	Yes	Yes	No
	Public- private coordination	No	Yes	No
	Inter-firm cooperation for specific projects only	No	No	Yes
Knowledge base	Synthetic or analytic knowledge base	Synthetic	Combination	Analytic
Knowledge infrastructure	Phase of industry	Mature phase	Growth phase	Emergent phase
	Innovation stimulation	Industry specific	Market-driven	Science driven
	Ex-post or ex-ante approach	Short term problem solving with ex-post support	Mix of ex-post support for incremental problem solving and ex-ante support for new technologies	Commercializing science with ex ante support
	Integration of knowledge and institutional infrastructure	Weak	Strong	Weak
Knowledge flow	Interactive or linear	Interactive	Interactive	More linear
Important stimulus of cooperation	Geographical, social and cultural proximity	Yes	Yes	No
	Planned, systemic networking	No	Yes	Sometimes
	Individuals with the same education and common experiences	Sometimes	Sometimes	Yes
Institutional infrastructure	Level of development	Less developed	More developed, intentionally strengthened	Developed
	Supports regions	Yes	Yes	No
	Results from policy interventions	No	Yes	No
	Integrated into national or international innovation systems	No	Most of the time not	Yes

The second independent variable covers the four stages of a well-functioning system of triple helix networks within the cleantech sector. The values of functioning are internal transformation in each of the helices, influence of one helix upon the other, creation of a new overlay of trilateral networks and a recursive effect of the triple helix networks on the spirals from which they emerged. The seven values will be measured as a ratio and will be rank-ordered with an index from 0-7, depending on how many values the region fulfilled. Zero values being the poorest functioning and seven the best. 7-5 values are regarded as 'good', 4-2 are 'mediocre' and 2-0 are 'poor'. On this basis, it will be evaluated how good the regions function.

In cross-sectional designs, the temporal order of the variables is not always clear and there is no control for intervening, third variables. It also has be noted that the selection of variables is limited. The independent variables give an insight into the topic, the scope of the study is however restricted. This thread is countered by the in-depth analysis of the three cases. The data in the right column of table 6 also gives an indication of the data collected, as it will be discussed in the following section.

In order to merely study the relationship between the dependent and independent variable, some variables will be controlled for, by holding them constant, as already mentioned earlier. This is achieved through the fact that the selected regions do not differ in the respect of the identified control variables such as unemployment rate or innovative entrepreneurship. If not identified as such, they could influence the dependent variable and falsify the outcome of the study. If the control variables correlate with the two independent variables, this has no consequences for the outcome, since all regions are exposed to the same control variables. This also increases the external validity of this research design, since it can be generalized over other regions with the same characteristics.

3.4 Data collection and analysis

The collected data for this study is unobtrusive, the type of data is mainly qualitative, combined with some quantitative figures and numbers. This unobtrusive data takes the form of existing data that is collected from published literature about the regions, containing qualitative as well as quantitative data. These are found in analyses and statistics in management reports, statistical overviews, (regional) policy plans, research papers or information sheets. There are differences in the quality of the data used for the different regions. The collected data for the Copenhagen region is exclusively derived from official documents of the organization; while Styria's data is one half derived from official RIS documents and the other half from regional websites; for Trento the least amount of official documents could be found, many information was obtained from websites, and a number of conclusions were solely based on that data.

The data is used to measure the variables and to answer the research questions. Table 6 gives an overview of the type of data that is mostly used to measure each variable. In order to respond to the first sub research question, no data, but scientific articles are necessary. These articles have already been discussed in the previous section. Scientific articles about the topic can be found through data bases like 'web of knowledge', or in the library data base of the University of Twente. The following journals are an example of practical resources when searching for data: Social Science Information and Journal of Technology Transfer. The second and third sub-questions will be answered in chapter 4. So as to answer the second sub-question, the gathered data from all three actors with obstructive and unobtrusive data collection methods, will be examined to consequently report about their relationship, according to the theoretical framework. Therefore a descriptive analysis of the three regions and their performance in the renewable energy sector will be given. The last sub-question will be answered on the basis of the collected data from the second sub-question. It is intended that the three selected regions will be compared in terms of their functioning and organization.

The study uses this approach because data that can be found through the websites of the regions and statistical offices like EuroStat or the Regional Innovation Monitor, provide sufficient and valid data that are needed for answering the research question. The data is appropriate for testing the theories previously discussed, because it provides sufficient information for the application of the constructed values of the variables to the regions, the data being quantitative as well as qualitative.

4. Analysis

After the theoretical background and methodology chapters, the analysis will now be presented. The three regions are discussed apart from each other. The first being the Copenhagen region, followed by Styria and Trento.

For each region the analysis is divided in three parts. The first part illustrates the outcome for the independent variable organization with the help of the criteria of the different RIS as developed by Asheim (1998, 2002, 2005). The second part depicts the outcome for the second independent variable functioning, whose values have been developed on the basis of the triple helix approach by Etzkowitz (2003, 2008). The three regions' organization and functioning are evaluated in the third part. Subsequently the outcomes of each region for the dependent variable innovation performance will be presented, which has been derived from the theories by Gregersen and Johnson (2005). It also answers the second sub-question: *How do the selected regions in Europe perform in renewable energy production?* The last section of this chapter compares the outcomes of the cases and reveals similarities and differences in order to answer the third and final sub-research question: *What differences and similarities exist between the selected European regions concerning the organization and functioning of the renewable energy innovation alliances?*

All RIS are organized in the triple helix structure, which is one of the conditions to join the GCCA, that is amongst others financed by the European Regional Development Fund. Below some basis information about the regions can be found, completed with table 8 that illustrates some facts about the regions, for a more detailed version see Appendix 6.

The Copenhagen Cleantech Cluster is centered around Copenhagen, but also counts the 'Capital Region' and the 'Region Zealand' to its terrain, which is often referred to as East Denmark. Its share of employment is 16, 09% in the Capital region, and 23,36% in Zealand. The Capital region spends the most on R&D in all of Denmark, since it uses 6% of the region's GDP on innovative projects (RIM, 2012). The main cleantech technologies developed there are smart grid, water and wind.

Styria is Austria's most innovative federal state, with the expenditure on R&D being 4.3% of the gross regional product, which also puts it in a top position in the EU context (Leo et al., 2011). This contrasts with its comparatively weak economic output. Furthermore can be noted that

18.8% of all Austrian R&D employees work in the region. In 2007, 74% of R&D expenditures were spent in the private sector, which shows how privately oriented the RTDI sector is (RIM, 2012). The region's renewable energy projects focus on biomass, solar and waste treatment.

The Italian region Trento prioritizes the development of an 'Energy Policy and Technology District' with a funding axis of around 33 million Euros. The share of employment in the industry is 28,2%. The contribution of businesses on R&D were around 27 million, which is equal to 0,36% of the national average (RIM, 2012). The economic situation was strongly affected by the economic crisis in 2008, in that year a total of 40.483 enterprises were registered in Trento. The renewable energy sector focuses mostly on solar, bioenergy and green buildings projects.

Tabel 8: Facts about regions

	Copenhagen region (East Denmark)		**Region Styria**	**Region Trento**
	Capital region	*Zealand region*		
Total population	1.300.000	818.000	1.200.000	477.017
Legal form	Administrative region of Denmark	Administrative region of Denmark	Federal State of Austria	Autonomous Province of Italy
Regional GDP	82.900	25.000	33.100	15.200
Per Capita GDP	50.600	30.600	27.500	29.900
Growth of regional per capita GDP	0,03%	0,03%	0,05%	0,03%
Unemployment rate	4,667%	3,97%	3,94%	3,28%
Gross Expenditure on R&D	4.310	296,55	1.200	170, 3

Next to the before mentioned sectorial focuses in each region, table 9 gives an overview of all categories of renewable energies that are worked with in the RIS.

Tabel 9: Summary of renewable energy sources

	Copenhagen	**Styria**	**Trento**
Air & environment	Yes	No	No
Biomass, Biogas, Biodiesel	Yes	Yes	Yes
Energy infrastructure	Yes	No	Yes
Energy efficiency	Yes	Yes	Yes
Energy storage	Yes	No	No
Solar Energy	Yes	Yes	Yes
Sustainable materials	Yes	No	No
Waste and material flows	Yes	Yes	No
Water and waste water	Yes	Yes	Yes
Wind energy	Yes	No	Yes
Green Buildings	No	No	Yes

4.1 RIS Copenhagen

The trilateral network Copenhagen Cleantech Cluster (CCC) works within five focus areas. Test& Demonstration gives access to research and demonstration facilities. Matchmaking refers to fostering connections between the involved actors. International Outreach is achieved by the cooperation with international clusters, such as the International Cleantech Network. Innovation & Entrepreneurship is about translating ideas about renewable energy sources into corporate ventures. Lastly, Facilitation entails the regular up-dates for CCC members about current projects.

4.1.1 Organization

The outcomes of the analysis in terms of organization is summarized in table 10.

Tabel 10: Copenhagen region organization

The organization of different types of RIS in the renewable energy sector

Variable	*Values:*	*Measurement:*	CCC	Type of RIS
IV1: Organization	Location of knowledge organizations	Local or outside location	Local	I and II
		Few or many knowledge organizations	Many	II and III
	Collaborators	Inter-firm learning processes on local level	No	II and III
		National and international actors from knowledge and governmental organizations	No	I and II
		Linkages to local industry	Yes	I and II
		Public- private coordination	Yes	II
		Inter-firm cooperation for specific projects only	Yes	III
	Knowledge base	Synthetic or analytic knowledge base	Analytical knowledge base	III
	Knowledge infrastructure	Phase of industry	Growth phase	II
		Innovation stimulation	Science driven	III
		Ex-post or ex-ante approach	Commercializing science with ex ante support	III
		Integration of knowledge and institutional infrastructure	Strong	II
	Knowledge flow	Interactive or linear	Interactive	I and II
	Important stimulus of cooperation	Geographical, social and cultural proximity	Yes	I and II
		Planned, systemic networking	Yes	II
		Individuals with the same education and common experiences	Yes	III
	Institutional infrastructure	Level of development	More developed, intentionally strengthened	II
		Supports regions	Yes	I and II
		Results from policy interventions	Yes	II
		Integrated into national or international innovation systems	No	I and II

4.1.1.1 Location of knowledge organization

The CCC entails 46 knowledge institutions, like the research institutes DHI, GEUS and Copenhagen Resource Institute as well as the University of Copenhagen and of Roskilde, the Copenhagen Business School and the Technical University of Denmark (Risø DTU). The University of Copenhagen in the city center participates with its Centre for Energy, Environment and Health (CEEH) in CCC; the Copenhagen Business School is located in the heart of the city as well. GEUS and the Copenhagen Resource Institute also lie in the city center, close to the faculties of the University of Copenhagen. The department 'Risø' of the Technical University of Denmark, is the National Laboratory for Sustainable Energy, which is located approximately 35 kilometers from Copenhagen, close to the city Roskilde in the region Zealand, where also the University of Roskilde is located. DHI Copenhagen lies approximately 25 kilometers from Copenhagen, in the city Hørsholm, which is located in the Copenhagen Capital region.

4.1.1.2 Collaborators

The CCC has a variety of members from knowledge organizations, industry and governmental institutions as well as NGOs. Examples include the University of Copenhagen as a knowledge institution; Dong Energy and Better Place as cleantech companies from the industry; and the Municipality of Roskilde or Copenhagen Capacity for regional governmental institutions and the Confederation of Danish Industry for national governmental institutions.

