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Biogas for a Distributed Development

Lessons learnt from Italian and Swedish cases

and

recommendations for Umbertide

Silvia Di Ponte

Supervisor

Tareq Emtairah

Thomas Lindhqvist

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silvia.diponte@gmail.com

Published in 2010 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

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"Dai diamanti non nasce niente, dal letame nascono i fiori" Fabrizio De Andrè

[Diamonds give rise to nothing, manure give rise to flowers"]

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Silvia

Abstract

This thesis has two values. On one side, it aims at being a contribution to a better understanding of the original concept of distributed economies. On the other side, it aspires at providing useful decision criteria to those stakeholders that plan to locally develop a biogas system.

This thesis is developed from the Distributed Economies concept, which envisions decentralized, self-reliant and synergistically networked systems of production and consumption, aiming at social well-being and quality of life. The study primarily focuses on energy, and more specifically on systems dealing with biogas from anaerobic digestion. It explores how biogas can contribute to a distributed development of an area, and how the implementation of such a system can be locally undertaken.

The research first looks into three existing biogas systems, namely, Kristianstad and Västerås in Sweden, and Camposampiero in Italy. Based on these cases, recommendations for an audience-case, which is Umbertide, in the Centre of Italy, are elaborated.

The findings underline the importance of a bottom-up and participative approach, meant to valorize local resources and to grasp context-specific opportunities.

Five factors enabling a distributed energy system have been identified, and they concern supply, demand, technology, actors and financing.

Executive Summary

The distributed economies (DE) concept argues that current production and consumption systems (in concern with food, energy and water) are vulnerable, lack of resilience and negatively impact the environment. Furthermore, such systems do not favour interconnections between consumers and producers, focusing on centralized configurations in which added value is eradicated. DE is a challenging and fascinating idea which reconsiders the incumbent patterns of development. It envisions small, local, diverse and synergistically interconnected systems of production and consumption, which have the ultimate ambition to promote social well-being and quality of life. There currently seem to be no real-life examples (in the developed world) of a fully distributed economy system. A localised biogas production system, based on anaerobic digestion, can be an example of a distributed model.

The aim of the thesis is to examine the contribution of biogas to distributed development and its implementation process in three case studies, namely, Kristianstad and Västerås in Sweden, and Camposampiero in Italy. A further purpose is to identify lessons that might be useful for an audience-case, Umbertide in the Centre of Italy. The Research Question is:

How can local actors tackle the implementation of a biogas system to enhance a Distributed Development in Umbertide?

The addressed audience is represented by local developers and academia.

This thesis is a multiple case study, investigating features of alignment to distributed development in biogas systems, and strategies adopted in tackling their implementation. Literature review, interviews and field visits have been conducted to investigate the issues.

The method used in inspecting the cases is a framework combining 9 DE criteria and the sub-processes that constitute a "transformation towards bioenergy" strategy.

The main barriers that can hinder or delay a bioenergy project are (typically) non-technical, and appear mostly during the implementation phase. National or international support is important in addressing some of the constraints. But upper level interventions need to be received and adapted to different local contexts in order to be translated into actual transformation processes. Decision-making is related to situational and context-based interpretation of actors. Local actions are important to overcome several barriers, namely economic, perceptual, organisational ones.

The above statements have been confirmed by the analysis on the three case studies. Here, the existing biogas systems, their stakeholders and the biogas implementation processes were analysed. Some of the DE features were identified, together with the main process drivers and barriers.

All the three cases are working and successful in relation to different aspects. In Kristianstad the key success factor was the ability to always include new actions and stakeholders in the process. In Västerås the key success factor was having managed to put in place a network directly benefitting many and local participants. In Camposampiero the economic viability, the exploitation of synergies and the partial acceptance of a pretty innovative technology constitute the successful elements.

A trigger or first mover that starts the biogas implementation process was noticed to be a basic condition. In the case studies there is always some actor pushed by a need that makes a number of stakeholders converge, start a debate and find a solution. In the 3 cases, different

engines moved the process forward: in the first case it was the vision itself, which is enhancing a self-reinforcing loop towards the fossil fuel free status; in the network the interconnections themselves are "independently" linking and sustaining the whole process; in Etra the internal need to improve management is leading the process. These are reasons why the three cases could be ranked as transformation through shared vision, networking and management culture. The importance of mobilizing actors and resources and communicating both the project and its results within the system and outwards was observed. A bottom-up and participative approach for intervention turned out to be essential in order to establish the system and obtain a more distributed outcome.

The analysis of the cases has been useful to elaborate 5 enabling factors to a distributed energy system. These criteria will be useful whenever a local developer intends to implement a bioenergy system, but could, in the view of the author, also be useful when analysing any system from a distributed economy perspective.

5 factors enabling a distributed energy system		
1	**Supply**	• Local • Multi-inputs • Multi-suppliers • Prioritize waste use
2	**Demand**	• for bioenergy: local or connected through grids to wider markets • for by-products: local re-cycling in the system
3	**Technology/type of production**	• aiming at system's energy efficiency and closing the resources loop • exploiting synergies • multiplicity of sources and operation
4	**Actors**	• several public and private bringing diverse expertise and resources in the system • directly involved in the supply or demand of material and non-material flows • networked, within the local system and towards the outside
5	**Finance**	• Various, external and local financial resources

In Umbertide, the municipality could extend its role of first mover and coordinator, amplifying what has already been started. It could create and add in the system a shared vision in order to connect all the local actions. It could act as a hub in the net, mediating the relationships among various participants, namely, the companies managing waste and sewage, farmers, energy companies, local industry, the slaughterhouse cooperative, and even those agencies responsible to grant permits.

