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Energy supply transitions in Swedish municipalities

Transferability of the lessons learnt to Tandil, Argentina

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Abstract

The author of this thesis wishes to contribute to transitions towards more sustainable energy systems in Argentina. In order to do so, two objectives are established. The first one refers to increasing the understanding of the transitions taken place at the local level within energy supply systems in Sweden. The second objective is to increase the understanding of the conditions that need to be in place in Tandil, Argentina, for technology transfer purposes within this area.

This work utilizes a case study approach. The cases are focused on energy transitions at the municipal level. Three cases studied in Sweden and one in Argentina, constitute the basis for the analysis. Cross case analysis based upon the advanced Swedish cases is used to provide guidance for advancement in Argentina. In each of the studied municipalities, the focus is on the institutional, technological and economic perspectives of energy supply streams. Analysis is underpinned by a framework built with theoretical context from technological innovation, institutional and contextualization fields.

The audience of this thesis includes national, regional and local promoters of renewable energy supply systems. Actors such as national and local governments, politicians, educational institutions, public service companies, actors working in the private sector, non-governmental organizations, engaged individuals aiming to make a change in their energy system, and related networks, are all potential readers of this thesis.

This study found that local actors initiating processes of transformation within energy supply systems in Sweden generally followed similar pathways of actions and behavior. Moreover, it was found that the similar manner in which these processes developed, and many of the drivers behind the change, could be rationalized using the analytical framework. Thus, although temporal and spatial contexts influencing local transitions provided the processes with unique features, generalization of key areas of actions to promote advancement in the Argentinean context could be made. Furthermore, pursuant to this generalization, this study concludes that it is possible to transfer many of the lessons learnt from Swedish municipalities to the city of Tandil.

Executive Summary

Energy security and climate change are two of the most serious issues facing humankind. On the one hand, energy security is threatened in many different ways. In the past, and after the oil crises of the 1970s, it was largely perceived of as a problem of oil and import dependence (WEA, 2000, p. 112). However, other threats have appeared. Supply disruption, capacity constraints both in production and refining sides, investment' insecurity on producer countries, and more, are events threatening to hamper the development of future supply streams (IEA, 2010b, p. 15).On the other hand, according to the IPCC (2007, p.5) global warming is unequivocal and the observed effects of this temperature increase are not only environmental but also social and economic, and are been felt locally, nationally and worldwide (Ochs, 2008). Approximately two thirds of all greenhouse gases originate in the production and use of energy carriers, mostly from fossil fuels (WEA, 2004, p. 20). Changes in the foundations and structure of the existing energy supply system need to be achieved. Two ideas can be highlighted in this regard: firstly, the development of new technologies and an increase in the production of renewable energies are fundamental for these changes; secondly, the important role local actors must play cannot be denied.

From another perspective, and in the aim of performing energy supply transformations worldwide, technology transfer processes are crucial. The different energy related scenarios existing between developed and developing countries show the importance of technology transfer (WEA, 2000; Wilkings, 2002; WEA, 2004; & Ochs, 2008). It is important to transfer not only manufacture objects (hardware) and knowledge required to manufacture and use such hardware (software), but also the institutional settings and rules for the generation of technological knowledge and for the use of technologies (orgware) (Dalhammar, Peck, Tojo, Mundaca & Neij, 2009).

The aspiration of this thesis is to contribute to transitions towards more sustainable energy systems in Argentina. Two objectives are established to pursue this. The first one refers to increase the understanding of the transitions taken place at the local level within energy supply systems in Sweden. The second objective is to increase the understanding of the conditions that need to be in place in Tandil, Argentina, for technology transfer purposes within this area. To address these objectives, a case study approach is followed, and three Swedish municipalities, Enköping, Kristianstad and Växjö, as well as one Argentinean municipality, Tandil, are been studied. Cross case analysis based upon the advanced Swedish cases is used to provide guidance for advancement in Argentina.

Two research questions are posed to contribute to the achievement these objectives:

- *How did local actors achieve a more secure and renewable-based energy system in Swedish municipalities?*

- *How can the municipality of Tandil, province of Buenos Aires, learn from the experiences of Swedish municipalities?*

Concerning the first research question, according to the findings of this thesis, local actors in Sweden have achieved the transformation of their energy supply, by building up and developing, as well as by recognizing the importance, of the following items:

Leadership: local actors with the role of guiding the transitions, and with the charisma to transform and influence the beliefs and behaviors of others stakeholders;

Creation and diffusion of a shared vision, by which local actors have aimed at addressing the same goals, objectives, and targets;

Cooperation and communication among participants: local actors have built up a system with important cooperative ventures and have developed within the city, and among them and external stakeholders, intensive communication channels;

Coordination among local and external actors: the developers of the transitions have been able to coordinate the roles and actions of the different local and external actors in a manner that have been positive for the transition;

Building of public understanding and confidence on the system: open communication channels, awareness campaigns and an educational support system, have all been important for developing this item crucial for gaining public acceptance of the system;

Building up skills among local actors: the development of scientific, trade and technical skills among local actors, through the creation of research centers, networks, and communication channels, have highly contributed to the transitions;

Strengthen networking processes both internally and externally: the actors have participated in networking processes that have strengthened their involvement in the system;

Institutional set-up evolving as the process developed: local actors have learnt to develop the institutional infrastructure necessary for building up and maintaining the new energy supply system. The transition and the institutional setting were like two forces that commenced, developed and maintained over time as reinforcing factors, both depending and feeding one each other;

Role of both hard and soft institutions: in the transitions, hard institutions, such as the government and regulators building a support system, actors forming well-established organizations that develop a capital market, and academic organizations creating an educational related system, had played an important role. The same can be said about soft institutions, such as NGOs, informal networks and groups of involved citizens building cultural features in the community;

Comparative advantages: local stakeholders have recognized the importance of discovering and utilizing the comparative advantages available to their specific context, such as the availability of a natural resource and determined geographical preconditions, present in their cities;

Public ownership of energy related infrastructure facilitated the transitions by allowing a more holistic planning and utilization of the infrastructure, and by reducing transaction costs of getting different actors to work together;

Creation of a local profitable system: the coordinating actor of the transitions, which has been the municipalities, has permanently pursued the profitability of the system;

Expansion of RD&D activities: RD&D activities carried out by different actors have been of particular importance in the local transitions.

Financial support: the availability of financial resources to develop and implement energy related projects within the city has been fundamental for smoothing the transitions. In obtaining this support, the role of the involved municipalities has been crucial.

In the transitions taken place in Växjö, Enköping and Kristianstad, similar pathways for doing things have been identified. This is due to the fact that after an initial period of 'testing and trying', local actors have stuck to those factors that allowed them to build trust and confidence on the system. They maintain those key elements that created familiarity among social stakeholders, and this led to the development of a system which, from being new and un-known, became one taken for granted and well known; in simple words, became accepted. Precisely, these factors appear to be operating in similar ways in the three studied cases.

With regard to the second research question, this study concludes that it is possible to transfer many of the lessons learnt from Swedish municipalities to the city of Tandil. Although many differences within actors, networks and institutional themes may exist among these two contexts, elements from the Swedish transitions can be copied (after adaptation to and interpretation of the local context) and applied in Tandil. The main issues to be considered in the development of any technology transfer (TT) process are as followed:

(a) In TT processes the *orgware* element must be accorded a high degree of importance; just as the study and analysis of the hardware and software elements often is much, more can be achieved by addressing the systems in which this processes are embedded;
(b) TT processes take place not only between countries, but may also take place within the country, within a region and even within the municipal level;
(c) Building up appropriate environments is of crucial importance for any energy supply transition to be initiated in Tandil;
(d) For creating proper environments, it is very important to work and focus on local entrepreneurs with the appropriate knowledge about and understanding of the needs of the local community; since by addressing and satisfying these needs it is more likely that the public will accept the new system;
(e) Deep transformations should be made within actors, networks and institutions themes (as the ones contained at the beginning of the concluding chapter).

The summarizing portion of this work provides a list of recommendations (in the form of what, how and why) for national, regional and local promoters of a renewable energy supply system. The recommendations include that actors such as national and local governments, politicians, educational institutions, public service companies, actors working in the private sector, non-governmental organizations, engaged individuals, and related networks, should each seek to:

- Articulate and adopt a vision, long-term goals and common and transparent strategies that will be shared by all the participants of the system;
- Identify a strong and committed local leader that will guide the process;
- Enhance the understanding of and confidence on the system by a broad range of social stakeholders;
- Build up scientific, trade and technical skills among local actors;
- Encourage an active participation of the municipality in the transition, recognizing its important role as planning authority, policy implementer, information provider and chief coordinator;
- Pursue alliances with industries, organizations and institutions that have control over the resources that the new sector requires;

- Promote both bottom-up initiatives and top-down supports;
- Develop and support a profitable system for all the participants;
- Articulate networking activities within the city, and between local actors and external stakeholders (at both national and international level) in order to obtain coordination (locally), exchange knowledge and experiences (nationally), and create funding and business opportunities (internationally);
- Develop a proper institutional framework for creating and maintaining the necessary infrastructure of the new system;
- Identify the comparative advantage the city has and maximize its utilization;
- Create the necessary financial support for developing and implementing energy related projects within the city;
- Consider the drivers that would soon or later force a deep transition in the energy supply matrix as an opportunity for a change, instead as of a problem to be solved.

The temporal and spatial context, which is unique in each transition, as well as the interconnections among the main elements of this process –actors, networks and institutions, will deeply influence the result of implementing any of the previous measures. The targeted audience should see these recommendations as part of a system to be developed, where linkages among the elements are as important as the elements itself. And finally, they should see the system as one evolving over time, gradually and slowly providing positive results.

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1 Introduction

1.1 Background

Energy security and climate change are two of the most serious issues facing humankind. On the one hand, according to the International Energy Agency (IEA), energy security is considered to be "the uninterrupted physical availability at a price which is affordable, while respecting environment concerns" (IEA, 2010a). Such security is threatened in many different ways. In the past, and after the oil crises of the 1970s, such issue it was largely perceived of as a problem of oil and imports' dependence (World Energy Assessment [WEA], 2000, p. 112). However, other threats to energy security have appeared. Supply disruption, capacity constraints both in production and refining sides, investment' insecurity in producer countries, geopolitical tensions and terrorism, and natural disasters, are all events threatening to hamper the development of future supply streams (IEA, 2010b, p. 15). The reality the world is facing in this regard include facts such as: (a) more than two billion people cannot access affordable energy services, (b) wide disparities in access to energy services exist among and within countries, and (c) the existing energy system is heavily dependent on fossil fuels geographically concentrated in a few regions of the world (WEA, 2004).

On the other hand, according to the Intergovernmental Panel on Climate Change (IPCC) global warming is unequivocal (IPCC, 2007, p. 5). The observed effects of this temperature increase are not only environmental but also social and economic, and are been felt locally, nationally and worldwide (Ochs, 2008). This matter has obtained international recognition. The "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (United Nations Convention on Climate Change [UNCCC], 1992, art. 2) is an international objective in place since 1992. Approximately two thirds of all greenhouse gases originate in the production and use of energy carriers, mostly from fossil fuels (WEA, 2004, p. 20). There are, thus, no scientist doubts that energy related human activities are the main cause of this problem (Ochs, 2008).

The relation between climate change and energy security, mainly security of supply, is strong and unavoidable. As stated by Ochs (2008, p. 13), their relationship can be seen from two sides: the problem side and the solution side. Firstly, 80% of global energy supply comes from fossil fuels which in many countries are imported, circumstance that increases energy dependence. Also, combustion of fossil fuels emits carbon dioxide (CO_2) and (as stated above) energy related CO_2 emissions are responsible for about 60% of man-made climate change. All in all, the dependence on fossil fuels is responsible for both a warming planet and a scarce energy supply. Secondly, it is feasible to solve both problems if changes on consumption and energy production patterns occurred (Ochs, 2008, p. 13). Moreover, the solution for these 'Siamese twins' problems of global scale are to be found through cooperation on all levels of political organization, from the global level, to the regional, national and local one (Ochs, 2008).

In recognition of such issues, it results obvious that changes in the foundations and structure of the existing energy supply system need to be achieved. Two ideas can be highlighted in this regard. Firstly, the development of new technologies and an increase in the production of renewable energies are fundamental for these changes. Secondly, the important role local actors must play cannot be denied. Concerning the first idea, three roles are attributable to renewables: improvement of energy security, empowerment of sustainable development and reduction of environmental impacts both locally and globally (Wilkins, 2002, pp. 1-31). The untapped renewable energy potential is considered to be enormous and widely distributed in industrialized and developing countries (InterAcademy Council, 2007).

With regard to the second idea, efforts should not only be made at the international and national level, but also locally (Collier, 1997; WEA, 2000; & Khan, 2004). Several are the options to be taken so as to improve energy security and climate change challenge. Some of them being: (a) diversifying supply, (b) encouraging greater reliance on local resources, (c) securing access to decentralized small-scale energy technologies, (d) removing obstacles and providing incentives to encourage the development and diffusion of new technologies, and (e) advancing innovation (WEA, 2004). Although such measures can be designed in international agreements or through national policies, the action of local stakeholders results crucial for their implementation. Municipalities, political parties, public facilities, the media, the public, non-governmental organizations, and small-middle size companies; are all stakeholders acting locally and with an important role to play in the transition (World Energy Council [WEC], 2009). Bottom-up initiatives integrating such actors are therefore fundamental (Reiche, 2002).

For these local transitions, suggestions are provided by the literature. The WEC report (2009) highlights the importance of the following issues: (a) strong and effective government and business institutions, (b) long-term-oriented policy objectives, (c) public acceptance of energy policy and understanding of energy issues as a pre-requisite of such acceptance, and (d) RD&D efforts. Other issues to be considered, are the importance of building up capacity (WEA, 2004), and networking activities (Aldrich & Fiol, 1994).

From another perspective, and in the aim of performing such transitions worldwide, technology transfer processes are crucial. As mentioned, the world's energy supply is dominated by fossil fuels and new forms of renewables play a relatively small role (InterAcademy Council, 2007). Argentina is not an exception to this trend. The country faces high dependency on fossil fuels in its energy matrix (including transport and electricity generation), of which 90% is oil and natural gas (Global Environmental Facility [GEF], 2009). The share of renewable sources of energy such as solar, wind or biomass is very small if compared to its potential (Secretaría de Energía de la Nación Argentina [SENA], 2009). In contrast to this figures, some OECD countries have developed long-term energy policies, which have brought different results. In Sweden, after decades of energy and climate policy' implementation, the use of renewable energy sources increased from 33% in 1990 to 42% in 2007 (Swedish Energy Agency [SEA], 2009, p. 39).

The different scenarios existing in these two countries show the importance of technology transfer. The crucial role of such transferability for performing the transformation of the energy sector in less developed countries is widely recognized (WEA, 2000; Wilkings, 2002; WEA, 2004; & Ochs, 2008). It results important to transfer not only manufacture objects (hardware) and knowledge required to manufacture and use such hardware (software), but also the institutional settings and rules for the generation of technological knowledge and for the use of technologies (orgware) (Dalhammar, Peck, Tojo, Mundaca & Neij, 2009).

Concluding, many are the factors influencing both the transition towards an endogenous and renewable energy supply system, and the technology transfer processes. Several are the drivers that have triggered and will continue to trigger these processes of change. Moreover, several are the constraints limitating the transition, and the facilitating factors contributing to it.

1.2 Objectives and Research Questions

The author of this thesis wishes to contribute to transitions towards more sustainable energy systems in Argentina. In order to do so, two objectives are established. The first one refers to increase the understanding of the transitions taken place at the local level within energy supply system in Sweden. The second objective is to increase the understanding of the conditions that need to be in place in Tandil, Argentina, for technology transfer purposes within this area.

To reach the first objective, the idea is to identify key drivers, facilitating factors and constraints that have influenced the transition. The research question of this stage is:

- *How did local actors achieve a more secure and renewable-based energy system in Swedish municipalities?*

For addressing the second objective, the idea is to discuss the transferability of the lessons learned from Sweden to the context of Tandil, Argentina. To do so the following research question is established:

- *How can the municipality of Tandil, province of Buenos Aires, learn from the experiences of Swedish municipalities?*

1.3 Justification of the Research

This research is justified on several counts. First, an increase in the understanding of local transitions taken place in energy supply streams, can contribute to addressing the climate change challenge. Such understanding could lead to the replacement of conventional sources of energy by renewable ones. Second, this work will contribute to improve the understanding of energy security issue at the local level. This has multiple facets: the security parameters of endogenous supply; the relatively wide distribution of exogenous renewable energy sources (such as biomass); and the significant capacity for expansion and more efficient utilization of local energy carrier resources (e.g. organic waste, forestry residues, and manure).

This study also responds to the identification of a gap in the research field. Although much has been investigated regarding particular Swedish cases, there is a dearth of explicit information about the general drivers, the main constraints and the facilitating factors influencing the transition of Swedish municipalities towards a renewable-based energy system.

From another perspective, technology transfer is globally needed if sustainable development is to be achieved and climate change is to be addressed (Wilkins, 2002). As stated in the previous section, a secondary objective of this thesis aims at increasing the understanding of the conditions that need to be in place for technology transfer purposes. Moreover, the analysis of transferability of sustainable approaches to a less developed country contributes to an increase in knowledge of how to ensure energy security and avoid its related risks in countries like Argentina (e.g. dependency on gas imports and price instability).

Regarding the reasons of including the Argentinean city of Tandil in the research design, two are provided. Firstly, the potential the city of Tandil has in terms of production of renewable energy sources (mainly from utilization of different residues) is quite important. Agriculture and livestock activities, as well as food industries, could all provide a cheap, reliable and renewable source of energy for the city. Furthermore, at the current state, some initiatives towards a shift in the energy production system towards a more secure and less environmentally-harmed scenario have been developed in the recent years. Both resources availability and political will are, among others and as state by recognized literature (see chapter 2), key elements for the transition. Secondly, the author of this thesis is from Argentina. This provides a good background when analyzing transferability options. It also constitutes an important and strong motivation to pursue the thesis aims.

Finally, as stated in the World Energy Assessment (WEA) report (2004), "*Whatever difficulties are associated with taking appropriate action, they are small compared to what is at stake. Because humankind is in a dynamic and critical period of (…) transition, and because energy systems take decades to change, the time to act is now*". The recognition of such statement as an urgent fact, is another reason for conducting the research of this thesis.

1.4 Methodology

The approach used in this work is that of case study research. A research design was performed and followed for each of the two thesis objectives.

1.4.1 First Research objective

For the first Research objective, a multiple-case design was chosen. Figure 1-1 bellow presents the research design.

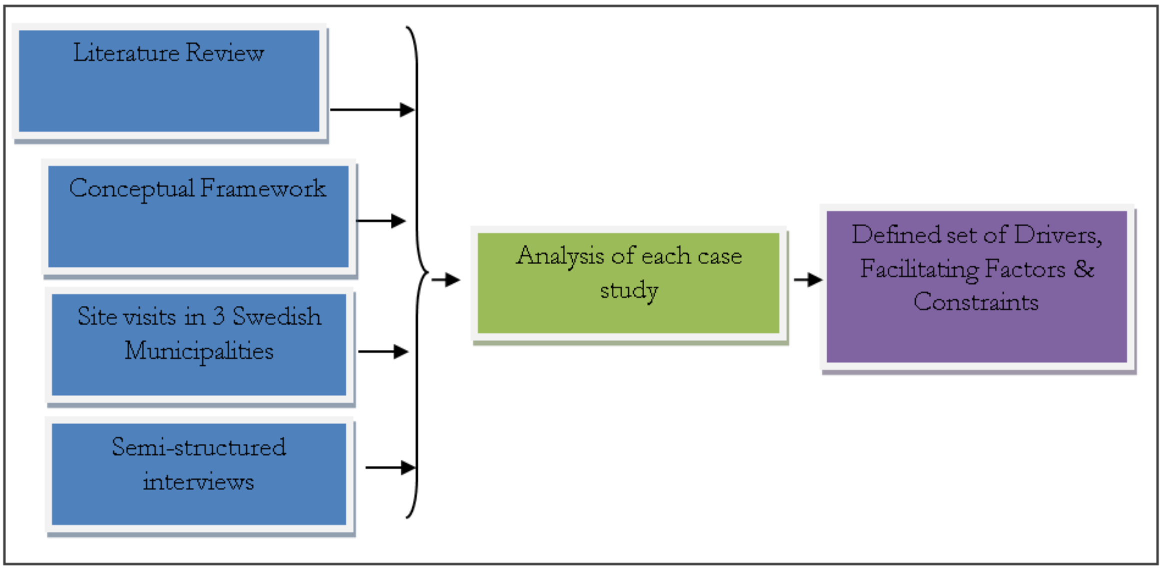

Figure 1-1 Research design for first thesis objective

In order to increase the validity of the findings of this thesis, methodological triangulation was used. Both quantitative (statistics from reports and databases) and qualitative data were gathered by means of the following **data collection methods**:

Literature Review: the research commenced with a secondary-source data collection from literature. Data from academic books, international and national reports, scientific articles and websites of different stakeholders created the background for the understanding of the topic. Knowledge gained through literature review was also used to select a proper conceptual framework and to determine the themes of the semi-structured interviews.

Conceptual Framework: a framework (present at the end of chapter 2) was used for this study. It provided a guide for both choosing of concepts to be investigated and framing of the research findings in a manner similar to that described by Corbin & Strauss (2008).

Site visits to 3 Swedish municipalities: visits to the municipalities provided significant primary data. Meetings with local authorities, energy companies, facilities producing renewable sources of energy, among others, were carried out during the on-the-ground research.

Semi-structured interviews: the research was also based on information obtained from different informants. Semi-structured interviews were performed on two stages of the research. First, insights for the thesis' questions and criteria for selecting the case studies were obtained from interviews conducted in the academia and industry field. Secondly, 25 interviews with important actors involved in the local transition (mainly municipalities, companies and research institutions) provided data for addressing the first research question. The use of semi-structured questionnaires facilitated not only the retrieval of necessary information but also additional and interesting comments and explanations.

After retrieving information with the previous methods, the analysis of each case study took place, where actors' participation, networking processes and factors conditionating the transition were all issues discussed. Finally, using the support of the conceptual framework, a set of common conclusions about actors, networks and institutions, as well as common drivers, facilitating factors and constraints was constructed.

Criteria for selecting Swedish case studies

Following the idea of Mårtensson and Westerberg (2007), the study used the 'strategic selection of cases'. With this approach, municipalities were chosen for their proactive role towards transformation in their energy supply streams. In order to narrow down the list of potential case studies, only examples of success stories were considered. As stated by Ivner (2009), the transition towards a renewable-based energy system is complex and takes place over a long period of time. It was assumed, therefore, that in the process of studying success cases obstacles and constraints would be also identified. In addition to this, the following conditions were established to select potential cases:

- The municipality should be small or middle size in terms of population. It was assumed that studying rather small municipalities would provide a clear overview of the whole local energy supply system.
- The municipality should be part of national or international networks working on issues such as sustainable development, climate strategies and/or renewable energy. Being a member of this type of association was considered preliminary demonstration of the proactive role of the municipality.
- The transition towards a renewable-based energy system should include the development of at least one of the following sources: solar, wind, hydro, wave, geothermal, biomass and waste. Peat was excluded.
- The municipality needed to be recognized as a success story by the informants contacted at the preliminary stage of this thesis.

Once the list of possible candidates for the case studies was built, it was reviewed with energy researchers and experts in the field. This was made to support a final decision of those most illustrative or useful cases for the project. The municipalities selected were: Växjö, Kristianstad and Enköping.

1.4.2 Second research objective

The objective of discussing transferability of the lessons learned from Sweden to the context of Tandil was also addressed with a case study approach. Figure 1-2 bellow presents the Research Design.

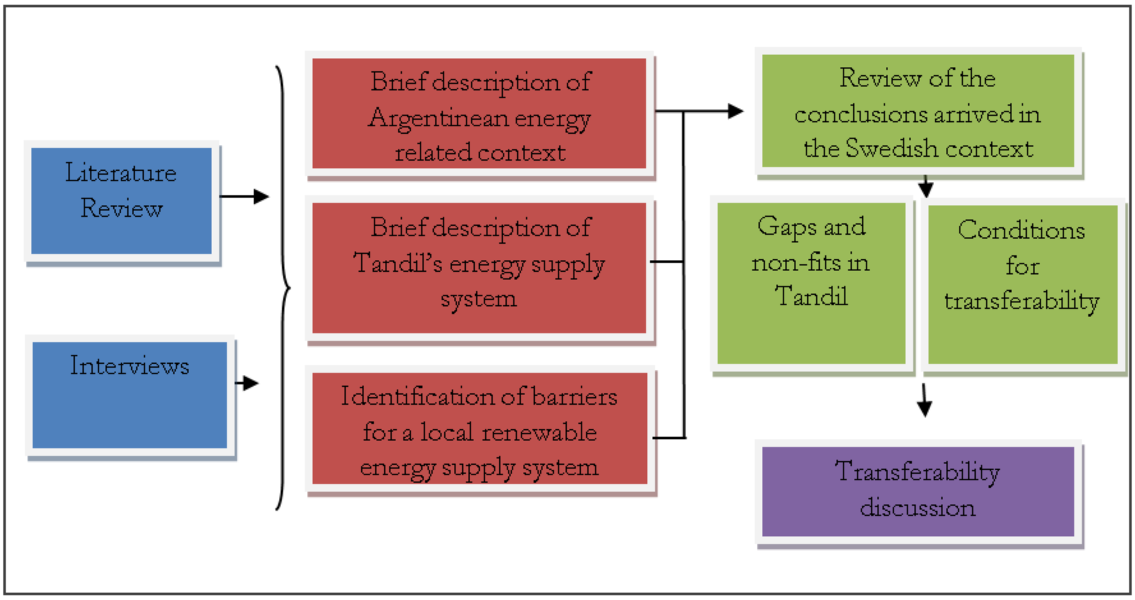

Figure 1-2 Research design for second thesis objective

For collecting data the two methods chosen were literature review and interviews. After retrieving information three tasks were performed: (a) brief description of the Argentinean energy related context; (b) brief description of Tandil's energy supply system; and (c) identification of barriers limiting the transition towards a renewable-based energy system. Once these tasks were performed, the conclusions arrived from the Swedish cases studied were reviewed. Afterwards, by comparing the two scenarios (a) gaps and non-fits in the context of Tandil and (b) the conditions that should be present in Tandil to allow any transferability process, were identified. Finally, all the previous activities led to discuss transferability alternatives.

1.5 Scope

Sweden is in the top four countries when judged by the increase of their proportion of renewable energy sources over the period 1990-2007 (SEA, 2009a, p. 39). The former justifies the selection of this country as a suitable example from where interesting lessons can be learnt. Moreover, it is worldwide recognized the significant influence of local efforts in achieving a more sustainable energy future. Scoping the research on the local level appears to be a desierable approach. The number of case studies chosen to address this topic is three. This decision is based on suggestions of academics in the field and in the need to have a proper generalization of the Swedish context. Although the study of the selected cases is not pursued to be an in-depth one, in each case institutional, technological and economic dimensions are covered. The institutional setting includes policies instruments.

The focus of this research is energy supply streams. It covers the local production of heat and electricity. Although the transport sector is generally outside the scope of this thesis, if vehicle fuel is produced locally from a renewable source, this is also included. Issues such as energy distribution, energy use and energy efficiency are beyond the scope of this thesis.

As already stated, this thesis falls within the municipal boundaries. However, drivers, facilitating factors and constraints might derive not only form the local context but also from higher level of authorities. Therefore, if that is the case, this is also included (e.g. national legal and policy frameworks, and international instruments).

1.6 Intended audience

The intended readers of this thesis can be mainly divided in two groups.

Firstly, one audience group includes local stakeholders aiming to transform the energy supply system of their municipality. This group covers a variety of possible readers since, as this study will discuss local municipalities, politicians, non-governmental organizations, public service companies, actors working in the private sector and engaged individuals, among others, can have a fundamental or influential role in the transition. This thesis contributes to increase the knowledge and understanding of entrepreneurs on the institutional and systemic aspects of their participation.

Secondly, the other audience group consists of policy markers working at different level of authorities. For local transitions towards an endogenous and renewable energy supply system, a regulated support system is of fundamental importance. This thesis contributes to increase the understanding of the role policymakers are to have in these transitions.

1.7 Thesis outline

In chapter 2 an overview of the theoretical considerations used for the discussion and analysis of this thesis is given. Chapter 3 contains a summary of the three Swedish cases studied. Chapter 4 provides a description of the legal and policy frameworks influencing the transitions taken place in Sweden. In chapter 5, an analysis of the three Swedish cases, in the light of a conceptual framework, is provided.

Chapter 6 introduces the Argentinean context. This chapter contains a description of the energy related context at the national level, and the legal and policy frameworks that have influenced the energy supply sector. Afterwards, the case of Tandil is introduced and shortly discussed. Finally, the chapter contains the drivers, facilitating factors and constraints with the potential to influence a shift in this sector.

Chapter 7 discusses transferability options, from the advanced Swedish cases to the city of Tandil. Finally, chapter 8 contains the conclusions arrived in this thesis, and some recommendations for national, regional and local promoters of renewable energy supply systems.

2 Theoretical considerations

The decisions on how to search what this thesis aims to investigate, how to organize the work and interpret the evidence and, finally, how to transpose the findings to another context; were all taken and based on the guiding principles and main ideas sustained by well-developed theories. This chapter contains a summary overview of those theoretical considerations that were followed and used. Moreover, the conceptual framework referred to in Section 1.4.1, present at the end of this chapter, was constructed by integrating themes of different theories. The sources used for this construction and the justification of the categories included, are also provided.

In the aim of addressing the two research questions, several are the aspects that one might try to investigate in each local context. So as to delineate the unit of analysis, elements of work from Jacobsson and Johnson (2000) were utilized. These authors use what they term a 'technological innovation system –TIS- approach' for studying the transformation of an energy system. According to Jacobsson and Johnsson a technological system is a "(…) network of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology" (p. 629). The constituent parts of a technological system are actors, networks and institutions.

Jacobsson & Johnson (2000) apply their studies to emerge of certain types of energy supply technologies in competition with each other. While important to this research, the intent of this work is to seek generalisability of concepts, so as to apply them in a different context (i.e. from Sweden to Argentina). In order to support the achievement of such generalisability, it was considered important to investigate and understand factors such as *what motivated local actors in Sweden to initiate the change? How did they get the whole group of actors moving? What held them all together in this initiative?* In order to cast light on such phenomena, the TIS approach alone appeared insufficient. Pursuant to this reasoning, it has been sought to underpin and enrich the ideas and themes of the TIS approach with themes from new institutionalism theory developed by DiMaggio and Powell (1983), and with works of others authors that have utilized such themes (such as Aldrich and Fiol [1994], among others), and with ideas proposed by the contextualization approach (described in Section 2.3).

Under the new institutionalism theory, DiMaggio and Powell (1983) aimed at understanding why organizations often appear to take on similar forms or behavior. They state that homogenization in structure, culture and output of organizations is a consequence of need for legitimacy. Aldrich and Fiol (1994) mention two types of legitimacy to be obtained: cognitive and sociopolitical. The first concept refers to the increase of knowledge about the new venture. The second refers to the process by which the different actors accept the venture as appropriate and right (p. 648). According to institutional theorists, there can be many instances when structural change is driven less by competition or by the need for efficiency, and more driven by the need for legitimacy. These authors use the concept 'institutional isomorphism' to describe the process of homogenization. By using this concept they considered that organizations "compete not just for resources and customers, but for political power and institutional legitimacy, for social as well as economic fitness" (p. 150).

2.1 Actors, Networks and Institutions themes

Having delineated the theoretical umbrella under which this thesis is developed, and having provided a short introduction of what each theory stands for, it is possible to proceed with the description of the different themes taken from them. To start with, the elements proposed by Jacobsson and Johnson (2000) -actors, networks and institutions- were the phenomena chosen to be studied in each local context and, therefore, included in the conceptual framework.

Actors: the importance of focusing on actors and their roles and competences when studying energy system' transformations has been highlighted by a number of analysts. Jacobsson and Johnson (2000) especially stressed the role of 'prime movers', who are considered to be "actors who are technically, financially and/or politically so powerful that they can initiate or strongly contribute to the development and diffusion of a new technology" (p. 630). Another important role is the one performed by leaders. Aldrich and Fiol (1994) consider that charismatic leaders can transform and influence the beliefs of their followers (p. 651).

There are many actors involved in local energy supply transformations. Not only local, but also regional, national and international stakeholders all interact together, coordinating efforts and contributing to the local development. These actors include inter alia: (a) municipal authorities (Collier, 1997; Khan, 2004; Mårtensson & Westerberg, 2007); (b) the local community (Khan, 2004; McCormick & Kåberger, 2005); (c) local politicians (Khan, 2004); (d) private stakeholders (McCormick & Kåberger, 2005); (e) research institutions (Peck, Berndes & Hektor, 2010); (f) national and international public bodies (Collier, 1997; Mårtensson & Westerberg, 2007); (g) networks (Aldrich & Fiol, 1994; Collier, 1997; Jacobsson & Johnson, 2001; Peck, Berndes & Hektor, 2010); and (h) non-commercial organizations (Jacobsson & Bergek, 2004).

Networks: in general, the importance of networks and the role they might play have been widely recognized by different fields of the literature. Jacobsson and Johnson (2000) indicate that networks are important channels for transferring tacit and explicit knowledge and ways through which its members can increase their resource base (in terms of information, knowledge and technology).

From another theoretical field, which examines the behavior of organizations in new technical activities, institutional theorists have also addressed the importance of networks. In an article about institutional context of industry creation, Aldrich and Fiol (1994) propose several strategies for gaining legitimacy (which is the ultimate goal of new organizations). Many of their propositions include strategies for networking. They provide a number of strategic pathways that outline how organizations can (or may) mobilize to take collective actions. Among these, are delineation of how organizations may seek to promote the new activity through third-party actors that already have the trust and understanding of social actors; how organizations may negotiate and compromise with other industries; and how proponents of new businesses may create linkages with educational curricula. The core principle behind such strategies is that by acting together and by cooperating with each other, time and resources can be saved, and legitimacy can be quicker obtained. Theorists such as Aldrich and Fiol advice that supporters of new business areas may deliberately pursue such strategies in planned work However, it is recognized in this work that such strategies may have evolved organically in the case studied here. The local transitions under studied may have started without a clear strategy. However, they may have still reached a better situation, and in the process of achieving such new situation the presence of important themes discussed by theorists as the necessary components of action (such as aspects of networks in this case) may be identified. This work shall both look for evidence of such themes (and its apparent effectiveness), and for a description of how each group of actors combined and used them in a particular way.

Institutions: academics of the TIS approach state that institutions specify the rules that govern interactions between actors (Jacobsson & Bergek, 2004, p. 818). They also classify institutions between categories they describe as "hard", where they include legislation, the capital market and the educational system; and "soft" ones, such as culture (Jacobsson & Johnson, 2000).

Although the 'institution' element is borrowed from the innovation system approach, its concept needs –for the purpose of this thesis- to be enriched with another perspective. Authors such as Jacobsson and Johnson (2000) and Jacobsson and Bergek (2004) view institutions in terms of rules and norms but not in terms of organizations (Bazilian et al., 2008). However, in this study the aim is to answer *how, why,* and *in which way* questions about institutions. To analyze a transformation process and the motivation, reasons and spirit that may underlie it, it appears more appropriate to follow a sociological view of institutions. By doing so, the focus is on the *way institutions interact* and *the way they affect society*. As stated by DiMaggio and Powell (1983) explain that organizational fields, as groups of organizations constituting a recognized area of institutional life, can only be identified by studying the processes that define them socially. Such processes consist on the following parts: (a) an increase on the level of interactions between organizations in the field, (b) the development of well-defined structures of domination and coalition, (c) an increase in the information related to the organizational field, and (d) an increase of participants awareness about their involvement in the field (p. 148). When analyzing the cases studied here, a focus on these processes will provide an understanding about the way local transitions have evolved, more than only describe formal and informal grouping of actors working together.

2.2 Drivers, Facilitating factors and Constraints themes

New institutionalism theory provides interesting ideas for the research. Two main themes are borrowed from this theory. One the one hand, of primary importance results the postulation about legitimacy and how it highly contributes to achieve organization's aim to survive (DiMaggio & Powell, 1983; Aldrich & Fiol, 1994; Jacobsson & Bergek, 2004; & Peck et al., 2010). On the other hand, another important idea is that of institutional isomorphism, concept DiMaggio and Powell (1983) use to explain the process of homogenization among organizations, how they imitate each other, and how they often follow similar pathways in doing things as a result of normative, mimetic or coercive institutional forces that act upon them.

2.2.1 Drivers

In the search of the reasons (drivers) that motivated Swedish local actors to act how they did and that might motivate Argentinean local actors to initiate a process of change, particularly interesting results one of the ideas presented by DiMaggio and Powell (1983). According to them, different forces shape the form of organizations and the behavior of actors within these organizations. They mentioned three mechanisms through which institutional isomorphic change occurs:

Coercive forces: this type of isomorphism results from formal as well as informal pressures exercise by other organizations and by cultural expectations present in the society. Examples of this mechanism are legal mandates and other requirements imposed by other stakeholders (DiMaggio & Powell, 1983). In the context of developing a renewable and endogenous energy supply system, informal coercion may be created by the growing awareness of environmental impacts.

Mimetic forces: the main reason why imitation occurs is uncertainty. When a new field of activity is largely unknown by an organization, and when they do not understand the way in which they should technically proceed, for example, then imitation can provide a low risk and low cost pathway towards achieving progress. In other words, under uncertain circumstances, organizations may decide to follow a peer recognized as a leader in the field (DiMaggio & Powell, 1983).

Normative forces, associated to the concept of professionalization: in terms of DiMaggio and Powell (1983), there are two aspects of professionalization that constitute important sources of isomorphism. One is that of professionals receiving similar training and education. The second one is that of professionals interacting with each other and building networks that further diffuse ideas among them (Mizruchi & Fein, 1999). In the development of a renewable-based energy supply system, it may be considered that *the more municipalities that have been pursuing such transition*, and *the more local technicians and politicians that have been considering this as a feasible and desirable pathway*, then the more entrenched and legitimate such development becomes among these jurisdictions.