Public and private institutions are coordinated through 'Research-to-Business' projects, which aim at advocating collaborations between knowledge organizations and the industry. The governmental organization Copenhagen Capacity is the responsible member for these projects and provides the needed communication platform for the public- private coordination for renewable energy projects. Another example includes the new city development Copenhagen Cleantech Park, which is initiated by the governmental actor Business Frederikssund. The park is supposed to provide a space for public- private partnerships, where many businesses and other organizations can locate. This also fosters inter-firm cooperation for specific projects, even though CCC is mostly aimed at inter-actor cooperation. Another measure to ensure public-private cooperation is the cleantech Smart Grid Network, which is a platform for companies, research facilities and public authorities to exchange knowledge, mainly about wind turbines. This network was initiated by Copenhagen Capacity to encourage cooperation and innovation in the renewable energy sector.

Smart Grid Network is also aimed at attracting foreign companies for partnerships with Danish actors. The present actors from knowledge and governmental organizations in CCC are mostly regional or national, but not international. Many multi-national renewable energy companies are located within the RIS, like Dong Energy or Novozymes, which opens possibilities for interaction.

The linkage to the regional industry exists, many multi-national firms have their headquarters or regular offices in the region and comprise 40% of all renewable energy related jobs in East Denmark. Also large Danish companies like Seas-NVE locate in the CCC region. According to the 2010 CCC report, 50% of the 522 cleantech companies within the RIS have less than 10 employees, which indicates the large amount of small companies next to the multi-nationals. Of all the companies, 21% have been founded in the period 2005-2010, these regional start-ups also connect the RIS to the regional economy.

4.1.1.3 Knowledge base

There are research collaborations between firms and research organizations, as has been discussed previously. The gained innovation is radical and scientific knowledge is required for problem-solving because the field of renewable energies still needs much exploration. Furthermore, the attained scientific knowledge is based on theories that will consequently lead to observations. This is called deductive reasoning and is mostly used in the involved knowledge institutions. They issue their findings as codified knowledge in publications and especially small research-intensive companies codify their knowledge in patents. Due to the fulfillment of the criteria, the CCC's knowledge base is analytic.

4.1.1.4 Knowledge infrastructure

The renewable energy sector in East Denmark is neither a mature industry, nor in the emergent phase. As the CCC report 2010 showed, the growth of the renewable energy sector has come to a stop and the annual turn-over declined in 2009 to 19% and labor productivity also went down. The employment growth was found to be at the same level as other Danish industry sectors, after years of continuous growth. Experts in the report argue that compared to other industries, cleantech industries experience high fluctuations in turn-over and labor productivity. Consequently it can be argued that the numbers will increase again in a short amount of time, experts expect a growth of 9% for the years after the recession.

The University of Copenhagen and Risø DTU lead a CCC project that aims at funding the gap between research and commercialization by providing funds for promising research projects that need to be developed further, so the industry can adopt that knowledge. This often takes form in spin-offs or new start-ups. 13% of the companies in this RIS are spin-off companies and 31% are recent start-ups. This commercialization is done with the assistance of the ex-ante approach, which can also be found in the initiative to build the Risø Park, a science park that will mainly collaborate with Risø DTU. The ex-post approach is not appropriate for this RIS, neither is the focus of short-term problem solving. New energy solutions are developed as long-term solutions, where existing industrial specialization is of no use. The Copenhagen region is science-driven, as already illustrated by the number of knowledge institutions and the linkages to renewable energy research, which the industry needs in order to keep up with the newest findings in the cleantech field. On the other hand is the RIS also market-driven, since the demand for renewable or green energy has increased over the past years. The construction of the Copenhagen Cleantech Park shows that the technology is actually used to build many houses, but this is more of a demonstration of research outcomes, than pure demand by the public.

Knowledge and institutional infrastructure are integrated with each other, for example the Copenhagen Cleantech Park, which is initiated by the regional governmental entity Business Frederikssund, where the knowledge about green technology can be put into practice by building 6000 houses with state-of-the-art knowledge of energy and environmental technologies. Copenhagen Capacity, another institutional actor, is responsible for matching different partners within CCC to provide a pool for the exchange of knowledge.

4.1.1.5 Knowledge flow

Through the established CCC networks, as discussed above, the knowledge within the region flows interactive between all involved actors.

4.1.1.6 Important stimulus of cooperation

In the region of East Denmark, cooperation is stimulated through a geographical, as well as cultural proximity, since the actors are located closely to each other and share the same nationality across the whole RIS. Furthermore is systemic networking, as the networks and events initiated by CCC, a stimulus of cooperation. The Network for Development of Hydrogen and Fuel Cell Technologies for instance, is meant to provide a platform for all stakeholders within the hydrogen and fuel cell sector and focuses on attracting investments in these fields. The Sustainable Biofuels Network encourages the development of sustainable energy, specifically biofuels, for shipping and heavy road transport.

The individuals that are employed in the renewable energy sector, mostly have a higher education from a university, like scientists or business administrators. Since renewable energy solutions are developed through radical innovation, there is not yet the need for manufacturers to produce great amounts, as is done with incremental innovation. Therefore they have a common education, experiences and point of views, which also works as a stimulator for innovation.

4.1.1.7 Institutional infrastructure

In 2007 there was a new reform in Denmark concerning the development and implementation of regional innovation policies, which established a new set-up that is ‘unique in the European context’ (Ebdrup, Nielsen & Nielsen, 2011, p. 6) and very independent and autonomous. Regional innovation policies fall under the responsibility of regional authorities, whose members are elected for four years. They do not have the power to tax and are therefore funded through national grants. The regional authorities have the full autonomy to use the funds to advocate initiatives and projects concerning innovation. Furthermore were Regional Growths Forums established, which are located in each region. These Forums provide a platform, where all actors from the industry, research and market labor come together to be part of the policy-making. The relation between the Forums and the national government is institutionalized to communicate regional as well as national issues. In the East Denmark region, many other regional governmental actors are involved, for example, the Risø Park, which will link research and industry. Another example is the Copenhagen Cleantech Park that is the responsibility of Business Frederikssund. The regional actor Copenhagen Capacity and the national actor Confederation of Danish Industry & Energy Map joined together to establish the One Stop Shop, which provides all information about the cleantech sector. All in all, is the CCC region intentionally supported by policy interventions like the extra funding for the commercialization for research, or through the Risø Park project.

4.1.2 Functioning

The outcomes of the analysis in terms of functioning is summarized in the next table.

Tabel 11: Copenhagen region functioning

Variable	Values	Measurement	Outcome
IV2: Functioning	**Triple helix transformation in the renewable energy sector**		Number of positive values: 7
	Bilateral networks		
	-Strategic alliances	Bad: No Good: Yes	Yes
	-Venture Capitalists	Bad: No Good: Yes	Yes
	-Tech. transfer offices	Bad: No Good: Yes	Yes
	-Grant programs	Bad: No Good: Yes	Yes
	Influence upon each other	Bad: No Good: Yes	Yes
	Creation of trilateral networks	Bad: No Good: Yes	Yes
	Effect on 3 actors and society at large	Bad: No Good: Yes	Yes

4.1.2.1 Internal transformation in each of the helices

Strategic alliances for R&D between companies

The CCC initiated the business-to-business network, which aims at introducing companies in the same sub field of renewable energy solutions to each other in order to expand a pool of tacit knowledge. These industry-specific networks are meant to provide a forum for collaboration in innovation and product development, technologies and business concepts. The argument of CCC for establishing these initiatives is that creating strong networks is fundamental to developing more innovative solutions in the renewable energy sector. Another example is the Copenhagen Cleantech Park, which will be build up to the state-of-the-art knowledge concerning thermal heat systems, wind power or solar cells to bring energy consumption to a minimum. The participating industry partners pool and share knowledge about the renewable energy innovations that have already taken form in a useable product.

Government taking the role of venture capitalists

There is a number of venture capitalists that specifically invest in the renewable energy sector in the Capital region and Zealand. Many of which are privately funded, but there is also a number of government funded venture capitalists. Examples include 'Vækstfonden', which translates into 'Growth Fund' and is a Danish state investment fund. The Growth Fund has invested into approximately 3.500 Danish renewable energy companies, an investment has the average worth of 440.000 Euros. The Danish Agency for Science, Technology and Innovation has established five pre-seed venture investment offices that invest in new cleantech companies that are close to commercial viability and therefore cannot reach for external funding. The last example is Østjysk Innovation that invests with own as well as state funds, also on behalf of the Agency of Science, Technology and Innovation. The investment of this agency in the area of sustainable energy and environment in 2012 is around 23 million Euros in Energy and Environment, and 5 million for Environmental Technology (Danish Agency for Science, Technology and Innovation, 2012).

Technology transfer offices between academia and industry

The University of Copenhagen has a technology transfer office with an extra portal for the CCC. They offer help with licensing as well as renewable energy research and student collaborations. The University provides a platform for external contacts that want to commercialize the research and for students who can participate in collaborative or contract research, consultancy or EU funded research. The DTU has 15,5 full time equivalents in the technology transfer staff, the Copenhagen University 8 and the Roskilde University 0,25. Compared with the rest of Danish universities, the DTU has the most people employed concerning technology transfer (Danish Ministry of Science, Innovation and Higher Education, 2011). In January 2011 a new piece of legislation on Inventions at Public Research Institutes took effect. Since then, researchers have to report their inventions to the Technology Transfer Office of their institution. Risø DTU also has plans to open a ´demonstratorium´ where companies can test and further their cleantech ideas and connect these with the research of the university. This project also acts as a large technology transfer office, which links the university´s research with industry projects and also has the function of matching students with prospective employers.

Grant programs for research support between academia and government

There is one grant program to support renewable energy research, which aims at funding the gap between research and the actual commercialization. At this stage, the university is done financing the project, when it has commercializing potential, but companies hesitate to fund the project further because the risk is still considered too high. The gap funding initiative identifies promising renewable energy research projects and provides extra funding for the researchers at the University of Copenhagen and DTU until the research is ready for the industry, this takes form in spin-off or spin-outs or new start-ups. The funding is organized between CCC partner universities and the government. The previously mentioned Regional Growth Forum is in charge of subsidies for innovation, but has no own funding at its disposal. It gives advice on how to spent the European Structural Funds and the Regional Development Funds. According to the Regional Innovation Monitor (2011), the Regional Growth Forum of the Capital region has roughly 25 million Euro at its disposal for business development per year, between 2010 and 2013. Nine million come from the EU Structural Funds. This is meant to give an indication about the funds that are available in the next two years.

4.1.2.2 Influence of one helix upon the other

Even though the Danish Act on universities requires them to provide their research results to the Danish community, the before mentioned Act of 2000, grants the knowledge institutions the right to commercialize their innovations, and obliges them to inform their technology transfer office about their outcomes. Through that obligation, the government furthers the cooperation between academia and industry, since the goal of the technology transfer offices is to match the two actors.

The bill for the Act on Technology Transfer etc. at Public Research Institutions from June 2004 entails provisions for enhancing 'competitiveness through promoting the transfer of new knowledge and technology between public research institutions, trade and industry' (Danish Parliament, 2004, p. 1). This includes the formation of research-based enterprises as well as stimulating co-operation amongst public research institutions, foundations and associations.

There are some limitations as to how the public research institution may invest the money gained from the collaboration. Examples include the reinvestment of the revenues may only happen within the purposes of the institution (Bill No. L 177, 4(6)). Furthermore, collaboration is only allowed if there are no conflicts of interest with the institution's public interests and if the relevant minister provided authorization for said collaboration (Bill No. L 177, 2(3)).