Recommendations to Umbertide	
1	Start operating from local needs
2	Start from locally available sources
3	Create an informal network among many actors and engage them in a formal common project
4	Coordinate

5	Adopt a participative approach
6	Be open and transparent
7	Use several financial sources
8	Develop the system "step-by-step"
9	Amplify the pilot plant experience
10	Favour a multi-digestion scheme, not limiting the system to a co-digestion configuration

A systemic view of the whole process and context (local, national and global) is required. Broad involvement, setting up formalized partnerships, joining of networks, creation of synergies, effort in closing the resource loop, are all elements that can help the establishment of a system and its progress towards a distributed outcome.

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Abbreviations

AD – Anaerobic Digestion

ATU – Alto Tevere Umbro (Upper Tiber Valley)

CAP – Common Agricoltural Policy

CHP – Combined Heat and Power

CO_2eq – Carbon Dioxide equivalent

D Lgs – Decree

DE – Distributed Economies

ESCO – Energy Service Company

GAL – Local Action Group

GC – Green Tradable Certificates

GWh – Giga Watt hour

IIIEE – International Insitute for Industrial Environmental Ecnomics

KLIMP – Climate Investment Programmes (Sweden)

kWh –kilo Watt hour

LIP – Local Investment Programme (Sweden)

MWh – Mega Watt hour

Nm^3 – Normal Cubic Meter

PEC – Territorial Energy Plan (Piano Energetico Comprensoriale)

PER – Regional Energy Plan (Piano Energetico Regionale)

PGR – Regional Waste Plan (Piano Regionale dei Rifiuti)

ppm – parts per million

SAT – Total Availbale Land

SPS – Single Payment Scheme

toe – tonne of oil equivalent

TPES – Total Primary Energy Supply

1 Introduction

Globally, the **incumbent pattern** of production and consumption is characterised by few large scale production units relying on non-renewable resources, which linearly supply an increasing amount of homogeneous products to passive consumers. By looking at the current global food system, it is possible to observe transport of goods across the globe, generic products and alike activities not contextualized to their territory. The energy sector is characterised by the transportation of large amount of fossil fuels and electricity over long distances, few large scale production plants owned by large companies, and the reliance on a limited amount of raw materials and suppliers. A similar pattern is also experienced in the water sector.

This phenomenon is well illustrated by the energy sector in Italy. Here the Total Primary Energy Supply – TPES – was 174.5 Mtoe in 2008 (OECD/IEA, 2010). Oil represented 41% of TPES, coal 9.0% and natural gas about 36%. Further, Italy is highly dependent on imports. These constitute 25% of electricity and 89% of TPES (imports after exports) (ENEA, 2009). The significance of fossil fuel is evident even in electricity production. In 2007 the amount of electricity produced was 313.89 TWh, 82% relying on fossil fuels: 55% was generated from natural gas, 16% from coal and 11% from oil (OECD/IEA, 2010). After the challenging black out experienced in 2003, the government is currently trying to increase the country's energy security. Nonetheless, the energy company Enel, is still a dominant operator in the market, with a market share of 30% in 2009. The top 5 companies cover 65% of the production of electricity in 2009 (AEEG, 2010). Eni, the leading company in the natural gas business, covers directly 40% of the imports of natural gas and indirectly (through the system of "innovative sales") a larger share (Portatadino, 2005).

The current paradigm not only is lowering diversification and quality of life, but lacks of resilience in reacting to endogenous and external disturbance. In an era when scarcity of fossil fuels, climate change and environmental degradations are increasing, this system is exposed to risks (Biggs et al., 2010; Johansson et al., 2005).

Distributed economies (DE) is a challenging and fascinating concept which reconsiders the traditional route of development, namely, its scale, linearly and homogeneity. It approaches infrastructure and critical service systems design from a network perspective, revaluing diversity, redundancy, local resources and proximity to demand (Biggs et al., 2010). The core of distributed systems are small, flexible and synergistically interrelated units. The DE concept calls for switching regime and establishing a new link between small and large scale units (Johansson et al., 2005; Mirata et al., 2005). Under the leading aspiration of improving people's quality of life and social well-being, DE suggests more localized, networked, modular and open systems. The consequent "positive complexity" requires holistic efforts and interactions.

Even though there is no awareness of any case completely working as a distributed economy (Mirata et al., 2005), it is possible to find some systems aligned with the DE concept. Several of these belong to the energy sector. This thesis focuses on energy production systems, and in particular on one of the available technologies, namely **biogas**.

A localised biogas production system can approximate the idea of a distributed model. It could both represent one unit within a broader regional system that it is connected with, as well as show some aspects of DE in its internal organisation. Its peculiarity lies in the connections with economic activities in the locality or region, especially the ones dealing with waste and agriculture. Biogas production and consumption could represent a way to positively solve several challenges within a sustainable development paradigm.

In the following section the reader will be introduced to the aim and core question of the thesis. Later on, research method and limitations will be presented. The final part outlines the structure of the whole dissertation.

1.1 Purpose and research question

Aim:

Examine the contribution of biogas to distributed development and its implementation in three case studies. Identify lessons that might be useful for the audience case Umbertide.

Research Question:

How can local actors tackle the implementation of a biogas system to enhance a Distributed Development in Umbertide (Central Italy)?

Objectives:

1. Observe the characteristics that make the 3 biogas cases contribute to a distributed development.

2. Observe boundary conditions and strategies in implementing biogas within the case studies.

3. Present observations, opportunities and recommendations for Umbertide.

1.2 Audience

This thesis has two purposes. The first is providing suggestions to local developers. The second is giving a contribution to the DE concept.