Literature on the development of renewable energy carriers identifies different drivers that have led local transitions. The list below summaries those highlighted by the literature:

International environmental, social, economic or geopolitical factors:

Oil price volatility: it is widely recognized that since the first oil crisis in 1973, and due to all the following events affecting the international price of oil in the 1980s and 1990s, there has been a great deal of experimentation with renewable energy sources (Jacobsson & Johnson, 2000; Reiche, 2002; Mårtensson & Westerberg, 2007)

International political volatility: according to Jacobsson & Bergek (2004) the debate over the future of the energy system involves intense lobbying over both policy goals and the design of an institutional framework. Policy making is, in terms of these authors, a highly political business. Moreover, the policy for the promotion of renewable energies has been intensively influenced by obligations set at the international level (Reiche, 2002). Following such reasoning, it can be said that the local transition towards a shift in the energy supply system is triggered by international politics which are, due to the tension existing between conventional energies and new alternatives (Jacobsson & Bergek, 2004), quite volatile.

Climate debate: the potential threat of climate change were first acknowledged by policy makers in the late 1980s (Collier, 1997). Since then, international debates on climate change have obtained increasingly importance, which was materialized by the signature of the UNFCCC in 1992. According to Collier, although the analysis of such environmental issue has largely focused on the international and national level of governance, it has also a local dimension. He considers that local power in areas of energy and transport policy is a crucial and strategic tool within climate challenge.

Moreover, fossil fuels and their role in global climate change rank high in the contemporary debates at the international level (Jacobsson & Johnson, 2000; McCormick & Kåberger, 2005 & McCormick, 2007). With such discussions, actions towards alternatives to fossil fuels and towards the introduction of renewable sources of energy appear to be the natural response.

National or regional socioeconomic factors:

Environmental concerns and expectations: among one of the reasons for renewable energy development, Mårtensson and Westerberg (2007) include public mind. The public awareness of the environmental consequences of the existing energy system, and the expectation to improve health conditions affected by this system, are some of the forces of change affecting the energy sector (Jacobsson & Johnson, 2000; & Reiche, 2002).

Energy security: a concern shared by most of the nations dependent on oil was and still is the security of energy supply (McCormick, 2007). If accepted that endogenous sources of energy, such as biomass, contribute to a great extent to improve energy security of supply (Peck & Voytenko, 2008; & McCormick, 2007), it derives obvious that such item is a key driver for the transition.

Employment and economic diversification: according to Peck and Voytenko (2008) the majority of the drivers influencing the focus on renewable energies (they particularly discuss the development of bioenergy) are linked to the potential such renewables have to provide co-benefits. One of these co-benefits is the improvement of economic and social security via economic diversification and creation of new additional income streams. Although this point referenced literature on one particular renewable energy carrier, it is considered to be applicable to other alternative sources as well.

The influence of the listed drivers is to be verified in each case study. Moreover, the three categories of forces provided by DiMaggio and Powell (1983) indicate the thesis' author the type of phenomena to look when seeking for each of the drivers, and create room for categorization and generalization. It should be noted that achievement of positive progress in areas enfolding each and every one of the national and regional socioeconomic factors listed above contributes to obtain legitimacy of renewable energy systems in some way. As such, the mechanisms included in this area are complementary and consistent with the ideas introduced by analysts that deal with institutional theory when describing the reasons underlying actions of actor groups – or when seeking to define strategies to 'change the actions' of such groups.

Besides drivers triggering changes within organizations, there are factors that influence the success these organizations might have. Some of them act as supporting tools, while others as constraining elements (Aldrich & Fiol, 1994).

2.2.2 Facilitating factors

For the construction of the list presented below of great influence has been Aldrich and Fiol (1994) proposed strategies for gaining legitimacy. These propositions, together with other facilitating mechanisms proposed by recognized literature, are included in the list.

Creation and diffusion of a shared vision: Aldrich and Fiol (1994) suggest using symbolic language and behaviors. Mårtensson and Westerberg (2007) also consider this element to be a facilitating one. A collective vision allows at developing short and middle term targets, as well as long term goals towards which the different stakeholders can work for.

Comparative advantage: this concept means that total output will be increased if actors engage in those activities for which their advantages over others are the largest or their disadvantages are the smallest (NetMBA, 2010). In the context of renewable energies, there are at least two elements that can be seen as comparative advantages: *resource endowment* and *geographical preconditions*. One the one hand, the availability of material to be used as renewable sources of energy is a positive argument in the discussion towards a shift on the energy supply system (Mårtensson & Westerberg, 2007). On the other hand, Reiche (2002) states that geographical and climate preconditions such as high amounts of rainfall, sunshine intensity, wind speed, among others, are factors that positively influence renewable energy development.

Technology development: the development of new technologies for the production of renewable sources of energy has been widely recognized as a stimulating factor (Reiche, 2002; & Mårtensson & Westerberg, 2007).

Active role of municipalities: municipal authorities are recognized to have an important role in the development of a renewable energy system as planning authorities, policy implementers, information providers, system owners and energy consumers (Collier, 1997; & Khan, 2004).

Public-private partnerships (PPPs): McCormick and Kåberger (2005) highlight the importance of PPPs, which are considered to be collaborations between public and private actors to form financial resources, know-how, and expertise. These authors state that PPPs combine features of each sector: social responsibility, environmental awareness, and accountability of the public sector, with the finance and managerial efficiency, and entrepreneurial spirit of the private sector (p. 1009). From another perspective, PPPs reflect the building up of legitimacy in its two versions, as presented by Aldrich and Fiol (1994).

Regulated system of support: according to Collier (1997), local authorities with the best will to achieve improvements, cannot design and implement effective policies in the absence of supportive national and international frameworks (p. 17). Moreover, Jacobsson and Johnson (2000) address the importance of a legal framework to support the development of new technologies. Aldrich and Fiol (1994) also highlight the importance of this factor, since it not only provides availability of resources, but also contributes to obtaining legitimacy.

Public ownership of energy related infrastructure: this facilitating factor is considered to operate well in European countries such as Germany and Sweden (Collier, 1997). Khan (2004) and Mårtensson and Westerberg (2007) also discuss the positive role municipalities have played as system's owners (as owners of the energy companies as well as other facilities involved in energy supply streams).

Existence of networks: the importance of networks, and therefore, the positive influence they have is discussed in Section 2.1.

Research development and demonstration (RD&D) activities: it is recognized that to bring costs of renewable energy carriers down, one of the measures is to support RD&D activities (WEA, 2004).

Environmental awareness of society: the extent at which the society is conscious of the environmental implications of fossil-fuel based energy systems, contributes to develop an easier and faster process of change (McComrick & Kåberger, 2005). That is so because citizens have both active and passive roles to play within the energy supply system. They are producers of renewable sources of energy (e.g. organic waste) as well as they are consumers of the system. Finally, Reiche (2002) considers that one of the success conditions for instruments promoting renewable energies is acceptance provided by society. Such acceptance is considered to be obtained on the base of environmental awareness.

The elements listed above, and their apparent efficiency, are to be identified and studied in each case study.

2.2.3 Constraints

The factors constraining the uptake of a new activity (and such is the development of an endogenous and renewable energy supply system at the local level) include:

Established technology characterized by increasing returns: in terms of Jacobsson & Johnson (2000) a new technology may suffer from competing with incumbent alternatives that have been able to undergo a process of increasing returns. This process allows a traditional technology to provide a product or service at a low price and/or high utility in terms of performance and infrastructure. (p. 631).

Market control by incumbent: Following Jacobsson and Johnson (2000), this means that the process in which renewable technologies are introduced to the energy system may not involve a free choice for customers.

Technical, market and economic risk: uncertainty in technological, economic and market terms creates a big risk that limits the involvement of actors as well as the expansion of the process (Jacobsson & Bergek, 2004; & Peck, et al., 2010). This also creates insecurity of investors (Reiche, 2002).

Lack of technical and intellectual capacity: Aldrich and Fiol (1994) state that training of inexperienced employees may be a big challenge for new organizations. Limited technological and intellectual capacity is a clear obstacle within the renewable energy field (McCormick, 2007; & Peck et al., 2010).

Underdeveloped organizational and political power of new organizations: Aldrich and Fiol (1994) consider that besides particular obstacles, many difficulties will raise for new organizations due to their nascent status. Lack of organizational and political power is one of these difficulties.

Weakness of actor' networks: the importance of networks in the development of a new energy system is discussed in Section 2.1. Weak connectivity of actors' network has been highlighted as a constraint by Aldrich and Fiol (1994), Jacobsson and Johnson (2000), Jacobsson and Bergek (2004) and Peck et al. (2010). In general, it can be said that if actors interacting in the system are not well connected with each other, if some actors depend on instructions provided by others and such orders are given in a wrong direction, or, finally, if members of a network fail to supply one another with the required knowledge, an important limitation may raise.

Supply chain coordination: the development of renewable energy systems requires well-organized supply chains, which overcome, in terms of McCormick (2007) the 'chicken and egg' problem. According to this author, this problem refers to the following idea: energy companies must have the will to purchase biomass so that suppliers invest on biomass resources; however, energy companies will not invest on conversion technologies if there are no biomass suppliers able to provide the material.

The development of such supply chain coordination is closely related to building up 'trust' among the actors and to obtaining legitimacy. According to Aldrich and Fiol (1994) the role of trust is essential to all social transactions, but mainly in areas where there is uncertainty about actions and outcomes. Moreover, these authors state that founders of new industries must deal with skeptical customers, creditors, suppliers and other resource holders (p. 650).

Limited customer understanding of technical possibilities: this constraint is introduced by Aldrich and Fiol (1994) and Peck et al. (2010) among others. This factor can be related to many reasons, some of them being: lack of appropriate channel of communication within the context where the change aimed to be introduced; lack of information exchange (Aldrich & Fiol, 1994); and weakness of the educational system (Jacobsson & Johnson, 2000).

Lack of an appropriate policy framework: Jacobsson and Johnson (2000) state that policy instruments may bias the choice of customers of the energy system in favor to the incumbent technology or the incumbent energy carrier. From another perspective, Aldrich and Fiol (1994) state that lack of institutional support for the diffusion of knowledge about new industries may destroy the effort such industries have made to obtain sociopolitical approval (p. 661).

Finally, Oliver (1991) considers that the following factors may help to remove resistance for institutional changes:

- High degree of economic gain perceived to be attainable by adapting to the change;
- Low degree of constituent multiplicity;
- High degree of consistency in institutional norms, requirements and goals; and
- Clear and meaningful legal coercion (e.g. rules, fines and regulations) behind the institutional change.

From the pointed factors it is possible to conclude that a policy framework highly influence the development of a new activity. Such influence can be positive or negative depending on which principles such framework is based on.

Lack of legitimacy: according to Aldrich and Fiol (1994) a fundamental problem innovating entrepreneurs have to face is the lack of legitimacy, in its two versions, cognitive and sociopolitical. The reason behind this is that "both entrepreneurs and crucial stakeholders may not fully understand the nature of the new ventures, and their conformity to established institutional rules may still be in question" (p. 645).

2.3 Contextual perspective

A last consideration within this chapter refers to the idea of temporal and spatial contextualization. As the aim of this thesis is to analyze the transitions taken place in Swedish municipalities and to provide general recommendations to be implemented in another context, important is to highlight some considerations about these concepts.

With regard to temporal contextualization, significant is to remember the idea that 'things evolved over time'. As stated by Peck et al. (2010), literature on technology lifecycles and industrial change distinguish three main phases of evolution: a formative phase, an intermediate development phase, and a mature industry phase. Particular features characterized each of these phases and influenced (by different means and ways) the transition.

Concerning spatial contextualization, it results suitable to mention few words about Mårtensson and Westerberg's article (2007). These authors state that in energy research, it is needed to place "situational and context-based interpretation of actors as well as their values and ways of organizing daily life" in the center of attention (p. 3). They consider that to use an institutional framework in a specific transformation process, it is essential to adapt such framework to the specific and unique context.

The described contextualization approach is also a tool guiding the research and analysis of this thesis.

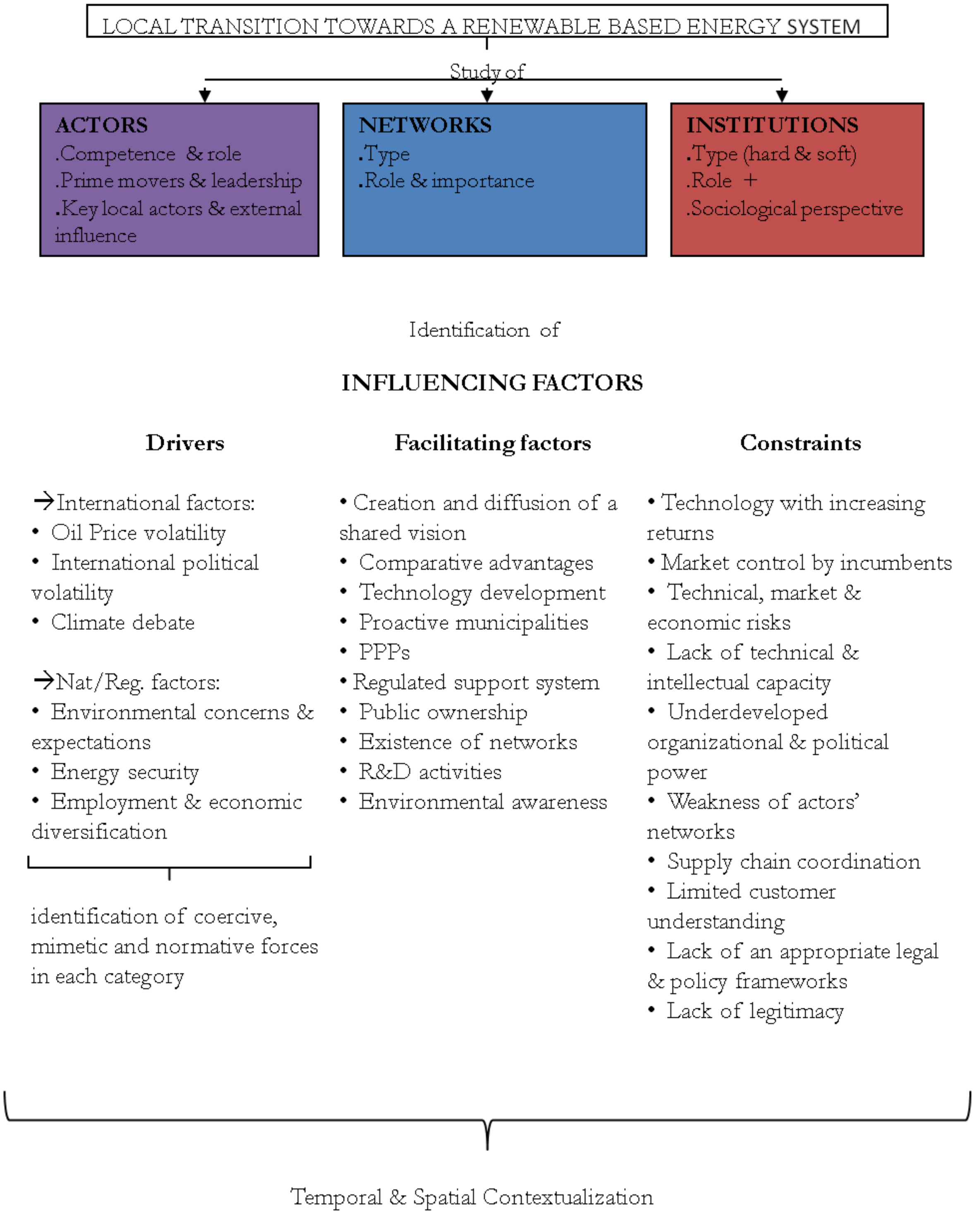

Figure 2-1 Analytical Framework

3 Swedish case studies

This chapter provides a summary of each of the Swedish case studies and preliminary conclusions for each. In its three sections, a short description of the process of change occurred, the actors involved and the networks identified, is included. Moreover, the sections contain a summary of the findings arrived concerning drivers, facilitating factors and constraints. A complete version of these cases can be found in Appendices I, II, and III. Figure 3-1 indicates the location of the studied municipalities.

Figure 3-1 Map of Sweden, location of case studies

3.1 Växjö case study

This central city of the Kronoberg County is located in southern Sweden. With a population of 81 000 inhabitants –of which 74% live in the city – and covering an area of 1 925 square km, Växjö is surrounded by lakes and forests. The basis for the local businesses is constituted by the service, commercial and educational sectors; agriculture represents a small proportion of the local activity (Växjö, 2008a).

3.1.1 The transition

Växjö has a biomass-based energy system. The development of the system can be divided in two periods: from the middle of the 1970s to the end of the 1980s, and from the 1990s until now. In the middle of the year 1973, when increases in oil prices were a big concern at the international and national level, the municipal owned energy company Växjö Energy (VEAB), was contacted by the Board for Economic Defense. The aim was to analyze and develop alternatives for oil. After some studies VEAB concluded that wood chips were the most suitable alternative to oil for Växjö (U. Johnsson, personal communication, April 15, 2010). In 1980 Växjö became one of the first municipalities in the country using biomass in the production of district heating.

In the beginning of the 1990s, with international debates about climate change, a new period started. In 1995, an intensive collaboration between the municipality and the non-governmental organization (NGO) Swedish Society for Nature Conservation (SSNC) began. In 1996, the executive committee of the city unanimously decided to adopt a fossil fuel free municipality vision (Växjö, 2008a). Several actions have followed the 1996' political decision. From a technical perspective, perhaps one of the most important events has been the construction in 1996 of Sandvik II, a biofuel-based combined-heat-power (CHP) plant (VEAB, 2010a). However, the achievements the city made at the heating and electricity sectors are not only due to technological improvements. The development of important knowledge-based activities (e.g. in 1996 a Bioenergy research centre was established at Växjö university) and the active participation of the city in several networks have also made the transition easier and faster (H. Johansson, personal communication, April 15, 2010).

3.1.2 Results of the transition

The Växjö strategy to reduce CO_2 emissions comprises a combination of behavioral changes, energy efficiency, and transition to renewable sources of energy (Växjö, 2008a). The 30 years transition that has taken place in Växjö resulted in important improvements. By the year 2008 the emissions of CO_2 have been reduced by 35% compared to the year 1993 (Växjö, 2008b). Concerning energy results, in the year 1993, the share of renewable sources of energy was as follows: heating 39.7%, electricity 51.7%, and transport 0.1%. By the year 2008 the percentages were: heating 92.5%, electricity 64.5%, and transport 5% (Växjö, 2008b).

Concerning socio-economic benefits, the municipality has been able to decouple economic growth and CO_2 emissions. It is considered that the economic development has not suffered from the shift to biomass-based energy (Växjö, 2010a). On the contrary, the shift has proven to be an important tool for the economic growth of the city (S. Nilsson, personal communication, March 23, 2010). Finally, the process towards a fossil fuel free municipality has created local jobs in the forestry industry (H. Johansson, personal communication, June 29, 2010).

3.1.3 Actors involved in the process and their importance

Växjö's energy system was built up and developed by local actors, as well as by the influence of stakeholders at the regional, national and international level. Table 3-1 provides an overview of important actors participating in the transition. It also contains a differentiation between those developing the first period of the transition from those participating in the second period. It finally provides an identification of the actors holding an important role nowadays.

Table 3-1 Participation and role of actors in Växjö transition

ACTORS					**Participation**			**Role**	
	Int	External			Transition		Actual System	Key	Influential
		Reg	Nat.	Int.	First period	Second period			
Individuals	X				X		X	X	
Politicians	X					X	X	X	
Municipality	X					X	X	X	
Energy Company	X				X		X	X	
University	X					X	X		X
Board of Econ Defense			X		X				X

NGO SSNC			X			X			X
Swedish Environ. Protection agency			X			X	X		X
Swedish Energy Agency			X				X		X
Energy Agency for southern Sweden		X					X		X
Växjö Värnamo Biomass Gasification Centre (VVBGC)		X					X		X
International networks				X			X		X

Two important findings for this case study can be highlighted. On the one hand, local actors have had a fundamental role. Engaged and motivated people working locally and deeply involved in the process were identified while performing the interviews. The role of the municipality, the local politicians, and the Energy Company, as well as the contribution of the Bioenergy Research Centre at the University (for building-up the necessary knowledge), have been of great importance for the transition. Moreover, the presence of a leader with the necessary strength to overcome obstacles and to empower others has proved to be essential in creating this motivation. The leader or champion role has been performed by different actors along the process. On the other hand, external actors have made the process easier and faster. The collaboration of the Swedish Energy Agency and the agency operating in the southern Sweden, as well as the contribution of the VVBGC for improvements in knowledge development, have been very influential.

3.1.4 Identification of networks and their importance

The city is involved in intensive networking process, not only at the local level but also nationally and internationally. At the higher level Växjö is part of the Covenant of Mayors, Energy Cities, Local Governments for Sustainability –ICLEI-, International DME Association – IDA -, and Union of the Baltic Cities – UBC-, among others. The city is also a member of the Climate Municipalities Association (Klimat Kommunerna) and the Swedish district heating association at the national level. Finally, an internal environment network can be also identified, involving representatives from each municipal Board, municipality owned companies and Lineaus University (Växjö, 2010b).

A general conclusion about the importance of these networks and their different roles can be drawn. International networks have served the purpose of promoting the city internationally and have therefore created funding and local business opportunity. They also have created competition among members and thus stimulated increasing efforts to be better on the competing field (S. Nilsson, personal communication, March 23, 2001; & B. Frank, personal communication, April 9, 2010). Regarding national and local networks, they have been interesting tools for sharing experience with other municipalities. Particularly with regard to national networks, they have had another role, since they have given its municipal members the strength to act as a powerful group when it comes to discussing an issue with the government (H. Johansson, personal communication, April 9, 2010).

3.1.5 Drivers, facilitating factors and constraints

As already mentioned, the changes experienced in Växjö took place in two periods, which had different political and international contexts. The triggering factors in each period differ considerably. Back in 1980, the main drivers were energy security and energy independence, within a context of international oil crisis and economic concerns (B. Frank, personal communication, April 9, 2010; & U. Johnsson, personal communication, April 14, 2010). Additionally, when VEAB started using biofuel in 1980, local growth became immediately a driving force for further increasing the use of this renewable.

In 1990s the context was different. Concerns regarding the negative environmental impacts of human activities and anthropogenic climate change were issues highly discussed at the international level. The Agenda 21, document which targets local actions for facing climate challenge, was one of the outcomes of the Conference held in Rio de Janeiro in 1992. In a number of interviews, informants indicated that this new background provided Växjö with a new driver for its transition. The city had the aim of demonstrating that it is possible to have, at a local level of authority, a global responsibility (S. Nilsson, personal communication, March 23, 2010; & B. Frank, personal communication, April 9, 2010).

Nowadays' international context is considered to be one where local governments are having an important role to play. For all the efforts done during the last 30 years, Växjö is recognized as the Greenest city in Europe in terms of sustainable development. As stated by the Mayor Bo Frank, such position is a motivation to work harder (personal communication, April 9, 2010). Additionally, there are two more drivers leading the process nowadays: competition (the city competes with other municipalities for international awards and recognition) and business opportunity.

Finally, it should be noticed that each international-political context within which local actions have taken place is *per se* a driving force. Therefore, in addition to local forces of change, it is possible to find external forces of change. Figure 3-2 is a synopsis of the above discussion.

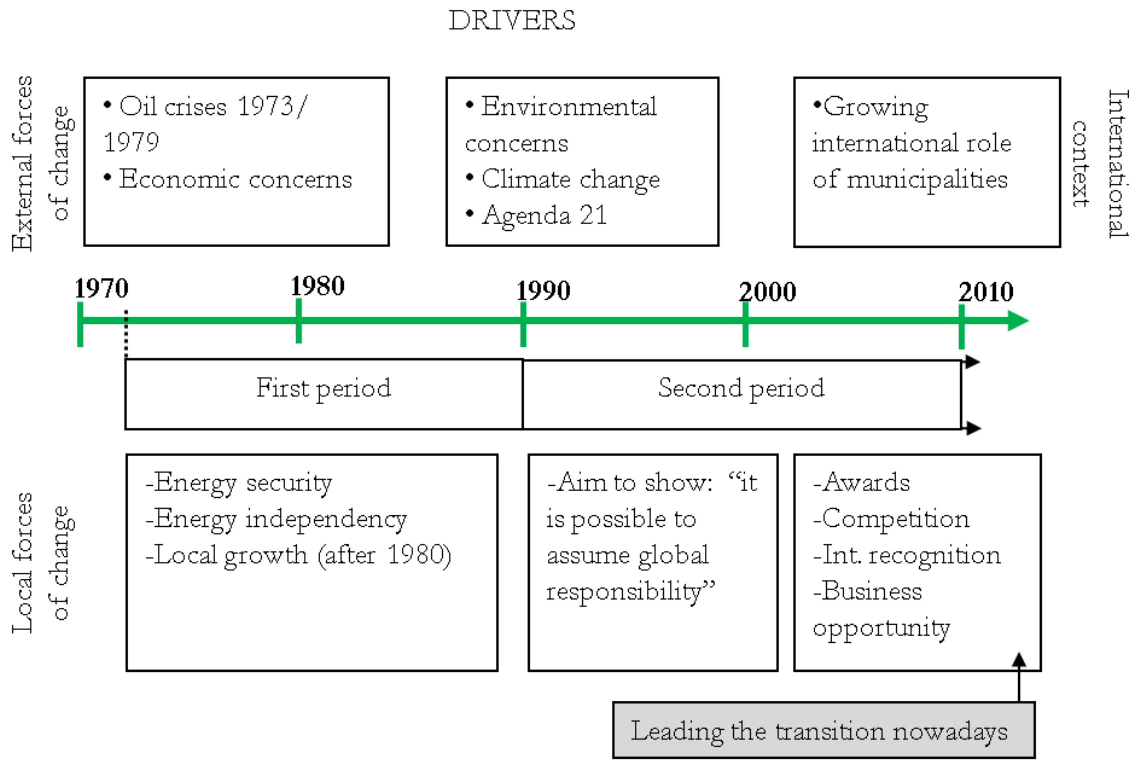

Figure 3-2 Drivers for Växjö transition

Besides factors triggering the process, there are others that have contributed to the local transition. A distinction between local facilitating factors and those externally influencing the transition has been identified (see table 3-2).

Table 3-2 Facilitating Factors identified in Växjö

FACILITATING FACTORS	
INTERNAL INFLUENCE	EXTERNAL INFLUENCE
Available, cheap and reliable natural resource (comparative advantage)	National policy framework
Broad cooperation among actors	International networks
Political unanimity	EU funding
Brave politicians	Awards

Finally, regarding constraints affecting the process, it is possible to distinguish between obstacles present while building up the system from, those limiting further improvements nowadays. Växjö was in 1980 one of the first cities in Sweden to use biomass for co-generation purposes (Energie-Cités, 2002). A whole new infrastructure had to be developed. Issues such as the re-construction of the energy plant, building up a supply chain, obtaining the necessary political support, and the engagement of the community, were all tasks that needed to be addressed. Furthermore, uncertainty about the technology that should be used and high investment costs were other limitations (U. Johnsson, personal communication, April 15, 2010).

Besides these initial challenges, actor's engagement and economic concerns remain as important limitations. From another perspective, in the view of Henrik Johansson, the transport sector has been the less developed in terms of increasing its share of renewable sources (personal communication April 9, 2010). To finalize this Section, it is interesting to highlight the opinion of the mayor of the city, Bo Frank, about this topic. He considers that "obstacles are creations of the mind" and that "only there lies the limitation of our success" (personal communication, April 9, 2010).

3.2 Enköping case study

Within Uppsala County, in east central Sweden, Enköping municipality is situated close to Lake Mälaren and the big cities of Stockholm, Uppsala and Västerås. Covering an area of about 1 300 square km, the city has around 38 000 inhabitants (Enköping, 2010a). A little more than 50% of the population lives in town and the surroundings, while the remainder resides in the countryside. The business-focus within the municipality is entrepreneurship and local innovation and development. More than 4 000 companies operate within the municipality, out of which less than 1% are energy-intensive industries. Farming land represents a significant part of the local economy.

3.2.1 The transition

In Enköping, the district heating system was introduced in 1969. With the formation of the municipal owned energy company in 1972, the expansion of the district heating network led to the gradual replacement of individual oil boilers (ENAE, 2010a). The beginning of the 1980s was the time for the first local experience in biofuel. In 1979 the Swedish Armed Forces, Government agency located in Enköping, wanted to ensure heat supply using domestic fuel. Hans Österberg, by that time managing director of the company, offered to fulfill the Armed Forces requirement. In 1981 a heating station with two woodchips boilers was commissioned

(H. Österberg, personal communication, May 05, 2010). During the 1980s several conversion technologies were introduced.

In 1992, influenced by national policy instruments (i.e. energy tax, carbon dioxide tax and an investment incentive introduced in 1992), the energy companies owned by the municipalities of Västerås and Enköping made a deal to construct a biofuel-fired CHP plant. In 1994 the CHP plant commenced to operate. In 2004 Enköping's energy company bought the other half of the company (ENAE, 2010a).

From another perspective, it should be mentioned that Enköping adopted in 1999 the first energy plan (obligation all Swedish municipalities have by law). This instrument consists in the description of the current energy situation in the municipality, as well as in a target document detailing what the city has to achieve (Enköping, 2009). Other sets of targets have also influenced the local efforts within the energy field. On the one hand and at the regional level, in 2003 Uppsala County adopted 15 environmental targets, one of which is to reduce CO_2 emissions. Moreover, and at the local level, in 2009 local politicians have adopted 12 environmental targets, one of which is that the municipality will be CO_2 neutral by the year 2050.

In the aim of providing a complete picture of Enköping's transition towards a renewable energy supply system, two interesting recycling projects should be mentioned. The first one refers to a project for developing salix plantation, started by the energy company (E. Johansson, personal communication, May 07, 2010). The main reason behind such process was the need to ensure the availability of biofuel. Moreover, an irrigation project was introduced as a spin off from the salix plantation programme. The main idea of the project was to irrigate these plantations with sewage water.

3.2.2 Results of the transition

As considered by Eddie Johansson, ex managing director of the energy company, the energy structure of Enköping can be characterized as part of a "locally optimized bioenergy system" (personal communication, April 28, 2010). As a result of all the technological developments, the recycling projects, as well as the introduction of institutional tools (such as the energy plan, the creation of different goals and targets, and the development of networks) many achievements have been obtained.

Concerning energy results, there is a virtually 100% bioenergy-based system in place in the CHP plant. During the period 1972 to 1980, energy production was based 100% on fossil fuel. For the year 2009, the share of fuels used was 418 GWh of biofuel and 5 GWh of fossil fuel. The later represents only around 1.2% of the total fuel used in ENA Energy (ENAE, 2009).

From another perspective, two are the important consequences of the salix plantation project. On the one hand, nowadays there are (a) 200 hectares of energy forest to be harvested by farmers who deliver salix to the energy company; plus (b) 196 hectares of energy forest to be harvested by ENA Energy (E. Johansson, personal communication, May 07, 2010). On the other hand, a mixture of 50% bottom ash from the CHP plant and 50% digested sludge from the Waste Water Treatment (WWT) plant is to be spread as fertilizer in such plantations (ENAE, 2010b). Regarding the Irrigation project, since 2001 at the 80 hectares' Nynäs Manor Farm, energy forest field located next to the municipal sewage plant, salix is being irrigated with fertile nitrogenous water. The project has been expanded to other 4 farms. Overall, the following socio-economic benefits have been identified: the energy company has a locally produced fuel guaranteed; farmers have a secure income from the salix plantations; residues are utilized as fertilizer and therefore recycled, and finally nitrogen emissions to Lake Mälaren and Baltic Sea are reduced (ENAE, 2010c).

3.2.3 Actors involved in the process and their importance

Enköping' *locally optimized bioenergy system* has been developed mainly by the influence of local actors. However, there have been also some contributions from external actors. Table 3-3 lists all the actors involved in the process and includes such distinction. It also contains a temporal delimitation of their participation and the type of actor's role: key or influential.

Table 3-3 Actor's participation and role in Enköping' transition

ACTORS					**Participation**		**Role**	
	Int	Ext			Transition	Actual System	Key	Infl.
		Reg	Nat.	Int.				
Individuals	X				X	X	X	
Swedish Armed Forces	X				X		X	
Energy Company	X				X	X	X	
Västeras' Energy company		X			X			X
Municipality	X				X	X	X	
Local politicians	X				X	X		X
WWT Plant	X				X	X	X	
Local farmers					X	X	X	
Consultancy agency Agrovärme			X		X			X
Uppsala County		X				X		X
Agrobränsle AB			X			X		X
Swedish University Agricultural science				X		X		X
Networks	X		X			X		X

Important is to mention that this case study has proven to be a clear example of a bottom-up initiative, with the necessary top-down support. It is an example of innovation and changes that have started at the lower layer of organizations, and where the actions performed by individuals have highly contributed in the local transition. Of course, this does not deny the importance politician support and acceptance of the proposed system have had.

3.2.4 Identification of networks and their importance

Enköping is member of different associations operating at the national level. The municipality is member of the: Swedish district heating association, Swedish bioenergy association, and National association for Swedish eco-municipalities. Also, it is possible to identify an informal network operating within the energy field internally. These networking processes have evolved while the transition developed.

Regarding the role and importance of these two types of networks, it can be said that the advantage Enköping and its energy company have obtained by being members of national networks is mainly knowledge and experience exchange (Bengtsson, personal communication, May 07, 2010). With regard to the informal network identified among local actors, it has created interactions and cooperation among the energy company, the WWT plant and the local farmers; as well as the involvement of politicians through goal and target settings. Such elements are considered crucial for Enköping's transition (U. Pillö, personal communication, April 28, 2010; & E. Johansson, personal communication, May 07, 2010). It is important to mention that the common idea shared by the interviewed actors is that the transition has been developed by the effort and empowerment of locals. Therefore, although one can recognize the importance of national networks, they have not been the key factor influencing in the success.

3.2.5 Drivers, facilitating factors and constraints

About the drivers identified in this case study some distinctions need to be made. Firstly, different are the forces that have pushed changes in - on one hand - the local energy plant and – on the other hand - the two recycling projects. Secondly, changes have taken place in different periods of time. Thirdly, in each of these periods, the international context has been determined by particular discussions and concerns. Such international contexts were also drivers for the local transition. Figure 3-3 summarizes these distinctions and lists the drivers identified in Enköping.

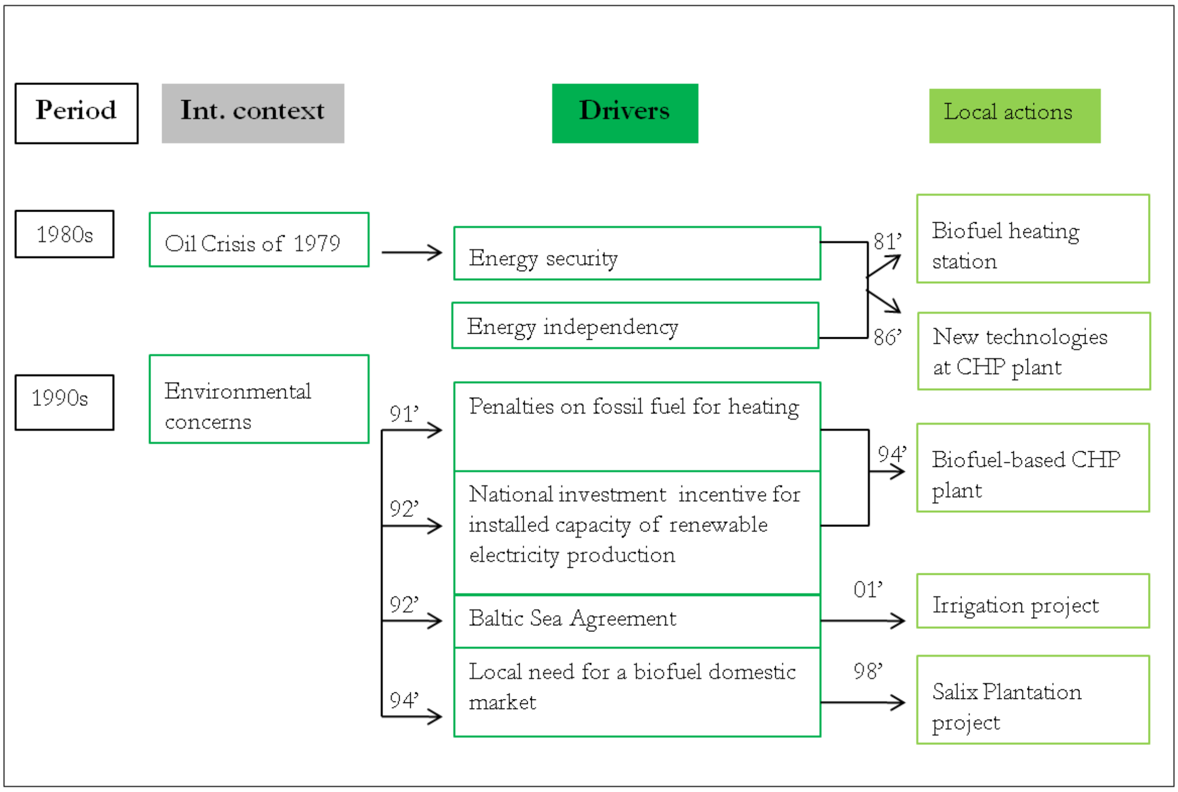

Figure 3-3 Drivers in Enköping's transition towards a renewable-based energy system

In Enköping, factors positively influencing the local transition have been identified. These factors have been both internal and external influences. Table 3-4 provides a list.

Table 3-4 Facilitating Factors identified in Enköping

FACILITATING FACTORS		
INTERNAL	EXTERNAL	
	Regional	National

Local Ownership	Cooperation between Enköping & Västerås	National policy framework
Local goals and targets		
Political commitment and unity		
Cooperation and support among actors		
Landscape (comparative advantage)		
District heating system		
Research and technological development	Research and technological development	

Finally, with regard to the constraints identified, the obstacles affecting the starting of the process were mainly two and both refer to the changes implemented at the CHP plant. On the one hand, when such facility was built in 1994, the company in charge of its operation was owned by the two neighboring municipalities. Frequent discussions about how to share the costs and how to deal with other administrative issues were a permanent obstacle (H. Österberg, personal communication, May 05, 2010). Moreover, when the Swedish electricity market was liberalized in 1996, the price of electricity became very low and the economic situation for Västerås –responsible of the electricity part of the energy production- became gradually worse (E. Johansson, personal communication, April 28, 2010). On the other hand, the second constraint was the lack of resource availability to be used at the CHP plan.

Besides these limitations, another obstacle identified was the constant need to improve the involved actor's benefits (E. Johansson, personal communication, April 28, 2010). In a system like the one developed in Enköping almost all the ones participating in the process have needed to receive the right incentive to be committed to it. Nowadays, this remains the biggest constraint. Particularly, an unresolved concern is how to maintain the profitability of the energy production system at ENA after the year 2012, when green electricity certificates will not be possible to be used.