4.1.2.3 Creation of trilateral networks

The Copenhagen region has plenty of trilateral networks, most of which have already been mentioned. Examples are the Copenhagen Cleantech Park, the One Stop Shop, the Smart Grid Network and the Sustainable Biofuels Network. The initiator of such networks is the Copenhagen Cleantech Cluster, which has members from all three areas- government, industry and knowledge organizations.

4.1.2.4 Recursive effect

There is enough evidence to claim that the universities that are involved in the renewable energy sector capitalize knowledge. The government provided the legal basis with aforementioned Acts and the numbers speak for themselves. The DTU commercialized 3.090 licenses, 9.677 software licenses and sold 495 patens in 2010 alone (Appendix 8). The University of Copenhagen owns 1.224 licenses and sold 50 patents in 2010 (Ministry of Science, Technology and Development, 2010). The graph in Appendix 7 illustrates the intellectual property exploitation by public research institutions, which has drastically increased since 2000. The role of the university in relation to the industry has changed since the university is no longer just an teaching institution, but has itself established as a partner of the industry, which is confirmed by the previously discussed private research partners of knowledge organizations. The government is supporting this development by playing the role of the venture capitalist and passing suitable legislation.

4.1.3 Conclusion

Concerning the independent variable organization, CCC has the most characteristics of the type II RIS, even though it also scores many characteristics on the other types of RIS also. This leads to a 'good' score for organization. The region furthermore scores seven out of seven positive values on the independent variable functioning, which is the highest score possible and is also rated as 'good'.

4.2 RIS Styria

Eco World, the trilateral network in for renewable energies in Styria, aims at strengthening R&D, technological pioneer projects, integration of career changer, internationalization and an improvement of framework conditions. It counts 179 members and made a revenue of 6,88 billion Euros in 2011. Eco World organizes networking projects such as the Innovators Club or Technical Roundtables. It regularly publishes the Eco Future Radar, which is the summary of a study Eco World conducts about the future trends and technic in the renewable energy sector.

4.2.1 Organization

The outcomes of the analysis in terms of organization is summarized in the table below.

Tabel 12: Styria organization

The organization of different types of RIS in the renewable energy sector

Variable	*Values:*	*Measurement:*	Styria	Type of RIS
IV1: Organization	Location of knowledge organizations	Local or outside location	Mostly outside	III
		Few or many knowledge organizations	Many	II and III
	Collaborators	Inter-firm learning processes on local level	No	II and III
		National and international actors from knowledge and governmental organizations	Yes	III
		Linkages to local industry	Yes	I and II
		Public- private coordination	Yes	II
		Inter-firm cooperation for specific projects only	No	I and II
	Knowledge base	Synthetic or analytic knowledge base	Combination	II
	Knowledge infrastructure	Phase of industry	Growth phase	II
		Innovation stimulation	Market driven	II
		Ex-post or ex-ante approach	Commercializing science with ex ante support	III
		Integration of knowledge and institutional infrastructure	Strong	II
	Knowledge flow	Interactive or linear	Interactive	I and II
	Important stimulus of cooperation	Geographical, social and cultural proximity	Yes	I and II
		Planned, systemic networking	Yes	II
		Individuals with the same education and common experiences	Yes	III
	Institutional infrastructure	Level of development	Developed	III
		Supports regions	Yes	I and II
		Results from policy interventions	No	I and III
		Integrated into national or international innovation systems	Yes	III

4.2.1.1 Location of knowledge organizations

Eco World collaborates with the Technical University (TU) Graz, which lies directly in the heart of the RIS and conducts research on 'sustainable systems', which includes 14 specializations such as power industry and energy innovation or future heating, cooling and climate technology. The 'Montanuniversität' in Leoben, lies 61 kilometers away from Graz and has many technical institutes like the Institute of Sustainable Waste Management and Technology. Other affiliated knowledge organizations lie outside the region Styria, in the capital Vienna and in the federal capital of Upper Austria- Linz. The technical University Vienna participates with its Institute for Water and Waste Economy and the Institute for Econometric. The Vienna University of Economics and Business, cooperates with the department for wind energy. The University of Linz lies 200 kilometers away from Graz.

4.2.1.2 Collaborators

There has been no evidence of local inter-firm learning processes. The inter-firm cooperation that actually takes place, takes mostly the form of events and workshops on specific renewable energy topics, such as the Biomass Business Talk 2011 (26.01.11). However there is no cooperation for specific projects. The region Styria collaborates with a number of national and international knowledge organizations. The national have been mentioned above, international include the Universities Hannover and Kassel. Eco World has around 100 regional industry members, mostly small and medium enterprises, therefore is the linkage to the local industry existent. Eco World is governed by public private coordination. It is partly owned by the 'Steirischen Wirtschaftsförderungsgesellschaft mbH' (SFG), the federal state Styria, the city Graz, the Binder+Co AG, the e^2 group 'Umwelt engineering GmbH', the FIBAG research centrum as well as the 'KWB Kraft und Biomasse GmbH'. Eco Styria additionally receives subsidies from the EU through the ERDF- Program.

4.2.1.3 Knowledge base

The new knowledge about renewable energy of the knowledge organizations takes the form of radical innovation. However, problem related knowledge in engineering is also of importance in Styria due to the many local firms that use their knowledge to produce services and goods like 'KW Solar technik GmbH' or 'ATM Recyclingsystems'. This leads to more concrete know-how.

4.2.1.4 Knowledge infrastructure

In the period 2006- 2011, the number of Eco World members rose by 97, the total revenue rose from 4,3 billions to 6,88 in 2010. The number of employees were 18.552 in 2006 and increased to 31.917 in 2010. These increasing tendencies show that the renewable energy industry is still in the growth phase. The produced innovation in Styria is more market than science driven due to the high number of companies actually employing the knowledge in relation to a small number of knowledge or scientific institutions. Styria employs a mix of ex-post and ex-ante approach. The ex-ante approach can be found in the development of new technologies with the assistance of knowledge organizations. This is fostered through the Cleantech Innovators Club that counts industrial as well as academic partners to its members. Initiated through Eco World, TU Graz and the Industry Association Styria, entrepreneurs as well as university professors and researchers came together to discuss the development of resource efficiency in smart cities, the worth of waste water or solar solutions for the food industry. Renewable energies is an existing industry specialization in Styria, hence the high number of SMEs in the region, like the company 'Renewable Energies' that offers Biomass heaters that have to be installed and connected to a biomass network. Such processes demand incremental problem solving, also in the short term. This illustrates the ex-post approach in Styria. The integration of knowledge and institutional infrastructure is rather weak. Government entities are greatly involved in the network of Eco World, but there is no strong evidence found on bilateral cooperation.

4.2.1.5 Knowledge flow

The knowledge flow in Styria is interactive due to the above mentioned network meetings and the trilateral network Eco World Styria that communicates knowledge to all three actors.

4.2.1.6 Important stimulus of cooperation

All members of the renewable energy industry enjoy geographical, social as well as cultural proximity to each other since they all live in the same country and the same federal state, which shows no evidence of strong cultural or social division. Especially through Eco World, there are a number of planned network meetings, such as the Mariazeller Dialog 2010 that was co-organized with the research center Joanneum, which around 90 people from politics, research and industry joined. The topic was 'How many people, how much consumption can our planet sustain? How many do we need to sustain our social systems?'. The employed people in this RIS have the same kinds of education, such as university degrees in technical sciences like engineering, econometrics or environment management.

4.2.1.7 Institutional infrastructure

The institutional infrastructure is developed, which is shown by the fact that the federal state Styria, the city Graz and the SFG all own parts of the network center Eco World. SFG also additionally offers grants, consulting, education and knowledge bases for companies in sustainable development (WIN). Therefore can also be concluded that the institutional infrastructure supports the region. The state Styria has written an action plan for its innovative development, naming the renewable energy sector as one of the three key issues (Das Land Steiermark, 2010). However, merely strategic goals were set but no implications given to specific policy interventions. This is in line with Austria's history of federalism, which divides competences between the federal government and the federal states ('Länder'). These are granted autonomy to a certain point and are represented in the Federal Council and the Second Chamber, which deal with lawmaking. Erk (2004) has therefore described the Austrian system as 'centralistic federation', also because of the fact that the federal states started out with more competencies, that have been taken away from them in the past. The outcome is that only few areas fall under the exclusive competency of regional policy makers. The legislative power belongs exclusively to the federal government. In 2007, first steps were made to establish a clear division of competences. The main bodies for innovation in Styria are the Departments of Economics and Innovation and for Science and Research as well as the Styrian Business Promotion Agency (Leo et al., 2011). The Department of Economics and Innovation sets strategic goals and assigns budgets to particular innovation activities. The Styrian Business Promotion Agency has the autonomy for giving away funds for innovation projects and is connected to the national Austrian Research Support Agency. However, Styria lacks a common innovation strategy for all institutions, which could increase efficiency. Walendowski et al. (2011) rated Austrian regions as 'medium' autonomous concerning RTDI policy, which undermines that institutions at the regional level (not federal state level) are still dependent on the federal states, which in turn are dependent on the federal government.

All in all can be stated that the federal states of Austria have little legislative powers. Therefore it can be concluded that the region of Styria is integrated into the national innovation system. It is also integrated in international innovation systems since 23.9% of the R&D funding comes from abroad and a significant part of industrial activity is conducted by multinationals with headquarters abroad (Leo et al, 2011).

4.2.2 Functioning

The outcomes of the analysis in terms of functioning is summarized in the table below.

Tabel 13: Styria functioning

Variable	Values	Measurement	Outcome
IV2: Functioning	**Triple helix transformation in the renewable energy sector**		Number of positive values: 4
	Bilateral networks		
	-Strategic alliances	Bad: No Good: Yes	Yes
	-Venture Capitalists	Bad: No Good: Yes	No
	-Tech. transfer offices	Bad: No Good: Yes	Yes
	-Grant programs	Bad: No Good: Yes	No
	Influence upon each other	Bad: No Good: Yes	No
	Creation of trilateral networks	Bad: No Good: Yes	Yes
	Effect on 3 actors and society at large	Bad: No Good: Yes	Yes

4.2.2.1 Internal transformation

Strategic alliances for R&D between companies

One project between different industrial partners is the energy and resources center in St. Margarethen. The project is called 'ZUERST' and will be used for research in different model situations for multi functioning energy centres, using biomass heaters or biogas plants. During one Technology Round Table, organized by Eco World, the company 'ATM Recycling machines' initiated a demonstration project about a new form of ash briquette making in cooperation with two other companies. Other industrial actors partnered on projects for Recycling or Alternative Solar Energy which had been financed by external contacts. In 2012, the Cleantech Innovator Club took place at the Technical University of Graz, where researchers and entrepreneurs developed new ideas for renewable energy projects. Also researchers from other Styrian universities presented their latest research outcomes, the network event created opportunities for new collaboration formation. The TU Graz has several competence centres where it collaborates with the industry, the one for climate technology is called 'alpS', where one of the collaborating partners is Mayr & Sattler engineering office.

Government taking the role of venture capitalist

The governmental actor SFG contributes 51,01% to the Styrian Equity Financing Association which undertakes silent partnerships and venture capital. Furthermore, the Styrian Investment Agency, a subsidiarity of SFG, offers an extra venture capital program, called 'Viel! Versprechend' (Leo et al., 2011). Another financing program is 'Teil! Haben: offensive', where up to 1,25 million Euros can be invested, when the entrepreneurs adhere to the previously agreed on time limit. These venture capital programs however are not directly aimed at renewable energy sources.