Biogas can entail a complex system to be put in places, mainly because it can be related both to energy resource issues and to waste treatment issue. The information contained in this work can be valuable even for decision and policy makers at national level, but they are firstly addressing local level actors. The latter's decisions and actions represent a crucial determinant in the implementation of such a kind of system. In particular municipalities and companies dealing with waste management may represent the key audience. Even all the other local actors involved both in the supply side and the demand side of the system are part of the targeted audience. In the first category could be included farmers and food industries who produce large amount of organic waste or have the potential to supply additional dedicated inputs. In the second one we find energy companies and public transport companies. Each of them, once aware about the opportunity and ways to implement such a system, can play a crucial "pulling role" and lobby for a certain outcome.

Academia can be identified as a further intended reader, in particular those researchers who are interested in the DE concept or to transformation processes towards bioenergy in general and biogas in particular.

1.3 Research methodology

This research is a comparative analysis of case studies. A multiple case study was performed in an attempt both to empirically find characteristics of Distributed Economies in existing biogas systems as well as discover organisational patterns in different local transformation processes that has led to a development with some of the DE characteristics. The analysis of multiple cases is considered a proper method when exemplary outcomes have been attained and research aims at finding out reasons and ways of success in specific interventions (Yin, 2003). Three are the reviewed cases: Kristianstad (South Sweden), Västerås (Central Sweden) and Camposampiero (North Italy). They are instrumental to give recommendation to an audience-case, Umbertide (in Umbria, in the Centre of Italy), where a pilot biogas plant is going to be started. The observation of more cases intends to give a stronger foundation to final conclusions.

The used analytical model is exhaustively presented in chapter three. Briefly introducing it here, the model is a two-step framework. First, it supports in analysing the enhancement of Distributed Development connected to biogas by providing DE criteria to be checked. Second, it helps in investigating the influence of local actors on the transformation towards a biogas system aligned with Distributed Economies by organizing the process in three equally important sub-processes: problem formulation, resource mobilization and communication. The framework facilitates the organisation of "stories and lessons". It is instrumental to the comparison among the cases, whilst similarities and differences are displayed.

Once the focus problem was established and the consequent research objectives formulated, the following have been the preferred approaches to gather information.

1. Documents and literature reviews
2. Interviews
3. Field visit

Literature review concerned distributed economies concept, biogas systems, barriers for bioenergy diffusion and transformation management towards bioenergy. Moreover specific documents on the cases were consulted. The data gathering has mainly relied on research engines like ELIN, LOVISA, Google and Google Scholar. Reference lists reported at the end of the relevant article has been used too. Key documents describing the specific cases were directly provided by some of the interviewees. The work is, consequently, a combination of primary and secondary data.

Semi-structured interviews has been conducted in order to achieve a more specific and deep knowledge, especially concerning the analysed case. They concerned two levels.

"Macro-level interviews" facilitated the understanding of energy and waste context mainly in Italy, which is the country hosting the audience case. They were extremely useful even in the initial part of the research because they provided information about working co-digestion cases within Italy and Sweden.

"Micro-level interviews" were functional for understanding features and dynamics within the cases. Several were useful in gathering information on history, reasons and steps during the implementation of the several biogas cases. I tried to get even partial quantification both of some of the main resource flows, as well as environmental, business and social benefits generated by biogas. Interviews were performed to construct a description of the current setting in the audience case and comprehend the specific context there.

The interviews were conducted by phone and in person through semi-open questions functional to start in-depth discussion on contexts, actors, connections and processes. Some of the data were obtained also by mail.

The field visit in Umbertide was useful to personally gather information and know better and directly peculiarities of the area. Dealing directly with some of the main stakeholders has been a unique experience that has added value to the research.

1.4 Scope, limitations and justifications

Limitations. According to what is stated above, the framework of this study is related to the listed objectives. The collected data and the analysis are linked to the specified cases of which Kristianstad, Västerås and Camposampiero represents the geographical scope. Umbertide is the audience case, where learning will be applied. The supplied observations and recommendations are strictly interrelated to it and to the selected analytical framework.

The present work argues on local biogas systems. This term refers to local system dealing with biogas resources, supply system, conversion technology and energy demand (Sims, 2002). Biogas is taken as an example of production system that can show some of the DE elements.

Even though the research includes partial quantitative assessments, it has to be stressed that they are not the focus of the research. They are instrumental to show some of the qualitative considerations contained in this work.

Why energy? In the energy sector there are more existing examples of systems with features that can be aligned with the distributed economies concept, than in other sectors. Moreover, it is a problematic area, which attract my attention. It is highly relying on fossil fuel and centralized pattern of production and consumption. This is particularly true in the Italian context, the country my audience-case belongs to.

Why Biogas? Biogas is an interesting topic for several reasons. It is connected with many issues, like energy, waste and food. Especially in co-digestion plants, it is possible to observe the intervention of quite a lot of actors, even belonging to different economic sectors, that converge around a certain project and are interconnected through material and not-material flows and networks. The originated systems can significantly differ from each other, especially because of local factors and the many actions and choice the actors can undertake. This makes biogas an attractive subject to be investigated.

Why Umbertide? Umbertide has already initiated a process that will likely lead to biogas introduction. The municipality is going to build a biogas pilot project using slaughterhouse waste, in order to show local actors a further technology based on renewable sources.

The three **case studies** have been strategically chosen from the beginning in order to cover the 3 strategy models Mårtensson & Westerberg (2007) present. In this way I am able to observe how in practice a biogas system can be successfully established, adopting different strategies within three different contexts. The selected cases belong to Sweden and Italy.