To conclude, an interesting finding is the fact that some elements of the system have acted as both facilitating and constraints, and as both drivers and constraints. This is the case of the cooperation among the municipalities (example of the first situation), as well as of the local need for biofuel supply (example of the second situation). Without the mutual support between Enköping and Västerås, perhaps Enköping would have just built a biofuel district heating plant. Meaning, the penalties on fossil fuel were enough reason for a change. However, without this particular facilitating factor, the national renewable-electricity investment incentive would have not been enough to force the change (E. Johansson, personal communication, April 28, 2010). All in all, the cooperation was a positive element. But at the same time, as stated above, was also a constraint. Finally, and with regard to the need for local biofuel, the obstacle became one of the reasons of the structure Enköping's system has nowadays. It was precisely this limitation and need what triggered the development of the two unique and interesting local recycling projects.

3.3 Kristianstad case study

Kristianstad is the capital of Skåne Region. More than 78 000 inhabitants live in the municipal area of around 1 300 square km. The landscape of this city is very attractive for farming activities. Agriculture and food industry are well-developed sectors (Kristianstad, 2008a).

3.3.1 The transition

C4 Energy, the municipal owned energy company, has been supplying heat to the inhabitants of Kristianstad since the early 1980s. The construction of the existing CHP plant took place in three steps. The first stage commenced in 1989 when the plant was only a heating station with 2 LPG boilers. One year after, 1990 with the installation of a biogas boiler the company began to burn biogas from the municipal landfill. The second stage took place in 1994 when the CHP was constructed. Together with the starting of electricity production, 2 wood chips boilers were installed. Finally, and as the 3rd stage in the year 2007 another wood chip boiler was installed. Moreover, in three villages, small-scale district heating plants using bio-fuel were established by C4 Energy during the years 2001 and 2003 (CE Energi, 2010). Together with the measures taken by the municipal owned energy company, outside densely populated areas where district heating was not profitable, oil boilers has been gradually converted to pellets (Kristianstad, 2007).

From another perspective, it is important to mention the development occurred within the biogas production sector in Kristianstad. Such renewable fuel has been produced at three different locations in the municipal area: the WWT plant, the Härvöv landfill, and the Biogas plant in Karpalund. In the WWT plant biogas has been produced since 1965 to satisfied heating internal needs, and since 1999 part of the biogas has been upgraded and used as fuel for vehicles (Kristianstad, 2009a). The methane produced in Härvöv, landfill nowadays closed, has been collected and sent to the local energy plan since the year 1989 (Kristianstad, 2009b). Finally, in 1996 the municipal waste management company established a biogas plant with a capacity of 40 000 MWh. Karpalund plant became the first Swedish facility to co-digest organic waste from households and food industry together with manure from farms (Kristianstad, 2009c).

For the development of the biogas supply system, in particular, and Kristianstad's renewable-based energy system, in general, political involvement has been present. In 1999 the executive committee unanimous decided to become a Fossil Fuel Free Municipality by the year 2020.

3.3.2 Results of the transition

As a consequence of all the actions performed within Kristianstad, in 2007 CO_2 equivalent emissions in the municipality were around 516 660 tones, representing a decrease of almost 26% compared to 1990 (Kristianstad, 2009c). Concerning energy results, the actions performed by C4 Energy have led to a system where 99% of the energy by them produced comes from renewable sources (H. Mattsson, personal communication, April 12, 2010). In general terms, the share of fossil fuels has decreased from 57% in 1990 to 48% in 2006. Instead, the use of renewable fuel has increased.

3.3.3 Actors involved in the process and their importance

In the transition undertaken by Kristianstad, the presence of key actors initiating and developing the change has been essential. As it can be seen in table 3-5 internal and external actors have participated in the process and contributed to the achievements mentioned above. Some have had a key role, while others have had an influential one. Finally, such participation has been either with an active role or with a passive but influential one.

Table 3-5 Participation and role of actors in Växjö transition

ACTORS			Role		Participation	
	Int	**Ext**	**Key**	**Influential**	**Active**	**Passive**
Individuals	X		X		X	
Politicians	X		X		X	

Municipality	X		X		X	
Municipal Waste company					X	
Municipal Energy Company	X		X		X	
Food Industries	X				X	
Farmers	X		X		X	
Household	X		X recognized as such but not performed yet		X	
Municipal Housing company	X			x	X	
Private companies (E.On; Mällberger)		X		X	X	
Public Company (Skånetrafiken)		X		X	X	
SEPA		X		X	X	
SEA		X		X	X	
Other municipalities		X		X		X
NGO (SSNC)		X		X		X

The actors leading the transition and promoting the necessary changes are those acting at the local level. Their involvement, commitment, cooperation and coordination have allowed the development of the current energy supply system. Moreover, private and public companies acting not only locally but also regionally, nationally and even internationally (such as Sydgas) have positively influenced and supported the expansion of the system. Finally, this case study shows how important it is to share experiences and knowledge as an inspirational tool. The transition Växjö initiated before, as well as the ideas of an NGO involving several municipalities (with the Challenger Municipalities programme) inspired Kristianstad and made the city to mimic good examples.

3.3.4 Identification of networks and their importance

The municipality is member of a number of networks both at the national and international level. Nationally, it is member of the Swedish district heating association, the Climate municipalities association and Värmek association. Internationally, Kristianstad is member of UBC and Covenant of Mayors. At the lower level of authority, the municipality has formed a Climate Alliance. Also locally, an informal network built by local actors is observed. Additionally, it should be mentioned that back in 1998 the city tried (without success) to join a regional network consisting on five leading municipalities and developed by the NGO Swedish society for Nature Conservation. This last point highlights the idea that Kristianstad recognized the importance networks have for the local transition towards a renewable-based energy system.

Few words about the role and importance of networks for Kristianstad's transition are hereby provided. Significant have been internal networks in terms of a making the process easier and faster via increasing cooperation among actors. Going to a higher level, although the local effort to join the regional network didn't bring the expected outcome, behind this attempt the importance of working together with other municipalities so as to undergo an smoother process can be recognized. National networks have contributed to the transition in terms of knowledge and experience exchange, and this is recognized as an important factor (L. Erfors, personal communication, April 12, 2010). Finally, with regard to international networks, they have created competition among its members and, therefore, challenged them to go further and make better improvements.

3.3.5 Drivers, facilitating factors and constraints

Kristianstad' transition started at the end of 1980s. Within a time frame of almost 20 years, the forces triggering local actions differ considerable if one aim at comparing factors influencing the beginning of the process from those being determinant nowadays. At the beginning, the changes made within the city were due to rising oil prices and concerns about the dependency on oil and energy security (K. Johansson, personal communication, June 2, 2010). Also, considering the number of individual chimneys burning oil, there was a need to increase air quality and reduce its related health problems (L. Erfors, personal communication, April 12, 2010). After 1990s, new and different factors have been determinant. In this sense, international discussions about climate change challenges were leading factors for the adoption of the 1999 fossil fuel free vision. As influential as the previous element was the competition developed among Swedish municipalities aiming at being a front runner in environmental matters. Another important driving force present during the whole transition has been the economic structure of the system. Economic concerns have been a key factor determining most of the actions taken in Kristianstad.

With respect to factors that have smoothed the process, table 3-6 provides a list of such facilitating elements. Either by making it easier for actors to be part of the system, or by allowing to obtain benefits in a faster way, both internal and external factors have been important.

Table 3-6 Facilitating Factors identified in Kristianstad

FACILITATING FACTORS	
INTERNAL INFLUENCE	**EXTERNAL INFLUENCE**
Municipal owned facilities	National policy framework
Good local tax system	National grants
Political unanimity	Awards
Local policies and long term vision	Carbon dioxide concerns
Biosphere reserve area (comparative advantage)	
Local cooperation	
Within biogas system: ✓ business opportunity behind a problem ✓ cheap and available raw material ✓ incentive system ✓ old and closed facility available to be used	

Finally, about the obstacles affecting the transition, the main constraint was and still is an economic one. Each actor involved in the system has needed to find such structure profitable. Keeping such convenience up to date has been a difficult challenge. Moreover, lack of citizen's involvement and awareness, lack of further improvements in the transport sector, and lack of commitment from some people working within the municipality, are other challenges present in this case study (L. Erfors, personal communication, April 12, 2010).

4 Legal and Policy frameworks influencing the Swedish context

This Section provides a brief overview of important legal and policy instruments that have influenced the Swedish local transitions. These transitions have been influenced by legal, economic and informative instruments from both the national government and the European Union. Although global agreements, such as the Kyoto Protocol, are becoming important in this area, they are not addressed in any detail within this work.

4.1 European Union' renewable energy policies

The European Union (EU) began working with a framework for renewable energy in the early 1990s (IEA, 2004). A summary of the most important renewable policy direction statements and energy policies is provided in the text below.

- **Directives 96/92/EC and 2003/54/EC, concerning common rules for the internal market in electricity**: with these directives Member States have been obliged to gradually open up an important proportion of their national electricity markets to competition. The liberalization process has had implications for renewable energy, particularly for the electricity sector (EEA, 2001).
- **Directive 2001/77/EC**, **on the promotion of electricity produced from renewable energy sources in the internal electricity market**: this policy directive (repealed by the Directive 2009/28/EC) attempted to address the issues raised by the liberalization of the electricity market. It aimed to create a framework for electricity from renewables and established an indicative target of a 12% renewable share in gross final energy consumption by 2010.
- **Directive 2003/30/EC, for the use of biofuels**: this directive created a Community' framework to promote the use of biofuels. It aimed to reduce greenhouse gas emissions and transport's environmental impact, as well as to increase security of supply.
- **Directive 2009/28/EC, on the promotion of the use of energy from renewable sources**: this directive established a common framework for the use of energy from renewable sources. By 2020, 20% of the EU's energy supply and at least 10% of energy use in the transport sector is to come from renewable energy sources. The first of the goals has been allocated between the member states through national targets[1].

Although not legal or policy instruments, few words about some European communications are given. The 1996' Green Paper on renewable sources of energy, the 1997' White Paper that had the goal of doubling the contribution of renewable energy in final EU energy consumption, and the 2000' Green Paper on the security of energy supply, have been important documents setting antecedents of actions at the European, national and local level.

In addition to the items listed above, different instruments have supported the European energy policy and, in this manner influenced actions taken at lower levels of authority. Together with legislative-based instruments, market-based tools such as the CO_2 emissions trading scheme, research and innovation measures, and financial instruments have been the ones supporting the energy policy' aims and in particular the renewable energy sector.

[1] According to the Directive 2009/28/EC the target for share of energy from renewable sources in gross final consumption of energy by 2020 for Sweden is 49%.

4.2 Renewable energy policies in Sweden

Renewable-based energy related policies have been developed in Sweden under the umbrella of the Swedish climate strategy and the Swedish energy policy. A short description of both the background of such strategy and policy and the legal framework in place nowadays, are provided here. Some additional details of policies that have shaped the way municipalities interact with energy issues in Sweden are also given.

4.2.1 Background

Swedish climate strategy has been developed since the end of the 1980s through a series of decisions made within the frameworks of environmental, energy and transport policies (SEA, 2009b). Particularly with regard to the energy sector, Sweden's current policy is based on the 1991 Government Bill, as well as Bills enacted in 1997 and 2002 (IEA, 2004, p. 571). Additionally, other instruments have early promoted renewable energies (see table 4-1).

Table 4-1 Instruments for the promotion of renewable energy in Sweden

Nuclear power policy	A law of 1980 established that by 2010 the country's nuclear power plants would be shut down. This decision was put aside by a Government' decision in 2007.
Promotion programmes for renewable energies	Renewable energy was mainly promoted by investment subsidies and procurement programmes (Reiche, 2002, p. 232). This promotion started in 1993 (IEA, 1997, p.67). Several programmes have followed this initiative.
Research and Development	Active research on the area of renewable sources of energy has been explicitly supported in Sweden since 1975 (IEA, 2004, p. 577).
Energy taxation	Sweden has a long tradition of energy taxation (starting as early as 1929) with the objective of these taxes being finance the State's public spending requirements. With the 1990-1991 energy tax' reform the environmental element of this system began to receive more attention.
Informative instruments	Informative instruments used to raise public awareness have been in place for decades in Sweden. As an example, since 1996 electricity can be labeled with the eco-label of the Bra Miljöval (good environmental choice) from the Swedish society for Nature Conservation (Naturskyddsföreningen, 2008)

It should be also mentioned that in 1999 and 2005 Sweden established 16 environmental quality objectives for different areas; one being to reduce climate impact (Miljömål, 2009).

Few considerations about policies affecting Swedish municipalities from another perspective should be made. In general terms, local self-government is a concept that has been strongly developed in Sweden. Moreover, an important condition for governance has been the right of Swedish municipalities to apply taxation and decide the level of the local tax. The main source of income for municipalities has been the local tax, which has been important for the development of energy projects.

Specifically concerning energy matters, in 1977 a law on municipal energy planning was enacted, setting the frame for the responsibilities and authority of municipalities over energy issues (Khan, 2004). Moreover, after the Earth Summit conference in Rio and the adoption of Agenda 21 programme in 1992, an important role has been given to municipalities in Sweden. With this, a new perspective was introduced in the energy policy arena (Khan, 2004).

Furthermore, there are two sectors that have been regulated in Sweden and that have been influential for the development of renewable energy at the local level. The first one refers to the management of sewage and household waste, which has been and still is a municipal affair, and the second one refers to land-use planning. Regarding the latter, the Planning and Building Act has given local authorities a monopoly on land-use planning and in this way has allowed Municipalities to diagram and decide the sitting of energy facilities and the permit-granting process for specific projects (Khan, 2004).

As a final point in this Section, mention is given to an aspect that has affected the municipal active participation in the energy sector. In 1996 the Swedish government (following the European obligation mentioned in Section 4.1), took steps to deregulate the electricity market. With this decision, municipalities were forced to open participation to external actors by selling all or part of the energy companies that they owned (Khan, 2004).

4.2.2 Current policy framework

Swedish climate strategy and energy policy were most recently set out in the Government's Bills: *A coordinated energy and climate policy- Climate* (No. 2008/09:162) and *A coordinated energy and climate policy- Energy* (No. 2008/09:163). As at the European level, the national energy policy is built on the foundations of ecological sustainability, competitiveness and security of supply (SEA, 2009b, p. 8).

Climate Bill 2008/09:162 sets national targets for the medium and long term (until 2020) as 40% reduction in climate emissions from the non-trading sector. Additionally, 50% of non-transport energy and 10% of transport energy must be from renewable sources by that date (SEA, 2009b, p. 27). This target has constituted one step forward towards the achievement of the Government's long term aim that, by 2030, Sweden's vehicle fleet should be independent of fossil fuels (SEA, 2009b, p. 8). Moreover, just to provide one example of the many national decisions aiming at developing specific renewable energies, at the request of the Government (bill 2008/09:163); Parliament has set a national planning framework target for wind power to deliver 30 TWh by 2020.

The development of nuclear power polices in Sweden has constituted a complex process that has shifted backwards and forwards in the past 30 years as the international and national context, and as external influences (such as the climate debate, the impact of nuclear incidents at 3-Mile Island and Chernobyl) have changed in relative importance within the public and political debate. This topic is quite beyond the scope of this thesis. However, since the decisions operated in this area have affected decisions taken with regard to other sources of energy (i.e. renewables ones) a few words about the situation should be provided. Under the present energy policy, the Government considers that nuclear power will be an important source of Swedish electricity production for the present time and into the foreseeable future. It also intends to put forward a bill to annul the Nuclear Phase out Act[2], which ban on the construction of new plants. Nevertheless, the Swedish Energy Agency states that no public funding support for nuclear power can be expected (SEA, 2009b, p. 11).

Several policy measures and incentives have been introduced in order to achieve the targets set out in the country's energy and climate policies.

Energy taxation: after the 1990-1991 reform, the Swedish energy tax system has been mainly used as a tool to achieve various energy and environmental policy objectives. After the oil crisis of the 1970s, so as to secure energy supply, the aim for the system was to reduce the use of oil while increasing the use of electricity at the heating sector. However, after Sweden became member of the EU in January 1995, environmental matters were emphasized within the system, and, today, national energy taxation aims not only at reducing oil use but also at decreasing the use of direct electricity. Overall, the encouragement of biofuels use and the

[2] Nuclear Phase out Act (1984:3) *Concerning Nuclear Technology Activities*

creation of favorable conditions for endogenous production of electricity are, among others, aims to be met through the current energy tax system (SEA, 2009b, p. 36).

There are different taxes on electricity and fuels, as well as on different gases. Table 4-2 describes the types of taxes and the different conditions that made tax rates vary.

Table 4-2 Types of taxes and tax rates

Type of taxes	**General energy tax**	Has existed for several decades and it is levied on most fuels. It is based on different factors such as the energy content of the fuel
	Carbon dioxide tax	Introduced in 1991 and it is levied on the emitted quantities of carbon dioxide from all fuels except biofuel and peat. The current level is 105 öre per kg of carbon (circa 1 euro cent/kg)
	Sulphur tax	Introduced in 1991
	Nitrogen oxide levy	Introduced in 1992. Since 2008 it has been applied at a rate of SEK 50/kg of nitrogen oxide, on emissions from boilers, gas turbine and stationary combustion plants supplying at least 25 GWh per annum (circa €5/kg)
Tax rates	They can vary depending on several conditions: .Whether the fuel is used for heating or as a motor fuel .Whether it is being used by industry, domestic consumers or the energy conversion sector .In the case of electricity: -the application -whether it is being used in northern Sweden or in the rest of the country	

(SEA, 2009b, pp. 37-38)

In Sweden, although the use of electricity is taxed, its production is exempted from energy and carbon dioxide tax. Heat production is affected by energy tax, carbon dioxide tax and, in certain cases, sulphur tax and the nitrogen oxide levy. The use of heat, however, is not taxed. In principle, biofuels and peat are tax free for all users. However the use of peat is subject to sulphur tax. CHP production is taxed in the same way as in industry. (SEA, 2009b, p. 38)

There are various tax levels for transport, depending on the type of fuel and the environmental class of the fuel. Moreover, as one of the measures established so as to encourage the use of low-pollution cars, new vehicles of this type, bought after 1st July 2009, are exempted from vehicle tax over a period of five years. In addition to this, different changes in vehicle taxation have been introduced, with the aim of encouraging the use of cars and commercial vehicles having lower CO_2 emissions (SEA, 2009b, p. 11).

Green electricity certificates: this is a market-based support instrument established in 2003 with the aim of increasing the production of electricity from renewable sources and from peat. The objective of the system - created by the Swedish Act 2003:113 and Government' Bill 2005/06:154 - is to increase the production of electricity from renewable sources on the level of 17 TWh by 2016 relative to the production level in 2002 (SEA, 2009b, p. 44). This is intended to achieve the target of 50% of energy use coming from renewable sources. A governmental proposal is that the green electricity certificate system should be further expanded (SEA, 2009b, p. 9).

Emission trading scheme: the EU emission trading scheme is in its second period of application, 2008-2012. The European rules have been applied in Sweden through the Emissions Trading Act (2004:1199) and the Emissions Trading Ordinance (2004:1205).

Technology procurement: this policy instrument, established in 1998, has the goal to encourage the development of new technology (IEA, 2004, p. 579) and provide incentives for innovative companies. Technology procurement' projects are carried out mainly, and among others, in the fields of heating and control systems, domestic hot water and industry.

Energy research: with the aim of establishing a sustainable energy system, the government's Bill 2005/06:127 has established a long term programme of research, development, demonstration and commercialization activities for the development of new technologies and processes (SEA, 2009b, p. 56). During 2008, the Agency has distributed a total of SEK 875 million for energy research. Additionally, the Science Council has received funding of SEK 40 million per year for energy research (SEA, 2009b, p. 11).

.**Information activities**: the SEA utilizes different ways of increasing the awareness of the public with regard to renewable energy and its importance. Moreover, Swedish municipalities receive the help of energy and climate advisors, which are supported both economically and through the provision of training by the Agency (SEA, 2009b, p. 60).

5 Cross case analysis of Swedish cases

As stated in chapter 2, the TIS approach was chosen for the selection of the elements to be investigated at the local context. The focus was on the actors involved in the transition, and the type and role of networks and institutions identified. Attention was also paid to the factors that have triggered and influenced, both positively and negatively, the process. Moreover, so as to understand the intrinsic reasons that motivated local actors to initiate and pursue a change in their energy supply streams, the insights from the institutionalism theory were utilized. This theory has underpinned the reasoning developed here to explain why and how the three cases followed similar pathways in doing things as a consequence of normative, mimetic and coercive institutional forces that have acted upon them. From another perspective, the contextualization approach was also taken into account.

After studying and analyzing with the mentioned approaches the Swedish cases individually, general findings and conclusions, both comparing the cases with each other and utilizing the conceptual framework presented in chapter 2, are obtained. In this chapter such findings and conclusions are provided. The following Section discusses the three technological system's elements. After providing common conclusions about triggering and influential factors in Section 5.2, Section 5.3 discusses the isomorphism concept and the reasons why similar pathways or behavior were identified in the cases. Finally, Section 5.4 shortly discusses the importance of the contextualization approach in the study of local transitions.

5.1 The three technological system's elements

5.1.1 Actors and their importance

Based on the literature reviewed and on the three cases studied, the following conclusions are drawn:

The role of prime movers 'technically, financially and/ or politically so powerful to initiate and contribute' (Jacobsson & Jonhson, 2000) to the transition, was found to be important in each of the cases. Växjö Energy Company was a prime mover in technical innovation. Moreover the municipality of Växjö had the political and financial power to encourage several challenges and pursue many improvements. They had the aim to be prime movers on sustainable development issues, and they achieved it.

The fact that these are high up organizations with politician links and general respect of social and political structures, also underlines that the processes were given a high degree of socio-political support. Aldrich and Fiol indicate that these help the progress of such new venture. Moreover, the incumbent energy actors have driven the change. In this sense, the new sector has been supported by the "competitor".

The presence of a leader with the necessary charisma to transform the beliefs of others has proved to give undeniable benefits to the processes. This confirms Aldrich and Fiol (1994) ideas. A leadership role has been played in the three cases by local actors. Their main contribution has been to convince politicians, potential suppliers and citizens to support the new infrastructure. The champion or leader role can be played individually by different actors, from a public servant working at the municipality (case of Kristianstad), to the director of the energy company (case of Växjö). It can also be played collectively by two actors, such as the manager of the Municipal WWT plant and the director of the energy company (case of Enköping). Moreover and finally, the figure of a leader can change over time and be played by different actors (case of Växjö). It can finally be said that leaders have lobbied the political elite and received legitimacy for the process.

The most important role for building up the system has confirmed to be attributable to **local stakeholders**. In the three cases a fundamental role was played by engaged individuals, local politicians, the municipality, the Energy Company and citizens. Moreover, the three cases are good examples of a combination of bottom-up initiatives and top-down support.

Important skills have been developed among local actors: scientific, trade and technical skills have evolved all along the process. The creation of research centers that have built up the necessary energy related knowledge, and of networks and communication channels that have increased the exchange of information among actors, have contributed to the development of these skills.

Building of public understanding and confidence on the new system, were found to **be crucial** for the transition, since socio-political legitimacy is to be obtained. The theorist view that a system will work better if the public understands its rules and if confidence and trust exist, seems to be confirmed.

Educational programmes and awareness campaigns targeted at citizens and other social stakeholders have aided acceptance. The provision of information to citizens has been crucial for stimulating and maintaining their cognitive legitimacy and for aiding acceptance of the system.

The presence of external actors has acted as a factor contributing to the system. These actors can be regional, national or international stakeholders supporting the transition with their specific competences. They have made the process easier or faster by means of financial contribution, experience-shared, and knowledge-based support.

5.1.2 Networks and their importance

In the three local transitions networking processes have been identified. They can be classified according to the level in which they act and the role they performed. The following items summarize the conclusions arrived at this respect. Some of them confirm what has been stated by recognized literature while others constitute findings obtained from the Swedish cases.

Networks have smooth the process, positively influencing the transition. The idea of Jacobsson and Johnson (2000), which states that members of networks are able to increase their resource base in terms of information, knowledge, funding and/or technology, appears to be confirmed.

Networking processes have contributed to a more rapid increase in socio-political legitimacy to the structural changes taking place within the energy sector. As discussed by Aldrich and Fiol (1994), by allowing local actors to take collective actions, to promote their initiatives through third-party actors, and finally to create compromises with other organizations, networks have been seen to increase the acceptance of the public and other relevant stakeholders; acceptance which is the ultimate goal of socio-political legitimacy.

Internal networks have opened informal channels of communication among local actors. From the cases studied, it was identified that internal networks are useful to create an opened communication channel and a cooperative atmosphere. Although these networks can be formally created (such as in the case of Växjö and Kristianstad), they can also be formed naturally among local actors.

Internal informal networks have been essential for maintaining the infrastructure of the change. All the networks identified in the cases were recognized as mechanisms that have supported and facilitated the change. However, the cases have demonstrated that internal networks created informally have an 'essential role' for the maintenance of the new energy system. They can highly contribute to keep the participants working together and sharing the same goal and objectives.

National networks have been used as tools for sharing knowledge and experience among its members. The study of the Swedish cases has demonstrated that this is the role to be attributable to national networks. By transferring technical, procedural and experimental-based information, one member of the network is able to learn on the base of the successes and failures experienced by other member.

International networks have served the purpose of promoting the city at the international level and creating funding and local business opportunities. The case of Växjö shows how, by being member of international networks, the city has been able to be visible in the world and – by this means - attract funding opportunities and visits from all over the world (which in turn has been observed to create a new business opportunity). This example has demonstrated how international networks can enhance political legitimacy, as politicians are able to show how good they are, in turn reinforcing the system and leading to further efforts.

5.1.3 Institutions

As discussed in Section 2.1, for the purpose of this thesis the concept of 'institutions' as viewed by the TIS approach was enriched with the institutionalism approach. In this way, the analysis of this element does not remain as a static one, aiming only at describing the formal or informal grouping of actors that work together to achieve a common goal. Such analysis also focuses on the way institutions interact and the way they affect society. After studying the Swedish cases, the following observed phenomena are highlighted:

Institutions have facilitated the creation of key infrastructure. In a manner as the one explained by Jacobsson and Johnson (2000), it has been confirmed that institutions contribute to create the continuity for the system; meaning the foundations of its deployment, development and continuity. Without a proper institutional setting, there may be a tendency that energy goals and targets would just be goodwill expressions, key actors of the system would only act individually and follow personal-private interests, and potential stakeholders such as the society would not understand the role they are to play in the transition.

Institutions have evolved markedly as the process has developed. From the cases studied, it was concluded that the institutions identified as important for the local transformations have been developed along with the process. It has been observed that the transition and the institutional setting are like two forces that commence, develop and maintain over time as reinforcing factors, both depending and feeding one each other. Few institutions, such as the government capable to enact legal norms, and the society building cultural features, were present when the transition started. But even in these cases, only with the passage of time they developed some characteristics appropriate for the transition. In other words, they strengthened over time in a feedback relationship with progress and evolved following the path drawn by the transition.

Hard and soft institutions have played a fundamental role in the transition in terms of obtaining legitimacy. In a manner reminiscent of phenomena discussed by Jacobsson and Johnson (2000) the performance of several institutions was identified. Hard institutions, such as the government and regulators building a support system, actors forming well-established organizations that develop a capital market, and academic organizations creating an educational related system, were found. Moreover, so called soft institutions, such as NGO, informal networks and groups of involved citizens building cultural features in the community, were also observed. Both of them have been crucial for the success of the local transition, by contributing to achieve legitimacy.

The existence of a regulatory support system has been a clear sign that sociopolitical legitimacy reached quite an advance stage. Aldrich and Fiol (1994) view, regarding the possibility to measure sociopolitical legitimacy by assessing government policies supporting the 'new industry', seems to be confirmed. Moreover, such support has proved to give stability to the new system (acting as a reinforcing factor) and in turn enhances overall acceptance.

The creation of well-established organizations developing an appropriate capital market has been a sign of growing legitimacy. Jacobsson and Bergek (2004) sustain the idea that in the development of local energy carriers, once the demonstration and small-scale production stage pass, and once such sources are produced at a rate that can widely compete with conventional sources of energy, a capital market supporting the new alternatives is fundamental. This appears to be confirmed in the studied cases. Moreover, as stated by Aldrich and Fiol (1994) the existence of such conditions highly contributes to obtain the legitimacy new organizations (such as the one leading the transformation of the energy supply) need. As a final remark, it should be noticed that capital market is very difficult to develop, and is still a constraint that local actors in the three Swedish cases are facing nowadays.

Academic organizations creating and implementing educational and research activities have increased the legitimacy of the transition. The case of Växjö provides a very good example of the importance educational centers have had for the transition. The participation of research centers has increased the knowledge about renewable energies and the environmental awareness and acceptance of the new system from the public. In simple words, and confirming the ideas developed by Aldrich and Fiol (1994) it has provided legitimacy to the transition.

NGOs and informal networking groups have built up new cultural norms that have contributed to the advancement of the system (they enhance sociopolitical legitimacy). By understanding culture as the set of knowledge and values shared by a society, it is possible to realize the importance of it for an energy transformation process. Culture provides a particular way of thinking; it can create environmental awareness and the possibility to add extra considerations (besides the economic one) when it comes to energy choices. A prime example of this is the case in Kristianstad, where the acceptance of the system from the society was partly based on their environmentally-related culture (built by a long relationship existing in the city between the community and the municipal wetland area).

5.2 Triggering and influential factors conditioning the local transition

The framework presented in chapter 2 contains those drivers, facilitating factors and constraints that the reviewed literature has identified as elements influencing the transformation of energy supply streams. The presence of these elements, and their important roles for the transitions studied, were verified in this research. The conclusions arrived in these points are provided in this Section.

5.2.1 Drivers

Drivers have been classified in two categories: a) International environmental, social, economic or geopolitical factors; and b) National or regional socioeconomic factors. Moreover, as discuss in Section 2.2.1 and following DiMaggio and Powell (1983) different types of forces can be grouped according to the relative manner in which they influence these factors. *Coercive forces*, as formal and informal pressures exercise by other organizations or cultural expectations, *mimetic forces*, as modeling tools use under uncertain circumstances, and *normative forces*, developed as a consequence of professionalization and diffusion of knowledge. Forces in all these categories were identified within the drivers affecting the Swedish transitions. For the first of the two categories of drivers, the following have been recognized:

Oil price volatility: the volatility of oil prices, characterized as a driver by Reiche (2002) and Mårtensson and Westerberg (2007), has been an important trigger for the transitions taken place in Swedish municipalities. It has mainly acted as a coercive force. As an example, volatility of oil price in 1973 was a pressure that triggered the start of Växjö transition. Moreover, in the autumn of 1980 as a consequence of the war between Iran and Iraq and the dramatic increase of oil prices, the energy company decided to further develop the energy production system based on biofuels.

International political volatility: Reiche's view (2002), sustaining that the international political context has been of great influence for energy related actions taken at the local level, seems to be confirmed. In the cases studied, the start of the transitions was identified with an international context where concerns about energy security and oil prices were at the higher level of importance in the political agenda. Later, a new stage of the transitions (in the 1990s) related to a new international context, where environmental concerns about anthropogenic causes of climate change were leading the political debates. Finally, nowadays the international context is characterized as one where local authorities are being widely recognized as important actors in sustainable matters. Such context has related with municipal efforts for recognition, competition and international awards. In general terms, all these contexts had acted as coercive forces of change.

Climate debate: since 1990, and as stated by Collier (1997) debates regarding anthropogenic causes and negative effects of climate change have been an important reason for local energy transformations.

Coercive forces: several have been the international agreements addressing climate change and acting as formal pressures that triggered energy related measures locally. In 1992 the UNFCCC was adopted. A result of this agreement was Agenda 21 programme, document considered to be of particular importance for the three Swedish cases. At the European level, some communications, such as 1996' Green Paper, 1997' White Paper, and 2000' Green paper, as well as some legal documents, such as Directives 2001/77/EC; have all constituted important pressures. Particularly, in the case of Kristianstad, climate discussions led to a local debate about the consequences such challenge could produce locally. Concerns about drops and possible flows preoccupied the community and have constituted an important pressure.

Mimetic forces: the driver discussed here has also appeared in the form of mimetic forces. Holding to the idea that urgent modifications in the energy sector needed to be done so as to address climate change challenge, Växjö adopted a fossil fuel free vision. Three years later, Kristianstad, influenced by the same international context and with a high level of uncertainty about how to proceed, decided to mimic Växjö initiative and adopted the same vision.

Within the second category:

Environmental concerns and expectations: in a manner discussed by Mårtensson and Westerberg (2007), two important triggering factors influencing changes in local energy sectors have been: public awareness of the negative environmental effects fossil fuel use has, and expectations for improvements emerging from social groups. In the three cases, these factors have operated as a driver mainly after the 1990s, and have been a reason to continue the initiated transition.

Coercive forces: in Sweden several policy instruments have meant a formal pressure forcing a change and have, by this way, influenced local actions. That is the case of environmental targets set in 1988 and 1991, the 1993' climate strategy, and the 16 environmental quality objectives adopted in 1999. Particularly for Enköping, the development of the irrigation project (part of the locally optimized energy system) had its main reason of being in the 1992' Helsinki Convention (international agreement). Besides legislative instruments, there have been tax based interventions aiming at raising society's awareness, which have also acted as formal forces of change. With the reform of the energy taxation system in 1991, the environmental element of such system began to receive more attention.

An example of an informal pressure derived from this driver is to be found in Växjö. After 1980 the energy company needed to further develop the production system and one alternative was to use coal. However, there was a negative public opinion about using coal and the company decided to increase the use of forestry residues. This public opinion can be translated in a social expectation acting as a driving force.

Mimetic forces: a good example of this force can be found in the case of Kristianstad. Other municipalities (especially Växjö) and the NGO SSNC have influenced the city' perception on environmental and energy matters. Kristianstad had learnt from them, and was inspired from them, to develop the transformation. This is an illustration of combined mimetic and normative forces influencing Kristianstad.

Normative forces: a normative force derived from this driver has been the baselines set by regional counties. In the case of Växjö the regional County stated that the region shall be more or less fossil fuel free in 2050. Another important force has been the award systems were municipalities have competed for recognition. In the case of Växjö and Kristianstad, the cities have been nationally competing to be a front runner in environmental matters. Moreover, Växjö is nowadays considered to be the greenest city in Europe, and this has constituted a pressure to keep environmental concerns as a main priority. A final example of normative force is the interchanges of information and knowledge from different groups of professionals. In 1993, Kristianstad established a working group to study the environmental impacts of heavy traffic and the possibility of an alternative fuel.

In a manner as discussed by Aldrich and Fiol (1994), all the previous examples show how the more jurisdictions pursuing energy transformations, and the more politicians talking about this as a desirable pathway, then the more legitimate such kind of actions become.

Energy security: since the 1970s Sweden, as many countries, has had the goal to ensure security of energy supply. As stated by Peck and Voytenko (2008), endogenous sources of energy contribute to improve this security of supply. This aim has been an important driver in the transitions occurred in the three studied cases.

Coercive forces: an important formal pressure related to this driver has been the tax based intervention. After the oil crisis of the 1970s, so as to secure energy supply, Swedish tax system's aim has been to reduce the use of oil while increasing the use of electricity at the heating sector. The general energy tax helped to achieve this. The reform operated in the tax system in 1991 has been also very important for the change. Finally, the same can be said about the investment incentive for building renewable-electricity production facilities introduced in 1992. In the case of Enköping for example, for the construction of the biofuel-fired CHP plant, it have been crucial the penalties on fossil fuel for heating in the form of energy tax and carbon dioxide tax, as well as the 1992 investment incentive.

Mimetic forces: an example of this force is found in Växjö. At the beginning of the transition, the original idea was to mimic the peat-based energy production system in place in Finland. Although the city did not follow such approach, the Finish' system was used as an inspirational tool.

Normative forces: different norms have influenced the Swedish transitions. In the case of Växjö the influence came from the Board of Economic Defense, which contacted this municipality, among others, to address the issue of how Sweden could be less dependent on oil. Similarly, in the case of Enköping, an important influence came from the Swedish military regiment, located in the city, which wanted to secure heat supply using domestic fuel. In a military school, the securing of supply lines is of key importance for the stability of the country. Pursuit of secure lines of supply is thus a norm in that field. The municipalities were influenced by these actors and influenced by their norms.

Employment and economic diversification: as in a manner discussed by Peck and Voytenko (2008), these have been important co-benefits of the development of renewable sources of energy in the studied cases. All the coercive, mimetic and normative forces described above have led to a new local energy system. This system has constituted an opportunity to diversify the economy and to create new jobs and businesses. As soon as these co-benefits have been acknowledged by the actors, they became new forces triggering further improvements.

5.2.2 Facilitating Factors:

The factors identified in the literature as facilitating ones were present in the cases studied here. A list of the conclusions arrived in this matter is hereby provided

Creation and diffusion of a shared vision: the strategy suggested by Aldrich and Fiol (1994) about developing a vision shared among local actors and by which they seek at addressing the same goals, has proven to facilitate the transition by contributing to achieve cognitive legitimacy. This has been the case of Växjö and Kristianstad that have established a fossil fuel free municipality vision. Enköping, although not having such kind of vision, has also adopted several energy related goals.

Comparative advantage: As mentioned by Mårtensson and Westerberg (2007) and by Reiche (2002), resource endowment and determined geographical preconditions, respectively, have proved to be comparative advantages in the studied systems. The availability of a cheap and reliable natural resource to be used as an endogenous energy source, have allowed to avoid transactional costs (related to import of fuels) and have became, for this reason, an attractive option. In this sense, the availability of forest residues, farming lands where to harvest salix plantations, and organic wastes, have all been very important for making the transitions of Växjö, Enköping and Kristianstad smooth and straightforward.

With regard to the second comparative advantage, the geographical preconditions present on the cases have acted as an inducement mechanism. For Växjö, the city is located in a forestry area. In the case of Enköping, the municipality is characterized for its landscape suitable for farming activity (important for the salix plantation project). Finally, in the case of Kristianstad, the existence of a wetland area (biosphere reserve) has allowed the citizens to build up a special relation with nature, which made the implementation of energy related policies easier.

Technology development: not only the development of new technologies but also the local experiences in implementing such technologies have constituted two stimulating factors for the transition. This confirms ideas sustained by Reiche (2002) and Mårtensson and Westerberg (2007), among others. As an example, the early experience Växjö had in the middle of the 1970s and the beginning of the 1980s has been important for future developments on the energy supply area.