Technology transfer offices between academia and industry

The so called 'Research & Technology House' at the TU Graz is the registration center for researchers' innovations, out-licensing procedures, spin-off projects or collaborative projects and regional technology transfer initiatives. It also provides R&D-related information brokering and a recruiting service, where TU graduates and firms can be matched. All institutes of the TU Graz are involved, consequently are the institutes concerning renewable energies also involved. At the Leoben University there is also a technology transfer office which is active in the fields of research management, research advise, company contacts and collaborations and intellectual property management.

Grant programs for the support of research between academia and government

On the national level, the law for the support of research and technology ('Forschungs- und Technologiefördersgesetz) BGB1 Nr. 36/2007 is enforced since 2007. This piece of legislation establishes an economy fund for deepening research, technology transfer and the establishment of high tech firms. It is however not aimed at any kind of commercialization. The fund agency will have its seat in Vienna and a legal personality. On the federal state level, the SFG has financing programs in collaboration with regional universities, often regardless of their industrial sector. The program 'Geistes! Blitz' advances together with academic institutions, R&D through several sub-programs like 'Innovations- Impuls' which funds consulting costs for Master theses, analyses etc. The sub-program 'Innovations- Performance' finances product development, prototyping up to company internal R&D. The fund can cover up to 40% of the total costs. The 'AplusB' program by the SFG has amongst others financed the Science Park Graz, together with the TU Graz, whose students get a chance to start their own business there once their graduate, an example for renewable energy sources would be '€cosys', which develops energy saving technology. The budget for the science park is currently 5.9 million Euros. The number of grant programs between research and government are however generally aimed at technology and not specifically at renewable energy technics.

The Styrian Environment Fund aims directly at renewable energy sources. The government supports the installation of biomass and solar heating systems. The biomass heating systems receive up to 25% of the total investment costs, solar heating systems, the funding varies between 300 – 500 Euros per house unit. The Styrian Fund for Green Electricity provides subsidies for renewable energy power plants that are based on solid biomass, liquid biomass, biogas, solar energy, geothermics, hydropower, sewage and landfill gas. The installation and implementation of studies, concepts and marketing actions is subsidized. However these funds are solely allocated by the government.

4.2.2.2 Influence of one helix upon the other

The federal government supported research in the before mentioned law for research and technology support, however the legislation signifies that commercialization of the supported research is not the goal. In regard of commercialization of research, the Patent Act of 1970 covers all inventions and the University Act of 2002 constitutes that innovations made at public universities shall be owned by the university. There is no evidence found though on any kind of law that advocates or advances technology transfer or any kind of commercialization efforts.

4.2.2.3 Trilateral networks and organizations

Eco World is an example of a trilateral organization, which fosters interactions among the three helices. It includes all three actors, for example the TU Graz or University of Leoben for academia, the SFG or the federal ministry of agriculture, environment and water economy for the government and Bluewaters and Eco Science for industry partners. Examples of trilateral networks are The Graz Science park or the Cleantech Innovators Club, which held their last meeting in March 2012 at the TU Graz, where 100 members of academia, industry and government came together to discuss mobility of the future, industrial waste management and resource efficiency. New aid programs for innovative SMEs were also presented and discussed.

4.2.2.4 Recursive effect of triple helix

The annual reports of the TU Graz disregarded facts like the number of scientific publications and produced patents up until 2007, when such facts were published for the first time. This shows that the foundation for the commercialization of research was not regarded as important until 2007. The number of granted patents rose from 6 in 2007 to 15 in 2010, the number of invention disclosures went from 41 up to 56. The number of patents actually filled however, fell from 33 to 29. The records of spin-offs and new start-up enterprises has increased over the years and the trend goes from a few big projects to many small SMEs. This has transformed the TU's role from just a knowledge institution to a participant in the industry by out-licensing or applying for patents. Especially the establishment of the technology transfer office symbolizes the new role of the university.

4.2.3 Conclusion

On the independent variable organization, Styria scores each six characteristics on types II and III with a number of in between points among the different types. This is an in-between score 'good- mediocre' for the organization in Styria. The lack of regional independence has hindered a classification as type II and therefore a score as a 'good' organization. On the second independent variable functioning, Styria scores four out of seven characteristics, which is a 'mediocre' score.

4.3 RIS Trento

Habitech in the province Trento is a trilateral initiative for the promotion of renewable energies, which reported a one billion turnover in 2008. With partners from the industry, governmental institutions and research centers, the spread of cleantech is promoted with the operational arm of Habitech- the Trentino Technology Cluster Consortium, which is led by a board, elected by RIS members. The consortium aims at converting Habitech projects into reality, however it is also aimed at other sectors in Trento. Habitech tells 167 private and 16 public members.

4.3.1 Organization

The outcomes of the analysis in terms of organization is summarized in table 14 on the next page.

Tabel 14: Trento organization

The organization of different types of RIS in the renewable energy sector

Variable	*Values:*	*Measurement:*	**Trento**	**Type of RIS**
IV1: Organization	Location of knowledge organizations	Local or outside location	Local	I and II
		Few or many knowledge organizations	Few	I
	Collaborators	Inter-firm learning processes on local level	Yes	I
		National and international actors from knowledge and governmental organizations	No	I and II
		Linkages to local industry	Yes	I and II
		Public- private coordination	Yes	II
		Inter-firm cooperation for specific projects only	No	I and II
	Knowledge base	Synthetic or analytic knowledge base	Combination	II
	Knowledge infrastructure	Phase of industry	Growth phase	II
		Innovation stimulation	Market driven	II
		Ex-post or ex-ante approach	Combination	II
		Integration of knowledge and institutional infrastructure	Strong	II
	Knowledge flow	Interactive or linear	Interactive	I and II
	Important stimulus of cooperation	Geographical, social and cultural proximity	Yes	I and II
		Planned, systemic networking	Yes	II
		Individuals with the same education and common experiences	No	I and II
	Institutional infrastructure	Level of development	Developed	III
		Supports regions	Yes	I and II
		Results from policy interventions	Yes	II
		Integrated into national or international innovation systems	Yes	III

4.3.1.1 Location of knowledge organizations

The university of Trento lies within the region and participates with the department of civil and environmental engineering in the RIS. The department includes laboratories and research centers amongst others for Biomass, Thermophysical measurements and Sanitary engineering. The three main research areas are environment and land-use analysis, environmental protection and management and building design. These research areas fall in line with Habitech's emphasis on green building. Research centers include the Bruno Kessler Foundation, MIT Mobile Experience Lab and Fiat Research center.

4.31.2 Collaborators

Habitech has 167 private members, representing 300 companies and 16 public members from academia and governmental organizations. Examples include the companies 'Energy save' or 'Sinergy Group', the local institution 'Comune de Trento' and the University of Trento. In the region are a number of multi-national renewable energy companies located such as 'Marangoni', the connection to the local industry is made by local industries and RIS members. Examples include the companies 'Enervals', 'Eco Tecnologie' and 'SWS engineering'. It has been found that there is inter-firm cooperation for specific projects, such as the building of the new science park by Progetto Manifattura, which was created by the province and is owned by Trentino Sviluppo, the economic development department of the province. The science park is planned to have buildings for sustainable energy research centers as well as participating companies for green building, renewable energy and environmental technology. However, there is also general industry collaboration, as fostered by Habitech, which offers amongst others assistance in the creation of a shared value chain for its member companies. OEDC (2012) has identified Trento as one of the renewable energy regions that increased the competitiveness of the regional industry by prioritizing the development of green technology. Not only bilateral collaborations got strengthened, but also the skills of workers received customized training and industry adjustments were made to respond to the necessities of a green economy (OEDC, 2012).

4.3.1.3 Knowledge base

At the research centers and the University of Trento, new knowledge is created concerning renewable energies. The research process is deductive since scientific workings start out with hypotheses that are tested through the conduction of research. The resulting knowledge is codified in the form of patents and scientific publications. Trento university has its own patent portfolio and also fosters research collaboration between companies that could profit from the radical research results. However, Habitech provides interactive learning with clients and suppliers like in the Kaizen Trainings organized by the Consortium, which teaches a method of production optimization for the local small and medium companies. Such teachings have resulted amongst others in an increased productivity from 10%- 50%, a reduction of 50% in working capital and a reduction in machinery time of over 50% (Trentino Sviluppo, 2011). The many local companies also rely on problem related knowledge, with which they are able to run their cleantech businesses. This also builds on the basic application of existing knowledge.

4.3.1.4 Knowledge infrastructure

Habitech fosters competitiveness in the RIS since 2006 and went from 2 to 27 full time employees in just six years. Habitech had a one billion turn over in 2008, many big projects such as the building of the science park are still planned and the RIS is developing. Many local companies build on the new renewable energy technologies, especially the focus of the region, namely green building, is put into practice already, for example the planning and redefining of green villages in Trento. The Consortium, MIT Mobile Experience Lab initiated the redesign of the village of Zambana with regard to future green building strategies. The project started in 2008. Another initiative is the Habitech project 'Green Valley', which transforms Primiero valley into an oil free zone, where mobility is ensured only through bio-methane, hydrogen and hydroelectric. In line with the mix of analytical and synthetic knowledge, Trento also employs a mix of ex-post and ex-ante approaches. New technologies get developed in the knowledge organizations, while incremental problem solving is being done at the SME level. The manufacturing sector in Trento is big and the building of new technologies happens at the local companies. The commercialization with the ex-ante approach is organized through the technology transfer office of the Trento university, which is responsible for research contracts with the industry and the initiation of technology that responds to companies' needs. The university's patent portfolio is offered to all interested industry partners, by selling licenses for instance.

The integration of knowledge and institutional infrastructure in Trento is exemplified by the Green House Alliance project that started in 2008, which is a strategic alliance for three years between the knowledge organizations MIT Mobile Experience Lab, the Design Lab, the Fondazione Bruno Kessler and the province of Trento. The research will be done amongst others concerning renewable energy systems and sustainable architecture.

4.3.1.5 Knowledge flow

As previously illustrated, in the renewable energy sector all three actors are involved. They interact with each other, there is no evidence found for merely a linear flow of knowledge.

4.3.1.6 Important stimulus of cooperation

The region belongs to the same nation and the inhabitants share a common cultural and social background. There are still living a few minorities such as the Ladin, the German-speaking Mócheno, and the Cimbrians, but this does not imply a major cultural division. One of the core aims of Habitech is being a network platform for its members that work in the renewable energy sector. There are regular network events such as in April 2012, which was a symposium about 'the incentives of the Province of Trento for sustainable construction', where all actors from the region came together to discuss the practical possibilities for Trento. Another example is Trentino Spirit, which was initiated by local governmental institutions such as the Consortium to provide a forum for local companies of all sectors that want to internationalize themselves. The previously mentioned OECD (2012) report indicated that inhabitants of Trento could receive training to adjust their knowledge to the requirements of a green energy RIS. Consequently are not only high educated researchers and managers involved in the RIS, but also manufacturer and regional entrepreneurs. The received training was also customized to the prospective employees of the green tech sector.

4.3.1.7 Institutional infrastructure

Starting in the 1990s, Italy has made some efforts to decentralize decision-making in the country. Significant landmarks on this way were the Bassanini Laws and the Bindi Reform in the period 1997-2000. That legislation established that regions received more administrative tasks from the higher levels, as well as additional functions (Walendowski, 2011). A major constitutional reform granted the regions more competences and restricted the higher levels to intervene in the regions at the same time. However, Italy still not arrived at a sub-national level with tax powers. A new law from 2009, about the 'delegation to the government in the matter of fiscal federalism' created a sub-national level with more taxation powers (Walendowski, 2011). According to Frosini (2009), the greatest issue is still the compatibility with the financial commitments that Italy agreed to by participating in the Stability and Growth pact.