Why Italy and Camposampiero? Due to the geographical scope of the audience case, Italy has been the area where I wanted to find an existing biogas case. Here I started to look for existing co-digestion cases, especially in the North that is the most developed part of the country, where the majority of biogas plants is located (Piccinini, 2008). I found the Camposampiero case, which not only seemed to rank in the "transformation through management", but presented some characteristics that from a rough evaluation looked in line with DE, like involvement of several stakeholders and employment of waste.

Then, in order to enlarge the Italian know-how, I decide to look at foreign experiences. Sweden was the country selected.

Why Sweden? There is interest towards the Swedish context, not only because biogas production is growing and has still a high potential (Lantz et al., 2007), but especially because of its symbiotic nature. According to Peck (Peck, 2010a&b), in Sweden the biogas system is closely correlated to waste issues. By making a comparison within two cases, the Swedish one and the German and Austrian one, it is possible to notice a clear difference: the former relies on waste and the latter on dedicated crops. In many Swedish realities, biogas plants has been built and started in order to face a local waste exigency involving one or (more frequently) more actors, like farmers, waste treatment companies, sewage companies, slaughterhouses, food industries etc… In Germany this is not the case. Biogas plants are primarily considered belonging to the energy industry. These facilities are built and the feedstock is supplied by farmers that grow dedicated crops.

Why Västerås? "The *Plant Power* project in Västerås is unique in its own way. The biogas plant is an important component of a complete system for re-cycling raw materials, waste, nutrients and energy between urban and rural areas" (SBGF & SGC, 2008). Moreover, considering the audience, the involvement of farmers that directly own and benefit from the systems make the case particularly interesting to be analysed. This case shows a pattern similar to a "transformation through networking".

Why Kristianstad? Kristianstad is located in Skåne, the region with the highest potential of biogas production in Sweden. The reason of this choice is that Kristianstad can be considered a typical example of the Swedish reality (Peck, 2010b). Or at least typicalness are the actors involved and some peculiarities. For example, Kristianstad is a self-standing reality, with its own local grid. This makes the case similar to many others in Sweden, where the methane national grid covers only a limited part of the country (Appendix 3). It is one of the most complete biogas system in the world (SBGF & SGC, 2008). Moreover, it seems to have similarities with the "transformation through shared visions" strategy. All the previous aspects has made it an attractive case to be analysed.

Delimitations. Even if this study is an attempt of a coherent work, it is delimited by some constraints. The scarcity of time and resources has played a first critical role in the organisation and outcome of the research. An additional challenge has been to find people available to be interviewed. Interviews were requested from a large number of key actors, like researchers and members of companies, even at national level. But some of them were not available during the period of investigation. Further interviews could improve the amount of data and understanding on cases and contexts. Otherwise, more contexts would have been presented in order to cover a broader sample of cases, and more people would have been interviewed in order to better understand the perspective of the many players that intervene in such a kind of system and process. One of the case study, Kristianstad, was already observed in a previous paper, as an assignment in one of the MSc in Environmental Management and Policy (EMP) courses. One of the contexts that has been very interesting to analyse is Val di Noto, in Sicily. It was one of the case studies during the Strategic Environmental Development (SED) course, within the MSc EMP, and one of my audience-case in the present research. Nevertheless, shortage of time and slowness in achieving some basic data, have led to the (formal) exclusion of the case from the thesis. In general, the lack of coherent, systemic and well organized legislative and informational systems in Italy, has been a challenge in the achievement of answers I was wondering about during the research. The mentioned limits leave room for additional future research.

1.5 Structure

Chapter two provides the thesis background. It reviews the distributed economies concept, the general peculiarities of biogas systems, biogas expansion in Sweden and Italy and theory on bioenergy barriers and transformation process towards bioenergy.

Chapter three wraps up theory and presents the analytical framework supporting to the whole research.

Chapter four presents and describes the three case studies. The aim is to provide a solid background on the current system peculiarities, the process that has been undertaken, and challenges or conditions that has enabled their development.

Chapter five is the section where the three cases are analysed and matched with the analytical framework. A case by case examination try to clearly highlights DE characteristics in each of the cases, the boundary conditions and the three different strategies adopted in realizing the biogas system.

Chapter six shows the current Umbertide's context, including actors, resources, networks and institutional setting. Moreover it describes the pilot plant that is going to be implemented.

Chapter seven represents the arena of discussion, where observations and recommendations for Umbertide are drawn.

Finally, the thesis is concluded illustrating the main findings and some suggestions for further research.

2 Litterature review

2.1 The concept of distributed economies

The Distributed Economies (DE) concept envisions decentralized, self-reliant and synergistically networked systems of production and consumption, which benefit social well-being and quality of life (Johansson et al. 2003).

The concept is not new. Distributed methods of production and consumption were common before large scale units became the competitive way to deliver services and products (McCormick, 2008). Furthermore, the notions of "localization" and "islands of sustainability", argued in scientific discussions, have a similar approach. Though, the latter concentrate more on environment and social well-being. The former focus more on economic feasibility of such schemes, still keeping in consideration consequences on environment and society under the incumbent system (Johansson et al., 2003).