Active role of municipalities: from the studied cases, Collier (1997), and Mårtensson and Westerberg (2007) views, related to the important role of municipalities in energy system' transformations, appear to be confirmed. It has been verified that if municipalities are actively involved in the process as planning authorities, policy implementers, information providers, systems owners and/or energy users, the benefits to be obtained are enormous. In Växjö, the availability of funding, the development and implementation of projects and the creation of business opportunities were mostly due to the daily efforts made by the municipality.

Public-private partnerships (PPPs): collaborations between public and private actors to form financial resources, know-how and expertise (as in a manner discussed by Aldrich and Fiol [1994], and by McCormick and Kåberger [2005]) have been confirmed to be very important for smoothing the path of the local transitions. In the cases studied here, they have clearly contributed to achieving cognitive and sociopolitical legitimacy. As an example, in Enköping, the political party leading the local government had the support of local farmers, which has proved to be crucial for the implementation of the recycling projects.

Regulated system of support: an appropriate national policy framework, as the one suggested by Collier (1997) and Jacobsson and Johnson (2000), has deeply contributed to the local transformations of the energy supply systems. This framework has been constituted by a set of legislative, administrative and informative instruments. In the three cases particularly important have been the national investment grants, the fossil fuel carbon tax, and the establishment of the green certificate system. Moreover, international legislation has also played an important role (such is the case of the Baltic Sea Agreement in Enköping's case).

Public ownership of energy related infrastructure: this is a peculiar factor suggested by Collier (1997) and Mårtensson and Westerberg (2007) that has proved to facilitate the transitions studied in the Swedish context. However, it should not be considered a facilitating element per se. As a first impression after studying the cases, the author of this thesis believes that the way public authorities have behave along time (in a transparent and non-corruptive way), and the perception Swedish society has had about these authorities, have contributed to make this factor act as a positive one. This might not be the case in another socio-political context.

Having clarified this, the local energy companies operating in the cities were municipal owned. This fact has been important for the implementation of technical changes within the plants. As an example, Enköping's CHP plant received a loan from the bank; the reason for such credit availability was the public ownership of the facility (this was enough guarantee for the bank). In the case of Kristianstad, besides the energy company, several other facilities owned by the municipality and have been involved in the energy supply system (Municipal Waste Company, WWT plant, Upgrading plants). This circumstance has facilitated decision making processes, has allowed a more holistic planning and utilization of infrastructure, and has reduced the transition costs of getting the infrastructure to work together.

Existence of networks: this factor has been discussed in Section 5.1.2.

RD&D activities: these activities have made a significant contribution to the transition – not least by promoting the legitimacy of such systems in the eyes of a range of stakeholders. Thus, the views of Jacobsson and Johnson (200) and the WEA (2004) seem to be confirmed. In Växjö, the university has a Bioenergy Research Centre where studies about biogas technologies have been performed since 1996. Also, as a cooperative venture between Växjö and Värnamo (neighboring municipality) there is the VVBGC in place since 2003. The centre owns an 18 MWh capacity biomass pilot plant (now under construction stage) that has the purpose to produce knowledge about biomass-to-gas production processes.

Environmental awareness of society: As in a manner discussed by Reiche (2002), for society to play an effective role in the promotion of renewables, in the studied cases it has been essential to raise awareness about environmental implications of energy choices. There have been identified different tools (mainly information campaigns and economic incentives) that aimed to raise this awareness. Environmental awareness has proved to be important in terms of obtaining sociopolitical legitimacy.

In addition to the factors listed above, while collecting data from the Swedish cases two additional elements were brought forward by a number of interviewees. On the one hand, political commitment and unanimity with regard to energy related decisions were held to be very important both for building up the structure and for maintaining the whole system. In Växjö for example, in 1969 a political decision to resolve the eutrophication problem of seven lakes was taken. The unity across party boundaries required for that endeavors has characterized public officials in Växjö. On the other hand, financial support for the development and implementation of energy related systems has proved to be of primary importance for the transitions. Available sources of finance obtained by the municipalities both at the European level (via networks) and the national level (via application to different programmes and grants) have been crucial in smoothing the processes.

Another conclusion has risen from studying the cases. If one wishes to categorize all the previous factors, it is possible to identify two types of contributing forces: internal and external ones. External factors, such as a national regulated support system, are needed, and authors like Collier (1997) doubt that many improvements can be made in the local level without such frameworks. This idea is strongly supported by the evidence gather in the three cases, since, most of the times, behind the local decisions there was a policy to comply with. However, it is recalled that the biggest potential, the main reasons for a change, and the fundamental actions of change, are to be found in the local context. In this local context a vision to follow is to be created, an affordable and available resource is to be obtained, public-private partnerships are to be established, research and technological activities are to be implemented, and environmental awareness is to be raised.

5.2.3 Constraints

This analysis indicates that the development of a renewable and endogenous- energy supply system involves different types of challenges. It therefore seems to confirm what theorists have said about this theme. Following the analytical framework and considering the individual findings of each of the three cases, some conclusions about this matter are provided below.

Constraints present while building up the process and obstacles limiting further improvements on the established system, are two types of limitations affecting the transition: As highlighted by Peck et al. (2010), the development of industrial changes takes place in different phases of evolution. From the cases studied, it has been concluded that within the different phases, particular constraints are to be found. Mainly, the blocking mechanisms present while building up the foundations of the system have differed from those affecting the development nowadays. This is further discussed in Section 5.3.

Established technology characterized by increasing returns: the idea developed by Jacobsson and Johnson (2000), about new technologies suffering from competing with incumbent alternatives characterized by increasing returns, appears to be confirmed. The Swedish cases referred mainly to bioenergy systems, where the main transformation process occurred in the heating sector (except for Kristianstad). Here, the discussed element has not been a big challenge. However, it has proved to be so in a number of projects related to solar and wind energy that have recently commenced in the three municipalities.

Market is controlled by incumbent? Jacobsson and Johnson (2000) consider that the process in which renewable technologies are introduced to the energy system may not involve a free choice for customers. This constraint has not been identified in the cases studied and this is due to the fact that the energy carrier conversion and energy service delivery systems were municipally owned. It was the municipality that felt threatened by exposure to the incumbent fuel system and therefore had the urgent need to face and support many changes.

Technical, market and economic risk: this constraint, identified as a limitation by Jacobsson and Bergek (2004) and by Peck et al. (2010), has been identified in the cases. It mainly affected the start up of the process. In the case of Växjö for example, in 1980 the city was one of the first municipalities in Sweden using biomass for co-generation purposes. A whole new infrastructure had to be developed. With it, high technical uncertainty for the reconstruction of the energy plant, and high investment costs and levels of risks, needed to be overcome. In Kristianstad, related to the biogas system, technical and monetary issues were also obstacles limiting the initial stages of the process.

Lack of technical and intellectual capacity: Aldrich and Fiol (1994) view, about the big challenge training inexperienced people may constitute for new organizations, seems to be confirmed. The cases studied demonstrated that this constraint has been just a temporal limitation present while building up the system.

The meaning of 'new organizations' term needs to be clarified. With fundamental roles in the studied transitions, municipalities and energy companies were actors already there before the process started. However, with the entrance of other new actors to the system, and with the development of a new concept to be achieved (that of producing energy from endogenous and renewable carriers), a new organizational field involving all the 'existent' and 'new' actors have been formed. This is why it seems reasonable to talk about 'new organizations'.

Underdeveloped organizational and political power of new organizations: According to Aldrich and Fiol (1994), these two kinds of powers are to be developed over time with the support of institutional setting. New organizations have a challenge to face in this regard and this has been the case of the studied municipalities.

Weakness of actor' networks: weak connectivity of the networks among actors, in the manner discussed by Aldrich and Fiol (1994), and Peck et al. (2010), has been confirmed as a considerable challenge to be defeat in the early stages of the transition. This constraint has affected the cooperation among actors and their contribution to the system.

Supply chain coordination: as discussed by McCormick (2007), in transitions such as the ones studied here, the construction of well-organized supply chain is required. This has been a hard challenge to overcome in the three cases. In Växjö, it was a main limitation the energy company faced at the beginning of the process, and intensive meetings with forestry business associations were needed. In Enköping, the lack of resource availability and the need to come up with new suggestions to expand the salix plantation projects (in simple words the need to develop a supply chain) was a need that rapidly arose when the CHP started burning biofuels.

Limited customer understanding of technical possibilities: this constraint, discussed by Aldrich and Fiol (1994) and Peck et al. (2010), has affected the transitions taken place in the studied municipalities. This has been the case of Enköping municipality for example, where some citizens were reluctant to the development of the salix and irrigation projects. An appropriate channel of communication and level of information exchange have helped to overcome this challenge present only at the beginning of the transition.

Lack of an appropriate policy framework: Aldrich and Fiol (1994) and Jacobsson and Johnson (2000) highlight how an inappropriate policy framework may affect the development of a new activity. In the three cases, the legal and policy frameworks supporting the development of renewable energy carriers have been important tools. Although not a limiting factor in the studied transitions, it has been possible to confirm that if such policy is one favoring conventional sources of energy, this would be a strong limitation for the local shift.

Lack of legitimacy: a lack of cognitive and sociopolitical legitimacy, in a manner discussed by Aldrich and Fiol (1994), has been a crucial challenge to conquer. From the studied cases, it has been possible to confirm that at the beginning of the process, the actors involved in it did not fully understand the nature of the new system. Furthermore, in the initial stages of implementation, this study has indicated that the new systems did not have the acceptance of the public. This limitation was found as an initial constraint in Växjö and Enköping. In Växjö, this was because the transition started quite early, at a time that no experience on using biofuel for energy purposes was present. In Enköping, the unique characteristic of the salix plantation and irrigation projects created the same limitation. As the systems grew and were found to function – trust and engagement grew-, and so did the acceptance of the public.

After collecting data in the Swedish context, another element, besides the ones highlighted by the literature, was found to be an important constraint. Actors involved in the planning phase and interested in keeping other actors actively participating in the system, faced the constant need to maintain the profitability of the system for all the stakeholders. The developed structure had to be as convenient and profitable as possible for everyone from the start. In a system like the one developed in Enköping for example, farmers, the WWT plant, the energy company, the municipality and private companies, in few words all the ones participating in the local biomass supply chain, needed to have the right incentive to be committed to it. Keeping the profitability of the system up to date across the entire supply chain has been a significant challenge for developers of the system. As the systems were local and with only limited opportunities to substitute actors at any one link in the chain, the central system owner (the municipality) has had to take on a responsibility in this regard for all actors.

5.3 Institutional Isomorphism

The findings provided in the two previous sections, open the discussion of another concept deeply studied by DiMaggio and Powel (1983), that of institutional isomorphism. The three studied cases allowed to discussed and examined general ideas about the importance of actors, networks and institutions. This is because these themes evolved in a similar way in the cases. Moreover, the actions and decisions taken by local actors involved in Växjö, Enköping and Kristianstad' transitions, led to general conclusions about the drivers, facilitating factors and constraints. Indeed it was found that these actors reacted in a similar way to the different triggering and influential elements acting upon their actions. It can be therefore said that common pathways for doing things have been identified. In this light, it appears useful to examine the mechanisms underlying such similarity through the lens of institutional isomorphism concept (as discussed in chapter 2).

Institutional theorists state that homogenization in structure, culture and output of organizations is a consequence of need for legitimacy. The achievement of cognitive legitimacy, which refers to increasing the knowledge about the new venture (in this case the new energy supply system), as well as of sociopolitical legitimacy, which implies that the public accept this new venture as right and appropriate, is often an important prerequisite for progress in a new organizational field. As such, this theory indicates it should also be a principal goal of the system proponents. When legitimacy in its two versions is obtained, then, the new venture is installed in the society, and its survival is assured. At the beginning of a transformation process, actors and organizations may seek different pathways in which to achieve their goals and obtain legitimacy. However, with the passage of time, and after trying and failing, they will stick to strategies that were successful in the provision of such legitimacy. In this last regard, and before stressing the studied cases, a comment made in chapter 2 about Aldrich and Fiol (1994) article should be remembered. These theorists consider that supporters of new business areas may deliberately plan to pursue different strategies in order to gain legitimacy. However, it was recognized in this work that such strategies in the cases studied have very likely evolved organically over time.

Pursuant to this analysis, it is held that these previous considerations clearly apply in the studied cases. Although each of the transitions taken place in Växjö, Enköping and Kristianstad have features that made their own process unique, they have all applied the same themes discussed by theorists as necessary components of actions. For obtaining legitimacy, they have essentially followed the same patterns of behavior. However, neither of these cases had a clear and planned strategy (as the ones suggested by Aldrich and Fiol [1994]) at the beginning of the transition. Such common strategies have evolved organically and over time, and indeed have involved the testing and proving of different alternatives and solutions.

5.4 Spatial and temporal contextualization

In this last Section, and so as to fairly state that it is possible to seek generalization about local transitions of energy systems, the *contextualization* concept introduced at the end of chapter 2 is recalled. In the three cases, events and progresses occurred within a spatial context that might not be replicable anymore, not even in the same cities. Moreover, these events occurred gradually over time. The particular spatial and temporal context within which process of changes occur, create a unique feature of the transitions.

As stated by Mårtensson and Westerberg (2007), in the local context municipal authorities are equally influenced by decisions in the energy sector taken at the national and international levels. However, when implementing such decisions, a process of interpretation and adaptation takes place and there are several conditions that influenced such process. The elements described in the previous sections, such as the actors and their roles and competences, whether a leader exists or not, the level of networking processes operating in the system, the institutions developed and the way they interact (supporting one each other or repressing one each other); all and each of these factors and their connections and bounds create a peculiar spatial context where things occur and develop.

Moreover, as discussed by Peck et al. (2010), the temporal boundaries within which any change or activity takes place deeply influence the results of such change or activity. This temporal context can hamper the process or support it. In this sense it was already highlighted how the international context where decisions about climate change were taken, has increasingly created an atmosphere that has stimulated further work in developing fossil fuel free municipalities' visions (e.g. as distinct from simply reducing dependence on exogenous fossil fuels as in earlier stages of the transitions). If such idea would have been developed 10 years, even 5 years before this particular context, it would have not been the same. Also, the Swedish transitions started and developed in a context characterized by a particular rate of technological development. This technological development is improving in daily basis and this would be a positive feature if the transition aims to start under the current context.

Concluding, the message to be delivered is that to develop a new energy system based on renewable and endogenous carriers, the system cannot be seen as a static grouping of elements. The system must be seen as an interconnected set of elements that is coherently organized in a way that achieves something (Meadows, 2008). Moreover, only some of these elements exist from the beginning of the system, others appear later in the transition. But all these elements reinforce themselves over time and become stronger through the creation of linkages with other system's elements.

6 Argentinean context

6.1 Background

Argentina has more than 36 million inhabitants, of which 90% live in urban centers. The average density is 13 inhabitants per square km and the distribution of population among the country is uneven. Argentina is a federal, representative, and republican state, with a decentralized political organization, consisting of 23 provinces and the Autonomous City of Buenos Aires. The economy of the country is favored by important natural assets as well as by qualified human resources (Gobierno de la República Argentina [GRA], 2007).

Argentina is the region's fourth biggest oil producer and the second largest gas producer (Business Monitor International [BMI], 2010). The country faces high dependency on fossil fuels in its energy matrix (including transport and electricity generation), of which 90% is oil and natural gas (Global Environmental Facility [GEF], 2009). Argentina has the third-biggest power market in Latin America. At the end of 2008 the estimated installed capacity was more than 29 GW (BMI, 2010). Energy resources are mostly far from major urban and industrial centers. However, thanks to the National Interconnected System, this does not represent a limitation in terms of supplying energy to these centers. Electricity generation is based largely on gas and hydro. Gas provides 54% and hydropower 30% of generated electricity. This share is followed by nuclear, of approximately 6%; oil, which in 2008 was almost 4%, and coal, which represents less than 2% of generated electricity (BMI, 2010). Despite the enormous potential of Argentina for wind power, by the year 2007 its share was only 0.06% (IEA, 2010c). According to the International Energy Agency, in the year 2007 renewable energy, other than hydropower, covered only 3% of the primary matrix (2010c).

Issues such as poverty alleviation and the related need to resolve unemployment problems, energy security challenges, the impact the actual energy supply structure has with regard to climate change, and Argentinean' vulnerability to this issue; all constitute important concerns for the country (discussed in detail in Section 6.4.1). There are a range of different options available to tackle these challenges. Of particular importance, due to its potential to deal with these problems at once in a collective way, is the use of renewable sources of energy. Argentina has a great potential for the development of this energy, not only due to resource availability, but also because it has great experience in hydro-electricity, as well as in the use of biomass and wind power generation (GRA, 2007). A shift in the energy supply sector in this direction would reduce the dependence on fossil fuel and its related CO_2 emissions. The development of renewable sources other than hydropower would reduce the country's climate change vulnerability. Moreover, the implementation of renewable energy projects at the local level offers significant potential to diversify the economy, create new job opportunities and contribute to poverty alleviation. Finally, it would secure energy supply in areas that -currently- are not being covered by the National Interconnected System.

6.2 National legal and policy frameworks for the energy supply sector

This Section provides an overview of the current energy policy and the policy instruments influencing the development of renewables. A summary of the most important national laws, as well as of the different national programmes is hereby provided.

In the current energy plan, the idea is to develop the infrastructure of the country's electricity generation. A part of this will involve promotion of the use of renewable energy. Also, in order to avoid a decrease in the supply of oil and gas in the coming years, the government has launched a plan to promote investment in exploration, production and infrastructure for distribution. There are also plans to eventually liberalize energy prices (BMI, 2010). Despite of the latter plans, national legislation is nowadays oriented towards keeping domestic prices isolated from rising international fossil fuel prices. The energy sector is highly regulated, with few participants and a high degree of government intervention to control fuel prices (Morgera, Kulovesi & Gobena, 2009). The current regulatory scheme is oriented towards short-term goals, without being necessarily consistent with the need to attract long-term investments to the energy sector (Morgera, Kulovesi & Gobena, 2009).

The following national laws relate, directly or indirectly, to the development of renewable sources of energy.

Table 6-1 Argentinean legal framework for RES

Law No. 24 295/93	Through it Argentina has ratified the **UNFCCC**.
Law No. 25 019/98	Established the national **system for solar and wind energy sources**. It provided different fiscal incentives for their development and security of energy sales in the national electricity market.
Law No. 25 831/04	Instituted the right of all to access to environmental public **information**.
Law No. 26 093/06	Aimed at **promoting the production and sustainable use of biofuels**. Among others measures, it promoted biofuels through fiscal benefits granted to specific projects and set a mandatory blending requirement of 5% of bioethanol or biodiesel in gasoline and diesel oil, respectively, as from 1 January 2010.
Law No. 26 190/07	Established a Promotional **Regime for Renewable Energy used for Electricity Generation**. It granted fiscal benefits until 2016 and other incentives to power plants using renewable energy sources (including biomass and biogas from facilities that do not fall under the Biofuel Law).
Law No. 26 123/05	Law on **promotion of hydrogen** use: declared of national interest the development of the technology, production, use and applications of hydrogen as fuel and energy carrier.

Besides these mandatory documents, several initiatives for the expansion of energy supply have been recently adopted. With regard to renewable energies, the strategy of the National Energy Agency (Secretaría de Energía de la Nación) includes solar energy, wind power, hydropower, biomass, geothermal and hydrogen energies (GRA, 2007). The following tools have been acting as incentives for their development.

Table 6-2 Argentinean programmes for RES

R&D Programmes	There is an important level of activity that covers technologies such as photovoltaic, wind power, hydropower, solar thermal, biomass and hydrogen (Secretaría de Energía de la Nación Argentina [SENA], 2009).
Education Programme	There is a 'national environmental education and training in climate change' programme that aims at providing information and promoting opportunities for participation. The objective is to involve society in climate change politics.
National Programme on Energy & Fuel	It was created in 2001 with the aim of promoting 'clean development mechanisms' –CDM- projects under the Kyoto Protocol (Morgera, Kulovesi & Gobena, 2009).
ENGIRSU	With funding from the World Bank, a national strategy for municipal

Programme	solid waste was developed in 2005. The main objective is to protect population health. However, it also aims to capture methane produced from composted solid waste (GRA, 2007).
National Strategic Plan on wind energy	It was launched in 2006. Through it, the Energy Agency plans the installation of 2000 MW of power in a first phase (for the year 2015) in various wind farms with an investment of the order of US$ 300 million. This plan is designed not only to develop clean energy, but also to generate new jobs opportunities (GRA, 2007).
PERMER Programme	This programme is to be applied in dispersed rural population areas and aims at supplying electricity from renewable sources (GRA, 2007).
Bioenergy Programme	It was created in 2008 with the objective of ensuring the provision of sustainable, equitable and affordable bioenergy sources and services. It aims at supporting sustainable development and national energy security.
Gas Plus Programme	In 2008 the government introduced this project to encourage companies to invest in exploration and development of unconventional gas reserves (BMI, 2010).
Renewable generation (GENREN) Programme	It was launched in 2009. Through the national owned energy company –ENARSA-, the government tendered the purchase of renewable energy for a total of 1 015 MW. Contracts will have duration of 15 years and the allocation will be in modules of 50 MW.
Green Credits	Using this line of credits, small and medium size companies may take actions to optimize the use of resources (raw materials; water and energy) and minimize waste, effluents and emissions (GRA, 2007).

6.3 Case study

The city of Tandil occupies an area of around 4 900 square km in the southeast of Buenos Aires province. The city is located in the Pampa Húmeda, more precisely in the mountainous system of Tandilia. There is a mild humid climate and the average annual temperature is 14°C. The average maximum temperature is 20°C (with its highest peak in the month of January), and the average minimum temperature 8°C (Tandil municipality, 2010a). The months of June, July and August are the coldest of the year, when temperature can drop almost to 3°C. The city has a population of a bit more than 108 100 inhabitants and is organized by quarters, one urbanized and the rest dedicated to rural development (Cyber Tandil, 2010). The city has natural resources, important educational and technological institutions and skilled human resources. There is also a good economic infrastructure and an environment for productive investment (Quesada Aramburú, 2006).

6.3.1 City's infrastructure

From the productive structure' point of view Tandil is characterized by a diversified economy, with primary activities such as agriculture and livestock being the most important in terms of land use. Agriculture and livestock productions occupy 39% and 31% of the land respectively, while the rest of the territory is occupied by other uses, distributed among primary, secondary and tertiary activities (Cyber Tandil, 2008a).

Approximately 79% of the primary sector is comprised by farming activities (mainly agriculture and livestock), while the remainder (21%) is represented by mining activity. About livestock operations, there are around 1 090 establishments, approximately 313.500 heads of cattle and approximately 12 000 heads of pigs. In the case of agriculture, there are important grain and oil farming activities (of soybean, flax, sunflower and corn). Dairy farming is a rapidly growing sector in Tandil, with 148 dairy farms producing about 600 000 liters of milk a day (Cyber Tandil, 2008a). The development of mining activity is being undermined in a society increasingly aware of its negative impacts and the deterioration of the landscape (J. San Miguel, personal communication, July 12, 2020). As for the secondary sector, it comprises industries such as metalworking, construction and food products (dairy and pork products), among others (Quesada Aramburú, 2006). Finally, there is an important tertiary sector that includes the banking and educational services and activities such as trade, transport, communications, hotels and restaurants (Cyber Tandil, 2008a).

There is also a significant development of tourism. At the beginning of 2010 a Strategic plan for sustainable tourism was developed in order to organize and promote this service. So as to attract people to the city, two tools will most probably be used. One refers to the promotion of the beautiful landscape, with mountains that cannot be seen in many other parts of Buenos Aires. The second one refers to the idea of working towards a Sustainable municipality with energy efficiency and development of renewable sources being the main core of the public policies (J. San Miguel, personal communication, July 12, 2010). While this "aim" has been expressed by the informant, it has not been yet formulated as a distinct public "vision" to guide the development of the region.

For the economic development of the city it is also important the tax revenues received from the national government under the Co-participation regime[3]. Moreover, the Air Base, the Army, and the National University of the Centre of Buenos Aires Province (UNICEN), are all located in the city. This represents many salaries being paid by the national government and mostly spent in the city, and an important flow of capital contributing to local economic growth (J. San Miguel, personal communication, July 12, 2010).

A final remark about the laboral and educational situation of Tandil should be made. On the one hand, for the year 2006 unemployment rate was 10.5%, while the underemployment rate reached 11.6%[4] (Cyber Tandil, 2006). On the other hand, according to data of the year 2006, only 3.5% of the local population has never received educational instruction. In Tandil, the concurrence of the group of 5 to 29 years old people to educational institutions is higher than that observed in the province of Buenos Aires and in the rest of the country (Observatorio PyMe Regional, 2008).

6.3.2 Energy sector

In terms of electricity generation, the Province of Buenos Aires has been divided into three major areas to provide electricity service. Across the province there are about 210 electric cooperatives. Particularly in Tandil, the company 'Usina popular y municipal de Tandil' (hereby Usina company) is the local distributor of electricity. This company distributes electricity to more than 49 800 residential, commercial and industrial customers and has an annual sale of 230 GWh (USINA, 2010).

Regarding the heating sector, the system is individual for each residence, commerce and establishment. In urban sectors, connected to the natural gas network system, citizens use this gas to feed individual heating, air heating equipment or boilers for heating water in under floor

[3] The Co-Participation regime is an instrument of fiscal re-distribution by which the National Government collects different types of tax revenues and then distrbute it to the Provinces and municipalities.

[4] Unemployment refers to a situation in which people that have the age, capacity and desire to work but cannot get a job. Underemployment refers to a situation in which people work less than 35 hours per week.

or radiators circuits. Residents with a higher purchasing power use cooling and heating split equipments that consume electricity. In rural and suburban areas where there is no natural gas distribution, citizens mainly use firewood or compressed liquefied gas (if user's purchasing power is higher).

6.3.2.1 Development of renewable sources of energy

The municipality of Tandil has only a few facilities producing small amounts of renewable sources of energy. However, according to literature review and the informants, the potential of the city to develop and expand this sector is quite important.

Wind Energy: since 1995 an Electric Cooperative is operating a wind farm consisting of two windmills of 400 KW each. The performance of the wind farm, connected to the national electricity net, is 25.9% (Cyber Tandil, 2008b). Additionally, some private establishments have installed small wind turbines for their own consumption.

There are also a range of other activities going on within this sector. Firstly, there is a plan to encourage the installation of small wind turbines in hotels and industrial facilities through promotional tools, tax incentives and environmental awareness campaigns (J. San Miguel, personal communication, July 12, 2010). Secondly, the Business Chamber of Tandil has initiated communication with private operators in charge of building wind turbines (within the GENREN programme) to discuss if some of the equipment' parts can be manufactured in the city (J. San Miguel, personal communication, July 12, 2010).

According to the Engineer San Miguel, an important element for the development of this technology is the fact that the first local industries were manufacturers of wind turbines (which served the purpose to pump water in rural areas). He believes that this idea is installed in the collective memory of the society and constitutes a positive aspect (personal communication, July 12, 2010).

Solar energy: there is no local production of solar energy in the city. However, some projects for the construction of solar panels are been developed. In this sense, three architects are working in enterprises for the manufacture of solar panels. Moreover, USICOM (company from USINA group), the National Institute for Industrial Technology (INTI), and the Department of Production and Environment of the municipality, are all working together in the aim of improving research and development of solar panels. Their idea is that two local industries nowadays manufacturing heaters (CTZ and Impopar companies), start constructing solar equipments with their help (J. San Miguel, personal communication, July 12, 2010).

Bioenergy: although there is no production at the moment, there are several projects for its utilization. In the first place, a Biofuel Generating plant is being built in the Industrial Park of Tandil. The aim of this plant is to use soybeans as raw material for producing oil (NextFuel, 2009). In second place, although the forestry industry is not an important economic sector in Tandil, a corridor involving the municipalities of Tandil, Lobería and Necochea is being promoted with the objective of exporting timber through the port of the latter city. As a spin off project, the city is studying a feasibility project to use forest residues, mill residues and urban yard waste as fuel in agro-industry boilers (dairy) or as input in a digester for biogas production (J. San Miguel, personal communication, July 12, 2010).

With regard to biogas production, a substantial amount of organic waste is being produced by pig farms, refrigeration and processing plants of meat and sausages, and dairy and poultry farms. Tandil has more than 20 feedlots that - due to new provincial regulations and municipal ordinances - are required to mitigate environmental impacts of their activities. There are two projects to be implemented in this area.

As a Global Environmental Facility (GEF) project, the first one refers to pilot projects to be developed in pig farms, feedlots, refrigerator facilities, dairy, and poultry farms and to produce biogas with different types of biodigestors. The projects will receive U$ 3 million from the funding agency GEF and will be co-financed from the Ministry of Science and Technology of Argentina. Regarding the later, the Inter-American Development Bank (IDB) has approved a loan for the Ministry of US$ 20 million to promote sustainable energy applications. This project will be eligible for financing with the IDB Loan (GEF, 2009). Currently, after the approval of the first draft, the National Environmental and Sustainable Development Agency and the IDB, are working in the preparation of the final version of the project. These five pilot tests will be conducted in Tandil and both the company Usina and the UNICEN will participate as local actors. Additionally, it is planned to make pilot tests with organic waste from landfill and sludge from two sewage treatment plants, and to use it for the production of biogas as: (a) fuel for waste collection trucks; (b) fuel in a pyrolytic furnace for burning pathogenic waste; and (c) fuel in a Crematory (which nowadays the city does not have) (J. San Miguel, personal communication, July 12, 2010). The implementation of this project will start on March of 2011 (GEF, 2009).

After the pilot projects (that will no cover more than 1000 animals) are implemented, it would be possible to determine (a) the best technology to be used, (b) the values of biogas production, (c) the capacity of the biodigestors, and (d) the capacity variation due to changes in temperature; and the second project will be then launched. This project consists on the installation of digesters on the Feedlot 'Valley Azuzena', which has between 14 000 and 21 000 animals. The idea is to produce biogas and to use it as fuel for electricity generation. This electricity (1.2 MW)[5] will be sold to the national energy company ENARSA and fed to the net under a contract of 15 years and with a promotional regulated price. The following actors participate in the project: the National Environmental Agency, the National Institute of Agriculture Technology (INTA), the National Institute of Industrial Technology (INTI) the Energy department of the province of Buenos Aires, Usina Company, and the Feedlot 'Valley Azuzena' (J. San Miguel, personal communication, July 20, 2010).

From another perspective, a local political party is working on a project of Ordinance for the research, development, production and use of renewable energy for heating purposes. Business organizations, environmental agencies, the UNICEN and other educational institutions are participating in its preparation (J. San Miguel, personal communication, July 20, 2010). Thirdly,

Finally, under the tourism development, according to the Engineer San Miguel there is the idea of building a theme park for Renewable Energies, not in a specific place, but covering the whole city. The project would begin with an Energy Museum where the first 10 oil engines which had given energy to the city at the beginning of the 1900 will be displayed (personal communication, July 12, 2010).

As it can be seen, the development of renewable sources of energy is in its immature stage and much remains to be done for the expansion of related projects. However, important is to highlight the clearly massive potential for production of local energy from wastes and the

[5] The figures within this project are based on preliminary estimates only.

important comparative advantage this constitutes. Moreover, the ideas are realizable from a technological point of view.

6.3.3 Identification of actors

Currently, there are not many local actors deeply involved in renewable energy related activities or projects. The following list includes the local players identified:

Engaged individuals: Tandil is a city that has just recently started the development of projects aiming at diversifying its economy and energy balance with the production of renewable technologies and energy sources. In this new process, of particular importance results the presence engaged individuals, such as the Engineer Jorge San Miguel, citizen of Tandil. He has been president of Usina Company between 1987 and 1991, and member of the Local Parliament between 1993 and 1997. He has also been working as a public servant at the provincial level (responsible of energy related issues), and is nowadays working as Coordinator of the Sustainable Energy Development Unit, at the National Environmental Agency. He has triggered several projects and has engaged many other actors. He is still working hard to develop ideas that most of the time seem difficult to be achieved, in a context where other priorities occupy the political agenda, and where the interest of the whole society not always prevails. Although Jorge San Miguel is now working at a higher level of authority, he can still be considered a local actor, since its role of citizen of Tandil and his history working within the city seem, to be part of the empowerment he nowadays has.

Local politicians: there is an active role of some members of the local Parliament that are interest in developing policies that would promote renewable energies locally. However, it is not possible to identify a clear and long term vision aiming at pursuing this goal. While retrieving data for this case study, it proved to be impossible to obtain an interview with the Mayor of the city. According to the Engineer San Miguel, although the political party leading the city is opened for listening to new ideas and projects, there is a lack of political leadership and strength to encourage changes in the energy supply sector. It can then be concluded, that although some examples of politician commitment towards an energy transition are identified, this is still not a main priority.

USINA Company: this company, owned by the municipality and the Business Chamber of Tandil, is in charge of the distribution of electricity in the city. Together with other internal and external actors, the company has been working for the development of project related to renewable sources of energy. In order to address this particular objective, a new subsidiary company, USICOM, was created (J. San Miguel, personal communication, July 20, 2010).

Business Chamber of Tandil: this actor is involved in energy related issues by being, together with the municipality of Tandil, owner of Usina Company, and by aiming at developing some business opportunities, such as the one related to the production of parts of wind turbines in the city.

Tandil Municipality: currently, this actor is only peripherally involved en energy related projects. There is great room for more participation.

The electric Cooperative CETRAL: this electric Cooperative is owned by the municipalities of Tandil and Azul, and is the actor in charge of operating the wind farm located in the city.

Private sector: some projects involve the participation of the private sector. In this sense, the presence of professionals (e.g. architects) in solar energy related projects, and the presence of some industries in wind and biomass energy related projects, are identified. However, in most of the cases their involvement is the result of the participation that the public sector gives to them. This means that their actions are a response to an 'invitation' to participate, rather than a personal initiative.

Educational and technological institutions: in Tandil the presence of the UNICEN University and the Technology and Agro-Technical schools should be highlighted. UNICEN has been characterized by a history of strong investment in the development of scientific and technological knowledge, and human resources' training for research (Lopez Bidone, 2010). Since 2003 the university has a Science and Technology Park, located in Tandil. The Park has been created with the objectives of strengthening innovative technology-bases enterprises, promoting the transfer of knowledge and technology to the productive sector, and facilitating the employability of graduates to related companies (Parque Científico Tecnológico, 2010). Moreover, within the University, the Faculties of Humanity, with its Environment Diagnosis and Management career (located in Tandil), and of Engineering (located in the neighboring city of Olavaría) is also important. This is due to their work and efforts in researching biogas related technologies.

Externally, stakeholders acting at the national and provincial level, as well as international funding agencies, are other players involved in projects to be developed in the city. At the national level, the participation of the INTA, INTI, and the National Environmental Agency is to be highlighted.

6.3.4 Networking activities in the city

Tandil is involved in a number of networking processes. The city is member of Merco-Cities Network. This network was created in 1995 within the framework of the Mercosur'[6] integration process, with the aim of strengthening municipalities' role and promoting exchange of experience and cooperation between the cities of Mercosur region (Tandil municipality, 2010b). Also, in 2008 Tandil became member of the 'Interlocal Red', a network for Latin American cities created for culture development (Tandil municipality, 2010c). Moreover, there is also an important and informal network serving strategic planning purposes by linking social and economic actors of different municipalities of Buenos Aires, such as the one existing among the cities of Tandil, Olavarría, Azul and Rauch (Observatorio PyMe Regional, 2008).Finally, with the goal to encourage experience exchange between local authorities of Europe and Latin America, in 1995 the European Commission developed the Urb-Al Programme. Tandil became an observer member in the year 2005 (Tandil municipality, 2010d).

Although the mentioned networks have been identified, it was not possible to determine how important they were for the energy related projects developed in the city. The Engineer San Miguel hopes they play an important role in the future (J. San Miguel, personal communication, July 12, 2010).

6.4 Triggering and influential factors affecting local energy transitions in Argentina

This Section contains a description of those factors that have the potential to trigger a local transition towards a more secure and renewable-energy supply system in Argentina. Barriers limiting and factors facilitating such transition are also provided. Although Argentina has a great variety of territory, weather and cultures, the energy system of the different Argentinean

[6] Mercosur is a regional trade agreement among Argentina, Brazil, Paraguay and Uruguay founded in 1991.

municipalities is widely influenced by policies and actions taken at the national level. This is because it is a highly regulated sector. Pursuant to this reasoning, if not explicitly stated, the factors included in this section all refer to the country level.

6.4.1 Drivers

From the literature review and the interviews performed, different reasons justified initiating a change in the Argentinean energy supply system, with more focus on the local level, and on the development of renewable sources of energy. The most important being:

Energy security: although the country has great availability of non-renewable and renewable sources of energy, security of energy supply constitutes an important concern. Although Argentina produces natural gas in sufficient quantities to satisfy domestic consumption and export part of its production, due to low levels of exploration since 1998, the proven natural gas reserves have been reduced (GRA, 2007). Another limitation is identified in the electricity sector. Due to the low population density outside the major cities and the dispersal of rural households, providing electricity to the rural population is still a challenge. By the year 2007, only 70% of the rural population has had access to this energy carrier. There are also difficulties to ensure the overall quality of service (GRA, 2007). One last remark about energy security should be made. In 2004 Argentina experienced an important energy crisis. State-imposed caps kept energy prices low, and this triggered an important increase in energy demand, which then exceeded energy supply. So as to deal with this situation, the government broke a natural gas export contract to Chile, reduced exports to Paraguay and Uruguay, and began importing gas from Bolivia (BMI, 2010). Currently, gas imports are at a price three times higher than that paid to local producers (Pisani, 2010).

Climate change: an important issue related to the Argentine energy supply system is that of climate change and there are two reasons for this. On the one hand, there has been an increase in CO_2 emissions from the energy sector of 28% over the period 1990-2000 (GRA, 2007). On the other hand, Argentina is potentially vulnerable to Climate Change, as a high percentage of its exports are agricultural commodities and manufactures of agricultural origin. In addition, as mentioned in Section 6.1, the country relies on hydro-power for an important share of its electricity generation. The climate projections indicate that the expected changes will tend to increase future pressure on energy supply, particularly in the electricity sector, due to the likely reduction of water availability in major production basins and the possible future expansion of supply hydroelectric power (GRA, 2007).

Environmental concerns: an important environmental problem Argentina is facing is pollution, mainly water pollution in urban areas –owing to harmful disposal practices – and in rural areas where rivers are being polluted by increasing use of pesticides and fertilizers. Moreover, some of the serious threats to the environment are reduction in its biodiversity, overexploitation of mineral resources, erosion problems due to inappropriate land use' practices, and deterioration of irrigated areas. Most of these concerns are partly caused or at least deeply related to the current energy supply system, characterized by the use of non-renewable sources of energy at a share of almost 90% (European Commission, 2004).