Trento has recently implemented a new research system, which is directed at making research more efficient and less constrained by bureaucracy. This strategy has also been implemented into the broader policy progress in the RIS. A new piece of regional legislation (Provincial Law No 14/005) has also renewed the formal relationship between the province and research (RIM, 2012). The regional government uses a multi-annual research program (PPR) as the medium that guides private and public research to common strategic goals and therefore fosters their collaboration. To make such collaboration easier, the province established one common fund for both kinds of research institutions (ICAR, 2009). Trento aims at investing more in RTDI to support SMEs in maintaining and improving their competitiveness, innovation and productivity as well as provide skills for the knowledge society by these policy interventions (RIM, 2012). The region is still integrated in the national innovation system, such as ICAR, the interoperability and application cooperation between regions. This national organization coordinates all Italian regions.

4.3.2 Functioning

The outcomes of the analysis in terms of functioning is summarized in the table below.

Tabel 15: Trento functioning

Variable	Values	Measurement	Outcome
IV_2: Functioning	**Triple helix transformation in the renewable energy sector**		Number of positive values: 3
	Bilateral networks		
	-Strategic alliances	Bad: No Good: Yes	No
	-Venture Capitalists	Bad: No Good: Yes	No
	-Tech. transfer offices	Bad: No Good: Yes	Yes
	-Grant programs	Bad: No Good: Yes	Yes
	Influence upon each other	Bad: No Good: Yes	No
	Creation of trilateral networks	Bad: No Good: Yes	Yes
	Effect on 3 actors and society at large	Bad: No Good: Yes	No

4.3.2.1 Internal transformation

Strategic alliances for R&D between companies

A project of the Trentino Technology Cluster Consortium is called Blue Eagles, which is a forum for companies which aim at increasing their competitive edge through each other's help, like new opportunities for R&D, the acquisition of new technology or know-how. Trentino Spirit helps local companies that want to expand to other countries by establishing networks from which all companies can profit. Still, these business-to-business initiatives are for all industry sectors, not specifically for renewable energies. There has been no evidence found for strategic R&D alliances within Trento in that area.

Government taking the role of venture capitalist

The Consortium offers information for entrepreneurs and advises on which venture capitals to use. Provincial Law No 6/99 provides for venture capital for SMEs in almost all industrial sectors. However investments in projects concerning environment and replacement activities are granted a higher investment in capital (Trentino Technology Cluster Consortium, 2012).

Seed Money is another option to obtain money for start-ups in high tech areas. The Consortium is in charge of evaluating the applications.

Technology transfer offices between academia and industry

The technology transfer office at the Trento university matches students with prospective employers, assists with the patent or license application procedure, establishes partnerships with companies for PhD theses or formulates research contracts on topics of business interests. Furthermore it supports start-ups and spin-offs from the university. It keeps track of the scientific publication of each department and updates the patent portfolio.

Grant programs for the support of research between academia and government

The support measure 'Promotion of research projects relating to the Energy and Environment Technology District' of the province Trento is co-financed by the EU regional funds and Trento itself. It aims at encouraging research in the sectors energy saving, development of alternative energy sources and environmental protection. This measure has been built on the Provincial Law No 6/99. In 2008, the investment by the regional public funds was around 10 million, while EU structural funds invested 4,5 million Euros. In 2009, investments sank to 2 million from the region and 900.000 from the EU. The Research- company Front Office (SRI) of the University of Trento assists in finding financing options for research activities, technological innovation or new companies. Such funds can be provincial, national or from the community.

4.3.2.2 Influence of one helix upon the other

Italian legislation regarding patent activities builds on the 2001 law n. 383 (art. 7), which holds that workers of universities and public research bodies hold the rights that arise from their invention. This code therefore protects the research of public institutions. There is no evidence found though that simplifies university-industry relations for example in terms of technology transfer.

4.3.2.3 Trilateral networks and organizations

As previously stated is Habitech a trilateral organization in the region of Trento. An example of a trilateral network is the planned science park, which will hold buildings for companies, as well as knowledge organizations, while governmental organizations are involved in the planning (Habitech, 2011).

4.3.2.4 Recursive effect of triple helix

In 2009, 67.250 Euros were projected through concessions, licenses, trademarks and similar rights at the University of Trento. This represents an increase of 38.832 Euros since 2007. The report however states that there was no value created by patents in 2009, which represents a decrease by 3.362 Euro. This illustrates the patent earning in 2007 (Università degli studi di trent, 2009). This shows that the university participates in the commercialization of research, however the patent value decreased in the last year and there is no evidence whether the commercialized licenses were concerned with renewable energies.

4.3.3 Conclusion

Trento scores on the variable organization the most characteristics of the type II RIS, with a great tendency towards type I. Consequently, the organization is 'good'. On functioning, Trento was only found to have three positive values, which is a 'poor' performance.

4.4 Renewable Energy Innovation Performance

This paragraph answers the second sub-research question by applying the values of the dependent variable to the collected data: *How do selected regions in Europe perform in renewable energy production?*

4.4.1 RIS Copenhagen's performance

The table below summarizes CCC's performance on the dependent variable.

Tabel 16: Copenhagen region renewable energy innovation performance

Variables	Values	Measurement	Outcomes	
Dependent Variable:				
DV₁: Renewable energy innovation performance			Number of positive values: 6	
	Number of renewable energy spin- off companies	Bad: 0-10 Good: 10 +	68	Good
	Renewable energy university- industry collaborations	Bad: No Good: Yes	Yes	Good
	Number of employees in renewable energy sector	Bad: 0- 15.000 Good: 15.000+	29.926	Good
	Number of renewable energy companies	Bad: 0- 250 Good: 250+	522	Good
	Joint ventures in renewable energy sector	Bad: No Good: Yes	Yes	Good
	Amount of regional capital investments in renewable energy sector	Bad: 0-5 million Good: 5 million +	10 million	Good

Number of renewable energy spin-off companies

The CCC region tells 68 spin-offs in the renewable energy sector. Most of them are concentrated within the cleantech fields Waste and Recycling (20%), Energy Saving (20%) and Sustainable Materials (18%) (Monitor Copenhagen Cleantech Cluster, 2010).

Renewable energy university- industry collaborations

Within the CCC, there are many university- industry collaborations such as the 'Research-to-Business' projects, the Copenhagen Cleantech Park and the Risø DTU ´demonstratorium´. The universities in the region further have an technology transfer office which provides a platform for university- industry collaborations. The DTU had 802 research agreements with private enterprises in 2011, Copenhagen University had 302, Roskilde University had 72 and Copenhagen Business School had 35 (Christensen, 2011). These agreements connect academia and industry with each other.

Number of employees in renewable energy sector

The International Cleantech Network (2012) reported that the CCC has 29.926 employees at this moment. The employment growth is reported to be currently the same as any other industrial sector in Denmark in 2010. The Monitor Copenhagen Cleantech Cluster (2010) further claims that the employment growth will have increased by 9% in 2012.

Number of renewable energy companies

The CCC has 522 companies in the renewable energies sector (International Cleantech Network, 2012), which is confirmed by a CCC report. Eleven of these have more than 500 employees and account for 40% of all jobs in the sector while the remaining companies have less than 10 employees on average (Monitor Copenhagen Cleantech Cluster, 2010).

Joint ventures in renewable energy sector

There are many business-to-business networks within the RIS. The CCC conducted a study which showed that intelligent energy systems, mainly wind turbines, have a great international demand and saw opportunities to partner with foreign companies to sell such technologies. The resulting Smart Grid Network is the platform where Danish actors can find partners for innovative collaboration concerning renewable energy sources. Other examples include the network for development of hydrogen and fuel cell technologies or the innovation network of environmental technology. The Copenhagen Cleantech Park project is also the result of joined investments of several companies.

Amount of regional capital investments in renewable energy sector

The CCC was a major policy focus in 2009 and received one of the largest investments by the Growth Forum, namely 10 million Euros (Ebdrup et al., 2011). 71% of Danish R&D investments from the business sector were meant for the Capital Region and 3.1% for Region Zealand (ØresundTrends, 2012). In 2009, the Growth Forum of the Capital Region initiated 10 new innovative projects and invested 19 million Euros in such, which accounts for 50% of the total investment in 2009. Entrepreneurship received 13% and the use of new technology received 10% of the annual investment. These sectors can be connected to the cleantech industry in the CCC region. In the time period 2010-2013, the annual investment was increased to 25 million Euros, inclusive 9 million Euros from the EU structural funds (Ebdrup et al., 2011). The Capital region reinvests 6% of the regional GDP into R&D, which is the highest expenditure level in Scandinavia. Furthermore, the private business enterprise expenditure on R&D is around 80% (Ebdrup et al., 2011).

4.4.2 RIS Styria's performance

The table below illustrates the RIS's performance on the dependent variable.

Tabel 17: Styria renewable energy innovation performance

Variables	Values	Measurement	Outcomes	
Dependent Variable:				
DV$_1$: Renewable energy innovation performance			Number of positive values: 3	
	Number of renewable energy spin-off companies	Bad: 0-10 Good: 10 +	8	Bad
	Renewable energy university- industry collaborations	Bad: No Good: Yes	Yes	Good
	Number of employees in renewable energy sector	Bad: 0- 15.000 Good: 15.000+	14.541	Bad
	Number of renewable energy companies	Bad: 0- 250 Good: 250+	~ 500	Good
	Joint ventures in renewable energy sector	Bad: No Good: Yes	Yes	Good
	Amount of regional capital investments in renewable energy sector	Bad: 0-5 million Good: 5 million +	1 615 600	Bad

Number of renewable energy spin-off companies

In the context of the Eco Future Radar, Eco World supports new start-ups and spin-offs in the renewable energy sector. The AplusB initiative by SFG supports new spin-offs and startups, one of these initiatives is ZAT, which has an annual budget of 4.3 million Euros and is a project of the Leoben university and the city of Leoben for start-ups in the field of applied technology and research. Since 2004, there have been 17 spin-offs at Leoben University through ZAT. These initiatives by SFG however are not directly for renewable energy sources.

In 2011, the TU Graz reported seven new spin- offs, and none of those were aimed at renewable energy. Since 1950, there were 8 spin-offs concerning renewable energy at the TU Graz. This number is however evenly spread throughout the years, the first being developed in 1970 and the last in 2010.

Renewable energy university- industry collaborations

Eco World organizes regular business club meetings with the industry and academia present. The Cleantech Innovators Club also connects the two parties, discussing energy efficiency and technology. Staff and students from the TU Graz, Joanneum Research GmbH, Leoben University and 70 participants from the industry attended. Furthermore, the TU Graz and the Leoben University have technology transfer offices which are a platform for university- industry collaborations such as Master or PhD theses or spin-off projects. There is also a recruitment service, which matches recent TU graduates from any study with respective employers.

Number of employees in renewable energy sector

Eco World reported 14.541 employees in the renewable energy sector (International Cleantech Network, 2012). This number includes all employees, regardless whether they are a member of Eco World or not.

Number of renewable energy companies

There are approximately 500 companies in this sector, of which 179 were a member of Eco World in 2011. Many of which received awards in 2011, such as ‘Energy Globe Austria 2011’ or the ‘Solar Pioneer Award of the Republic of Singapore’.

Joint ventures in renewable energy sector

A regional joint venture is for example found in Biomass heating system producer KWB, that started a joint venture in 2009 to put additional emphasize on the field of energy production through biomass gasification plants.

The RIS member Andritz AG is member of the joint venture GEHI of General Electric, of which it acquired the majority holding. GEHI is an international company that employs approximately 200 employees and offers hydro test laboratory, production plants in Finland and that has access to production capacities that belong to the Brazialian joint venture partner ‘Inepar’.