The concept of Distributed Economies is increasingly catching attention. It represents a way to rethink the organisation of a sustainable economy (Ryan, 2009). The current system is at risk. It is based on big scale units, linear and vertical connections (not cyclic), excessive use of non-renewables resources and a footprint of production and consumption enlarging more and more. It is progressively detaching from consumers and focusing on efficiency at quality expense. The risk is intrinsic in its lack of flexibility and ability to promptly react to endogenous and external stimuli (Biggs et al., 2010; Johansson et al., 2005). Moreover, the increasing scarcity of fossil fuels, the progressing of climate change and the increasing of environmental degradation are enlarging the hazard (Biggs et al., 2010; Johansson et al. 2005). To summarize, the negative effects related to the traditional pattern of development can be listed as follows (Daly, 2009; Johansson et al., 2005; Folke et al., 2002; Lovins & Lovins, 1982):

- a vulnerable system that lacks of resilience
- negative impacts on the environment, that turn to be limits for growth themselves
- lack of active interconnection between consumers and producers
- value creation is centralized and "exported" far from where it was generated

Cleaner technology, pollution prevention and eco-efficiency strategies, whose ultimate purpose is uncouple growth and resource consumption, have successfully addressed some environmental issues. But they are unable to reduce the overall environmental impact of the production-consumption system. Rebound effect can represent one of the explanations to the previous statement (Biggs et al., 2010; Johansson et al., 2005; Johansson, 1992).

Not incremental enhancements but radical changes "at the regime level", revolutionary restructuring and a new mindset are needed to pursue sustainability (Ryan, 2008; Smith et al., 2005; Rotmans & Kemp, 2001).

Distributed economies reconsider the traditional route of development, namely, its scale, linearly and homogeneity. It approaches infrastructure and critical service systems (supplying energy, water and food) design from a network perspective, revaluing diversity, redundancy, local resources and proximity to demand (Biggs et al., 2010).

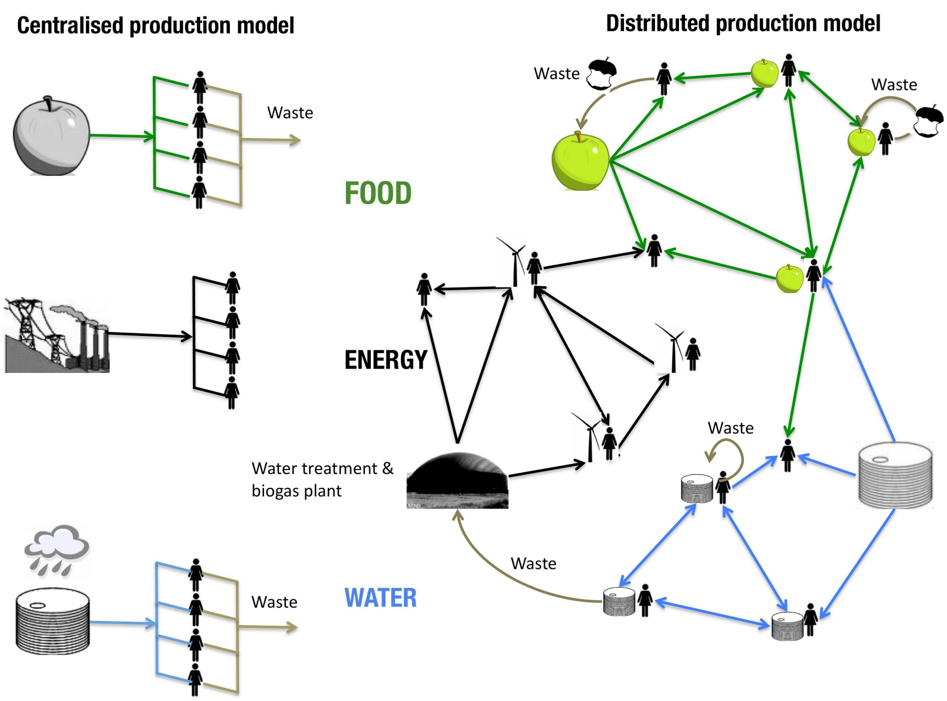

Figure 2-1 Contrasting centralized and distributed systems

Source: Biggs et al. (2010)

Main areas of concern in DE are (Johansson et al., 2005):

- wealth for a larger number of people
- quality before efficiency
- heterarchies and open innovations
- flexible small-scale production systems
- unique consumers (because of several needs and wants)
- symbiosis instead of competition
- social, economic and ecological diversity is prerequisite to avoid fragility and gain efficiency in production systems
- life quality "included" in development
- integration between design and innovation
- advantage through social and ecological capital
- renewed relation and coexistence between the large and small scale production systems
- individual initiatives within collaborations

Summarizing the above statements, the main features of distribute systems are **localization**, **networking**, modularity and openness (Biggs et al., 2010). The concept promotes small units, local resources, active interconnections, **multiplicity** and **variety**.

The emphasis is on using local resources (material and "not-material"), and locally maintaining both resources and related benefits. The system centres more on symbiotic interactions than on participants' competitive behaviours (Johnson, 2000). But this does not denote economic or geographic isolation with respect to horizontal (other activities in the local contexts) and vertical (national and global) levels. On the contrary, flows of information, know-how and high quality material are crucial (Johansson et al., 2003). The aspiration is distribution instead of decentralization, because large scale units and upper level networks still remain an important component the new concept wants to integrate with (Ryan, 2009; Mirata et al., 2005).

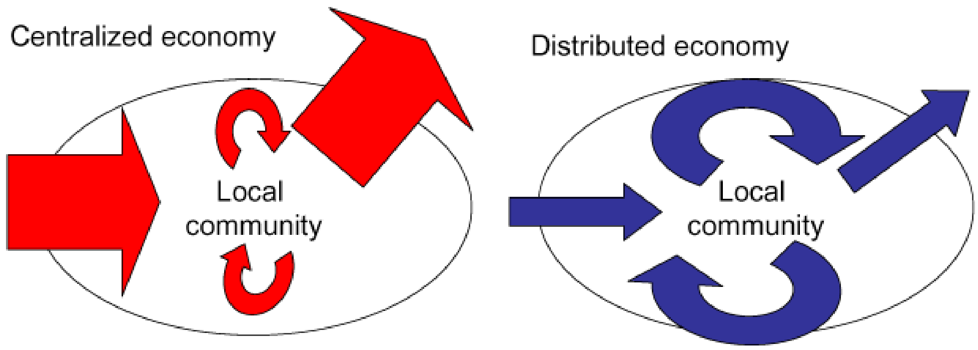

Figure 2-2 Mass flow in centralized and distributed economy

Source: Johansson et al.(2003)

Technology advancement and innovation are even more increasing the interest in this idea. A tangible way to start intervening can be "amplifying emerging paradigm shift" (Ryan, 2008).