Poverty alleviation: The Argentine economy experienced a long and deep recession between 1998 and 2002. The recovery of the economy was initiated in the second quarter of 2002. However, the social debt is still important, as unemployment is still 10.4% and the number of people with employment problems is estimated at around 22%. Poverty still affects approximately 24% of Argentine homes. As a consequence, one of the basic features of public policy is the budgetary effort to alleviate poverty (GRA, 2007). One of the co-benefits the development of renewable energy sources has is the diversification of the economy and the possibility to create new job opportunities (see Section 2.2.1) and generally reduction of the economy's exposure to price fluctuations on the world market. This has been already acknowledged by Argentine authorities. Some policies regulating renewable energy field provide special benefits to those companies participating in renewable energy projects that contribute to the creation of job opportunities (such is the case of Law N° 26190 and the national plan for wind energy).

6.4.2 Barriers

In June of 2009 an interesting document about diagnosis, barriers and proposals for renewable energy in Argentina was presented by the National Energy Agency (SENA, 2009). The document represents a recent update of the current situation regarding renewable energy in the country. Moreover, for the development of the project a wide variety of actors involved in the country's renewable energy field have been consulted. For the previous considerations, it results sufficient for the purpose of this Section to refer to the conclusions arrived in the mentioned document. A short summary about the barriers for renewable energy identified in the document is hereby provided. Additionally, some new items identified from the literature review and the interviews performed are also included. When not explicitly referenced, the items correspond to the "Renewable Energy: Diagnosis, barriers and proposals" document.

The document classifies barriers in the following categories: policy and institutional, economic and financial, regulatory, technical and socio-cultural barriers.

Policy and institutional barriers: within this category the following limitations are highlighted:

- There is lack of coordination among the different authorities acting in the area. As an example of this, the Energy Agency establishes active policies, but it does so in different sections such as electric power, fuels and strategic planning. On the other hand, the Mining Agency, the Environment and Sustainable Development Agency and Livestock, Fishing and Food Agency among others; are all authorities acting in the area.
- There is duplication of efforts in terms of research and development activities. The study of new technologies is almost free and without coordination among the various research groups.
  Relevant to both of these categories, Aldridge and Fiol (1994) indicate that social confusion (a problem of cognitive legitimacy) can be generated by multiple searches and efforts for developing new technologies.
- Conventional sources of energy receive some subsidies that renewable ones do not share, making difficult to compare alternative projects under equal bases.
- Both country's institutions and private sector lack clear policy guidance on the path to be followed in terms of renewable energy development. As consequence of this, investment is curtailed in this field. This lack of clear rules and policy directions is noted by many analysts, such as Christine Oliver (1991) as an important problem to be overcome.
- Argentina's energy policy seems to be reactive rather than proactive. Argentina does not currently have a long-term perspective in its energy policy (GRA, 2007).
- Most of the middle management public servants (and its immediate teams) are recruited on a temporary basis, and change along with the political turnover (European Commission, 2004). This situation leads to the impossibility of constructing institutional 'history' and tacit knowledge.
- Corruption is a serious concern for Argentine citizens (European Commission, 2004). Corruption at all levels of authorities, and from the political and institutional point of view, has been identified by the interviewees as a big challenge to be faced in Argentina (J.

Finkelstein, personal communication, July 13, 2010; F. Gil Vidal, personal communications, July 13; &D. Castro, personal communication, July 15, 2010).

Economic & financial barriers: the following items are included in this category:

- Renewable energy' projects generally demand greater capital investments and higher transaction expenses than the projects about conventional sources of energy. This bears with it additional challenges when seeking investment sources.
- Risk management and insurance are key issues for private investors and not yet resolved.
- Incentives tools provided by law to promote renewable energy have proven to be insufficient to start a process of mass dissemination.
- Companies working in renewable energy generally lack adequate funding support. On the other hand, the guarantees required by funding agencies are high and very difficult to meet. In turn, the lack of soft loans and subsidies, and lack of incentives further reduce access to credit.
- Public and private credit institutions lack special regulations and experience to manage renewable energy projects.
- Controls on gas prices resulting in artificially low market prices have been the main reason for the country's deteriorating energy balances in the past decade (BMI, 2010).

Regulatory barriers: some of them being:

- In general terms, actors involved in renewable energy issues do not know in detail the regulatory framework affecting the area.
- Legal incentives are insufficient; they do not consider the price of conventional energies and they also lack of an update mechanism to provide flexibility.
- There is a significant legal vacuum, particularly in the area of heat utilization where there are almost no laws promoting thermal uses of renewable energy.

Technical barriers: Capabilities at the individual level already exist. They are even present at the institutional level. However, there are flaws in the so-called systemic level, meaning in the constructive joint efforts aiming at generating comprehensive and concrete results. The following items are recognized as main limitations:

- Sufficient capacity to collect, organize and promote information diffusion already exists, but such measures still need to be taken.
- Partly as a result of these gaps in knowledge and the urgent need to meet energy demand, the electrification process would be favoring the extension of the centralized electricity grid and the installation of conventional generators over the exploitation and use of renewable energy.
- Areas with low density population -where great renewable resources are located- lack adequate electricity transmission infrastructure.
- Some simpler technologies could easily be developed at industrial level since capacity to do so already exist. However, the lack of a functional market explains the near zero level of implementation in these areas.
- There are some technological gaps in the area of biomass and solar energy, for domestic and productive uses.
- Human resources in the technological area are underutilized and may require periodic training.

Socio-cultural barriers:

- Poverty affects nearly 25% of Argentinean households, where basic needs are not covered (GRA, 2007).
- Even though civil society has been increasingly active, it still lacks enough political vigor to promote social change.
- Users of renewable energy projects have a low level of environmental awareness. Particularly for Tandil case study, in order to produce biogas from livestock waste it is crucial to raise environmental awareness of waste value in local producers (SENA, 2009).

6.4.3 Facilitating factors

The following factors have been identified as elements with the potential to contribute to the development of a secure energy system based on renewable sources in the Argentinean context and particularly in the case of Tandil:

Resource availability: Argentina has great availability of renewable sources of energy. Just to provide some examples, with regard to wind energy, some studies show that the technically exploitable wind potential in the country would be approximately 5000 MW (SENA, 2009). Concerning bioenergy, a study made by Morgera, Kulovesi and Gobena (2009) for the Food and Agriculture Organization (FAO) indicates that the total biomass accessible and potentially available amounted to more than 148 million tons, while the so-called commercial biomass[7] accessible and potentially available reached over 124 million tons; values of great importance for energy generation purposes. All the interviewed people have considered this as the main facilitating factor for an energy supply transformation (F. Gil Vidal, personal communication, July 5, 2010; J. Finkelstein, personal communication, July 13, 2010; & D. Castro, personal communication, July 15, 2010). Particularly with regard to Tandil, the city has massive potential for production of local energy from wastes.

Determined geographical preconditions: great extensions of territories, landscape with suitable conditions, weather characteristics such as sunshine intensity, great wind speed, and important river streams, among others, are all comparative advantages present in Argentina for the development of renewable sources of energy. In Tandil, the characteristics of the landscape, which allow developing intensive farming activities, and the suitable rural design for developing agriculture and livestock activities, create a suitable environment for biogas production.

Civil society dynamism: new civil society organizations have increasingly been emerging since 2001 as important actors seek to provide answers to the social demand for actions against the crisis. There is a strong social articulation through networks: barter networks (between 3 to 6 million people have attended these markets), recovered companies' workers, borough assemblies, pickets, etc (European Commission, 2004). Specifically for Tandil case study, according to Lopez Bidone (2010), an important feature of the city is that the kinds of its competitive advantages are not static; they do not depend on the quantity or quality of natural resources. There is an important dynamism that allows creating new competitive advantages based on cooperation and joint actors. The role civil society has for local energy transitions is apparently very important.

[7] The study for the FAO considers comercial biomass that potential sources of supply that ensure adequate sustainable production of biomass energy such as to justify the cost of trnasportation and management

7 Discussion of Case implications and Transferability

In the aim to understand the relevance of discussing transferability options to Tandil case study, the importance of technology transfer (TT) should be recalled. As cited by Bazilian et al. (2008), IIASA considers technology to be the main driving force of productivity and economic growth, issues of crucial relevance in developing countries. As introduced in the first Section of chapter one, the fundamental role of TT for performing the transformation of the energy sector in less developed countries is widely recognized (WEA, 2000; Wilkings, 2002; WEA, 2004; Jomasb, 2007; & Ochs, 2008). Moreover, Foray (2009) states that one of the main forms of knowledge dissemination, which is essential for developing renewable sources of energy, is TT. As discussed in the previous chapter, Tandil has a great potential to develop renewables and important projects are being discussed. However, to speed-up the process and initiate a deep transformation of the energy supply system, technology transfer processes should take place.

Following the IPCC (2000), technology transfer is the "broad set of processes covering the flows of know-how, experience and equipment (…) amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NOGs) and research/education institutions" and "comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies". In this broad definition the three technological parameters defined by IIASA (2007) are included: (a) *hardware*, meaning the manufactured objects; (b) *software*, referring to the knowledge required to design, manufacture, and use the technology hardware; and (c) *orgware*, which refers to the institutional settings and rules for the generation of technological knowledge and for the use of technologies (Bazilian et al., 2008). As cited by Bazilian et al. (2008), Outhred highlights that the role orgware is to play in TT processes is often underestimated, and notes the importance of considering not just hardware, but the systems in which this processes are embedded (i.e. electricity generation and distribution systems, including markets and infrastructure).

Many authors have stressed that the achievement of TT is strongly connected to the building up of 'enabling environments' (Bazilian et al. 2008; & Dalhammar et al., 2009). Through this approach, the focus is not only on policy, market and regulatory conditions, but also on people and institutions (Dalhammar et al., 2009). There are five enabling parameters which presence in the context where a TT process is to be implemented may highly contributes to obtain better results. These are:

(a) Existence of necessary infrastructure;
(b) Technology absorption capacity;
(c) Legal, regulatory and policy frameworks;
(d) Human and institutional capacity; and
(e) Market penetration capability of the technology or the system within which the initiative is embedded (Dalhammar et al., 2010, p. 64).

The listed parameters cover aspects that can highly be influenced by policymaking. However, behind each of these items there are aspects that cannot be influenced by such measures (at least not to a great extent). As stated by Bazilian et al. (2008), this is the case of tacit knowledge (which cannot be easily transferred to another person since it is gathered by experience), the internal organization of the firm, interactions via inter-firm linkages, supply chains and networks, and 'learning by doing' (p. 24). All these issues refer to the idea of building up capacity, a fundamental input in any TT process (Bazilian et al., 2008, p. 25). Moreover, as cited by Dalhammar et al. (2009), Foray establishes that for enabling proper environments, it is important to work with local entrepreneurs and other local players that have pertinent knowledge about and understanding of the needs of the local community (p. 22).

Also, for enabling environments an important issue is governance. Dalhammar et al. (2009) indicate that the government and authorities at different levels may be part of the problem, instead of being part of the solution. They consider that this might be the case of countries with high corruption levels, and suggests that capacity building projects should target local entrepreneurs and local communities, in order to avoid deficiencies in the process (p. 45).

Pursuant to the previous considerations, and in the aim of considering transferability options from the Swedish case studies to the city of Tandil, it appears to be of primary importance to focus mainly on the technological parameter referred to as *orgware*. The analysis within this thesis strongly supports the idea that the institutional setting and the establishment of proper rules governing actors' interactions are of particular importance for the generation of a new energy supply system. Moreover, this work provides clear evidence that suggestions should target the local players involved in the energy transformation process.

In the Argentinean literature, much has been said about the ways in which different barriers limiting the development of renewable energy sources (discussed in Section 6.4.2) can be overcome. The document presented by the National Energy Agency in 2009 (SENA, 2009) contains a list of suggestions and measures to be taken in each of the following areas:

- **Institutions**: such as the design of a long-term energy policy, the generation of political will to incorporate renewable energy issue in the political agenda, and changes in State role towards renewables.
- **Economy and finance**: such as to create soft loans and mechanisms to reduce the cost of renewable energies.
- **Regulation**: such as putting in place proper legal and regulatory frameworks, coherent, consistent and clear.
- **Technical issues**: such as coordinate and strengthen groups of research and development.
- **Social issues**: such as introduce renewable energy issue in educative curricula.

While this analysis recognizes the importance of the mentioned suggestions and considers that much can be done by implementing them, after studying the three Swedish cases, new or different lessons can supplement them. While the previous suggestions can be (relatively) easily attended to by national bodies through different policy instruments, the lessons learnt from Sweden highlight the significance of the actions taken by local actors. All these ideas refer to learning experienced by the local players, by those being the key stakeholders involved in energy supply transformations, by those dealing with constant limitations but also receiving permanent co-benefits from the new system.

The purpose of this short chapter was to bring light about the importance of considering key concepts, such as *orgware*, if TT processes are to be developed. Moreover, it aimed at highlighting how relevant is to target local players as main actors in such TT processes. Now, it is finally time to consider how feasible is to transfer the lessons learnt from Sweden to the context of Tandil.

It is the wish of the author of this thesis that at this point, readers have already acknowledged the importance of key themes, such as actors, networks and institutions, and of key concepts, such as spatial and temporal contextualization, and institutional isomorphism. They are of primary importance in the study of transformations in the energy supply system, and in the analysis of TT processes. These themes and concepts are the basis for considerations that can be made about transferability from the Swedish context to Tandil. These considerations can be broadly divided between (a) those referring to the existing differences among the contexts, and (b) those referring to potential similarities that can be developed.

Regarding the first type of considerations, after studying each of the local cases - three in Sweden and one in Argentina - it can be concluded that the differences existing among the contexts would most probably bring different results. There are differences in actors, networks and institutions. Firstly, the competences of actors involved in the Swedish transitions, the cooperation developed among them, and the level of awareness about the importance of encouraging an energy supply transformation, are features that seem not to be present in Tandil at the current state. Secondly, the networking activities present in Växjö, Enköping and Kristianstad have reached a mature stage. This is not the case of Tandil, were their importance in a possible energy supply transformation was not even possible to be confirmed. Thirdly, regarding the institutional setting, a big difference between Sweden and Argentina also seems to exist. In general terms, trust on the national government and its long-term policies, on public authorities and their actions, on the local politicians, and on the systems developed within the society, appears to be a great element that have contributed to the Swedish transitions. In Argentina, studies have demonstrated that two important blocking mechanisms for the development of renewable energy carriers are corruption at different levels of authority, and lack of stability of energy related policies. Moreover, institutions such as Educational and Research centers, and non-governmental organizations, have played an important role in Sweden. They have mostly acted in coordination with each other. This kind of institutions appears to be present in the context of Argentina. However, an identified barrier is the lack of coordination among them, creating duplicity of efforts.

Another issue related to differences that can be drawn among the cases, relates to different spatial and temporal contexts that influence energy transitions. Even under the Swedish context, each studied case had its own features that made the transition unique and therefore un-replicable. Much has been said in this thesis (see sections 2.3 and 5.4) about the importance of studying local transformations with a contextualization approach. Under the lenses of this approach, it can be concluded that any TT alternative should be analyzed considering the temporal boundaries and the particular spatial context present in Tandil. Here, two special mentions are to be made: one regards to the ownership of the infrastructure and the other one to technological development. On the one hand, in Sweden, the public ownership of the infrastructure has proved to facilitate the transition. This was in a context where public authorities have acted in a transparent and non-corruptive way. It should be considered that it might not be the case of Argentina, where corruption affects many levels of authority and where the trust of the society in these authorities remains a big challenge to be addressed. On the other hand, many of the constraints affecting Swedish transitions (see sections 2.2.3 and 5.2.3) were related to a period characterized by an immature technological development. Nowadays, the stage of such development is different, and many renewable energy related technologies are in an advance stage. This is a positive aspect for Tandil, since such technological limitations will not affect the transition.

With regard to the second type of considerations, the following can be said. Although many differences exist among the Swedish and the Argentinean contexts, in the aim of successfully carry out TT processes, it is possible to work on developing similarities among the local contexts. If some aspects present in Swedish transitions can be developed in Tandil, this would most probably help the Argentinean transition. The next chapter provides some recommendations for local actors, which were derived from the Swedish cases. Following them would be like creating sort of similarities among the different contexts and would most probably allow Tandil to develop a success transition towards renewable energy carriers.

In order to value the importance of creating similarities, as well as to judge how feasible this is, the institutional isomorphism concept needs to be recalled. As mention in section 5.3, institutional theorists state that homogenization in structure, culture and output of organizations is a consequence of need for legitimacy, which in turn is the principal goal of the system proponents. In Växjö, Enköping and Kristianstad, in the aim of achieving this legitimacy, common pathways for doing things were identified. In Tandil, local actors will need to achieve legitimacy. And they may, in order to do so, follow determined patterns of behavior that have already proved to provide legitimacy. Of course this does not mean that everything will be resolved for Argentinean local actors. They will still have much of 'learning by doing'. These possible strategies would act just as guiding principles to be followed.

Regardless the specific recommendations provide in next chapter, it seems suitable here to list the strategies suggested by Aldrich and Fiol (1994). They distinguish between strategies for gaining cognitive legitimacy and those for obtaining sociopolitical legitimacy. For achieving the cognitive legitimacy, the following actions can be taken:

(a) Utilizing symbolic language and behavior;
(b) Encouraging convergence around a dominant product/ service design;
(c) Promoting the new activity through third-party actors; and
(d) Creating linkages with established educational curricula.

For achieving sociopolitical legitimacy, some of the following strategies can be adopted:

(a) Communicating internally consistent stories regarding their new activity;
(b) Mobilizing to take collective action;
(c) Negotiating and compromising with other industries; and
(d) Organizing collective marketing and lobbying efforts.

As an overall conclusion of this chapter, and pursuant to all the previous considerations, it is possible to state that it seems feasible and desirable the aim of transferring the lessons learnt from Sweden to the context of Tandil, Argentina.

8 Conclusions and recommendations

8.1 Conclusions

The aspiration of this thesis was to contribute to transitions towards more sustainable energy systems in Argentina. Two were the objectives established to pursue this. The first objective referred to increasing the understanding of the transitions taken place at the local level within energy supply systems in Sweden. The second objective was to increase the understanding of the conditions that need to be in place in Tandil, Argentina, for technology transfer purposes.

To reach the first objective, the purpose was to identify key drivers, facilitating factors and constraints influencing the local transition. The question was:

- *How did local actors achieve a more secure and renewable-based energy system in Swedish municipalities?*

According to the findings of this thesis, in Sweden, the local actors involved in the transitions achieve the transformation of their energy supply, by building up and developing, as well as by recognizing the importance, of the following items:

Leadership: in the three cases the transitions have been guided by leaders with the charisma to transform and influence the beliefs and behaviors of others. These leaders have been local actors, which main contribution has been to convince politicians, suppliers and citizens to support the new infrastructure.

Creation and diffusion of a vision: local actors have shared the same vision, by which they have aimed at addressing the same goals, objectives, and targets. This vision has proved to contribute to achieve cognitive legitimacy.

Cooperation and communication among participants: local actors have built up a system with important cooperative ventures. Public-private partnerships have formed financial resources, know-how and expertise and have therefore smoothed the path of the local transition, contributing to achieve cognitive and sociopolitical legitimacy. Moreover, they developed within the city, and among them and external stakeholders, intensive communication channels that greatly contribute to increase cognitive and sociopolitical legitimacy.

Coordination among local and external actors: in Sweden, the most important role for building up and developing the system was attributable to local stakeholders. External actors have acted as factors contributing, with their specific competences, to the system. The developers of the transitions have been able to coordinate the roles and actions of the different actors in a manner that have been positive for the transition.

Building of public understanding and confidence: through open communication channels, awareness campaigns and an educational support system, public understanding of and confidence on the new system have been built. These have been very important for the acceptance of the system.

Building up skills among local actors: local actors have developed different skills that have been fundamental for the transition. Scientific, trade and technical skills among the involved actors have evolved over time, and have been of primary importance for achieving positive results. The establishment of educational and research centers and the creation of networking processes creating communication and cooperation among the participants of the system, have highly contributed to this point.

Strengthen networking processes both internally and externally: in the three cases studied within Sweden the actors have participated in networking processes that have strengthened their involvement in the system. These actors have recognized that networks smooth the process and contribute to a more rapid increase of socio-political legitimacy. Networking processes within the city, which have been essential for maintaining the infrastructure of the change, have opened informal channels of communication among local players. National networks have provided the actors with tools for sharing knowledge and experience. Finally, international networks have served the purpose of promoting the city at the international level and creating funding and local business opportunities.

Institutional set-up evolving as the process developed: Swedish actors have learnt to develop the institutional infrastructure necessary for building up and maintaining the new energy supply system. They built the proper institutional setting where energy long-term goals, actors working towards the same direction, and stakeholders (such as the society) understanding the role they are to play, were all features present in the transition. In the cases, the transition and the institutional setting were like two forces that commenced, developed and maintained over time as reinforcing factors, both depending and feeding one each other.

Role of both hard and soft institutions: in the transitions, hard institutions such as bodies creating a support system, actors forming well-established organizations that develop a capital market, and academic organizations creating an educational related system, had played an important role. Moreover, soft institutions such as NGOs, informal networks and groups of involved citizens building cultural features in the community, were also very important for the transition. These institutions have both contributed to obtain legitimacy, and acted as a sign of growing acceptance of the system, in a reinforcing manner.

Comparative advantages: local stakeholders have recognized the importance of discovering and utilizing the comparative advantages present in their cities. Local availability of a cheap and reliable natural resource and determined geographical conditions, have been the comparative advantages present and used in the Swedish municipalities.

Public ownership of the infrastructure: this factor has proved to facilitate the transitions studied in the Swedish context, by allowing a more holistic planning and utilization of the infrastructure, and by reducing transaction cost of getting different actors to work together. The way public authorities have behaved along time (in a transparent and non-corruptive way), and the perception Swedish society has had about these authorities, have contributed to a great extent to make this factor act as a positive one.

Creation of a local profitable system: the coordinating actor of the transitions, which has been the municipalities, has permanent pursued the profitability of the system. They have recognized that the creation of this profitable system was a necessary condition to keep all the participants involved in the system.

Expansion of RD&D activities: in the local transitions of particular importance have been the RD&D activities carried out by different actors. They have mainly contributed to obtain cognitive legitimacy of the system.

Financial support: the availability of financial resources to develop and implement energy related projects within the city has been fundamental for smoothing the transitions. In obtaining this support, the role of the involved municipalities, by creating financial opportunities both at the international level (through networking activities), and at the national level (applying for grants and programmes), has been crucial.

In the transitions taken place in Växjö, Enköping and Kristianstad, similar pathways for doing things have been identified. This was due to the fact that after an initial period of 'testing and trying', local actors have stuck to those factors that proved to provide legitimacy to their actions. Moreover, this research arrived to the conclusion that the local players have followed such factors not by adopting a planned work or a set of strategies (as the ones provided by Aldrich and Fiol), but by discovering them along the transition. In simple words, the factors providing legitimacy to the system have evolved as the transitions developed.

This idea about **'things evolving over time'** has been of primer importance for this research. The drivers triggering Swedish transitions, and the factors facilitating and constraining local actions, have all evolved along with the process of the transition. The actors involved in it have had the wisdom to understand each of these conditionating factors as elements operating within a context. Moreover, they have been able to take each of the different contexts as opportunities for a change.

In the aim of addressing the second objective of this thesis, the idea was to discuss the transferability of the lessons learned from Sweden to the context of Tandil, Argentina. To do so the following research question was established:

How can the municipality of Tandil, province of Buenos Aires, learn from the experiences of Swedish municipalities?

In Chapter 7, it was concluded that it is possible to transfer many of the lessons learnt from Swedish municipalities to the city of Tandil, in the aim of initiating a transition towards an endogenous and renewable energy supply system in this latter context. Although many differences within actors, networks and institutional themes may exist among these two contexts, elements from the Swedish transitions can be copied (after adaptation to and interpretation of the local context) and applied in Tandil.

The main issues to be considered in the development of any TT process are as followed:

(f) TT processes go beyond the exchange and diffusion of hardware and software. They should also cover the organizational aspect of the initiative. Orgware element is as important as the study and analysis of the hardware and software elements, and much more can be achieved by addressing the systems in which this processes are embedded.
(g) TT processes take place not only between countries, but may also take place within the country, within a region and even within the municipal level, through networking processes that must necessary be encouraged.
(h) Building up enabling environments is of crucial importance for any energy supply transition to be initiated in Tandil. Parameters such as existence of necessary infrastructure; technology absorption capacity; legal, regulatory and policy frameworks; human and institutional capacity; and market penetrations capability of the new system; are all important elements to be developed.
(i) For enabling proper environments, it is very important to work and focus on local entrepreneurs with the appropriate knowledge about and understanding of the needs of the local community. By addressing these needs the system would obtain sociopolitical legitimacy.

(j) Deep transformations should be made within actors, networks and institutions themes, such as the ones described at the beginning of this section.

8.2 Recommendations

As followed, a list of recommendations for national, regional and local promoters of a renewable energy supply system is provided. These suggestions constitute actions to be taken by the interested parties, which can be national and local governments, politicians, public service companies, actors working in the private sector, educational institutions, non-governmental organizations, engaged individuals, and related networks. Each of the mentioned stakeholders should seek to:

- Articulate and adopt a vision, long-term goals and common and transparent strategies that will be shared by all the participants of the system. It is suggested to develop these with the participation of as many participants as possible. A broad participation will contribute to set a local plan involving different actor's expectations, and will facilitate its implementation. This action will promote broader acceptance of sector activities, at the time that will bring stability of the system, increasing investors' trust;
- Identify a strong and committed local leader that will guide the process. This may be done by promoting an open participation in the system, by increasing the channels of communication, and by recognizing the important role local actors are to have in the transition. Leaders will most probably be found in the local community, since local players are the ones with a concrete knowledge about the unique conditions, special needs and particular socio and cultural features characterizing such community. A leader may increase the involvement of other actors to the process, bring coordination and harmony among them, and may finally lobby the political elite (to obtain its support) and achieve legitimacy for the process;
- Enhance the understanding of and confidence on the system by a broad range of social stakeholders. This may particularly be done by gathering and dissemination of information on the technical benefits and constraints of the system, through environmental awareness campaigns, and by promoting linkages with established educational curricula. This recommendation seeks to highlight the importance of research and educational institutions, of non-governmental organizations, and of the public, to the development of the transition. It will contribute to increase both cognitive and socio-political legitimacy of the system;
- Encourage an active participation of the municipality in the transition, recognizing its important role as planning authority, policy implementer, information provider and chief coordinator. This action may be performed by different actors. The national government may develop policy instruments aiming at providing incentives to municipalities taken such role; the public may demand municipal commitment and responsibility in this area, pushing the issue until it become a priority in the political agenda. Also non-governmental organizations may increase the public commitment and involvement on the issue and aim to pursue the latter. An active participation of the municipality is desirable since is a key actor to build alliances at different levels of authority;
- Build up skills among local actors. Scientific, trade and technical skills can be developed by establishing educational and research centers and by creating networking processes and open communication channels for increase information exchange among participants. Building up this capacity among local actors would reduce the dependence of the system to external stakeholders and improve its benefits;
- Pursue alliances with industries, organizations and institutions that have control over the resources that the new sector requires. This can be done by developing private-public partnerships, which make each sector to contribute with its own competences (social

responsibility and accountability of the public sector, and managerial and entrepreneurial spirit of the private sector). This action has the potential to smooth the path of local transitions, contributing to achieve cognitive and socio-political legitimacy;

- Promote both bottom-up initiatives and top-down supports. The developers of an energy supply transformation may encourage the initiatives of local players that aim to develop small-size projects, which all together will optimized the locally developed system. Moreover, the benefits will be wider if such initiatives received the proper support of politicians and public authorities;
- Develop a profitable system for all the participants. Such action, of very difficult realization, can be addressed with a proper regulated system of support, which will include necessary legal and economic instruments. This action is of fundamental importance to assure the participation of all the necessary actors in the system;
- Articulate networking activities within the city, and between local actors and external stakeholders (at both national and international level). Here, informal networks within the city, involving public servants, private companies, NGOs, educational and research centers, and citizens, may be developed. Moreover, the municipality may form alliances with other municipalities or regional governments for addressing energy solutions. Finally, the municipality may become member of international networks working within sustainable development issues and supporting local energy projects. By developing such networking processes coordination can be obtained (locally), knowledge and experiences can be exchanged (nationally), and funding and business opportunities can be created (internationally);
- Develop a proper institutional framework. This framework may be developed by forming, managing and/or strengthening different institutions with specific roles to be performed. Both formal and informal institutions are important. It should be acknowledged that these institutions will evolve as the transition develops. This institutional set-up is crucial for creating and maintaining the necessary infrastructure of the new system;
- Identify the comparative advantage the city has and maximize its utilization. Giving proper participation to different local players (with appropriate knowledge of the particular local conditions, and increasing gathering information processes (through the promotion of RD&D activities for example) these comparatives advantages may be identified. Comparative advantages can be the availability of a cheap and reliable natural resource, and/or determined geographical preconditions present in the city. This action can highly increase the profitability of the system (via increasing of returns or avoiding costs);
- Create the necessary financial support for developing and implementing energy related projects within the city. Local actors can create finance opportunities by participating in networking activities at different levels of authority, and by applying to suitable energy related programmes. National bodies (i.e. government and regulators) can create this support by developing suitable financial programmes to which local authorities can apply. The availability of sources of finance highly contributes to smooth the process and develop a faster transition.
- Consider the drivers that would soon or later force a deep transition in the energy supply matrix as an opportunity for a change, instead as of a problem to be solved. This will require a profound understanding of the temporal and spatial contexts that influence local actions and to be able to coordinate such actions to know when and how to react.

In general terms, it is considered that by following the listed suggestions, developers of renewable-based energy supply systems may easily obtain legitimacy of their actions, fundamental pre-requirement of its survival. However, the previous does not mean that this will be the necessary outcome. The temporal and spatial context, which will be unique in each transition, as well as the interconnections among the main elements of this process –actors, networks and institutions, will deeply influence the result of implementing any of the previous measures. The targeted audience should see these recommendations as part of a system to be developed, where linkages among the elements are as important as the elements itself. And finally, they should see the system as one evolving over time, gradually and slowly providing positive results. The process might be an uphill road and only by understanding this they will not lose strength in the middle of it.

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Karlsson, Steve. (2010, March 23). Personal interview. Project Manager of the municipality.

Nilsson, Sarah. (2010, March 23). Personal interview. Acting Head of Planning and Development of the municipality.

Olsson, Stefan. (2010, April 9). Personal interview. Energikontor Sydost.

Tranvik, Lotta. (2010, March 24). Personal interview. Växjö Energi AB.

Argentina

Castro, Dardo. (2010, July 15). Email interview. Business Manager of Lupatech SA.

Finkelstein, Javier M. (2010, July 13). Email interview. Technical, Sustainable Energy Development Unit, National Environmental and Sustainable Development Agency.

Gil Vidal, Francisco J. (2010, July 5 & July 13). Personal and Email interview. Technical Expert, Sustainable Energy Development Unit, National Environmental and Sustainable Development Agency.

San Miguel Jorge. (2010, July 5, July 12, & July 20). One personal interview and two Email interview. Coordinator of the Sustainable Energy Development Unit, National Environmental and Sustainable Development Agency.

Appendix A

VÄXJÖ CASE STUDY

This central city of the Kronoberg County is located in southern Sweden. With a population of 81,000 inhabitants –of which 74% live in the city – and covering an area of 1 925 square km, Växjö is surrounded by lakes and forests. The basis for the local businesses is constituted by the service, commercial and educational sectors; agriculture represents a small proportion of the local activity (Växjö, 2008a).

This appendix commences with a description of how the process towards a renewable-based energy system began. It continues with a characterization of the actual energy system from the energy production point of view and the results achieved until now. An overview of the actors and networks identified, together with an analysis of their importance, are presented in sections A.4 and A.5. Section A.6 identifies drivers, facilitating factors and constraints influencing the process. The first 3 sections are based on factual data obtained through literature review, study visits and interviews. The last 3 sections contain factual data as well as personal analysis and considerations.

A.1 THE PROCESS

Växjö has a biomass-based energy system. The development of the system can be divided in two periods: from the middle of the 1970s to the end of the 1980s and from the 1990s until now. The political and international contexts of these periods differ considerably, and so do the reasons behind the changes performed in the city.

At the beginning of the 1970s oil prices increased markedly and discussions concerning a potential oil crisis were present at the international level. Sweden had a high dependence upon oil and it was deemed that alternatives needed to be assessed. The aim to be achieved was less vulnerability and dependency. In the middle of the year 1973, the Board for Economic Defense contacted Swedish energy companies to address such goal. The municipality owned energy company, Växjö Energy AB (VEAB), was one of them. After studying the Finnish peat-based energy production system[8] and the local possibilities, VEAB concluded that wood chips were the most suitable alternative to oil for Växjö (U. Johnsson, personal communication, April 15, 2010).

Financed by the national Government, VEAB started the reconstruction of a boiler for district heating production from oil to wood burning. In the summer of 1980 Växjö became one of the first municipalities in the country using biomass in the production of district heating. A technology transfer process between Växjö and other Swedish municipalities was then pursued (U. Johnsson, personal communication, April 15, 2010).

In the autumn of 1980 and as a consequence of the war between Iran and Iraq, oil prices increased dramatically. In order to further reduce oil consumption, VEAB needed to further develop the energy production system. Other companies decided to use coal. However, considering the experience Växjö already had accrued in the utilization of biomass, as well as the negative public opinion the use of coal might generate, VEAB decided to increase the production of biomass-based energy. In 1983, with national support to cover 50% of the

[8] The original idea of the Board of Economic Defense was to mimic the system in place in Finland

costs, the company reconstructed another boiler from oil to biomass fuel fired for co-generation purposes (U. Johnsson, personal communication, April 15, 2010).

In the beginning of the 1990s a new period started. Climate change discussions present in the political agenda, both at the international and national level, became the new main driver for local actions (S. Nilsson, personal communication, March 23, 2010). In 1995, an intensive collaboration between the municipality and the NGO Swedish Society for Nature Conservation (SSNC) began. An open dialogue about climate change affairs involving the NGO, local politicians, companies and inhabitants was the basis for the next important step (Växjö, 2008a).

In 1996, the executive committee of the city unanimously decided that: (a) Växjö shall be a fossil fuel free city (in its own organization and in the total geographical area); and (b) emissions of carbon dioxide from fossil fuels in the whole municipality shall be reduced by 50% per capita by the year 2010 compared with 1993. This goal was complemented in 2006 with a reduction target of 70% per capita until 2025 (Växjö, 2008a). The year when Växjö should be totally free from fossil fuels was determined by a regional target. The County of Kronoberg stated that the region shall be more or less fossil fuel free in 2050 (Växjö, 2008a).

It is important to highlight that when the decision was taken, nobody in Växjö knew if the 2010 goal was actually feasible, or what kind of actions needed to be carried out (S. Nilsson, personal communication, March 23, 2010). Moreover, regarding the baseline for the goal, in 1993 Växjö was already at quite a low level of fossil carbon dioxide (CO_2) emissions due to the introduction of biomass in the heating and power production system in the 80s. In 1993, the CO_2 emissions were only 4.63 kg per capita –figure including emissions from heating, power and transport sectors-. The goal for 2010 was 2.315 kg per capita, a very ambitious one (Växjö, 2008a).

Several actions have followed the 1996' political decision and contributed to build the international image Växjö holds nowadays, as the Greenest City of Europe from a sustainable development' point of view (Växjö, 2010a). From a technical perspective, perhaps one of the most important events has been the construction of Sandvik II in 1996, a biofuel-based combined heat power (CHP) plant (VEAB, 2010a). However, the achievements the city made at the heating and electricity sectors are not only due to technological improvements. The development of important knowledge-based activities (e.g. in 1996 at Bioenergy research centre was established at Växjö university) and the active participation of the city in several networks have made the transition easier and faster (H. Johansson, personal communication, April 9, 2010).

A.2 DESCRIPTION OF THE ENERGY SYSTEM

Växjö' strategy to reduce CO_2 emissions comprises a combination of behavioral changes, energy efficiency, and transition to renewable sources of energy. The first aspect is addressed by providing cheap and convenient district heating, attractive public transport and good walking and cycling paths. Energy efficiency is addressed mainly through the construction of highly efficient wooden houses. Finally, the goal of increasing the use of renewable sources of energy is achieved through the continuous improvement of the district heating system, the development of new technologies and the implementation of different small-scale projects (Växjö, 2008a).

An overview of the energy supply in Växjö, the different types of energy sources, and the energy use corresponding for the year 2008 is provided in the following paragraphs. The information is obtained from the Energy balance document prepared annually by the municipality.

The energy supply for the year 2008 was 2 413 GWh. Of it, almost 30% was for electricity use, 38% for heating and 32% for transport. Electricity demand (721.50 GWh) is satisfied mainly with power produced outside the city. Within Växjö, electricity is produced in local hydro powers, wind power turbines and in the CHP plant. Of the 907.88 GWh heating consumption, almost 91% is provided by VEAB at the cogeneration plant. The remaining 9% is covered by: (a) wood, briquettes, wood chips, pellets and oil (circa 11.5 GWh oil used in small-scale district heating systems); (b) household boilers using pellets, wood and oil (only 2.36 GWh oil); and (c) household heat pumps –both geo-heat and air-heat. Finally, regarding transport, the Wastewater Treatment (WWT) plant, Sundet, produces fuel for vehicles (Växjö, 2008b). In 2009 51 833 Nm3[9] of biogas for vehicles was produced at the Sewage plant (H. Johansson, personal communication, April 26, 2010).

A description of the energy sources used for electricity, heat and transport purposes is provided as followed. The sources satisfying the electricity demand are: nuclear and fossil power produced outside Växjö, 34%; hydro, wind and bio-power produced outside Växjö, 37%; biomass, 25%; peat, 2%; and local hydro and wind power, 1%. In this sector the share of renewable sources of energy is more than 50% In the case of heating the sources are as followed: biomass 85%, heat pumps 7%, peat 4%, and oil 3%. A very small percentage of heat is satisfied by biogas and solar energy. Here the share of renewables is 92%. Finally, in the transport sector, with an energy demand of 783 GWh, 95% of the supply is covered by non renewable sources of energy (Växjö, 2008b). This sector contributes with 80 % of all the CO_2 emissions from Växjö and represents the biggest challenge the city must address in the coming years (see figure A-1) (Växjö, 2008a).