Amount of regional capital investments in renewable energy sector

SFG Styria invested in 2006, 408.600 Euros into green energy technologies. There was also an direct investment to Eco World Styria, which is the sum of employees multiplied by an average annual cost of 46.000 Euros per full time employee, this left Eco World in 2006 with 207.000 Euros. The federal district of Styria received around a million Euros regional public expenditures for R&D in the field of green energies and an additional 7 million from national ministries (Sakulin et al., 2008). This illustrates the limited budget of regional institutions in comparison to national governmental institutions in Austria. The total regional investment was 1.615.600 Euros (408.600€+ 207.000€+ 1.000.000€).

The SFG invested 62 million Euros in Styria in 2008 and into their core innovation fields: location development, innovation and R&D investments, entrepreneurs, human potential and internationalization of regional companies (SFG Jahresbericht, 2008). Comparing these kind of numbers shows that green energy is less of a priority of SFG Styria.

4.4.3 RIS Trento's Performance

The table below summarizes the RIS's performance on the dependent variable.

Tabel 18: Trento renewable energy innovation performance

Variables	Values	Measurement	Outcomes	
Dependent Variable:				
DV$_1$: Renewable energy innovation performance			Number of positive values: 2	
	Number of renewable energy spin-off companies	Bad: 0-10 Good: 10 +	1	Bad
	Renewable energy university- industry collaborations	Bad: No Good: Yes	Yes	Good
	Number of employees in renewable energy sector	Bad: 0- 15.000 Good: 15.000+	8.000	Bad
	Number of renewable energy companies	Bad: 0- 250 Good: 250+	300	Bad
	Joint ventures in renewable energy sector	Bad: No Good: Yes	No	Bad
	Amount of regional capital investments in renewable energy sector	Bad: 0-5 million Good: 5 million +	10 million	Good

Number of renewable energy spin-off companies
Between 2007 and 2011, there have been six spin offs from Trento university and one deals with renewable energy ('Mountain-eering s.r.l.') that was founded in 2008. The other five concern biotechnology and ICT.

Renewable energy university- industry collaborations
The technology transfer office at the Trento University provides a platform where Master and PhD students can search for prospective industry partners to start a collaboration with. In 2011, the Fondazione Bruno Kessler research center organized a workshop together with Habitech about transdisciplinary economics for sustainability.

Number of employees in renewable energy sector
Habitech reports 8.000 employees in the Trento renewable energy sector (Habitech, 2011). The organization was established in 2006 and is therefore relatively young and the number of employees is still growing. Many initiatives are still in planning like the Green Valley project, which will account for an increase in employment numbers.

Number of renewable energy companies
Habitech reported in 2011 that the renewable energy sector consisted of 300 companies. This can be explained with the same reasons as the comparatively low number of employees. The new projects will probably also stimulate the formation of new companies.

Joint ventures in renewable energy sector

There are a number for joint ventures in Trento, for example one is the COSBI research center, which is a collaboration between Microsoft Research and the University of Trento since 2005. The main aim are biological processes using programming languages. It however has nothing to do with renewable energy solutions. There was no evidence found on cleantech joint ventures in the RIS.

Amount of regional capital investments in renewable energy sector

The Regional Innovation Monitor (2012) states that the Autonomous Province of Trento identified 'Energy Policy and Technology District' as their first priority since 2007. The total budget was 33.4 million Euros, the ERDF covered about 10 million of the total, while the region itself invested around 10 million itself (43% of the costs after the ERDF investment), while 23.4 million were accounted for by the national government.

4.5 Comparison

This part of the paper aims at answering the third sub-research question, namely: *What differences and similarities exist between the selected European regions concerning the organization and functioning of the renewable energy innovation alliances?*

Tables that summarize the scores of each region on the variables, can be found in Appendix 9, 10 and 11.

First, the regions will be compared in terms of organization. The similarities are that all regions were found to have linkages to the local industry; public- private coordination; a system of integrated knowledge and the institutional framework; interactive knowledge flow; geographical, social and cultural proximity; planned systemic networking; an institutional framework that supports the region and all regions are in the growth phase of their renewable energy sector. All in all, eight out of twenty possible scores have been identical across the three RIS. The values of these scores were either a type II or a mixture between type II and I. The pyramid scheme, where the regions are placed in, shows how the RIS are related to each other and all three are similar in the respect that they have the greatest tendency towards type II.

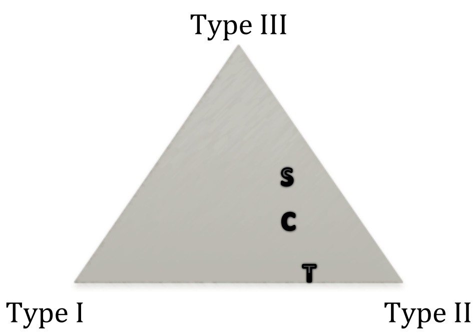

Figure 2: Positioning of the three RIS

The RIS share some similarities when one compares the three regions in pairs of twos. Copenhagen and Trento have the least values in common, while Styria and Trento share the most common values, but these differences are not very significant. The fact that Styria and Trento share the most common values is striking when comparing this to the pyramid and spotting them placed so far apart from each other. The explanation could be that their shared values are mostly of a type II nature and their explicit scores on either type I (Trento) and type III (Styria) drive them apart. Hence, there are many differences in the organization, as table 19 shows. Here, the exact scores of each region on each type of RIS can be found.

Tabel 19: Scores on organization

Comparison of the regions in terms of organization

Variable	Copenhagen	Styria	Trento
IV_1: Organization			
	Type I: 0 Type II: 6 Type III: 5 I and II: 7 II and III: 2 I and III: 0	Type I: 0 Type II: 6 Type III: 6 I and II: 5 II and III: 2 I and III: 1	Type I: 2 Type II: 8 Type III: 2 I and II: 8 II and III: 0 I and III: 0

Styria's knowledge organizations lie mostly outside of the region, while Copenhagen's and Trento's lie within the regions. In contrast to the other two regions, Trento only has few knowledge organizations. It was furthermore found to have distinct inter-firm learning processes, which miss in Copenhagen and Styria. Styria was the only region to include international actors from knowledge organizations such as Universities Hannover and Kassel. In comparison with the other regions, Copenhagen has very distinguished and specific projects for collaboration such as the Copenhagen Cleantech Park and the Demonstratorium. Copenhagen is also very busy developing high tech renewable energy solutions with few companies that actually put the knowledge into practice. Therefore Copenhagen was found to have an analytical knowledge base, which contrasts with the combination of analytical and synthetic knowledge base in the other two regions. For that exact same reason, Copenhagen was rated to be more science than market driven, while the other two regions produce more knowledge for the actual market.

Concerning the commercialization of science, Trento employs a mix of ex-post and ex-ante approaches. There is a high level of incremental problem solving at the SME level. The manufacturing sector in Trento is large and local companies construct the new technologies. The OECD (2012) report stated that Trento's inhabitants of could receive training to adjust their knowledge to the new green energy RIS. This illustrates that there are not only high educated managers involved, but also manufacturer and regional entrepreneurs. Due to the regional policy making at the Regional Growth Forums in Denmark, is the institutional framework supporting the Copenhagen region very developed. The renewable energy sector is specifically supported. Copenhagen is also the region which is the most independent from the national government. Furthermore, in all countries except Styria, was evidence found for policy interventions to improve the institutional framework.

Copenhagen and Trento are both considered to have 'good' organization since they score the most criteria on type II, Trento however has a higher score than Copenhagen. Styria's organization is between 'mediore' and 'good' since it scores fifty- fifty between type II and III.

The comparison above illustrates that the organization of these renewable energy RIS tend towards a 'good' organization, where the actors cooperate, bilateral initiatives are facilitated and the region is overall supported in its collaboration efforts.

The regions scored very differently on functioning, the CCC gets the score ‘good’, Eco World ‘mediocre’ and Habitech ‘poor’. One similarity is that each region has established a technology transfer office for renewable energy technic (bilateral network). The cooperation between academia and industry seems to be the most advanced bilateral network, while government and industry collaborations are not fully developed as empirically illustrated by the fact that governmental organized venture capital programs for renewable energy is the only bilateral collaboration that is found in a single RIS. Other differences are that strategic alliances between companies for R&D and grant programs between academia and government were each found in two of the three regions. The regional government in Styria failed to act as venture capitalists and also did not cooperate with the academia for grant programs. The government in Trento also did not act as a venture capitalist in this sector, R&D alliances are as well not established, which contradicts the assumption that academia and industry often collaborate. The CCC fulfilled all bilateral networks criteria, while the other two established half of the networks. There is no apparent common pattern as to how the regions score on the values.

Influence of one helix upon the other was only found in one of the three regions, which shows that there is a need for national governments to alleviate bilateral cooperation through law, or that academic institutions should be encouraged to take up activities outside their current scope, such as lobbying. Still, the outcomes show differences between RIS.

Each region has established trilateral networks, which was a prerequisite for this study and once again illustrates that many European legislators have recognized these networks as desirable. This is a similarity of the functioning of the renewable energy innovation alliance. Two regions had effects on trilateral networks and society at large. This indicates that the actor’s roles have started to transform towards the roles of the others. However, the analysis projected a difference since one region (Trento) has not reached this stage yet.

Copenhagen has a ‘good’ renewable energy innovation performance with six out of six positive scores, Styria is ‘mediocre’ with three and Trento scores ‘poor’ with two positive scores. The only similarity is that all RIS have established renewable energy university- industry collaborations. This affirms previous assumptions that the working of academia and industry are very developed.

Only Copenhagen has a high number of employees and spin- off companies in the renewable energy sector and therefore an advanced share of renewable energies in the region. The high number of employees illustrates that the renewable energy sector in the CCC is bigger than in the other two, however the number of renewable energy companies in Styria is in turn also considered ‘good’. This could be explained by arguing that the companies might have less employees in Styria than in Copenhagen, which implies that Styria has a higher number of small and medium enterprises. The share of renewable energies in Trento seems to be smaller than the other two, hence the small number of employees and companies. Styria counts many spin-off companies, but not in the renewable energy sector. Trento has a low number of spin-offs in any sector.

The values ‘number of companies, joint ventures and regional capital investments in the renewable energy sector’ are fulfilled by two regions each. Styria only scores negatively on the amount of regional capital investments, which is in line with the outcomes on functioning and organization, which also showed limited initiatives of the Styrian regional government. Trento however witnessed high regional capital investments, but shows a low number of renewable energy companies and no joined ventures. Both will probably increase in the next years due to the investments by the region.

5. Conclusion

This cross-sectional study aims at explaining the relationship between renewable energy innovation performance and the organization and functioning of renewable energy innovation alliances with the help of three regions as case studies. After a discussion of relevant theories and concepts, two independent variables were operationalized and tested. They comprise organizational and functional values. The main research question of this study can now be answered with the implications given by the analysis. The research question is:

To what extent do the organization and functioning of renewable energy innovation alliances in European regions explain differences in innovation performance?

The three case studies exposed the interaction between regional actors, illustrated the contributions of the institutions and depicted the influence of policy measures at any level. The cases furthermore actually showed different patterns of innovation performance and this study examined whether different kinds of organization and functioning of the triple helix within the innovation system could explain such differences.