2.2 Biogas aligned with distributed economies

There is no awareness of any case completely working as a distributed economy (Mirata et al., 2005). Nevertheless, for research and decision-making purposes, it can be useful to discuss DE aspects in existing systems. In this thesis the focus is within the energy sector, and in particular on biogas.

A localised biogas production system can approximate the idea of a distributed model. It could both represent one unit within a broader regional system, which is connected with, and even show some aspect of DE in its internal organisation. It is usually linked to other economic activities in the locality or region. Its peculiarity lies in the recurring connections with the waste system and food system. Biogas production and consumption can offer ways to positively solve several of the challenges that can be encountered in the process towards a sustainable development By using biogas, consumption of fossil fuels can be reduced. This can contribute not only to a reduction of carbon dioxide emission, but it is also an option for improving energy diversification and security of a country. Biogas represents an additional technique for waste treatment. The anaerobic digestion of organic waste reduces the amount of waste to be composted, incinerated or directed to landfills, and the methane emissions related to the latter practice. Moreover, it can run on local resources. Transportation of fossil fuels (and possible leakages) over long distances can be avoided, and job opportunities can arise locally. High transportation cost for sludge, reduction of odour, costs for waste handling for society and industry, commitment to reduce greenhouse gases, energy security issues, can be all determinants that push for the biogas implementation.

2.2.1 Anaerobic digestion and some of the peculiarities in Sweden and Italy

Biogas originates from decomposition of organic matter in an oxygen-free environment. This process, named anaerobic digestion, can take place spontaneously in nature. Otherwise, it can occur in a biogas facility. Here the organic material to be decomposed (**feedstock** or substrate) is placed or pumped in a digestion chamber (reactor or **digester**), where, in absence of oxygen, a biochemical process take place generating a methane-rich **gas** and a nutrient-rich residue (bio-manure or **digestate**). The content of methane can vary in relation to the conditions during the production process. Biogas usually contains 45-85% methane and 15%-45% carbon dioxide. The excess of ammonia (for example, from pig manure) can inhibit the conversion process and requires the addition of substances less rich of nitrogen to maintain an optimum Carnon to Nitrogen ratio (C:N). The feedstock can be constituted by sewage sludge, manure, agricultural crop or by-products and food waste. In case of co-digestion, a mix of substrates feeds the process and a higher methane content can be achieved.

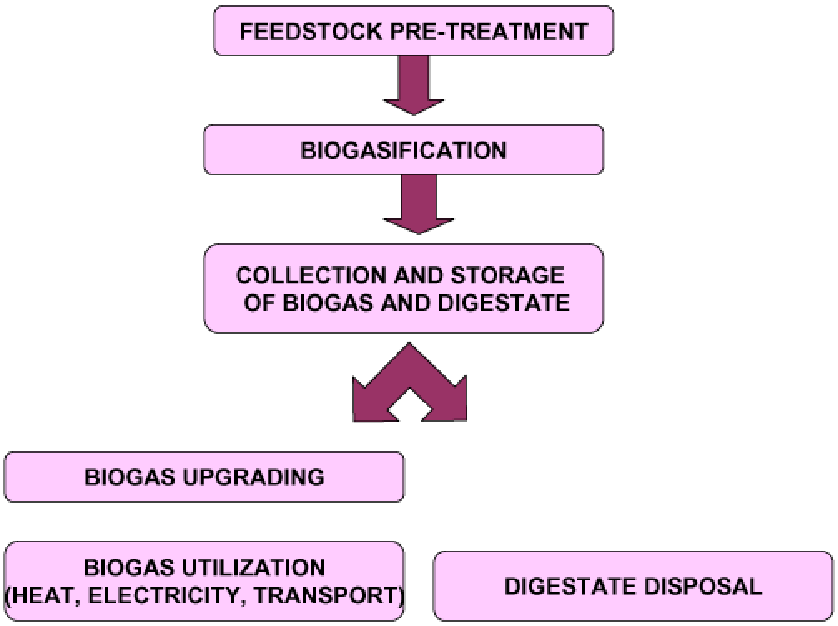

Figure 2-3 Key steps within the biogas process

The biogas plant has to be designed and developed in connection with some factors, like the type and volume of feedstock, seasonal variation, fertilizer requirements, biogas quality requirements, compression and pumping technology and minimization of technical problems. The retention time, that is the span the substrate is left in the reactor, varies between 10 and 40 days. Mixing of the digester content is important to maintain a certain temperature and a homogeneous feedstock, and avoid settlement of solid and crust formation. The biogas can be used to produce heat, just by removing the water vapour from it. Alternatives are the Combined Heat and Power (CHP) production or the use as a vehicle fuel, which requires upgrading. The gas can be even injected in the gas grid, a possibility that removes the problem of looking for an adequate demand. The digestate can be utilized as soil fertilizer, if not containing contaminants (SBGC & SGC, 2008).