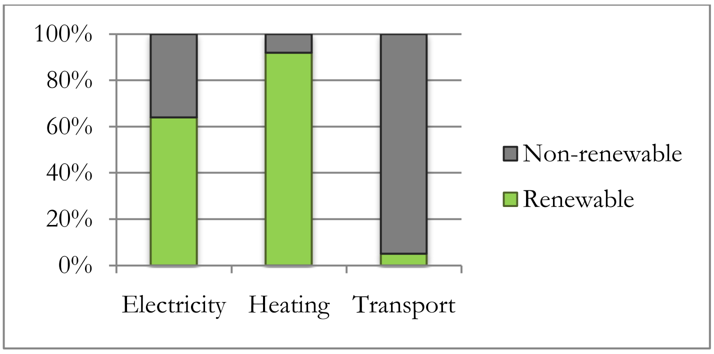

Figure A-1 Share of renewable sources of energy in Växjö, 2008

A.2.1 Actions for renewable heating and cooling

So far, the main achievements in the aim of reducing CO_2 emissions are in the heating sector. The following list summarizes the actions taken in this area, as well as the planned actions for the future:

-1980: VEAB starts using biofuels for district heating.

[9] 1 Nm3 biogas is equivalent to 1 litre gasoline

-1997: VEAB builds Sandvik II, a new 100 MW cogeneration plant for the production of electricity and district heating based on wood chips.

-1997/1999: Biofuel based small-scale district heating systems are built in four minor villages. Three are built by VEAB and one by Sydkraft Heating Ltd (VEAB, 2009).

-1998: Solar panels are installed on the roof of the public swimming baths to heat the water for the showers (Växjö, 2007).

-1997/2005: Municipal subsidies are given to private persons for conversion from oil to biomass heating (Växjö, 2007).

-2001: VEAB begins a conversion of heating systems in single-family houses, from electric to district heating (Växjö, 2007).

-2011: Foundation of a regional district heating cluster by connecting the district heating networks of Växjö and neighboring Alvesta (Växjö, 2007).

A.2.2 Actions for renewable power production

As mentioned before, 71% of all electricity used in Växjö is imported from other parts of Sweden. Locally, small hydro plants owned some by the municipality and some by private actors, a privately owned wind turbine, and Sandvik II, all represent the actual infrastructure for electricity production in the city (Växjö, 2008a). A list summarizing the actions performed in this sector follows:

-1997: 100 MW CHP Plant producing electricity mainly fired by wood chips.

-1997/2009: Solar panels are installed at household level with the support of national subsidies.

-2008: The first PV plant is built in the roof of Teleborg School. It supplies about 13% of the school's power need. The PV plant also serves educational purposes (Växjö, 2007).

-Coming future: Plan for installing more wind turbines in the southern and eastern parts of the city (Växjö, 2008a).

A.2.3 Actions for renewable fuel for transport

In Växjö the first fuel station for ethanol was established in 1999 (Växjö, 2008a). Even though biogas has been produced for years at the WWT plant –Sundet-, it was not until 2007 when it started to be used for vehicle fuel production. The interest in utilizing upgraded biogas is very high in Växjö. However, only about 50 cars are running on biogas (H. Johansson, personal communication, April 9, 2010). As part of EU-project SESAC (see Section A.1.5) there is a plan to increase biogas production at Sundet. The project includes food waste collection from restaurants and school kitchens (so as to increase the reception of organic waste in the plant) and the construction of additional digester chambers. It is estimated that such production will supply the city busses, 400 cars and heating needs of the facility (J. Alhrot, personal communication, April 15, 2010).

Finally, since the year 2004, a research project aiming to develop second generation biofuels has started. The project consists in the reconstruction of a plant in the city of Värnamo, which will function as an 18 MWh biomass gasification pilot plant. The purpose of this pilot plant -owned by Växjö Värnamo Biomass Gasification Centre[10] (VVBGC) - is to produce knowledge and demonstrate the biomass IGCC process. The rebuild is part of the CHISGAS project, funded by the European Commission and the Swedish Energy Agency (VVBGC, 2010). Lineaus University, Volvo and other 3 companies are involved in the project; however, at least one more partner is needed. The total cost of such project is approximately €40 million (U. Johnsson, personal communication, April 15, 2010).

Figure A-2 below provides a timeline summarizing all the important facts occurring in the development of the renewable-based energy system in Växjö.

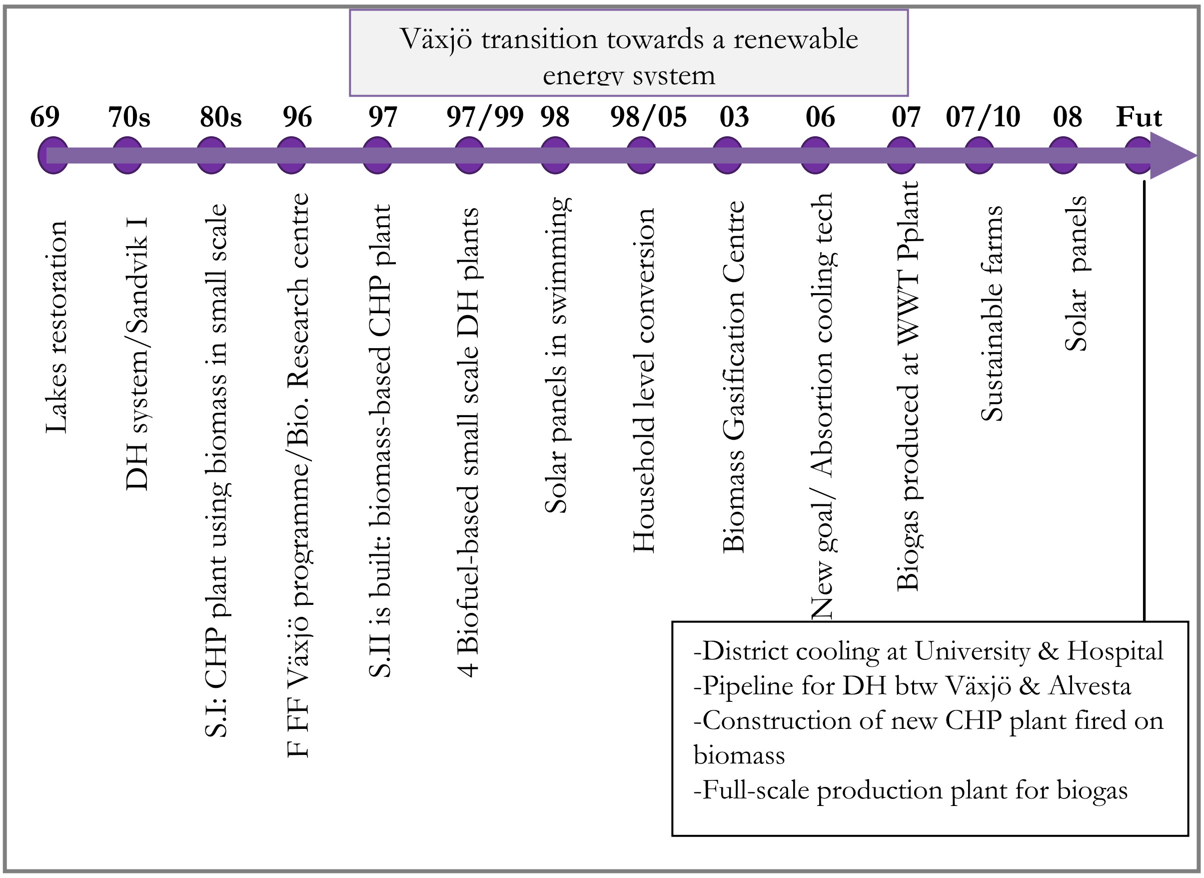

Figure A-2 Växjö transition towards a renewable energy system

A.3 RESULTS

A.3.1 Reduction of fossil carbon dioxide emissions

As a result of all the actions described in Section A.1.2, by the year 2008 the emissions of CO_2 have been reduced by 35% compared to the year 1993. Moreover, within the heating sector, emissions have been reduced by 84% (Växjö, 2008b). The main reasons for such reduction have been: the easy and feasible way chosen to convert heating systems, the

[10] VVBGC is a non-profit project based company created in 2003 and owned by the Lineaus University.

expansion of the district system, and measures adopted for energy efficiency purposes (Växjö, 2008a). Within the electricity sector, emissions have been reduced by 40.5 % (Växjö, 2008b). Finally, in the transport sector emissions have increased by 6.7% in 2008 (Växjö, 2008b). As stated by Sarah Nilsson, from the strategic planning department of the municipality, the goal of reducing CO_2 emissions per inhabitant by at least 50% by the year 2010 was not reached (personal communication, . To achieve the 2025 goal (reduction of 70%), changes in the transport sector must be achieved (see figure A-3).

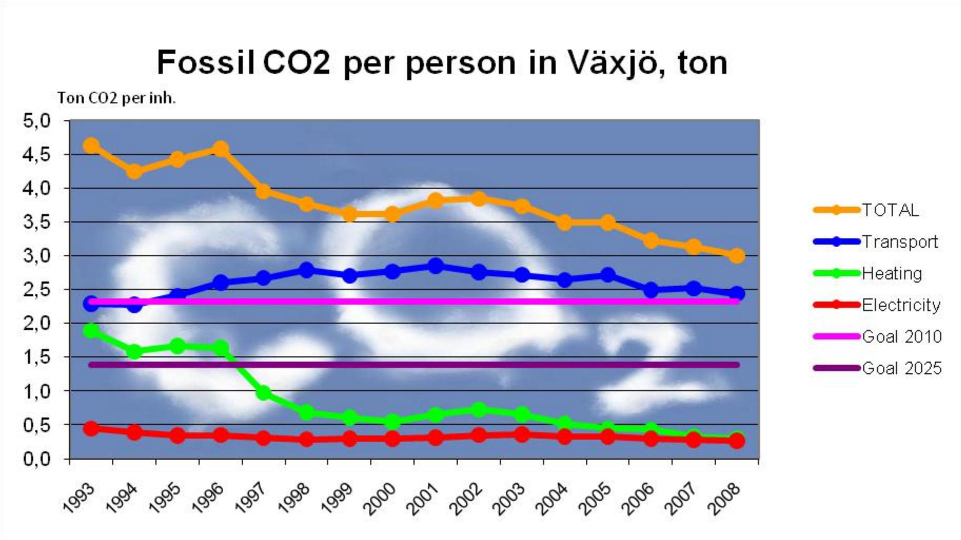

Figure A-3 Fossil carbon dioxide emission per person in Växjö

Source: Växjö, Energy balance 2008

A.3.2 Energy results

In the year 1993, the share of renewable sources of energy was as follows: heating 39.7%, electricity 51.7%, and transport 0.1%. Due to all the changes that have been implemented in the city of Växjö, this share has increased considerably in each of these sectors (Växjö, 2008b).

Although a very difficult task, the municipality has estimated the level of self-dependence in terms of energy security. If they consider that all biomass and peat comes from local or regional sites (within a radius of 80 km from Växjö), the level of energy independency of the city is 43%. Then, the sources included are biomass, peat, local wind and hydro power, heat pumps, solar energy, and biogas. The remainder consists of all the energy needs for transport, 33%, and the power that is produced outside Växjö, 22% (Växjö, 2008a).

A.3.3 Socio-economic results

The municipality of Växjö has been able to decouple economic growth and CO_2 emissions. It is considered that the economic development did not suffer from the shift to biomass-based energy (Växjö, 2008a). On the contrary, according to Sarah Nilsson, the shift has proven to be an important tool for the economic growth of the city (personal communication, March 23, 2010).

No evaluation about jobs creation has yet been performed. However, the municipality estimated that the process towards a fossil fuel free municipality would lead to local jobs in the forestry industry. They also considered that no important negative influence on other jobs has arisen due to the change (S. Nilsson, personal communication, March 23, 2010). In order to provide an example, people who used to install oil boilers in households are nowadays installing pellets boilers or solar panels. Moreover, within energy efficiency projects, those working in the construction industry, nowadays have the possibility to learn how to build energy efficient wooden houses. A positive influence is therefore identified (Växjö, 2008a).

A.4 ACTORS INVOLVED IN THE PROCESS, IMPORTANCE

Växjö's renewable-based energy system was built up and developed by local actors, as well as by the influence of stakeholders at the regional, national and international level. Figure A-4 provides an overview of the important actors participating in the local transition. The figure also contains a differentiation between those actors developing the first period of the transition (building up the system) from those participating in the second period of change. It finally provides an identification of the actors holding an important role nowadays. At the end of this Section table A-1 constitutes a summary of the discussions and conclusions about actor's involvement hereby provided.

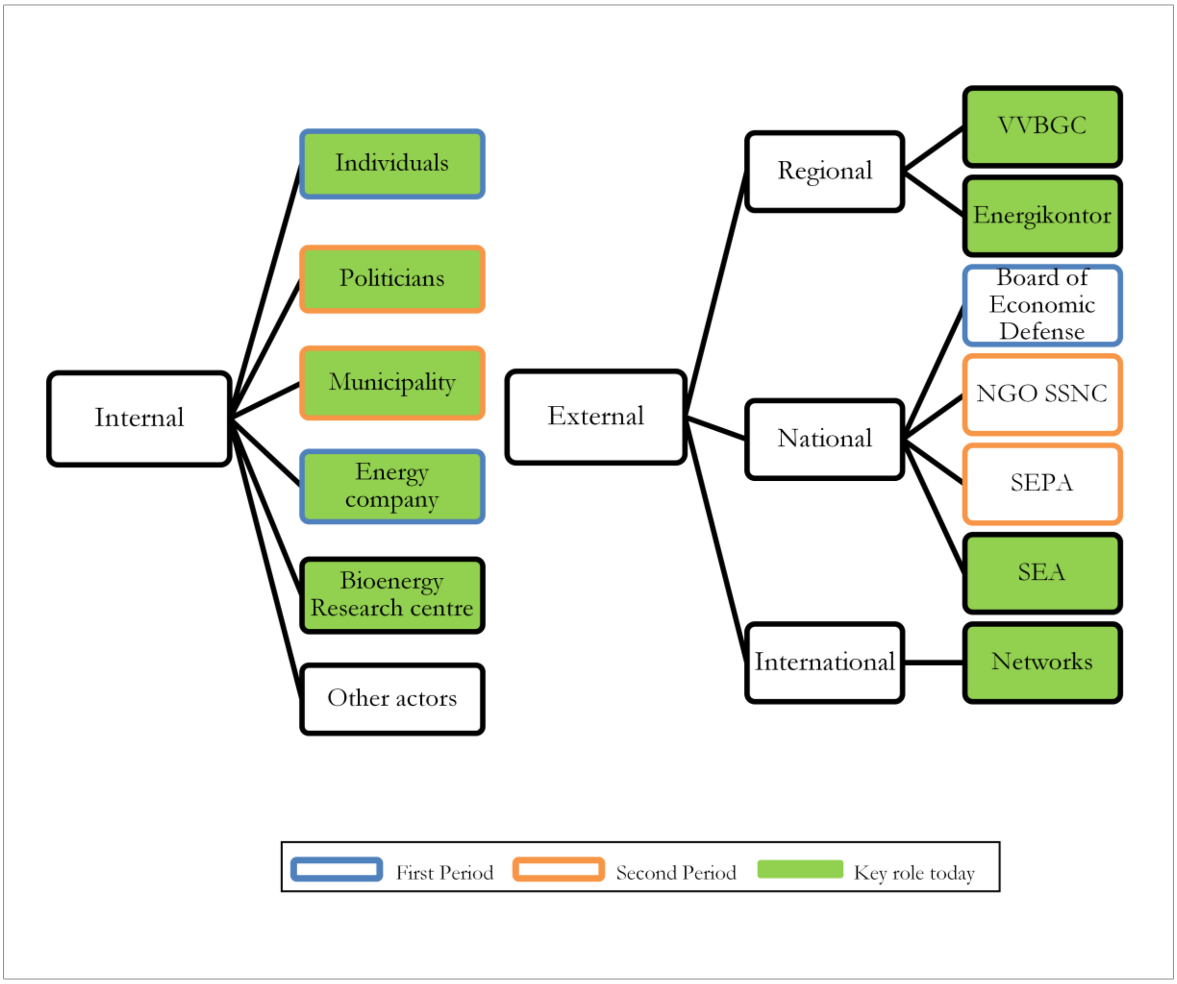

Figure A-4 Actors involved in Växjö transition

Internally, the following actors have been identified:

Individuals: under this title two typologies are included: (a) engaged people leading the process (point addressed at the end of this Section), and (b) citizens'. Regarding the later, since social legitimacy has a high value for local politicians, the community holds an important role (B. Frank, personal communication, April 9, 2010). After visiting the city and performing interviews, the author of this thesis realized that citizens' will to adapt their behavior is very important. Moreover, the inhabitants of Växjö have been participating in the transition both as active parties (e.g. with project proposal back in 1997 when the city received national subsidies [Växjö, 2008a]) and as users of the new energy system.

Politicians: back in 1969 a political decision to resolve the eutrophication problem of seven lakes was taken. The unity across party boundaries required for that endeavors has characterized public officials in Växjö (Växjö, 2004). Today, differences might exist regarding how to address one particular topic, but all political parties share Växjö' vision of becoming a fossil fuel free city (S. Nilsson, personal communication, March 23, 2010; B. Frank, personal communication, April 9, 2010; & H. Johansson, personal communication, April 9, 2010).

Municipality: the proactive role of the municipality, and in particular of the Strategic planning department, should be highlighted. The availability of funding, the development and implementation of projects, the creation of business opportunities -among other achievements- are mostly due to the effort the municipality put in its daily work. The pleasant working environment and the existence of an open dialogue were identified as important features by the interviewees working at the city hall (S. Nilsson, personal communication, March 23, 2010; S. Karlsson, personal communication, March 23, 2010; & H. Johansson, personal communication, April 9, 2010).

Energy Company AB (VEAB): all along the transition, the actions taken by this actor have been fundamental for the city. The technological changes performed by VEAB at the CHP plant have been essential for increasing the share of renewable sources of energy. However, this actor has contributed with more than technical improvements. Knowledge transfer processes between VEAB and other actors such as the Bioenergy Research centre, other municipalities, and national and international networks, constitute other ways in which the company has been involved (VEAB, 2010b). The role of VEAB within EU-project SESAC is particularly important. Finally, the fact that this company is owned by the municipality is considered to make the process easier.

University of Växjö: the University has a Bioenergy Research Centre where studies about biogas technologies have been performed since 1996. All the interviewees have recognized the importance of this centre in the development of a more sustainable energy system. Crucial is its participation in achieving the biggest challenge the city has within its energy miens: transport sector and production of biofuel for vehicles.

Other actors: although not essential for the development of the system, other actors such as the WWT plant –Sundet-, Växjö Airport and Teleborg High School, have contributed to the system with small scale projects.

Externally, different actors have positively influenced Växjö' transition. Some of them, such as the Board of Economic Defense with its request of finding alternatives to oil in 1973, had an important role in the past. Back then, the Power Company already knew oil was not going to last forever (U. Johnsson, personal communication, April 15, 2010) but it was the Board that triggered and stimulated the local action. The same can be said about the work done by the Swedish Society for Nature Conservation in 1996, when Växjö decided to become a fossil fuel free municipality (Växjö, 2008a). Also at the national level, it was important the support provided by the Swedish Environmental Protection Agency (SEPA). The city has received subsidies within Local Investment Programme –LIP- twice and within Local Climate Investment Programme –KLIMP- three times, between 1997 and 2009 (H. Johansson, personal communication, April 9, 2010). Two of the KLIMP projects are still running and the final number is not defined, but until now the national economic support has been some €8.7 million. Finally, Sarah Nilsson recognized as important the support the Swedish Energy Agency has provided to the city in terms of knowledge and experience exchange (personal communication, March 23, 2010).

Regionally, since 2003, VVBGC has been contributing in increasing the knowledge about biomass gasification process (see Section A.2.3). Also, since 2005, Energikontor Sydost (Energy Agency for Southeast Sweden) has been coordinating part of the EU-project SESAC together with the municipality of Växjö (S. Olsson, personal communication, April 9, 2010). The municipality and the Company VEAB consider Energikontor to be an important actor for technical support. Finally, the international networks in which Växjö is involved have acted as facilitating factors when it comes to EU funding opportunities (see Section A.5).

After conducting this case study, it is concluded that the presence of a champion or leader with the necessary strength to overcome obstacles and to empower others, was and still is a key element for the success of Växjö transition. This role has been performed by different actors along the process. At the beginning, Ulf Johnsson, head of the cogeneration plant from 1973 to 2007, was the person who saw the possibilities for a change after the request made by the Board of Economic Defense. He encouraged other actors, from politicians to whom he pursued, to forest corporative organizations to build up the biomass supply chain. In the second period of the local transition, from the 1990s and until now, the municipality of Växjö as a whole has had a determinant role. The work done by the planning office and the engagement of the Mayor of the city have resulted in the establishment of different strong networks.

As a conclusion, two points can be highlighted. On the one hand, local actors have had a fundamental role. Engaged and motivated people deeply involved in the process were identified while performing the interviews. Moreover, the presence of a leader has proved to be essential in creating this motivation. On the other hand, external actors have made the process easier and faster. Their participation, although not essential, supported the system.

Table A-1 Participation and role of actors in Växjö transition

ACTORS			Participation			Role	
	Int	Ext	Transition		Actual System	Key	Influential
			First period	Second period			
Individuals	X		X		X	X	
Politicians	X			X	X	X	
Municipality	X			X	X	X	
Energy Company	X		X		X	X	
University	X			X	X		X
Others	X				X		

Board of Econ Def		X	X				X
NGO SSNC		X		X			X
SEPA		X		X	X		X
SEA		X			X		X
Energikontor		X			X		X
International networks		X			X		X

A.5 IDENTIFICATION OF NETWORKS AND THEIR IMPORTANCE

This Section describes the networks identified in the city. It also discusses the importance some of them have had for the transition. A distinction between international, national and local networks, and the different purposes they have served, is made.

The municipality of Växjö considers that significant positive impact on climate and the environment can only be made by acting together. For this reason, the city is involved in an intensive networking process, not only at the local level but also nationally and internationally. At the higher level Växjö is part of: Covenant of Mayors, Energy Cities, Local Governments for Sustainability –ICLEI-, International DME Association –IDA-, and UBC –Union of the Baltic Cities-, among others. The city is also a member of the Climate Municipalities Association (Klimat Kommunerna) at the national level. Finally, an internal environment network can be also identified, involving representatives from each municipal Board, municipality owned companies (i.e. the housing company and the local energy company) and Lineaus University (previously named Växjö University) (Växjö, 2010b).

The importance of networking can be measured through the following example. At the international level the city has been involved in the EU project SESAC –Sustainable Energy Systems in Advanced Cities- since the year 2005. Within SESAC, demonstration projects are being carried out in Växjö, Delft (Netherlands) and Grenoble (France) with the aim of demonstrating how the local economy is able to increase at the same time as less CO_2 is emitted. In the Välle Broar, area where SESAC project is been implemented in Växjö, different actions regarding renewable energy supply, energy efficiency in buildings, and poly-generation technology (i.e. the use of absorption cooling), have resulted in positive environmental achievements (SESAC, 2010).

According to the Sarah Nilsson, from the Strategic planning department of the municipality, and the Mayor Bo Frank, ICLEI and Energy Cities are important networks in terms of promoting the city at the international level (personal communication, March 23, 2010; &, personal communication, April 9, 2010). Such promotion is an essential tool for funding opportunities. Moreover, by being visible in the world the city found a way to attract people for study visits and, therefore, to create a local business opportunity. Such economic benefit was and still is a key element to maintain the different actors involved and committed to the process (S. Nilsson, personal communication, March 23, 2010). Also, Bo Frank stated that through international networks "we compete… and competition is very good for us, it constitutes a driving force to go further" (personal communication, April 9, 2010).

National and local networks have had a different function. Climate Municipalities Association has been identified as an interesting tool for sharing experience with other municipalities. Henrik Johansson from the Strategic Planning department also considers that this network have allowed municipalities to act as a powerful group when it comes to discussing an issue with the national government (personal communication, April 9, 2010).

Considering the above, a general conclusion about the different role of international networks, on the one hand, and national and local networks, on the other hand, can be drawn. The former served the purpose of promoting the city internationally and therefore creating funding and local business opportunity. Regarding the latter, a process of knowledge transferability is considered to be the common element present in national and local networks. Table A-2 summarizes the conclusions arrived in this Section.

Table A-2 Types and purposes of networks in Växjö

Network	Purpose it served	Example
International	-International promotion and thus: .Funding opportunity .Local business opportunity -Competition	-SESAC -ICLEI -Energy Cities
National	-Transferability of knowledge	-Climate Municipalities Association

A.6 DRIVERS, FACILITATING FACTORS AND CONSTRAINTS

A.6.1 Drivers

As described in Section A.1, the changes experienced by the city of Växjö within the energy sector took place in two different political and international contexts. The triggering factors that initiated the local transition differ considerably to those leading the process in the 1990s and that are supporting the system nowadays. Back in 1980, the main drivers were energy security and energy independence, within a context of international oil crisis and economic concerns (S. Nilsson, personal communication, March 23, 2010; & U. Johnsson, personal communication, April 15, 2010). The increase of oil price in 1973, the oil crisis of the 1980s and the high level of dependency Sweden had on oil imports, were all combined reasons for developing an alternative and new energy system. An energy source able to secure the domestic energy demand and to bring independency from the external market was needed. Additionally, when the local energy company started using biofuel in 1980, local growth became immediately a driving force to further increase the use of this renewable.

In 1990s the context was different. Concerns regarding the negative environmental impacts of human activities and anthropogenic climate change were issues highly discussed both at the international and national level. The Agenda 21 document was one of the outcomes of the international Conference held in Rio de Janeiro in 1992. Containing a comprehensive list of actions related to sustainable development to be taken globally, nationally and locally this programme set a new context within which local actions were going to be triggered. Because energy and climate change are topics deeply related, implications in local energy systems were the necessary consequence. The interviewed actors indicated that this new background provided Växjö with a new driver for its transition. The city had the aim of demonstrating that it is possible to assume a global responsibility at the local level, and to work for it (S. Nilsson, personal communication, March 23, 2010; & B. Frank, personal communication, April 9, 2010).

Due to all the efforts done, and the achievements obtained during the last 30 years, Växjö is nowadays recognized as the Greenest city in Europe (in sustainable development issues). As stated by the Mayor Bo Frank, such position is both a pressure and a motivation to work harder (personal communication, April 9, 2010). Additionally, there are two more drivers leading the process nowadays: competition and business opportunity. Regarding the first one, the city competes with other municipalities for international awards and recognition. Regarding the second driver, the actors involved in the system have identified a business opportunity in developing a greener energy sector. Finally, it is possible to consider nowadays' international context as one where local governments are holding an important role, and where –as a consequence- recognition, competition and awards are goals to achieve.

Concluding this discussion, it should be noticed that each international-political context, within which local actions have taken place, is per se a driving force. Therefore, in addition to those expressly mentioned, oil crisis and economic concerns (for first period), climate change (after 1990s), and local participation at the international level (in the current period), are all drivers by themselves. Figure A-5 is a synopsis of the conclusions arrived in this Section.

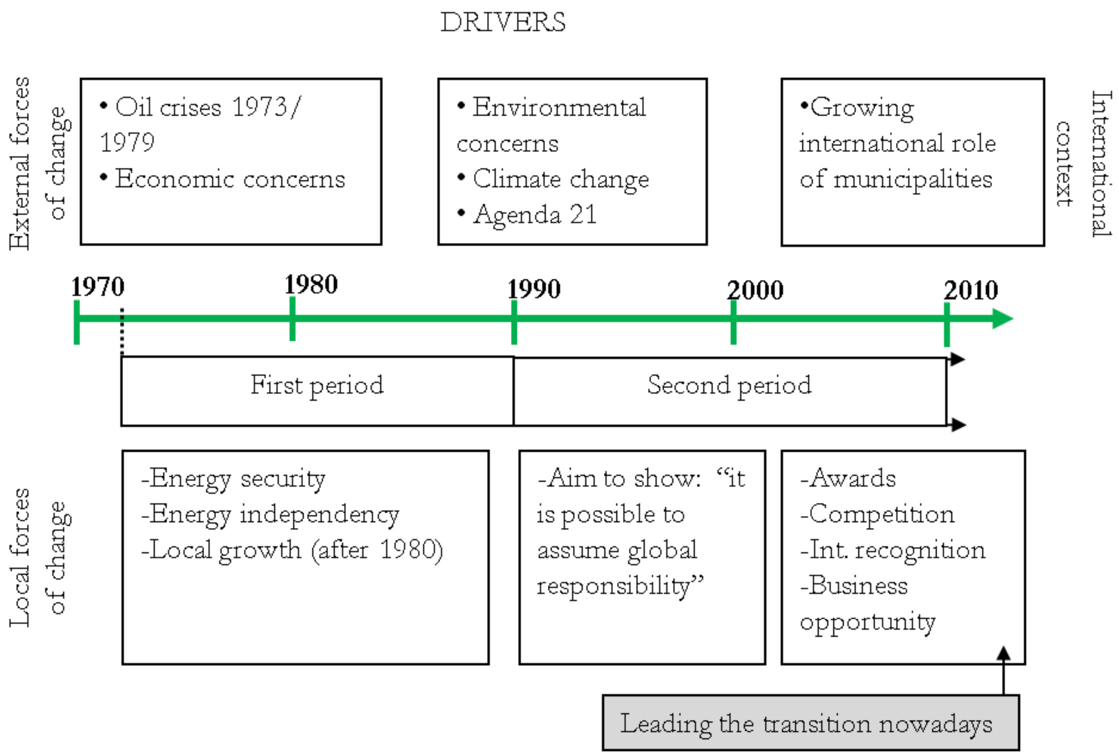

Figure A-5 Drivers in Växjö transition

A.6.2 Facilitating Factors

In this case study it is possible to recognize the presence of factors that have positively contributed to the local transition. By either making the process easier or faster, these factors have had an influential, though not essential, role in Växjö's efforts towards a more sustainable energy system. A short description of these factors is hereby provided. At the end of the Section, table A-3 summarizes the findings.

A distinction between those factors present at the local level and those externally influencing the process is identified. On the one hand, Växjö is surrounded by forest. This has been the comparative advantage the city had. The availability of a natural resource both cheap and reliable to be used as a renewable source, made the shift of the energy system smooth and straightforward. Moreover, it concomitantly provided for additional economic activity and income streams for the local forest industry (through the economic valorization of forest waste). Another element that has paved the way has been the cooperation among local actors. An open communication channel between them, together with knowledge and experience exchange, through the establishment of a local climate commission for example, are tools that has proved to be positive for the transition. The positive working climate at the municipality has been another contributing factor. Finally, the existence of political unanimity in energy related issues and the presence of brave politicians have both been important facilitating factors.

On the other hand, there have been external circumstances or elements facilitating the process. A national policy framework supporting the development of a renewable-based energy system, with a set of legislative, administrative and informative instruments, has had a crucial supporting role. Particularly important have been the national investment grants, the fossil carbon dioxide tax, and the establishment of a green certificate system (S. Nilsson, personal communication, March 23, 2010; L. Ehrlen, personal communication, March 24, 2010; H. Johansson, personal communication, April 9, 2010; & U. Johnsson, personal communication, April 15, 2010). The same can be said about international networks and EU funding. Finally, the fact that the city of Växjö won several awards has been identified as a motivation to face the constraints that may appear in the process (S. Nilsson, personal communication, March 23, 2010; & L. Tranvik, personal communication, March 24, 2010).

Table A-3 Facilitating factors identified in Växjö

FACILITATING FACTORS	
INTERNAL INFLUENCE	EXTERNAL INFLUENCE
Available, cheap and reliable natural resource	National policy framework
Broad cooperation among actors	International networks
Political unanimity	EU funding
Brave politicians	Awards

A.6.3 Constraints

The development of a renewable energy system involves different types of changes. Technical, structural, organizational, political and social transformations are some examples to illustrate the complexity of such transition. Constraints affecting the process are a natural consequence.

In the case of Växjö it is possible to differentiate obstacles present while building up the system, from those limiting further improvements nowadays. Växjö was in 1980 one of the first cities in Sweden to use biomass for co-generation of district heating and electricity (Energie-Cités, 2002). A whole new infrastructure had to be developed. Issues such as the re-construction of the energy plant, building up a supply chain, obtaining the necessary political support, and the engagement of the community, were all tasks that needed to be addressed (U. Johnsson, personal communication, April 15, 2010). Furthermore, uncertainty about the technology that should be used, and high investment costs were the main limitations (S. Nilsson, personal communication, March 23, 2010; B. Frank, personal communication, April 9, 2010; & U. Johnsson, personal communication, April 15, 2010).

Besides these initial challenges, all along the process there have been obstacles to overcome. Actor's engagement and the economy of the system remain as important limitations nowadays (S. Karlsson, personal communication, March 23, 2010; & L. Ehrlen, personal communication, March 24, 2010). From another perspective and particularly, the transport sector has been the less developed in terms of increasing its share of renewable sources (H. Johansson, personal communication, April 9, 2010). Concerns regarding the absence of an established supply chain and citizens behavior are issues that should be targeted if improvements in the transport sector are to be obtained. To finalize this Section, it is interesting to highlight Bo Frank's opinion about this topic. The mayor of Växjö considers that "obstacles are creations of the mind" and that "only there, lies the limitation of our success" (personal communication, April 9, 2010).

Appendix B

ENKÖPING CASE STUDY

Within Uppsala County, in east central Sweden, Enköping municipality is situated close to Lake Mälaren and the big cities of Stockholm, Uppsala and Västerås. Covering an area of about 1 300 square km, the city has around 39 300 inhabitants (Enköping, 2010a). Few more than 50% of the population lives in town and the surroundings while the remanding is located in the countryside. The business-focus within the municipality is entrepreneurship and local innovation and development. More than 4,000 companies operate within the municipality, out of which less than 1% are energy-intensive industries. Farming land represents a significant part of the local economy.

B.1 THE PROCESS

In Enköping, the district heating system –originally based on 5 oil boilers- was introduced in 1969. During the 1970s, with the formation of the municipal owned energy company Enköpings Värmeverk in 1972, the expansion of the district heating network led to the gradual replacement of individual oil boilers (ENAE, 2010a).

The beginning of the 1980s was the time for the first local experience in biofuel. In 1979 the Swedish Armed Forces, Government agency located in Enköping, wanted to ensure heat supply using domestic fuel. But the reason behind such decision corresponds to a broader context. Although Sweden itself declared neutral in the I World War' conflict, the country had problems with a number of strategic items such as –among others- rubber, chemicals and oil. Sweden built –for this cause- a number of huge storing facilities for oil. The original idea was to have enough stored oil to secure the entire nation's needs for one year. The system came to be very expensive in the long run. Since initiatives to develop biofuel technology had already commenced at the national level, this was a natural step for the Armed Forces to take. Additionally, in Enköping, the former Armour regiment was discontinued and replaced with the Signalregiment, leading to a major demand for new facilities and buildings. As a result of these circumstances, it was essential to find new heating technologies (B. Gelin, personal communication, May 10, 2010). Two were the possible solutions at the local level: either the Swedish Military regiment built their own biofuel-based heat plant in the city, or the Energy Company was to take the lead. Hans Österberg, by that time manager director of the company, offered to fulfill the Armed Forces' requirement. In 1981 a heating station with two woodchips boilers was commissioned at Stenvreten (area where the big new customer was located) (H. Österberg, personal communication, May 05, 2010).

During the 1980s several conversion technologies were introduced in the heating plant. Also, different projects were designed for the central station at Kaptensgatan, with the aim of adapting the boilers to use the fuel that had the most favorable tax benefits. Wood pellets, coal and liquefied gas were used. The 1980s was also a period for improvements in terms of energy efficiency. In 1986 a flue gas cooler was installed at Stenvreten and one year later an accumulator tank was built at Kaptensgatan.

In the 1990s, changes at the local and national contexts were experienced. Locally, the Energy Company needed to update its generation equipment according to the domestic needs (ENAE, 2010a). Nationally, and within the heating sector, the penalties on fossil fuel (i.e. energy tax and carbon dioxide tax) represented an important difficulty for energy companies. In addition, in 1992 the Swedish Government created an investment incentive for companies aiming at building electricity production plants based on biofuel. The incentive consisted in 4000 SEK per kilowatt of installed capacity (E. Johansson, personal communication, April 28, 2010). Everything was pointing to a substantial shift in the energy production system.

Influenced by the national policy instruments mentioned above, in 1992 the Energy Companies owned by the municipalities of Västerås and Enköpings made a deal to construct a biofuel-fired combined heat and power plant. In order to implement these plans, a company was formed, owned 50% by each municipality (ENAE, 2010a). In 1994 the biofuel-based CHP plant commenced to operate. Three years after, an oil-fired boiler was converted to use wood powder, leading to a district heating system virtually based 100% on biofuel. Finally, a technology combusting crushed pellets was established in 2003 (McCormick & Kåberger, 2005). Due to the negative economic results Västerås was experiencing from the electricity part (which they owned), they did not want to continue as part of the company. In 2004 Enköping bought the other half of the company and since 2006 the local facility is called Ena Energy AB (ENAE, 2010a).

In the aim of providing a complete picture of Enköping's transition towards a renewable-based energy system two interesting recycling projects should be described. And to do so, two circumstances influencing the development of such projects must be highlighted. One of these circumstances refers to a concern regarding energy supply that Ena Energy had. After the investment made in the Bioenergy CHP plant, the company needed to ensure the availability of biofuel. The other issue refers to the increased effluence of nitrogen and phosphorous in Lake Mälaren' and Baltic Sea' waters. In the year 1992 all states bordering the Baltic Sea, together with the European Community, singed the Helsinki Convention with the objective of assuring the ecological restoration of the Baltic Sea. Such regional agreement established, among other measures, that nitrogen and phosphorous emissions to the sea needed to be reduced (U. Pillö, personal communication, April 28, 2010). This meant a specific obligation for the WWT plant of Enköping, since the sewage water (rich in nitrogen and phosphorous) finds its way to Lake Mälaren, which finally drains to the Baltic Sea.

Triggered by the first factor described above, and bearing in mind that most of Enköping's area was covered by farming land, the local energy company started a project to develop salix plantation (E. Johansson, personal communication, May 7, 2010). The programme was not very successful in terms of the number of hectares included (E. Johansson, personal communication, May 12, 2010). However, an interesting irrigation project was introduced as a spin off from the programme. The idea was to irrigate the salix plantations with sewage water (E. Johansson, personal communication, May 12, 2010). It should be mentioned that the obligation established by the Baltic Sea Agreement was a key factor for the implementation and further development of the irrigation project.