Renewable energy innovation performance has been examined according to the broad innovation performance approach by Gregersen and Johnson (2005), since this includes 'all aspects of interactive learning and innovation' (Gregersen & Johnson, 2005, p. 4). Copenhagen scored a 'good' innovation performance, Styria 'mediocre' and Trento 'poor'. Copenhagen has the highest share of renewable energies, as indicated by the number of employees and companies in the sector. This might increase joint venture projects, supported by the stable RIS. This is confirmed by the high number of joint ventures in Copenhagen, and the low number in Trento in both categories. Furthermore, it could be assumed that a region with a high capital investment also scores high on the other values, which is affirmed by Copenhagen with a high investment and a great number of spin-offs, and Styria where it is the other way round. The assumption is contradicted however, by Trento, which received the highest regional capital investment for the renewable energy sector, but has no joint ventures in this sector. This irregularity could be explained by the fact that the investment in Trento was recently made and that the outcomes have not yet been documented, or are still to come. All RIS have established renewable energy university- industry collaborations. However Styria and Trento have a low number of spin-offs in the renewable energy sector, but are also found to have industry- university collaborations. It might be concluded that the collaborations are either not very effective, or simply oriented at small specific research projects.

The following two paragraphs will explain the effect of the independent variables organization and functioning on renewable energy innovation performance.

The organization of the RIS has been analyzed with the distinction of three kinds of regional innovation system (Asheim, 1998, 2002, 2005), because a RIS should not simply imitate other successful regions. One should rather concentrate on the region's institutional characteristics, knowledge infrastructures and knowledge transfer systems in order to promote innovation activities (Doloreux & Parto, 2004). The regions all lean towards the RIS type II, which is illustrated by the eight common type II values they share. The comparison depicted some differences such as: Copenhagen was found to have an analytical knowledge base and be more science than market driven. Copenhagen is furthermore the RIS that is the most independent from the national government. Styria's knowledge organizations lie mostly outside of the region and international actors from knowledge organizations are also involved. There was no evidence found for policy interventions to improve the institutional framework. Trento uses a mix of ex-post and ex-ante approaches, which is illustrated by the high level of incremental problem solving at the SME level.

According to the results of the analysis, the organization within a RIS is not directly correlated to its renewable energy innovation performance. An empirical illustration of this argument is the region Trento, which scored the highest in terms of organization, but got the lowest score on performance. Copenhagen however scored 'good' on both variables, but Trento had a better organization by two positive values. Styria had an in-between score 'mediocre- good' for organization and a 'mediocre' score for innovation performance. Copenhagen and Styria contradict the assumption that organization has no linear influence on innovation performance, the empirical illustration of Trento however approves it. This is somewhat not in line with the literature, which argues that the distinction of different types of RIS is crucial for the success of a region (Asheim, 1998; Cooke, 1998; Asheim & Isaksen, 2002). On the other hand, this study merely argues that the two variables are not linear correlated, it is possible that the three types of RIS still have an impact on innovation performance. It might just influence it in another way. The organization of a RIS is still of relevance, since there are 'different logics behind constructing regional innovation systems' (Asheim & Coenen, 2005, p. 1180) and the categorization according to the regional infrastructure is crucial in optimizing the region's capacities. It can be concluded that these RIS have a great tendency towards a 'good' organization. Therefore it might be generalized that European renewable energy RIS, that employ the triple helix model, also have this 'good' tendency.

The functioning has been analyzed according to the four stages of triple helix transformation (Etzkowitz, 2008). This approach focuses on the bilateral and trilateral organizations within the RIS and how they interact. This is in line with the claim by Doloreux and Parto (2004) that the emphasis of RIS studies should not be on the institutions themselves, but on their interaction in different systems as well as different levels of interaction. All regions under study have trilateral networks and the development of bilateral networks is advanced but not fully developed, as two of the regions illustrate. The roles of the involved actors start to transform, since in two regions effects of the society at large were detected. The influence of one actor on the other was only found in one region and is therefore the least developed stage of the triple helix transformation in this sample of cases. In the context of the study, the outcomes show that the functioning of an renewable energy innovation alliance is a factor that explains the region's innovation performance in the renewable energy sector. One 'good' functioning region, namely Copenhagen, with many bilateral and trilateral networks, also showed a high renewable energy innovation performance. It scored all possible values in both the dependent as well as the independent variable. The two less 'good' functioning RIS, Styria and Trento, consequently failed to score a 'good' performance. Styria was found to perform, as well as function 'mediocre', while Trento scored 'poor' on both variables. Consequently the outcomes are in line with the scholars' claims that RIS with advanced and numerous networks, which emerge by the evolution of the triple helix, also have a high innovation performance (Etzkowitz, 2003, 2008; Etzkowitz & Leydesdorff, 2000).

Thus, regional policy makers should concentrate on establishing bi- and trilateral networks between the three actors in order to stimulate the innovative performance in a renewable energy innovation system. Or alternatively, stimulate the actors to establish these themselves. All three regions showed evidence of university-industry relations, which suggests that universities and the industry already search each other's assistance and cooperation. The importance of this bilateral relationship was also emphasized by Asheim and Coenen (2005) who concluded that RIS that build on an analytical knowledge base, need high-skilled local labour. Therefore the knowledge infrastructure has to be strengthened by university- industry interactions (Asheim & Coenen, 2005). Etzkowitz (2008) takes is a step further by demanding that entrepreneurship skills, such as writing a business plan, should be part of the curriculum at every faculty of the universities. When learning such skills, students would probably be more competent and willing to engage in an collaboration with the industry. The national government can furthermore improve the development of the triple helix by passing legislation that simplifies university- industry cooperation, such as allowing the commercialization of government sponsored research or simplify the process in general. That way the government would indirectly stimulate collaboration and the development of entrepreneurial universities, without spending high amounts of money.

Other implications for a high innovation performance was the regional investment. Policy makers should recommend to place more investments in the renewable energy sector. This however also requires support at the national level. The literature emphasizes the organizing and financing role of the public actor (Viale & Campodall'Orto, 2002) in order to provide a framework that stimulates the evolution of the collaboration between research and innovation. On the regional government level, the performance can be improved by taking an active role in already established networks, provide subsidies or take charge as a venture capitalist for renewable energy solutions. It is crucial that a RIS has a stable portfolio of venture capital entities (Etzkowitz, 2008). Policy makers should stimulate the establishment of venture capital for cleantech technologies at any development stage. Especially in geographical large regions, such as the Federal States in Austria, many small regional actors, such as many knowledge and regional institutions, can restrain the development of triple helix platforms due to the absence of a center or a common denominator (Etzkowitz, 2008, p. 144). To overcome the sense of competition in such a region, national actors should invite the regional actors to collaborative activities. High-status institutions such as the Austrian Federal Ministry for Transport, Innovation and Technology would be in an optimal position to bring the regional actors together.

6. Limitations

This study would have had an increased external validity if the number of analyzed cases had been larger. This was however outside the scope of a Bachelor thesis and a future study could analyze more RIS from all parts of the EU, so the generalization across other innovative European regions would be more valid. Future studies should test for more independent variables in order to assess their influence on renewable energy innovation performance. Furthermore this study included no region that performed very poorly, since it was not possible to acquire data from less developed regions due to their fragmented or incomplete documentation. A follow-up study could acquire data by conducting surveys in such regions.

The fact that some values of the variable organization are mixed types of RIS, made the outcome vague and less significant and the regulations for the measurement were not operationalized by scientific regulations. A new conceptualization could account for this limitation, such as additionally sub-dividing the term 'network' into different types. Many scholars, such as Sternberg (2000), argue that there are three types of networks and that their distinction is crucial in understanding regional innovation systems. The knowledge network mainly concerns know-how regarding cooperation, while information networks entails the issues of which actors will enter the collaboration and what they have to contribute (Kogut et al., 1993). Innovation networks are the outcome of information exchange between the actors in the knowledge networks, such as the combination of know-how (Johannsson, 1991). Such a classification could give a more in-depth and structured insight into the specific workings and emergence of regional networks and possibly give more insights into the relation between organization and renewable energy innovation performance. This could be a valuable addition for a follow-up study.

The measurement of all variables could be more detailed in future studies, such as the specific percentages of employees that have acquired a scientific degree and those that did not, or the exact number of university- industry collaborations. Such data can be acquired by in-depth surveys, which would have to be sent to every RIS member. The dependent variable was only measured with six values, since it was difficult to find data on more implications of innovation performance. A future study with more financial means could collect data on a higher number of values for the dependent variable. The same is applicable for also using the narrow innovation performance approach by Gregersen and Johnson (2005) in a follow-up study, which requires more detailed data such as the number of patents or the use of an UNCTAD Innovation Capability Index. Besides, the development of theories and indicators for the relation between innovation performance and learning and innovation capability would produce more detailed insights (Gregersen & Johnson, 2005, p.13). Another practical issue that constrained the data collection was the language barrier, since most regional documents are not translated into English.

Additionally, future research could explore how organization influences innovation performance, or aim at researching whether the relationship between the two variables includes third variables that can contribute to the understanding of the cause and effect of renewable energy innovation performance.

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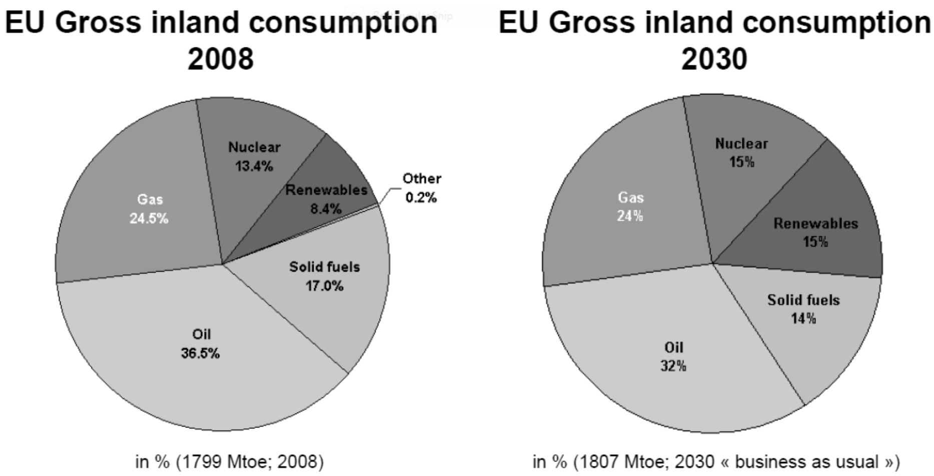
8. Appendix

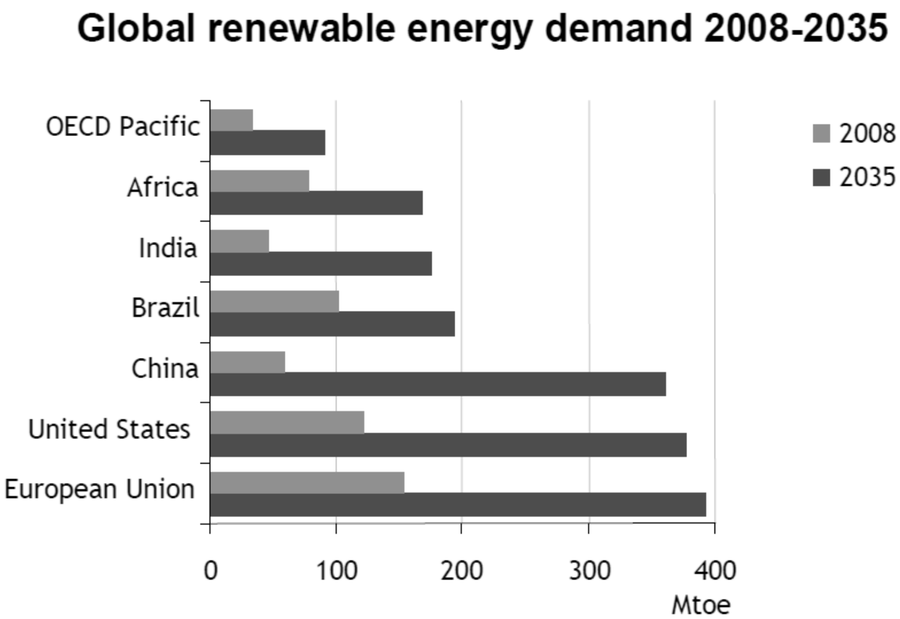
Appendix 1

EU Gross inland consumption of renewable energies in 2008 and the predicted numbers for 2030 (European Commission, 2011)