European biogas production was about 5.9 Mtoe in 2007 (Table 2-1). In Italy biogas is mainly generated by landfills, even if an increasing amount has been produced by agricultural plants. Only 9 facilities deal with urban biowaste (alone or in co-digestion) out of the total 306 existing plants (the total does not include plants using biogas gathered from landfills) (Piccinini, 2008). In 2008, there are 227 biogas plants in Sweden, out of which 138 sewage treatment plants, 18 co-digestion plants and 8 small scale farm plants (SBGC & SGC, 2008).

Table 2-1 Primary energy production of biogas in the EU in 2007 (ktoe) (estimate)

	Landfill gas	Sewage sludge gas	Other biogases	Total Energy
Italy	357.7 (88%)	1	47.5 (12%)	406.2
Sweden	9.2 (34%)	17.1 (63%)	0.8 (3%)	27.2
EU	2,905.2 (49%)	887.2 (15)	2,108.0 (36%)	5,901.2

Other biogases: Decentralised agricultural plants, municipal solid waste methanisation plants, centralized codigestion plants.

Source: EurObserv'ER (2008)

Table 2-2 Gross electricity production from biogas in EU in 2007 (GWh) (estimate)

	Electricity plants only	CHP	Total electricity
Italy	1,125.6	256.3	1,381.9
Sweden	-	46.3	46.3
EU	8,297.7	11,639.5	19,937.2

Source: EurObserv'ER (2008)

In Italy biogas is mainly used for electricity production. There is no production from "heat plant only", and the small amount of heat comes from CHP plants (41 ktoe). There is no significant biogas utilization as a vehicle fuel.

On the contrary, beyond using biogas in cogeneration or just for heat production, the interest is towards biomethane in Sweden. Despite the still small amount of produced biogas, Sweden is known as a leading country in the world for the use of it is as a vehicle fuel. In 2007 there were 37 scrubbers in operation to get biomethane. In the same year sales for automobile fuel (28 million Nm^3) were higher than the natural gas ones (25 million Nm^3) (EurObserv' ER, 2008).

2.3 Key barriers for bioenergy in Europe

Bioenergy is one type of renewable energy. The term refers to energy generated from biofuels. Biofuel is a solid, liquid or gaseous fuel deriving from biomass. Biogas belongs to this category. Biomass is any material with biological origin, not significantly processed by chemical or biological treatment (McCormick & Kåberger, 2005). There are many kinds of biomass, encompassing biowaste, and agricultural and forestry products and by-products. Energy can be in the form of electricity, heat or vehicle fuel. The potential of bioenergy is underexploited all over Europe, and the same is happening for biogas (Colonna et al., 2009; Lantz et al., 2007). The literature shows and analyses some of the barriers that can impede the development and diffusion of bioenergy systems. As McCormick & Kåberger (2007) specify in their article, barrier is a metaphor to refer to those constraints that influence to a certain extent the implementation and development of a bioenergy system. The main barriers that can hinder or delay a bioenergy project are non-technical rather than technical, and appear mostly during the implementation phase (Rösch & Kaltschmitt, 1999; Roos et al., 1999).

Table 2-3 Barriers for bioenergy

Barriers	Source
• Market failure/imperfection • Market distortion • Economic and financial • Institutional • Technical • Social and cultural • Other (Uncertain policies, lack of infrastructure ..)	**Painuly (2001)**
• Integration (with other economic activities) • Scale effect • Competition with other business • National policy • Local policy and opinion	**Roos et al. (1999)**
• Financial • Administrative • Organisational and infrastructural • Perceptual	**Rösch & Kaltschmitt (1999)**
• Economic conditions • Know-how and institutional capacity • Supply chain co-ordination	**McCormick & Kåberger (2007)**

Rösch & Kaltschmitt (1999) claim that some of the difficulties may arise in relation to economic viability and market risks. Asking for insuring or funding both to private and to public actors or lack of governmental support can represent crucial negative issues. Additional challenges can be embodied by adverse legal and administrative requirements, like the obtainment of specific permits to be operative, by the lack of knowledge and proper ways to transmit information or even by weak links and connections among the several actors. Also negative perception by the broad public or authorities and politicians can act like impediments to the spreading of a bioenergy system.

Policy, and tools at its disposal, can try to address part of the barriers. Europe has intervened through several policies in order to catalyze bioenergy expansion, but it remains a member states responsibility. Indications within energy, climate, agriculture and waste areas can all affect the expansion of bioenergy in general and biogas in particular.

The Green Paper from the European Commission (2008) aims at improving biowaste management. It mentions anaerobic digestion as a possible **waste** treatment. The Paper is in line with the effort started in the past with the Landfill Directive (1999), which intended to divert biowaste from landfill and reduce the negative environmental effect from landfills.

In 1997, the White Paper introduced a community strategy on renewable **energy**, aiming at establishing a minimum penetration (12%) of renewables on the total energy sources. It called for an effort in each of the renewable sectors (wind, solar, biomass…). In 2000 was enacted the Green Paper "Towards a European strategy for the security of energy supply". It was the consequence of an evident weakness intrinsic in the European energy system, namely the large reliance on imports (which cover 50% of the energy needs), further highlighted by a sharp rise of oil price at the end of 2000. Two crucial directives were the 2001/77/EC, dealing with electricity production from renewable sources and the 2003/30/EC promoting biofuels for transport. The former sets the objective to cover with renewables 21% of the electricity production in Europe in 2010, the latest a minimum percentage of biofuels to replace diesel or petrol in national market (2% by 2005 and 5.75% by 2010), in order to tackle carbon dioxide and other pollutants harmful for health and environment. It is within this framework that in many countries have been introduced feed-in-tariff and Green Tradable Certificates. In 2009 the Directive 2009/28/EC has created a common framework for energy from renewable resources. It has repealed the 2001/77 and 2003/30 Directives. Each member is assigned a target, with renewable that has to account at least for 10% of final energy consumption in the transport sector by 2020. The effort within the Kyoto Protocol is in line with those actions. The related European Climate Change Programme and the establishment of the Emission Trading Scheme are executions of this commitment.