From the previous paragraphs it can be concluded that Enköping's transition has been influenced by several factors, some of them acting as driving forces for the change, others characterized as business and local opportunities that were recognized.

B.2 DESCRIPTION OF THE ENERGY SYSTEM

B.2.1 Energy strategy

Swedish municipalities are obliged by law to have a local plan for the supply, distribution and use of energy. Enköping adopted the first energy plan in 1999. Such instrument consists in the description of the current energy situation in the municipality, as well as in a target document detailing objectives the city has to achieve (ENAE, 2009). Bellow, table B-1 summarizes the goals of the city within the energy sector for the years 2015 and 2020. Other sets of targets have also influenced local efforts in the energy field. On the one hand and at the regional level, in 2003 Uppsala County adopted 15 environmental targets, one of which is to reduce carbon dioxide emissions by the year 2020. On the other hand, and at the local level, in autumn of 2009 local politicians have adopted 12 environmental targets -in line with Sweden's national environmental objectives-, one of which is that the municipality will be carbon dioxide neutral by the year 2050. It should be finally mentioned that there are also national and international goals influencing the local efforts.

Table B-1 Enköping Municipality's energy plan

Target 2015	Target 2020
Electricity used in Enköping municipality's operations shall come from renewable energy sources	Enköping municipality shall be *the best municipality example* in the energy field
Commercial activities in the municipality shall be heated from renewable sources of energy (electricity generation from renewable energy sources is included)	Enköping municipality shall use only energy from renewable sources.
New locals that Enköping municipality builds for its own activities shall be equipped with exhaust–air ventilation and heat-exchanger ventilation systems	
The municipality own cars shall be environmentally friendly	
Engine-driven machines own by the municipality shall be driven by renewable fuels	
The local and school buses shall be driven by renewable fuels	
Enköping municipality shall reduced its climate impact by 20% in comparison to 2008	
All equipments and facilities purchased by the municipality shall be energy efficient	

(Enköping, 2010b)

As stated in Enköping's energy plan, the concrete work towards the goals contained in table B-1 have taken place within the public administration and the public companies. The municipality, as organization and employer, is the major producer, supplier and consumer of goods and services. It is for this reason very important that the municipality acts as a pioneer in terms of energy efficiency and environmentally sound choices. Furthermore, the municipality is able to influence local actors' behavior by means of different tools. Examples of this are the service provided by the Energy advisor through which citizen's choices can be influenced, and the set of specific conditions that need to be followed while constructing a new building -through which energy consumption can be controlled-. When it comes to addressing citizens' behavior, the municipality has chosen the approach of acting as a model. They aim at demonstrating how feasible and desirable a change is and –by this mean- influencing citizens' actions.

B.2.2 Energy supply and energy use

An overview of the energy balance in Enköping, describing the supply and use sides, is provided in the following paragraphs. Although more recent data is available for specific items (e.g. electricity production at the CHP plant), for a matter of clarity and convenience all the figures hereby provided correspond to the year 2007.

Energy supply was 1 350 GWh. Of all the energy transferred to Enköping: 40% was wood fuel, 39% was fossil fuel (gasoline, diesel, fuel oil and LPG), 20% was electrical energy, and 3% corresponded to district heating[11]. More than one third of the total energy supplied to the municipality has direct fossil origin. This energy source is used mainly for transport purposes. District heating has replaced a large part of the previously oil based and individual household heating system. Finally, wood fuel is mostly used for district heating and electricity production in the cogeneration plant (Enköping, 2009). Figure B-1 shows the total energy supply in 2007 distributed in the respective energy types.

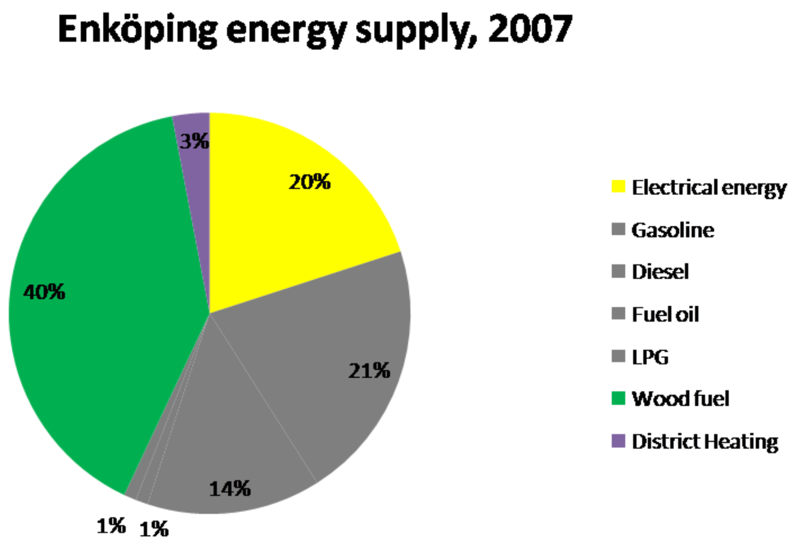

Figure B-1 Enköping Energy Supply, 2007

Concerning electricity production within Enköping, in the local cogeneration plant there was a net production of 84 GWh of electricity in 2007. The electricity production at the plant represents 31% of Enköping electrical energy supply. Wind power represents a small percentage of local electricity production. There is one wind mill with a capacity of 250 KW and other smaller ones with less than 125 KW power capacity; all of them privately own (Enköping, 2009). It is expected that further development occurs in this area. Together with two municipalities, Enköping has received a 75% in contribution from the national government to build up a wind power plant plan. It is not defined yet which will be the capacity of the plant. The latter will depend on the acceptance of the citizens (H. Bengtsson, personal communication, May 07, 2010). There is no production of solar electricity within the city.

With reference to biogas production, in the WWT plant of Enköping biogas is generated from an anaerobic process that takes place within the broader wastewater purification process. This biogas is burnt and the resulting heat is sent to the CHP plant so as to be

[11] Due to rounding, total figure is greater than 100%

delivered in the district heating network. With regard to biogas produced as vehicle fuel, there is no upgrading biogas production in Enköping. Currently, the organic waste produced in the city is collected and sent to Västerås municipality, and there converted to vehicle fuel. Although there is no concrete plan, Henrik Bengtsson, head of the Environmental department of the municipality, recognizes the huge potential a project of this nature might have. The resource availability, with pig production and other farming activities, as well as the amount of household organic waste produced, is quite important in the city for this matter (personal communication, May 07, 2010).

Continuing with the description of the local energy system, the supply of energy is controlled by the demand made by energy users, which in turn depends on what features they need to cover; heat, light, transportation, refrigeration or production processes. In other words, it is the use of energy that controls the production of such electricity and heat. In Enköping, transport and household account for a large proportion of the energy use, with a share of 39% and 31% of the total respectively. In the transport sector, the energy use has increased by 80% compared to the year 1970. One fourth of the energy supplied to the municipality is used for agriculture, forestry, fishing and public activities and other services. Finally, industry accounts for 5% of the energy use. The later is a natural consequence considering that within the municipal area there are only 32 industries and few electricity-intensive industrial processes.

B.2.3 Locally optimized bioenergy System

As considered by Eddie Johansson, the energy structure of Enköping can be characterized as part of a "locally optimized bioenergy system" (personal communication, April 28, 2010). A recycling process involving different local sectors and actors makes Enköping a particularly interesting case study. In the aim of explaining such process, a description of ENA energy production system, as well as of the Salix Plantation and Irrigation projects is provided in the following sections.

B.2.3.1 ENA Energy AB

General information about this company, with a short description of its operational units, and a characterization of its inputs and outputs is hereby provided.

The company has a biofuel-based CHP plant, which mainly consists in the following units: a wood powder-fired hot water boiler, an oil/gas-fired hot water boiler, an oil-fired hot water boiler, an electric boiler and an accumulator tank. The plant is located on Kaptensgatan, from where district heating is supplied to the central areas of Enköping. Electricity production is supplied to the Nordic electric Power market. The company also owns another production facility located in Stockholmsvägen where two chip-fired boilers were built at the beginning of the 1980s. Nowadays these boilers are out of operation and the plant only has an oil-fired hot water boiler as a backup unit. Finally, built at the beginning of the 1970s, there is an oil-fired boiler station on Fabriksgatan which also serves as a backup unit (ENAE, 2010d).

For the year 2009, the share of fuels used was 418 GWh of biofuel and 5 GWh of fossil fuel. The later represents only around 1.2% of the total fuel used (ENAE, 2009). The biofuel mix for the period 2009-2010 is as follows: residues from logging and forestry industries, 80%; energy crop, salix, 10%; and demolition wood, 10% (Camilla Åhlund, personal communication, May 11, 2010). The net production of energy for the same year was: 205 GWh of heating and 95 GWH of electricity (ENAE, 2010c).

With regards to the district heating network, its biggest customers are residential houses, representing 40% of the total customer structure. This is followed by: public administration, 23%; single-houses, 20%; small shops, hotels and restaurants 12% and manufacturing industries 5% (Enköping, 2009). The proportion of households connected to the network is increasing every year. It is estimated that 90% of Enköping heating need in the urban areas is covered by ENA Energy AB.

B.2.3.2 Salix plantation and Irrigation projects

As described at the end of Section C.1, two important projects have been developed in Enköping, and influenced the structure of the local energy system. As follow, a description of them is provided.

The first programme was initiated in 1998. The local Energy Company requested to the consultancy agency Agrovärme AB a suitable suggestion on how to involve local farmers in a 1000 ha salix plantation project. The response from the farmers was not as expected, and only around 200 ha were added to the programme. Six years after, with the aim of increasing the amount of local biofuel production, a re-start of the project was initiated. ENA Energy took the decision to rent farming land and have its own salix plantations. As a consequence, the company is nowadays leasing 196 hectares from local farmers (E. Johansson, personal communication, May 07, 2010). Nowadays, the programme has two main parts. On the one hand, there are (a) 200 hectares of energy forest to be harvested by farmers who deliver salix to the Energy Company plus (b) 196 hectares of energy forest to be harvested by thy company. On the other hand, a mixture of 50% bottom ash from the CHP plant and 50% digested sludge from the WWT plant is to be spread as fertilizer in such plantations. The company Agrobränsle AB is in charge of the dispersal of the mix and responsible, in association with the Swedish University of Agricultural Sciences (SLU) for the administration of land analyses. Also, the local Energy Company is obliged to perform periodical ash analyses. Such laboratory tests are fundamental for the continuity of the programme, since a key condition of the 12-year permit granted by Uppsala County Council Administration is that emissions of heavy metal comply with the prevailing regulations (ENAE, 2010b).

Regarding the Irrigation project -called the spin off project-, since 2001 at the 80 hectares' Nynäs Manor Farm, energy forest field located next to the municipal sewage plant, salix is being irrigated with fertile nitrogenous water after going through the conventional purification process. Reject and decanted water is blended with the outgoing purified water and distributed through 350 km. As a result, 250 to 300 kg of nitrogen per hectare is being dispersed every year, and therefore avoided to be introduced in Lake Mälaren and the Baltic Sea. After about three years the energy forest is harvested and the chips are burnt in the CHP plant. The salix plantation at Nynäs Manor Farm has an annual average yield of 5 GWh, which is the equivalent to 2% of ENA Energy (ENAE, 2010b). Furthermore, at Lundby, Göksbo, Djurby and Viggeby farms, the municipal council has constructed two sludge ponds per farm, with a volume of approximately 3 500 m3 per pond. Sludge from septic tanks and smaller sewage plants, is tipped into pond 1 until the end of June, where the sludge is allowed to rest for a year in order to be fully sanitized. Meanwhile, pond 2 is being filled and after the sanitation process, the sludge is dispersed on the farm Salix plantation. The production of biofuel produced on the irrigated plantations is also delivered to ENA Energy.

Overall, the following socio-economic benefits can be identified: the energy company has a locally produced fuel guaranteed, farmers have a secure income from the salix plantation, residues in the form of bottom ashes and digested sludge are utilized as fertilizer and therefore recycled, and finally nitrogen emissions to Lake Mälaren and Baltic Sea are reduced (ENAE, 2010c). Bellow, figure B-2 provides an overview of the recycling process that has been developed in Enköping, with some figures and flows.

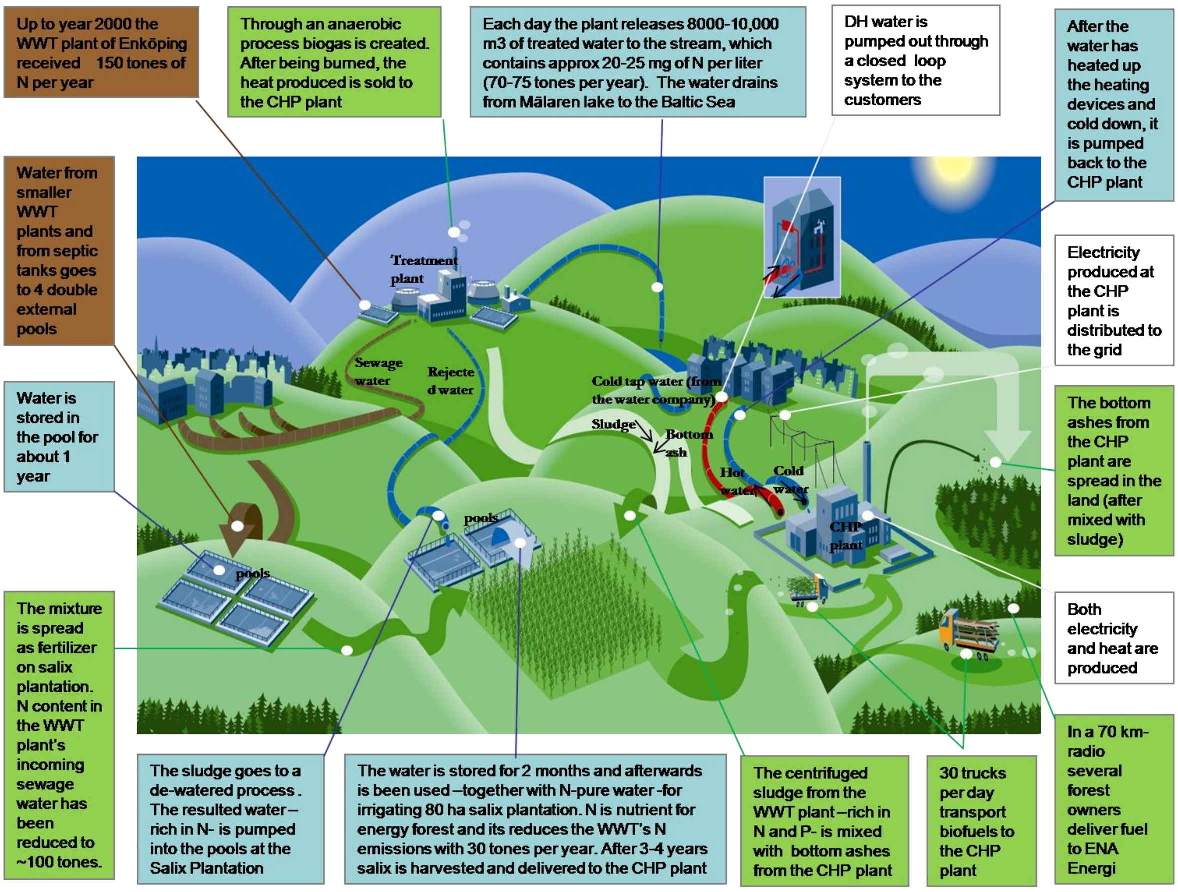

Figure B-2 Enköping Recycling process

Source: Picture from ENA Energy website

B.3 RESULTS

Although some figures have already been provided, this Section shortly summaries the most important results obtained from all developments occurred in the Municipality of Enköping. As follows, a list of such outcomes is provided:

Energy results: there is a virtually 100% bioenergy-based system in place in the energy production plant. During the period 1972 to 1980, energy production was based 100% on fossil fuel. Since 1997 and after gradually improvements, oil consumption has been reduced down to a value close to zero. Furthermore, coal and LPG are fuels not longer used in the facility (see figure B-3).

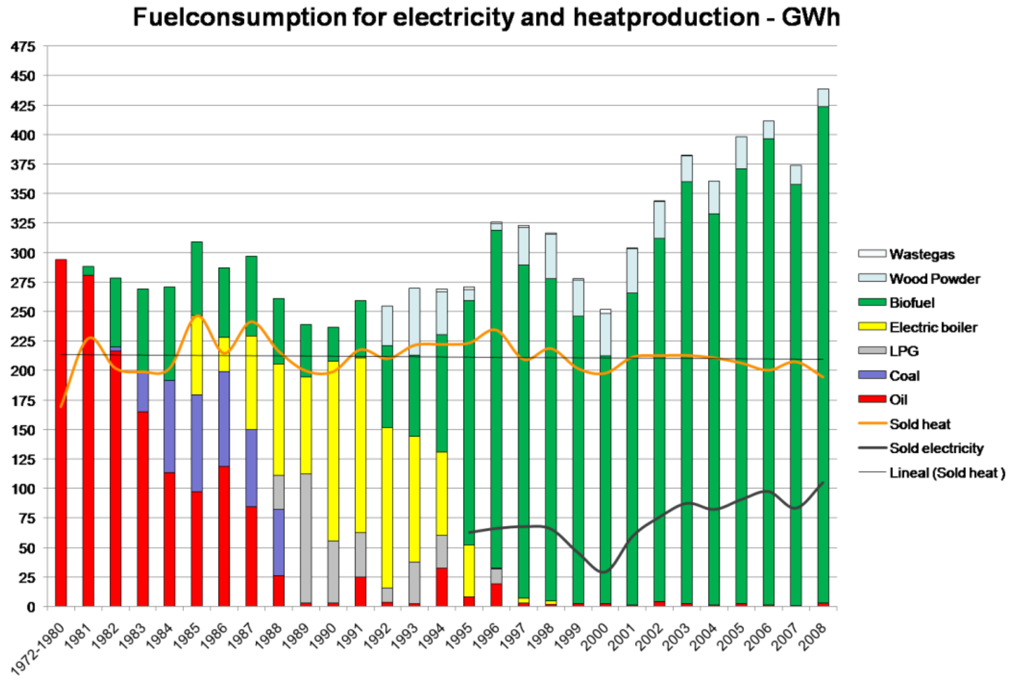

Figure B-3 Fuel consumption at Enköping's CHP plant

Socio-economic results: the positive environmental consequences of having a biofuel CHP plant and the salix plantation and irrigation projects, go hand by hand with the socio-economic benefits these developments provide. Profitability for the Energy Company, the WWT plant and the local farmers, in the form of either avoided cost or new incomes, is an example of this.

B.4 ACTORS INVOLVED IN THE PROCESS, IMPORTANCE

The energy system developed in Enköping is, as mentioned above, part of a broader recycling system. Such structure was developed by the influence of local actors, and supported by the contribution of external stakeholders. Figure B-4 describes the actors involved in the two main areas where changes were introduced. It also provides a temporal delimitation of their participation and the importance of their involvement.

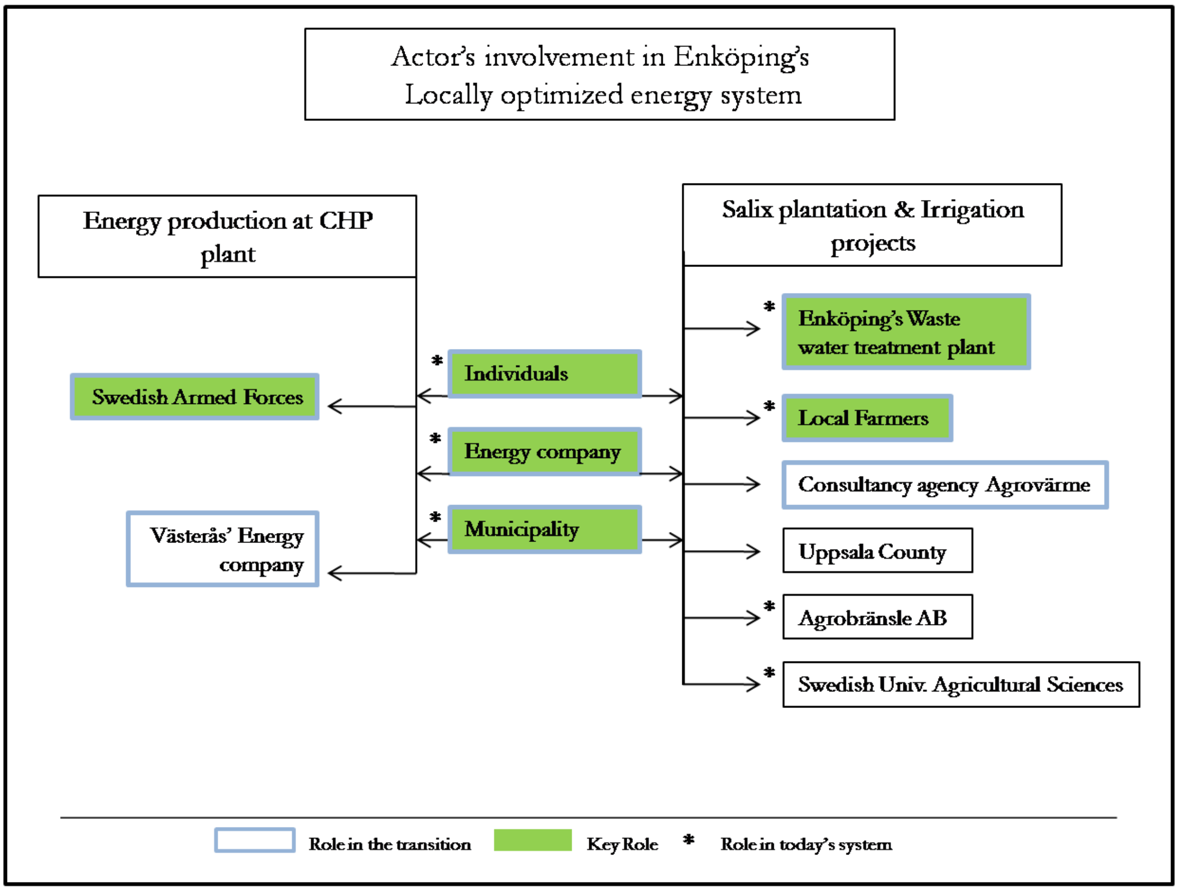

Figure B-4 Actor's participation in the Locally optimized energy System

A short description of the role each of these actors has played is hereby provided:

Individuals: up until now and since the beginning of the transition, the presence of engaged individuals is considered to be fundamental for the results experienced in Enköping. Hans Österberg and Eddie Johansson as manager directors of the Energy Company, Ulf Pillö as manager of the Municipal Waste and WWT plant and Herman Arosenius, owner of Nynäs Manor Farm, are persons who have had the necessary commitment and determination. These are some examples of people believing in the potential of a local solution and highly contributing to the development of system.

Municipal Owned Energy Company: ENA Energy AB has played an essential role since the beginning of the transition back in 1980s. The strategy developed by the company, (a) coping with the international and national context, (b) implementing the development of new technologies, (c) aiming at securing locally produced biofuel, and finally (d) rapidly responding to the different policy instruments Sweden has established within the energy sector; has proved to be fundamental. Nowadays they still have an important role to play not only in terms of energy production, but also with regard to the Salix plantation and Irrigation projects.

Municipality: this is another example of an important local actor involved both in the transition and the actual energy system. The fact that the Energy Company is municipal owned, as well as the fact that the WWT plant is a local public department, has been extremely important in terms of cooperation. Moreover, the municipality (specifically the local county council) has participated in the construction of the local ponds for the irrigation project. Finally, the sets of targets and goals established by Enköping municipality (discussed in Section C.2.) have influenced the actions taken locally.

Swedish Armed Forces: the reasons why the Swedish military regiment aimed at securing a domestic fuel for heating purposes at the beginning of the 1980s has been discussed in Section C.1. Here it is enough to highlight that this need was the reason why ENA Company decided to start experimenting with biofuel. As stated by Hans Österberg, the company needed the Armed Forces as a customer (personal communication, May 05, 2010). The presence and request of the military regiment triggered important decisions at the energy company and was, therefore, important for the local transition.

Västerås' Energy Company: this actor contributed to the construction of the biofuel-fired CHP plant in Enköping. It can be said that they had an important role in Enköping´s transition, in terms of cooperation and economic support (E. Johansson, personal communication, April 28, 2010; & H. Österberg, personal communication, May 05, 2010). Back in 1992 both municipalities worked together to face the development of such challenging project. However, it cannot be concluded that they had a key role for the transition, since Enköping's fundamental changes would have still taken place without the presence of this particular actor (E. Johansson, personal communication, April 28, 2010).

Waste water treatment Plant: this actor is involved both in the salix plantation and in the irrigation projects. The purification facility has been actively participating in Enköping recycling process, through the delivery of digested sludge to be used as fertilizer as well as through the supply of purified waste water to be used for irrigation purposes. It can be concluded that the role of this actors is fundamental in the locally optimized energy system.

Local Farmers: this actor supplies biofuel to be used in the CHP plant. They have been and still are fundamental actors in the salix plantation and irrigation projects. The cooperation between farmers, ENA Energy Company and the WWT plant has been highlighted as essential for the local success.

Consultancy Agency Agrovärme AB: in the aim of developing the project to involve local farmers in the plantation of salix, the Energy Company contacted Agrovärme A.B. so as to come up with a suitable plan. Therefore, it can be said that the participation of this actor has contributed to the local transition, though not to a great extent.

Finally, acting at the regional and local level, there are other actors involved in the actual development of the locally optimized energy system in Enköping. This is the case of **Uppsala County council**, who granted the permission for the recycling projects, the **company Agrobränsle AB**, involved in land analysis and dispersal of the bio-fertilizer in the farms, and the **Swedish University of Agricultural Sciences**.

As a conclusion of this Section, important is to mention that this case study has proven to be a clear example of a bottom-up initiative, which received the necessary top-down support. It is an example of innovation and changes that have started at the lower layer of organizations, and where the actions performed by individuals have highly contributed in the local transition. Table B-2 summarizes the discussion of this Section.

Table B-2 Participation and of actors in Enköping transition

ACTORS					Participation		Role	
	Int	Ext			Transition	Actual System	Key	Influential
		Reg	Nat.	Int.				
Individuals	X				X	X	X	
Swedish Armed Forces	X				X		X	
Energy Company	X				X	X	X	
Västeras' Energy company		X			X			X
Municipality	X				X	X	X	
Local politicians	X				X	X		X
WWT Plant	X				X	X	X	
Local farmers					X	X	X	
Consultancy agency Agrovärme			X		X			X
Uppsala County		X				X		X
Agrobränsle AB			X			X		X
Swedish University Agricultural science				X		X		X
Networks	X		X			X		X

B.5 IDENTIFICATION OF NETWORKS AND THEIR IMPORTANCE

In this Section a short description of the networks identified in Enköping's case study, as well as a short discussion of their importance for the development of the current energy system is provided. Enköping is member of different associations operating at the national level. It is also possible to identify an informal internal network within the energy field operating in the city. Nationally, the following associations have been identified:

Swedish District Heating Association: Ena Energy has been member of this association since the 1980s. Its work mainly consists on the research of district heating technologies and related issues. The activities performed by this association are transferred to its members through conferences and reports and have been interesting tools for energy companies in terms of knowledge and experience transfer (C. Ahlund, personal communication, April 28, 2010).

Swedish Bioenergy Association: also at the national level, ENA Energy is member of SVEBIO. Founded in 1980 after the oil crisis of 1979, the main objective of this non-profit organization has been to increase the knowledge on the bioenergy field (SVEBIO, 2010).

National Association for Swedish eco-municipalities: In the late 1990s, the municipality of Enköping joined Sveriges Ekokommuner (Sekom) network. The aim of this network, formalized in 1995, is to encourage the development towards a more sustainable society (Sekom, 2010).

The objective of building an ever growing knowledge base in the energy field is the common feature shared by the associations mentioned above. The advantage Enköping and ENA Energy Company have obtained by being members of these networks is mainly knowledge and experience exchange. According to Camila Åhlund, support manager of the energy company, being member of the Swedish District Heating Association and of SVEBIO provides a possibility for the company to receive technical support (C. Ahlund, personal communication, April 28, 2010). Moreover, Henrik Bengtsson, head of the Environmental department of the municipality, considers that the major benefit for Enköping of being involved in Sekom network is the possibility to participate –with other municipalities- in meetings where ideas for dealing with local issues are shared (H. Bengtsson, personal communication, May 07, 2010).

From another perspective, an informal network among different actors has been identified at the local level. It has been a very important element for the deployment, development and maintenance of the actual energy system. Interactions and cooperation among the energy company, the WWT plant and the local farmers, as well as the involvement of politicians through goal and target settings, have led to the construction of a network that, although informal, is recognized as fundamental for Enköping's transition (U. Pillö, personal communication, April 28, 2010; L. Helgstrand, personal communication, May 02, 2010; & E. Johansson, personal communication, May 07, 2010). Finally, it is important to mention that the common idea shared by the interviewed actors is that the local energy system has been developed by the effort and empowerment of locals. Therefore, although one can recognize the importance of national networks in terms of transferability of knowledge, they have not been the key factor influencing in the success. On the contrary, the network naturally built among different local actors has been and still is essential in this matter. Table B-3 summarizes the conclusions of this Section.

Table B-3 Type and purpose of networks in Enköping

Network	Purpose it served	Importance	Example
National	Transferability of knowledge and experiences	Relatively important	-Swedish District Heating Association -SVEBIO -Sekom
Local	Deployment, development and maintenance of the actual energy system.	Very important	-Informal network among local actors involved in energy system and recycling projects

B.6 DRIVERS, FACILITATING FACTORS AND CONSTRAINTS

B.6.1 Drivers

About the drivers identified in this case study some distinctions need to be done. Firstly, different are the forces that have pushed changes in -on one hand- the local energy plant and –on the other hand- the two recycling projects. Secondly, changes have taken place in different periods of time. Thirdly, in each of these periods, the international context has been determined by particular discussions and concerns. Such international contexts were also drivers for the local transition. Figure B-5 contains these distinctions and lists the drivers identified in Enköping.

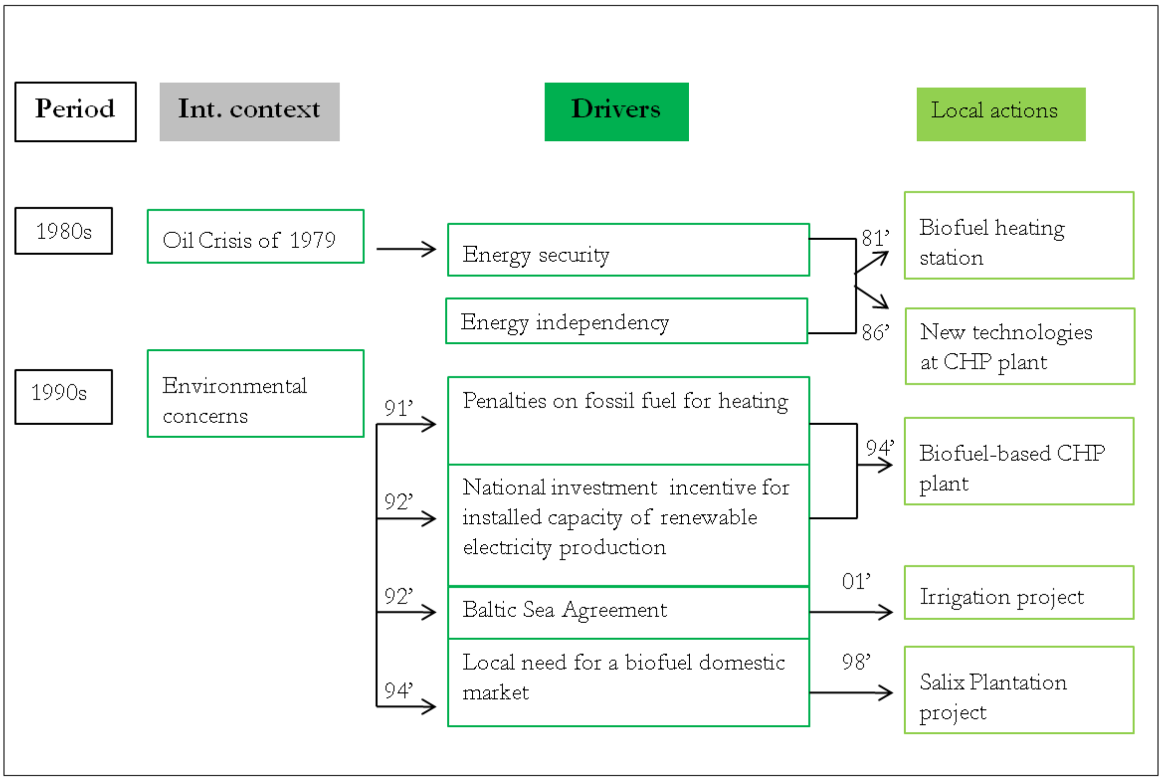

Figure B-5 Drivers in Enköping's transition towards a renewable-based energy system

At the international context, the oil crisis of the year 1979 has deeply characterized the period commenced at the beginning of the 1980s. Such context has also influenced the actions taken both nationally and locally. In the case of Sweden, although neutral in the conflict, it needed to secure energy supply and made a shift from oil-import dependency. In other words, energy security and energy independency have been the drivers that forced: (a) the Swedish military regiment towards the decision of having a heating production from domestic fuel, and, as a consequence of this, (b) the local heating company towards the construction of a biofuel heating production plant. These triggering factors were also the reason why in the middle of the 1980s new conversion and energy efficient technologies were implemented.

In 1990s the political context was different. Environmental concerns and anthropogenic climate change issues were leading discussions at the international level and influencing national decisions. In such scenario, in 1991 the Swedish taxation system was modified, and penalties on fossil fuel for heating, in the form of energy tax and carbon dioxide tax, became higher and higher. At the same time, in 1992 the Swedish government created an investment incentive for companies building renewable-electricity production facilities. The incentive was 4000 SEK per kilowatt of installed capacity[12]. Both Enköping and Västerås received 90 million SEK from the government, almost 30% of the total investment cost of 320 million SEK. In 1994 a biofuel-fired combined heat and power plant commenced to operate.

From another perspective and regarding the recycling projects, two drivers belonging to different spatial contexts are identified. Locally, it was precisely the new built facility and the need of securing domestic biofuel what triggered new changes. Such necessity was the main

[12] Note that this is an incentive per installed capacity of renewable electricity. It therefore differs from the Green Electricity certificates introduced in 2003, which are incentives per kilowatt hour of produced electricity.

driver for the development of the salix plantation in 1998. Also, but at the international level, the degradation of the Baltic Sea led to the adoption of the Helsinki convention in 1992. Due to such agreement Enköping needed to reduce the emissions of nitrogen to the Baltic Sea by 50%. It can be therefore concluded that the irrigation project initiated in 2001 finds its reason of being in the Baltic Sea Agreement.

B.6.2 Facilitating Factors

In Enköping, factors positively influencing the local transition towards a more secure and renewable-based energy system has been identified. Elements present in the local and internal context, as well as elements coming from an external source are considered to be facilitating factors in this case study and hereby provided. Locally, the following can be mentioned:

Local Ownership: this refers to the fact that the energy development of Enköping has involved local actors with individual interests in making the process possible. It also refers to the idea that the energy company is municipal owned. This has deeply contributed in the implementation of all the technical changes made at the plant. As an example, for the construction of the CHP plant the company received a loan from the bank. The precise reason for such credit availability was that the company was municipal owned. Such is the opinion of Eddie Johansson, ex-manager director of the CHP plant.

Local goals and targets: a set of goals and targets creates a long term perspective where objectives can be gradually achieved. It also provides security for the local actors in terms of political commitment and municipal involvement.

Political commitment and unity: this was an important element for the establishment of the local policy framework. Furthermore, the construction of the CHP plant was a risky investment for the energy company to take by itself, and the political support was therefore necessary.

Cooperation and support among actors: the involvement of all local actors and their commitment in cooperating with each other has been highlighted as an essential factor for the local transition by the people interviewed in Enköping. Furthermore, the political party governing the municipality has the support of local farmers, and this has proved to be important for the implementation of the salix plantation and irrigation projects (U. Pillö, personal communication, April 28, 2010; L. Helgstrand, personal communication, May 02, 2010; E. Johansson, personal communication, May 07, 2010; & H. Bengtsson, personal communication, May 07, 2010).

Landscape, comparative advantage: the municipality of Enköping is characterized for its landscape suitable for farming activity. This was fundamental for the development of the local biofuel infrastructure and constituted a comparative advantage for the city (U. Pillö, personal communication, April 28, 2010; & E. Johansson, personal communication, May 07, 2010).

District heating system: this system was well introduced in Enköping, and an important part of the town was connected to the net when the decision of investing in the CHP plant was taken. The fact that the energy company had a big proportion of customers to whom delivered heating made the decision easier (E. Johansson, personal communication, May 07, 2010).

From another perspective, externally, the cooperation between Enköping and the municipality of Västerås was fundamental for the construction of the Biofuel CHP station. According to Eddie Johansson, ex manager director of ENA Energy, a small municipality like Enköping could not have taken the risk of investing in electricity production at a time where the market situation was not well developed (E. Johansson, personal communication, April 28, 2010). Also externally but from a higher level, the national policy framework related to energy issues has been an influential and important factor. Besides those economic instruments that have acted as a driver –discussed in Section above- other administrative, informative and legislative instruments has been recognized as positive for the change. A special mention should be made about the green electricity certificate system introduced in Sweden in 2003. After a long period of low electricity price that started in 1996, these certificates have made electricity production at the biofuel CHP plant profitable.

Finally, there is another important factor influencing the whole transition, corresponding not only to the internal context but also to the external one. This factor refers to Research and technological development. A knowledge-base in issues such as renewable energy production, energy efficiency, and other environmental developments, has been fundamental for this case study. Activities such as the ones developed by ENA Energy (experimenting with biofuel back in 1981), Agrovärme AB (for salix plantation project), Agrobränsle AB (for irrigation project idea), Ulf Pillö (head of the WWT plant and deeply involved in the development of the irrigation project plans), and the Swedish University of Agricultural Sciences (involved in land tests); have all characterized the structure the actual local energy system has. Table B-4 summarizes the discussion present in this Section.