Appendix 2

The international renewable energy demands in 2008 and the projected demand for 2035 (European Commission, 2011)



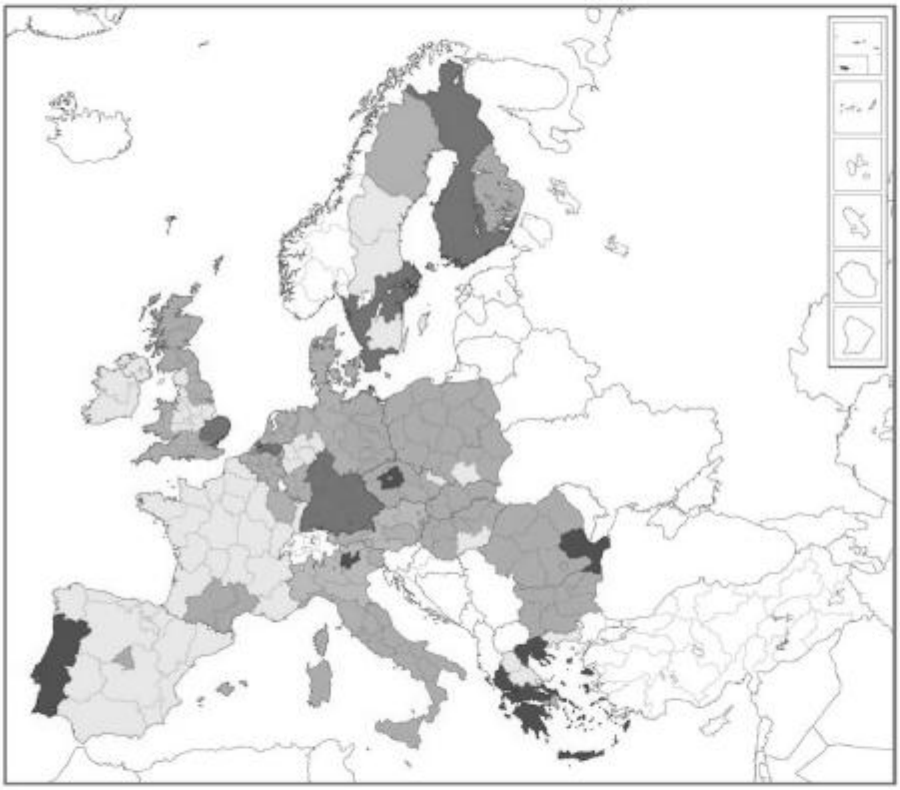
Appendix 3

Illustration of Innovation performance in a broad and narrow context (Gregersen & Johnson, 2005)

	Narrow performance	Broad performance
Narrow NSI approach	Patents Scientific publications New high-tech products	Number of high-tech spin-off companies University-industry collaborations
Broad NSI approach	New to the market innovations (incl. medium and low tech sectors) UNCTAD Innovation Capability Index ArCo (Archibugi and Coco)	Organizational innovations Innovation in the health care and education

Appendix 4

Classification of European regions according to general regional innovation performance (Walendowski et al., 2011)



Appendix 5

Importance of policy level in RTDI policy making (Walendowski et al., 2011)

Most important policy level	Frequency	Percent
Regional Level	95	49.7
National Level	91	47.6
Sub-Regional Level	5	2.6
Total	191	100.0
Most important policy level		
National Level	BG, CZ, FI, GR, IE, NL, PL, PT, RO, SK; (FR)	
Regional Level	AT, BE, DE, DK, ES, HU, IT, UK; (FR)	
Sub-Regional Level	SE	

Source: RIM survey.

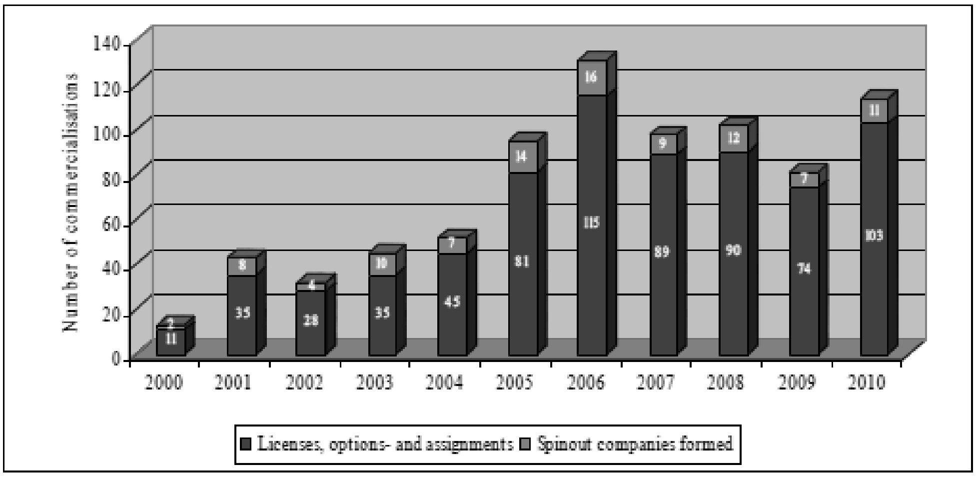
Appendix 6

More detailed information about the three regions under study

	Copenhagen region (East Denmark)		**Region Styria**	**Region Trento**
	Capital region	*Zealand region*		
Total population	1.300.000	818.000	1.200.000	477.017
Legal form	Administrative region of Denmark	Administrative region of Denmark	Federal State of Austria	Autonomous Province of Italy
Regional GDP	82.900	25.000	33.100	15.200
Per Capita GDP	50.600	30.600	27.500	29.900
Growth of regional per capita GDP	0,03%	0,03%	0,05%	0,03%
Share of Employment in Industry (including Construction)	16,09%	23,36%	30,24%	28,2%
Unemployment rate	4,667%	3,97%	3,94%	3,28%
Gross Expenditure on R&D	4.310	296,55	1.200	170,3
Gross Expenditure on R&D per GDP	5,1%	1,16%	3,61%	24,67%
Workforce in the region (all industries)	1.300.000		505.875	-
Main cleantech technologies	Smart Grid, water, wind		Biomass, solar, waste treatment	Solar, Bioenergy, Green Bulidings

Appendix 7

IP exploitation by public research institutions in Denmark 2000- 2010 (Danish Ministry of Science, Innovation and Higher Education, 2011)



Appendix 8

Data on research outcomes and commercialization for all Danish universities (Danish Ministry of Science, Innovation and Higher Education, 2011)

Institutional data

	Invention disclosures received	Patent applications filed	Patents issued	Licenses, options and assignments (incl. software)	Total license portfolio (excl. software)	Spin-out enterprises formed	Technology transfer staff (full-time equivalents)	Commercia-lisation costs (in DKK 1,000)	License income (in DKK 1,000)	Research agreements with private enterprises
Universities (8)										
Aalborg University	53	13	0	35	9	4	4,5	1.801	2.347	391
Aarhus University	49	11	0	17	21	4	14,3	7.808	3.663	331
Technical University of Denmark	87	46	6	22	10	2	15,5	14.010	31.208	802
IT-University	6	2	0	0	0	0	0,9	406	0	7
Copenhagen University	40	11	2	18	58	0	8	5.009	5.063	306
Roskilde University	4	1	0	1	1	0	0,25	0	350	72
University of Southern Denmark	16	11	0	3	8	0	7	1.604	214	76
Copenhagen Business School	0	0	0	0	0	0	0	0	0	35
Government research institutes (2)										
Statens Serum Institut	4	2	3	0	3	0	2	3.875	64.770	7
GEUS	0	0	0	0	0	0	0,1	102	0	-
Research hospitals (4)										
Region of Northern Jutland	10	4	0	2	1	0	4	400	0	68
Region of Southern Denmark	3	1	0	0	0	0	1	0	0	25
Capital Region of Denmark	34	13	2	2	16	0	10	6.300	2.617	466
Region of Central Jutland	22	7	0	3	0	1	0,2	808	189	151
Total (14 institutions)	**328**	**122**	**13**	**103**	**127**	**11**	**67,8**	**42.123**	**110.401**	**2.737**

Appendix 9

Comparison of all regions in terms of the independent variable 'organization'

The organization of different types of Regional Innovation Systems in the renewable energy sector

Variable	*Measurement:*	Copenhagen	Styria	Trento
IV_1: Organization	Local or outside location	I and II	III	I and II
	Few or many knowledge organizations	II and III	II and III	I
	Inter-firm learning processes on local level	II and III	II and III	I
	National and international actors from knowledge and governmental organizations	I and II	III	I and II
	Linkages to local industry	I and II	I and II	I and II
	Public- private coordination	II	II	II
	Inter-firm cooperation for specific projects only	III	I and II	I and II
	Synthetic or analytic knowledge base	III	II	II
	Phase of industry	II	II	II
	Innovation stimulation	III	II	II
	Ex-post or ex-ante approach	III	III	II
	Integration of knowledge and institutional infrastructure	II	II	II
	Interactive or linear	I and II	I and II	I and II
	Geographical, social and cultural proximity	I and II	I and II	I and II
	Planned, systemic networking	II	II	II
	Individuals with the same education and common experiences	III	III	I and II
	Level of development	II	III	III
	Supports regions	I and II	I and II	I and II
	Results from policy interventions	II	I and III	II
	Integrated into national or international innovation systems	I and II	III	III
		Type I: 0 Type II: 6 Type III: 5 I and II: 7 II and III: 2 I and III: 0	Type I: 0 Type II: 6 Type III: 6 I and II: 5 II and III: 2 I and III: 1	Type I: 2 Type II: 8 Type III: 2 I and II: 8 II and III: 0 I and III: 0

Appendix 10

Comparison of all regions in terms of the independent variable 'functioning'

Variable	Values	Copenhagen	Styria	Trento
IV_2: Functioning	Triple helix transformation in the renewable energy sector			
	Bilateral networks			
	-Strategic alliances	Yes	Yes	No
	-Venture Capitalists	Yes	No	No
	-Tech. transfer offices	Yes	Yes	Yes
	-Grant programs	Yes	No	Yes
	Influence upon each other	Yes	No	No
	Creation of trilateral networks	Yes	Yes	Yes
	Effect on 3 actors and society at large	Yes	Yes	No
		7 Yes	4 Yes	3 Yes

Appendix 11

Comparison of the regions in terms of 'renewable energy innovation performance'

Variables	Values	Copenhagen	Styria	Trento
Dependent Variable:				
	Number of renewable energy spin-off companies	Good	Bad	Bad
	Renewable energy university- industry collaborations	Good	Good	Good
	Number of employees in renewable energy sector	Good	Bad	Bad
	Number of renewable energy companies	Good	Good	Bad
	Joint ventures in renewable energy sector	Good	Good	Bad
	Amount of regional capital investments in renewable energy sector	Good	Bad	Good
		6 Good	3 Good	2 Good