Table B-4 Facilitating factors identified in Enköping

<table>
<tr><th colspan="3">FACILITATING FACTORS</th></tr>
<tr><th rowspan="2">INTERNAL</th><th colspan="2">EXTERNAL</th></tr>
<tr><th>Local</th><th>National</th></tr>
<tr><td>Local Ownership</td><td rowspan="6">Cooperation between Enköping & Västerås</td><td rowspan="6">National policy framework</td></tr>
<tr><td>Local goals and targets</td></tr>
<tr><td>Political commitment and unity</td></tr>
<tr><td>Cooperation and support among actors</td></tr>
<tr><td>Landscape</td></tr>
<tr><td>District heating system</td></tr>
<tr><td>Research and technological development</td><td colspan="2">Research and technological development</td></tr>
</table>

B.6.3 Constraints

In the case of Enköping, the constraints affecting the starting of the process were mainly two, and both refer to the changes implemented at the CHP plant. On the one hand, it should be remembered that when such facility was built in 1994, the company in charge of its operation was owned by the two neighboring municipalities, Enköping and Västerås. Frequent discussions about how to share the costs and how to deal with other administrative issues were a permanent obstacle they needed to overcome (H. Österberg, personal communication, May 05, 2010). Moreover, when the Swedish electricity market was liberalized in 1996, the price of electricity became very low and the economic situation for Västerås –responsible of the electricity part of the energy production- became gradually worse (E. Johansson, personal communication, April 28, 2010). One the other hand, the second constraint was the lack of resource availability to be used at the heat and power station.

Besides these limitations, another obstacle identified by some interviewees was the constant need to improve the involved actor's benefits (E. Johansson, personal communication, April 28, 2010). In a system like the one developed in Enköping almost all the ones participating in the process need to have the right incentive to be committed to it. Such incentive can be translated in the form of economic income, like in the case of the local farmers, in the form of fulfillment of a legal obligation, like in the case of the WWT plant with the reduction of nitrogen emissions, or finally, in the form of a business opportunity. The later is particularly the case of the Energy Company.

Nowadays, the biggest constraint presents in Enköping remains more or less the same and is constituted by the need of having a profitable system with positive result for all the participating actors. Particularly, an unresolved concern in Enköping is how to maintain the profitability of the energy production system at ENA Energy after the year 2012, when green electricity certificates will not be able to be used anymore.

To conclude this discussion, an interesting finding is the fact that some elements of the system have acted as both drivers and constraints, and as both facilitating factors and constraints. This is the case of the cooperation among the municipalities, as well as of the local need for biofuel supply. Without the mutual support between Enköping and Västerås, perhaps Enköping would have just built a biofuel district heating plant. Meaning, the penalties on fossil fuel were enough reason for a change. However, without this particular facilitating factor, the national renewable-electricity investment incentive would have not been enough to force the change. All in all, the cooperation was a positive element. But at the same time, as stated above, was also the main constraint according to the people interviewed at ENA Energy AB. Finally, and with regard to the local biofuel need, the obstacle became one of the reasons of the structure Enköping's system has nowadays. It was precisely this limitation and need what triggered the development of the two unique and interesting local recycling projects.

Appendix C

KRISTIANSTAD CASE STUDY

Kristianstad is the capital of Skåne Region. More than 78,000 inhabitants live in the municipal area of around 1 300 square km. The landscape of this city is very attractive for farming activities. Agriculture and food industry are well-developed sectors. UNESCO classified Kristianstad's wetland area, Vattenrike, a Biosphere Reserve in the year 2005. Municipal efforts within climate protection affairs are mainly focused in two areas: (a) reduction of flood's risk as a protective approach, and (b) reduction of greenhouse gas emissions as a proactive approach, aiming at being a forerunner (Kristianstad, 2008a).

C.1 THE PROCESS

The energy system developed in the municipality of Kristianstad is the result of a combination of policies implemented and decisions taken by different actors. Actions performed by Kristianstad Energy Ltd (C4 Energy), by both the municipal waste and municipal WWT plants, by local politicians and, finally, by other private actors, have all been important for Kristianstad's transition towards a more secure and renewable-based energy system.

To commence with, C4 Energy has been supplying heat to the inhabitants of Kristianstad since the early 1980s, period where such energy production was based 100% on oil fuel. The construction of the existing CHP plant, Allöverket, started at the end of the 1980s and took place in three steps. The first stage commenced in 1989 when the plant was only a heating station with 2 LPG boilers. One year after, with the installation of a 5 MW biogas boiler the company began to burn biogas from the municipal landfill. In this year, 1990, the production of heat increased to 173 GWh, of which 8% was produced from biofuel. The second stage of Allöverket took place in 1994 when the CHP was constructed. Together with the starting of electricity production, 2 wood chips boilers, with a total capacity of 50 MWh, were installed. In 2001 flue gas condenser technology optimizing the system was put into operation. Finally, and as the 3rd stage of Allöverket construction, in the year 2007 a 25 MWh wood chip boiler was installed (C4 Energi, 2010). Moreover, in three villages, small-scale district heating plants using bio-fuel were established by C4 Energy during the years 2001 and 2003 (C4 Energi, 2010).

The actions performed by this municipal owned company have led to a system where 99% of the energy by them produced comes from renewable sources (H. Mattsson, personal communication, April 12, 2010). Together with the measures taken by C4 Energy, outside densely populated areas where district heating is not profitable, oil boilers has been gradually converted to pellets. In public building the municipality has converted 42 boilers from oil to pellets and 1 boiler from oil to straw between the years 1998 and 2006. Many households have also converted, partly thanks to municipal grants, their heating system from oil to pellets (Kristianstad, 2007).

From another perspective, it is important to mention the development occurred within the biogas production sector in Kristianstad. Such renewable fuel has been produced at three different locations in the municipal area: the Waste water treatment plant, the Härvöv landfill and the Biogas plant in Karpalund.

Biogas from the WWT plant: in this facility biogas has been produced since 1965, providing 7 000 MWh/year of energy. Back then, this biogas was used only for internal purposes, and since such demand was not that high, approximately 50% of the gas produced needed to be flamed (Kristianstad, 2009b). Since 1999 until now partly of the biogas production has been upgraded and used as fuel for vehicles (Kristianstad, 2009a), while the rest continue to be used for internal heating production.

Biogas from the landfill: the methane generated in Härvöv, landfill nowadays closed, has been collected and sent to the local energy plant as fuel material since the year 1989. (Kristianstad, 2009b)

Biogas from the plant in Karpalund: in December 1996 the municipal Waste management Company, Kristianstad Renhållnings AB, established a biogas plant (in an former sugar facility) with a capacity of 40 000 MWh. Karpalund plant became the first Swedish facility to co-digest organic waste from households (6%) and waste from food industry (60%), together with manure from farms (34%), for the production of useful energy and fertilizer. Karpalund's biogas is used as vehicle fuel and as fuel for heating and electricity production in the CHP plant (Kristianstad, 2009a).

As it can be appreciated, several decisions and actions have taken place for the development of the existing local biogas supply system. Table C-1 summarizes the most important steps undertaken within this area.

Table C-1 Kristianstad's biogas development

Year	Important events
1965	-production of biogas for internal heating at the local Sewage plant. Remaining is flamed
1989	-biogas generated at Härlöv landfill is sent as fuel to the district heating plant (landfill nowadays closed)
1991	-for the first time, biogas as fuel for vehicle is proposed in a motion presented by the Green political party. -two other motions address the issue of the environmental impacts of heavy traffic and the possibility of an alternative fuel -the municipality decides to establish a working group to further develop these ideas
1993	-the Central party proposes a feasibility study for a co-digestion unit at the site of a former sugar facility in Karpalund. The raw material for such unit is to be waste from food industries and households, and from manure.
1994	-the working group reports that biogas is the most environmentally friendly alternative fuel. Further studies shall be undertaken while the preconditions for the biogas plant are assessed. -in parallel the gas burnt off at the Sewage plant is seen as a resource that should be utilized
1995	-several activities to raise awareness of citizens take place: .movie "full gas into the future" .exhibition of gas bus and gas car in operation
1996	-Consultancy report shows that there is good availability of gas and a large number of potential customers -Karpalund Biogas plant is inaugurated in December
1997-1998	-the municipality seeks partners for gas sales. The chosen company is Sydgas (now E-On) -agreement is reached between the County Traffic, the municipality and Sydgas
1999	-Malamberg company builds the first Gas purification plant -Two filling stations of biogas vehicle fuel became operational. One for six buses and one for the

	public
2001	-the municipality of Kristianstad receives an EU award for their biogas efforts
2002	-gas supply system is extended -new large-bus depot at Allöverket -the municipality received another award
2003-2005	-market project aiming at introducing biogas at a local market is supported by the Swedish Energy Agency (project run by the municipality and E-On company) -the municipality films a movie about biogas (awareness raise)
2004	-digester number 2 is installed in Karpalund Biogas plant
2004-2007	-exports of biogas to neighboring municipalities is initiated (Hässleholm, Olofström, Åhus and Ystad)
2007	-second Gas purification plant is built by Malmberg at Allöverket (within the CHP territory, but not own by C4Energy company)
2009	-inauguration of filling station in Åhus -filling station unit for waste trucks is built -more exhibitions of biogas vehicles are displayed to the public

(Kristianstad, 2009b)

For the development of the biogas supply system, in particular, and Kristianstad's renewable-based energy system, in general, political involvement has been present from the beginning. Besides the concrete decisions taken within the biogas sector, in 1999 the executive committee of Kristianstad unanimous decided to become a Fossil Fuel Free Municipality by the year 2020. Since then, several actions were taken in order to address such goal; the most important ones being discussed in the following Section.

C.2 DESCRIPTION OF THE ENERGY SYSTEM

C.2.1 Energy strategy

In the aim of achieving the Fossil Fuel Free Municipality vision, in 2005 Kristianstad adopted a Climate strategy (Kristianstad, 2008b) and five complementary documents, namely: an Energy plan, a Waste management plan, and three Strategy documents for transports, agriculture and information sectors (Kristianstad, 2006). Moreover, the city council adopted several objectives in order to achieve the climate strategy (see table C-2).

Table C-2 Climate strategy objectives

Climate Strategy objectives	
By 2012	All municipal councils and companies have to take into account future climate change in its operations and planning. Adaptation refers both to reduce the risks of existing activities/ measures in building and in progress/reprogramming
By 2020	Emissions of carbon dioxide in the municipality shall be reduced by 40% compared to 1990
By 2020	Greenhouse gas emissions shall be reduced by 30% compared to 1990
By 2020	Kristianstad municipality's own operations should be fossil fuel free

(Kristianstad, 2009c)

The objectives are to be pursued targeting the following areas of action: Fossil fuel free Municipality in terms of heat and electricity; Energy efficiency; Transport; Biogas; Waste; Reduced climate impact of agriculture; Climate-food; Enhancing energy perspective in planning and improved knowledge; Adaptation; and Information for reducing greenhouse gas emissions.

Among the documents complementing the climate strategy, the Energy plan includes guidelines and objectives for the use of different fuels, for the use of energy in an efficient way, and for planning processes (Kristianstad, 2006).

C.2.2 Energy supply and energy use

The present Section provides data regarding energy supply and energy use in Kristianstad. From the information retrieved through literature review and personal interviews it was possible to obtain several figures that, although not corresponding to one specific year, provide an overview of the municipal energy balance.

In the year 2007 energy supply amounted for 2 675 GWh. Approximately 535 GWh of the energy transferred to Kristianstad in this year was from local sources, which represents about 20% of the local energy need. As it can be seen in figure C-1, out of this percentage more than 50% is covered by biofuel-based district heating energy produced by C4 Energy Company. The production of solar energy is underdeveloped up to the point that its production does not appear in the figure (Kristianstad, 2009c).

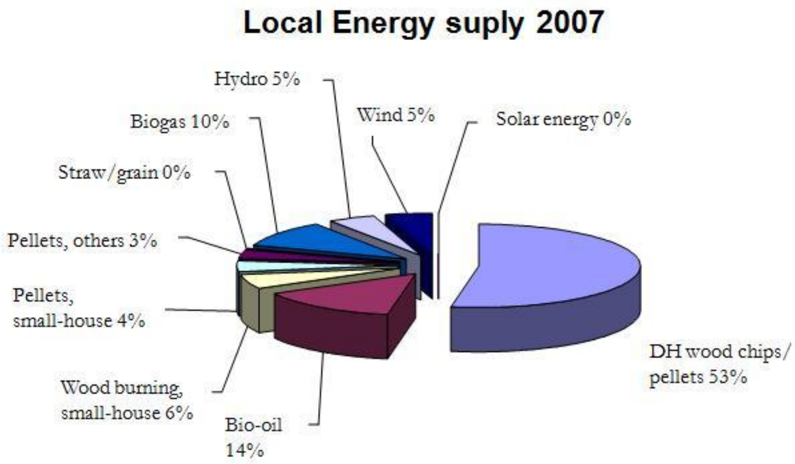

Figure C-1 Local Energy supply 2007

Specifically with regard to renewable electricity, Allöverket CHP plant has produced about 70 GWh of electricity in 2008. Wind power has been gradually expanded. By the year 2009 25 wind power stations produced 50 GWh of electricity. There are 100 more in progress, which will produce approximately 400 GWh/year of energy (Kristianstad, 2010). Moreover, a wind energy plan developed by the municipality has given a potential of 750 GWh of wind energy, figure that would cover 75% of the demand in the municipality. Concerning other renewable sources of electricity, in the locality of Torsebro there is a hydroelectric plant producing about 25 GWh of electricity per year. Finally, there is only one photovoltaic plant in Kristianstad, at Österäng, which produced about 11 MWh of electricity per year (Kristianstad, 2009c).

Shifting to the energy use side, the share of fossil fuel use in 2006 amounted to about 43%. Over 60% of that value was used in transport sector. Most of the biofuel, which accounts for about 14% of the total energy input in Kristianstad, is used for district heating production. A smaller proportion is used in about 1 350 small-scale wood burning boilers in the municipality. The small-scale pellet use in 2007 amounted to about 22 GWh (Kristianstad, 2009c). Energy use per capita has increased by 5% by 2007 compared to the year 1990. Finally, energy use has somewhat decreased at the household level, while in other sectors, such as industry, service and transportation, it has risen (Kristianstad, 2009c).

C.2.3 Heating

The municipal investment on biofuel-based district heating has been the most relevant venture Kristianstad has made until now in order to reduce local emissions of CO_2. Wood chips represent the biggest share of fuel used in the district heating system, followed by biogas produced at Härlöv landfill, Karpalund and the Sewage treatment plant. The district heating structure is gradually being expanded, and in the year 2008 approximately 11 800 dwellings were connected to the district heating network (Kristianstad, 2009c).

With regard to small houses, in 2007 direct electricity has remained the dominant source, with a share of 44%. Such percentage has however been reduced if compared to the previous year. The other heating sources are: heat pump, 29%; oil, 8%; firewood, 7%; district heating in small houses, 7%; and pellets, 5%. The number of oil-fired single-family houses has been gradually decreased and replaced by heat pumps and district heating system. In 2007 the proportion of connected houses in district heating areas was about 25% (Kristianstad, 2009c).

Also, since 1998 Kristianstad has made several investments in the municipality's own operations to reduce dependence on fossil fuels. The major improvements resulted from connecting municipal building to district heating and from –outside the network area- converting oil boilers (Kristianstad, 2009c).

C.2.4 Biogas production

As mentioned before, biogas has been produced at three different places. At Härvöv landfill, about two thirds of the methane formed is to be burned in the CHP plant. In 2008 the biogas of this facility gave about 15 000 MWh of energy, representing approximately 1 500 m3 of oil, which is equivalent to reducing CO_2 emissions by about 4 000 tones. Biogas generation in the WWT plant was approximately 8 000 MWh in 2008, which is equivalent to 800 m3 of oil and a saving of about 2 100 tons of CO_2 per year. A bit less than half of the biogas produced in this facility is upgraded and used as a vehicle fuel, while the rest (approximately 4 000 MWh) is used for internal heating. Finally, in Karpalund 40 000 MWh of biogas was produced in 2008, which means that approximately 3 500 m3 oil or gasoline could be replaced and 9 500 tons of carbon dioxide could be saved (Kristianstad, 2009d).

At present, approximately 70% of the produced biogas is used in the CHP plant while 30% is used as fuel for busses and other vehicles. In Kristianstad there are two upgrading plants, using water scrubber technique, with a combined capacity of around 50 000 MWh/year (Kristianstad 2009d). There are 24 buses and 250 other vehicles presently running on biogas in Kristianstad (Kristianstad, 2009d).

C.3 RESULTS

C.3.1 Reduction of fossil fuel carbon dioxide emissions

In 2007 CO_2 equivalent emissions in the municipality were around 516 660 tones, representing a decrease of almost 26% compared to 1990. Reductions have primarily occurred in the energy sector. The largest reduction has taken place in the energy supply sector, due to the fact that industrial and house owners have replaced oil with alternatives for heating. The expansion of biofuel-based heating has had a significant impact (Kristianstad, 2009c).

C.3.2 Energy results

The amount of energy input increased by approximately 18% between 1990 and 2007, but in recent years -2005 and 2006- a slight decline can be seen in such increasing trend. The share of fossil fuels has decreased from 57% in 1990 to 48% in 2006. Instead, the use of renewable fuel has increased (see figure C-2). In terms of renewable electricity produced locally, figure C-3 provides an overview of its development between the years 1990 and 2007.

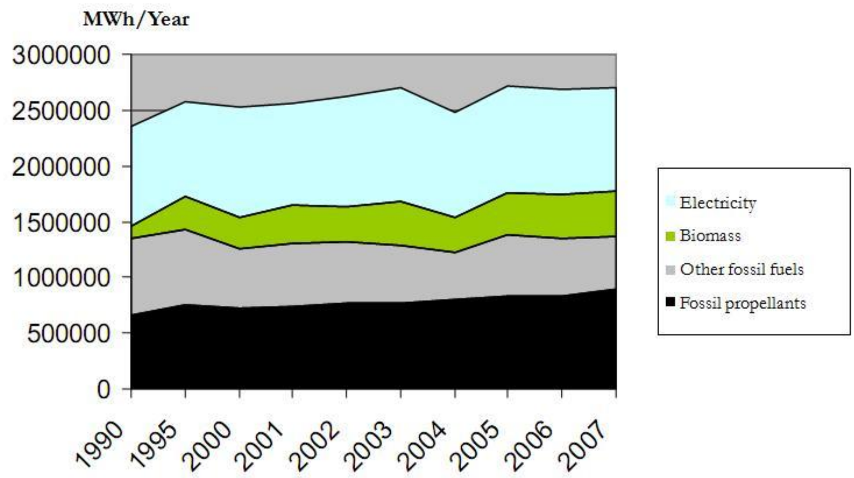

Figure C-2 Gross inputs of energy in Kristianstad 1990-2007

Source: Kristianstad, 2009c

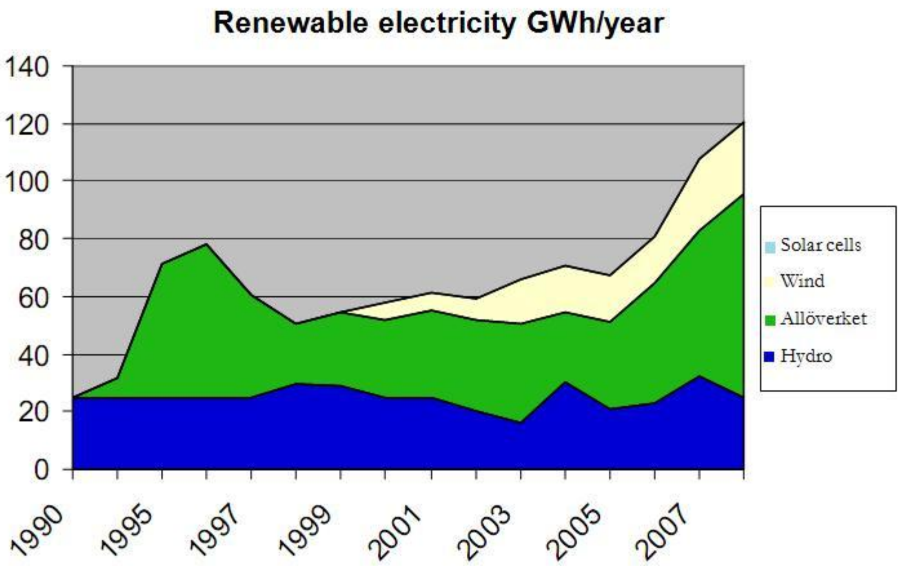

Figure C-3 Locally produced renewable electricity between 1990-2008

Source: Kristianstad, 2009c

C.4 ACTORS INVOLVED IN THE PROCESS, IMPORTANCE

In the transition undertaken by Kristianstad, the presence of key actors initiating and developing the change has been essential. As it can be seen in figure C-4 internal and external actors have participated in the process and contributed to the achievements mentioned above. Such participation has been either with an active role or with a passive but influential one. Moreover, as the biogas supply system developed in the city constitutes a particular feature of Kristianstad' case study the stakeholders cooperating in such structure are included in the figure.

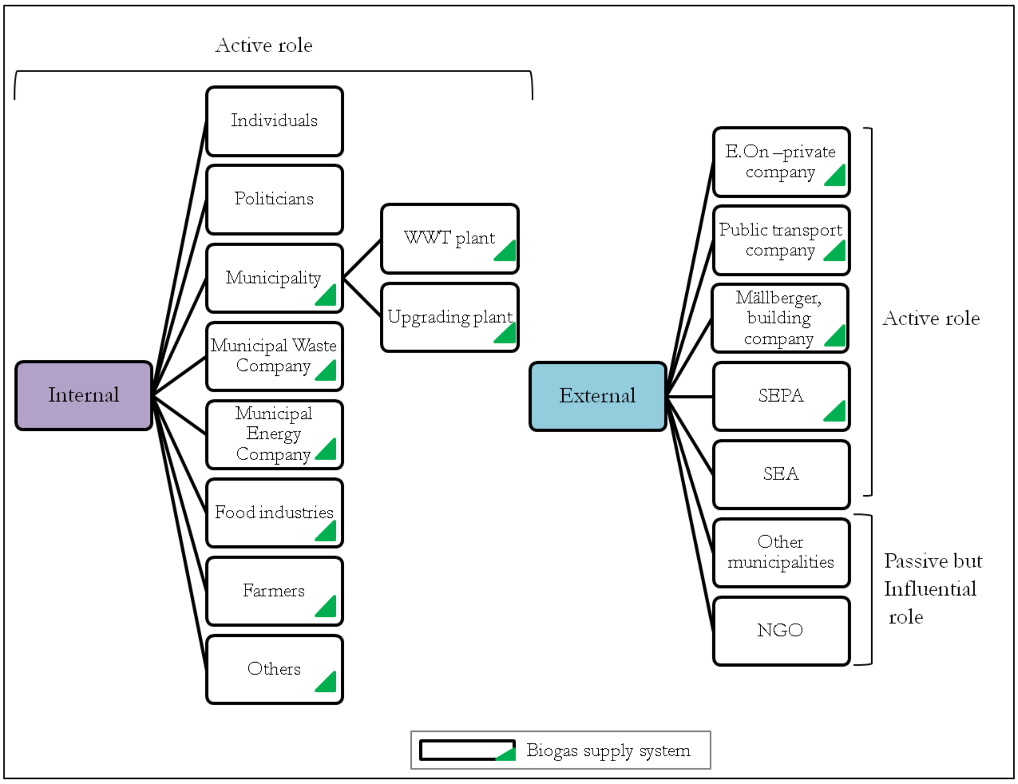

Figure C-4 Kristianstad's actors

The following local actors were identified:

Individuals: as in the case of Växjö, this term includes both engaged people and citizens'. On the one hand, the contribution of committed public servants was fundamental for the transition. Particularly, the determination of the municipal climate strategist Lennart Erfors in mimicking good local examples and developing a long-term vision has proven to be essential. In this case a bottom up initiative can be identified, as the efforts of people like Lennart Erfors led to the involvement of politicians and other actors. On the other hand, citizen's acceptance and interest on the system was identified as a factor that -although not completely present nowadays- is important for the expansion of the process. Kristianstad community was not involved in the process but it has an active role to play if its continuity is to be expected. The conversion of oil boilers, waste separation and the use of environmentally friendly vehicle fuels, for example, are all decisions to be taken by citizens and essential for a further development. Up until now constant efforts has been made by the municipality so as to create incentives for citizens to contribute to the system (L. Erfors, personal communication, April 12, 2010).

Politicians: in 1991 the Green political party proposed biogas as vehicle fuel for the first time (Kristianstad, 2009b). Since then, different public motions and decisions have revealed the existence of a strong political commitment in Kristianstad. Information exchange within the municipality and openness towards new suggestions were important elements for the unanimity present in and for the decisions taken by the politicians.

Municipality: this actor has been the one taking the lead in most of the actions developed within the energy sector. In the early decision of producing biogas for heating purposes and in the newer decision of developing a market for biogas vehicle fuel, in actions such converting oil boilers, adopting a fossil fuel free vision and seeking for national funding; in each and all of these measures the municipality has had a fundamental and pro-active role.

As part of the municipality, and particularly within biogas supply system, both the WWT plant and the two municipal Upgrading plants have contributed to a great extent to the development of such system. The following actors complete the description of those stakeholders acting in the biogas supply system at the local level:

Renhållningen Kristianstad, responsible for the collection of household refuse and that has established the Biogas plant in Karpalund;

C4 Energy, using surplus biogas in the CHP plant;

Food industries, which residues are resources for Karpalund Biogas plant;

Farmers, who cooperate with the Biogas plant providing manure (the plant's input) and receiving bio-fertilizer (plant's output). The plant pays for taking in and out the product from and to the farmers, while they pay for the fertilizer. Although such cooperation is working properly, these actors still find quite expensive to spread the fertilizer in the field (C. Lilliehöök, personal communication, April 12, 2010).

Households, responsible for separating organic waste, another input for Karpalund' plant.

It should be mentioned that the Energy Company is involved not only in the biogas supply system but in the whole energy production structure. The expansion of the district heating grid, the use of biofuel and the production of renewable electricity at the CHP plant, are examples of actions performed by this actor and that has highly contributed to the existence of a more secure local energy system. Finally, another internal actor cooperating in the system, though not with a key role, is the Municipal House Company that has participated in project related to district heating and solar heating and electricity (L. Erfors, personal communication, April 12, 2010).

Externally, it is possible to distinguish actors with an active participation, meaning acting in the energy structure via cooperation and coordination with other actors, of those that have influenced Kristianstad' transition in a passive way. In the first case, the following actors are included:

National bodies: Kristianstad has received six times grants from the Swedish Environmental Protection Agency through the participation in two types of programmes: (a) LIP –local investment programmes- between 1998 and 2002, from where approximately 630 million € were handed out to 1814 projects; and (b) KIMP –climate investment programmes- since 2003 up until now, from where approximately 195 million € were received (Kristianstad, 2008c). Also, the Swedish Energy Agency collaborates through an energy advisor that works locally providing advice to citizens and small and middle companies.

Companies: the participation of public and private companies has been particularly important in the development of the biogas supply system. The company Skånetrafiken, regional public transportation authority and operator in the south of Sweden, has expanded the biogas use in Kristianstad with the introduction of biogas buses in the city. Also, the multinational energy corporation E.ON has been involved in marketing activities to further expand the use of biogas and it is the company owning filling stations in the city. Finally, the company Mällberger has contributed with its experience in technology by building the two purification biogas plants.

With regard to the second case, the author of this thesis is referring to those actors that without having an active role have influenced the decisions made by Kristianstad. In this sense, other Swedish municipalities and the NGO Swedish Society for Nature Conservation (SSNC) have had a passive role and have been the ones inspiring and influencing Kristianstad's efforts. Particularly important for the beginning of the process was a project developed by the SSNC in 1998 called "the Challenger Communities" (L. Erfors, personal communication, April 12, 2010). The project, aiming at developing a role model of municipal sustainable development and challenging municipalities to become independent from fossil fuel, was to involve only five municipalities. Although Kristianstad worked without success to be part of the programme, this was the necessary inspiration the city needed to initiate the transition. One year after, in 1999, the political decision of becoming a fossil fuel free municipality was to be taken.

Overall, it can be concluded that the actors leading the transition and promoting the necessary changes are those acting at the local level. Their involvement, commitment, cooperation and coordination have allowed the development of the current energy system. Moreover, private and public companies acting not only locally but also regionally, nationally and even internationally (such as E.On) have positively and highly influenced and supported the expansion of the system. Finally, this case study shows how important it is to share experiences and knowledge as an inspirational tool. The transition that Växjö initiated before, as well as the ideas of an NGO involving several municipalities inspired Kristianstad and made the city mimic good examples. Table C-3 contains a summary of the findings of this Section.

Table C-3 Participation and role of actors in Växjö transition

ACTORS			Role		Participation	
	Int	**Ext**	**Key**	**Influential**	**Active**	**Passive**
Individuals	X		X		X	
Politicians	X		X		X	
Municipality	X		X		X	
Municipal Waste company					X	
Municipal Energy Company	X		X		X	
Food Industries	X				X	
Farmers	X		X		X	
Household	X		X recognized as such but not performed yet		X	
Municipal Housing company	X			X	X	
Private companies (E.On; Mällberger)		X		X	X	
Public Company		X		X	X	

(Skånetrafiken)						
SEPA		X		X	X	
SEA		X		X	X	
Other municipalities		x		X		X
NGO (SSNC)		x		X		X

C.5 IDENTIFICATION OF NETWORKS AND THEIR IMPORTANCE

Different networks operating within Kristianstad case study were identified. The municipality is member of a number of networks both at the national and international level. Locally, the municipality has formed a Climate Alliance. An informal network built by local actors was also observed (see table C-4). Finally, it should be mentioned that back in 1998 the city tried to join a regional network consisting on five leading municipalities and developed by the NGO SSNC.

Table C-4 Identification of Networks in Kristianstad

	Level	Name	Description
NETWORKS	Local	**Climate alliance**	In 2008 the municipality formed this internal network where local companies and other energy actors meet periodically to discuss new ways of reducing green house gas emissions (L. Erfors, personal communication, April 12, 2010).
		Informal network	Local informal organization built by the collaboration of the municipality, farmers, industry and consumers. Such cooperation provided different benefits: a) the opportunity to solve a waste problem for food industries, and b) the provision of raw material to the biogas plant and of bio-fertilizer to farmers.
	National	**Swedish District Heating association**	Association working on research of district heating technologies and related issues.
		Climate Municipalities Association	Association of municipalities, counties and regions actively working with local climate issues.
		Värmek	Economic association with the objective to manage the procurement of products such as fuel and heating equipment in the best way for its members. C4 Energy is member of this association.
	International	**Union of the Baltic Cities (UBC)**	Since 1995 the city has been a member of this network, which main objective is to activate the potential of its member cities for economic, social, cultural and environmentally sustainable development of the Baltic Sea Region (UBC, 2010).
		Covenant of Mayors	By belonging to this network, signatory towns and cities assume the commitment to go beyond the objectives of EU energy polity in terms of reduction in CO_2 emissions (Covenant of Mayors, 2010). The city is part of the network since September of 2009.
		Sustainable Energy Europe Campaign	Kristianstad has participated in the Sustainable Energy Europe Campaign 2005-2008 (Kristianstad, 2007).

If one aim at determining the way in which such networks has contributed to Kristianstad's transition, the following can be stated. Internally, the contribution of local networks has been to create a communication channel and a cooperative atmosphere. The Climate Alliance and the informal network present within the city have continuously contributed to the long term vision established in 1999. Shifting to the national level, organizations such as the Swedish District Heating association, Climate communities and Värmek were recognized by different interviewees as important tools for information, experience and knowledge exchange. They have, in such way, supported the development of Kristianstad's energy transition (L. Erfors, personal communication, April 12, 2010; & K. Johansson, personal communication, June 2, 2010). Finally, with regard to the international level, it was not possible to identify the role the Covenant of Mayors has in the local transition, since Kristianstad has joint this network in September of 2009. Therefore, not much action has been done (L. Erfors, personal communication, April 12, 2010). Regarding the Sustainable Energy for Europe campaign, that started in 2005 and will last until 2012, the municipal climate strategist Lenart Effors does not find an important contribution of such network for Kristianstad. The reason behind this is that the city have participated in some awards ceremonies without success. However, he recognized that the campaign could have been important if the municipality would have won an award, since such recognition is an inspiration and incentive for local actors (personal communication, April 12, 2010).

So as to conclude, few words about the importance of networks for Kristianstad's transition are hereby provided. Significant have been internal networks in terms of a making the process easier and faster via increasing cooperation among actors. Going to a higher level, although the local effort to join the regional network didn't bring the expected outcome, behind this attempt the importance of working together with other municipalities so as to undergo an smoother process can be recognized. National networks have contributed to the transition in terms of knowledge and experience exchange, and this is recognized as an important factor (L. Erfors, personal communication, April 12, 2010; & K. Johansson, personal communication, June 2, 2010). Finally, with regard to international networks, they create competition among its members and they, therefore, challenge them to go further and make better improvements (see table C-5.

Table C-5 Types and purposes of Networks in Kristianstad

Network	**Purpose it served**
International	Competition
National	Transferability of knowledge
Regional	Cooperation and coordination (potential)
Internal	Cooperation and coordination

C.6 DRIVERS, FACILITATING FACTORS AND CONSTRAINTS

This Section provides an overview of the driving forces that have led the local transition, together with those factors that have made the process easier and/or faster and those that have limited further improvements.

C.6.1 Drivers

Kristianstad' transition started at the end of 1980s. Within a time frame of almost 20 years, the forces triggering local actions towards a renewable-based energy system differed considerable if one aim at comparing factors influencing the beginning of the process from those being determinant nowadays. At the beginning, the changes made within the city (that started mainly at the Heating plant) were due to rising oil prices and concerns about the dependency on oil and energy security (L. Erfors, personal communication, April 12, 2010; & K. Johansson, personal communication, June 2, 2010). Also, considering the number of individual chimneys burning oil, there was a need to increase air quality and reduce its related health problems (L. Erfors, personal communication, April 12, 2010). After 1990s, new and different factors have been determinant for the expansion of the domestic energy system as well as for the development of other sources of electricity and the production of biogas for vehicle purposes. In this sense, international discussions about climate change challenges and the consequences it could produced locally (from drops to flows considering Kristianstad's geography) were leading factors for the adoption of the 1999' fossil fuel free vision. As influential as the previous element was the competition developed among Swedish municipalities aiming at being a front runner in environmental matters.

From the interviews performed, another important driving force present during the whole transition was identified. Economic concerns have been a key factor determining most of the actions taken in Kristianstad. Any energy alternative, such as heating energy source, electricity source or vehicle fuel, needed to be either cheaper than the fossil fuel option or provide an economic benefit or incentive for the energy actors.

C.6.2 Facilitating Factors

As follow, a list of the factors that have smoothed the process is presented:

National policy framework: most of the interviewed people have identified carbon dioxide tax and electrical green certificates as the most important national policy instruments positively influencing the process.

National grants supporting local projects: since 1997 the Swedish Environmental Protection Agency has been contributing via the provision of funding to Kristianstad' transition.

Awards: although Kristianstad has not received any international award within the energy sector, they have been good tools to raise the knowledge and involvement of politicians and public servants.

Municipal owned facilities: several facilities related to energy production are owned by the municipality, which facilitates decision making processes.

Good local tax system: about 30% of the citizens' income is collected by the municipality. With an important percentage of Kristianstad's population working and contributing to the system, there is enough money to invest in local projects without having the need to depend on external help.

Carbon dioxide concerns: the importance the issue of carbon dioxide emissions has in high political levels has helped to obtain the necessary local political agreement and actor's support.

Political unanimity: partly thanks to the previous there is an important political commitment and unanimity when it comes to environmental decision.

Local policies and long term vision: over the time the municipality has developed several policies, such as an Environmental policy and a Climate Strategy with additional strategies for specific sectors. All of them, together with the fossil fuel free vision adopted by the politicians in 1999, have been the umbrella under which several measures and actions were taken.

Biosphere reserve area: the presence of this area has allowed Kristianstad's citizens to build a special relation with nature. According to the mayor of the city, Bengy Gustaffsson, this has made easier for the municipality to implement different environmental and energy policies (B. Gustaffsson, personal communication, April 20, 2010).

Local cooperation: the collaboration and communication existing among local actors has led to the creation of an informal network that facilitates the process;

Within the Biogas supply system the following facilitating factors were identified: (a) opportunity to solve local actors' problems, such as what to do with the waste produced by food industry and farming activities; (b) the presence of a slot house both for pigs and chickens, several food industries and a landfill, all allowing to have a cheap and available raw material; (c) incentive system to influence customer's choice, such as free parking spaces, low price of biogas compared to petrol, and tax subsidies; and (d) the possibility to construct Biogas Karpalund plant in the building of an old and closed sugar plant.

All the above elements have been very important for the results experienced in Kristianstad. Either by making it easier for actors to be part of the system, or by allowing to obtaining benefits in a faster way, both internal and external factors have been positively influencing the municipal transition (see table C-6).

Table C-6 Facilitating factors identified in Kristianstad

FACILITATING FACTORS	
INTERNAL INFLUENCE	**EXTERNAL INFLUENCE**
Municipal owned facilities	National policy framework
Good local tax system	National grants
Political unanimity	Awards
Local policies and long term vision	Carbon dioxide concerns
Biosphere reserve area	
Local cooperation	
Within biogas system: ✓ business opportunity behind a problem ✓ cheap and available raw material ✓ incentive system ✓ old and closed facility available to be used	

C.6.3 Constraints

As in the previous cases studies, different obstacles needed to be overcome in Kristianstad's transition and some of them are still present, limiting further developments and improvements. The main constraint was and still is an economic one. Each actor involved in the energy system needs to find such structure profitable and convenient. Keeping such convenience up to date has been a difficult and hard challenge to achieve. Moreover, lack of citizen's involvement and awareness, lack of further improvements in the transport sector and lack of commitment as well as different priorities of some people working within the municipality (L. Erfors, personal communication, April 12, 2010) are other challenges present in this case study.

Particularly with regard to the biogas system, technical and monetary issues were constraints acting at the beginning of the process. Nowadays, the following remain as limitations of the system: (a) filling station network, which needs to be improved; (b) few available vehicle models; (c) biofuel vehicles are more expensive than traditional alternatives; (d) lack of education and training; and (e) support for suppliers of biogas, which needs to be increased.

As a concluding remark, it can be said that all factors mentioned above were limiting factors that made and make the process harder or slower. However, none of them constitutes a barrier in the system. Moreover, if some of the facilitating factors were to be reinforced, some of these limitations would not be as such. That would be the case, for example if cooperation among actors were stronger at higher levels, or if international networks were to play a more important role. All in all, as they are established nowadays, the elements leading as well as positively and negatively influencing the process cop with each other in such way that the balance and result is a very optimistic one.