The Common Agricultural Policy (CAP) supports both supply of bioenergy from **agriculture** and forestry as well as the use of it in farms (European Commission Agriculture and Rural Development, 2010). The CAP reform in 2003 introduces a system of decoupling support payment from output for each farm. It introduces the Single Payment Scheme – SPS – that combines a number of existing financial supports in one. The reform reinforces the already existing set-aside scheme that was introduced in 1992 to favour the utilization of land for non-food purposes, like energy crop production. The reform assures a further support to crops for energy use (European Commission for Agriculture, 2003).

Policies and incentives constitute an important driver for bioenergy introduction. But they need to be received and adapted to different local contexts in order to be translated into actual transformation processes. According to Mårtensson & Westerberg (2007) decision-making is related to situational and context-based interpretation of actors. The stakeholders' values, relations and positions in an organisation or network and the structure itself of an organisation or network, have great impact on decisions and work organisation. Their action is not only correlated to national and international policies, but to further contextual elements, like the position of the different actors, the way the infrastructure is owned and geographical peculiarities. Thus, in understanding how the local bioenergy systems transform, it is crucial to have clear how the local reality works and how in the local context opportunities are perceived.

3 A model to examine distributed energy systems

3.1 First part of the analytical framework: the strategy

In order to analyse the process that local actors can undertake in implementing a biogas system, it will be broken down in three sub-processes: problem formulation, mobilization and communication (Table 3-1). This organisational framework is contained in the article by Mårtensson & Westerberg (2007).

In the problem formulation some new exigencies call for a change; a problem and its possible solutions are identified. In the mobilization, actors, networks and the whole system are activated and the work is organized. The communication includes activities to spread and share the process and its outcome.

Table 3-1 Three steps in the process of transformation towards bioenergy

Problem formulation	"how the problems and its solutions are understood and related to one another"
Mobilization	how both existing and new actors (and their resources), networks and structures are activated and organized
Communication	"how the process of change is organized and communicated"

Source: Elaboration from Mårtensson & Westerberg (2007)

By thinking of the decision-making as a contextual and situational practice, the process of change in the energy sector is seen as a progressively developing strategy. The meaning given to the concept of strategy is "a way to position the present in relation to a desired future" (Mårtensson & Westerberg, 2007, p.6096). This perspective was originally created by Mintzberg (1988), who associated strategy development to a process involving negotiations, compromises and many actors, where the organisation has continuously to be reviewed and updated. The planned strategy changes during the process, and at the end the realized strategy differs from the initial one (Mintzberg, 1988). Mårtensson & Westerberg (2007) present a framework which contains 3 possible strategies to implement a bioenergy system at a local level (Table 3-2).

Table 3-2 Summary of the three strategies

Transformation through shared visions	"Supports a visualization of the specific value chains connecting bioenergy to local resources, industries and markets, knowledge and identities". It may include actors not directly involved in the building of the system.
Transformation through management	Helps the actors to socially legitimize large investments in situation where bioenergy is not yet established.
Transformation through networking	"Focuses on the possibilities to connect local actors with different resourses to build a mutual energy system". It usually includes actors directly involved in the energy system.

Source: Elaboration from Mårtensson & Westerberg (2007)

When the sub-processes are put in the reality, they develop in a way that reflects what are the existing actors, structures conditions and relations between the stakeholders. Such a kind of structure is particularly relevant because it is appropriate in describing a micro level case and a local process, aspects this research is aiming to analyse.

3.2 Second part of the analytical framework: DE criteria

In order to describe the characteristics of Distributed Development through biogas, I am going to explore the relevance of the following **DE Criteria** in the 3 cases. The formulation of the criteria is mostly relying on the article "Production systems aligned with distributed economies: Examples from energy and biomass sector" by Mirata et al. (2005).

	9 'Distributed Economies' Criteria
1	Increasing the share of renewable resources in economic activities
2	Decreasing pollution and waste generation (even shorter distances and "prosumers"
3	Increasing the 'sustainable use of' and 'value addition to' local resources in economic activities
4	Increasing the share of added value benefits retained locally
5	Increasing the diversity and flexibility of economic activities
6	Intensifying connections through non-material vertical flows
7	Intensifying connections through added value material outbound flows
8	Engaging diverse actors in material and non-material flows within the system
9	Contributing to satisfy local needs

The structure contained in the article I am referring to has been partially modified. Criterion 1 represents the core of distributed economies and in general sustainable development. Through point 2, the localization peculiarity is going to be stressed. By cutting distances, a system can better contribute to diminishing overall pollution, not only the local one. Moreover it tries to make explicitly evident the importance of consumers, which should not merely receive packaged solutions coming from the top, but can have an active role in finding solutions for themselves. Prosumers (concept created by Kotler in 1986) together with the general aim to cut distances are sort of the essence of the DE concept. Criteria 3 and 4 stress on the valorisation of local resources and the crucial role of economic viability. Without positive feedbacks from empiric experience on the viability of such projects, even the economic one, it is difficult to keep on thinking that this concept could really represent an alternative to the incumbent paradigm. Furthermore it is the local retention of benefits that contributes both to trigger the change and boost it. Statement 5 is an attempt to show the relevance of diversity for the general flexibility of a system. Point 6 aims at making clear the crucial role communication plays in the organisation of transformation as well as in the well-working of a system. Together with criteria 7 and 8, they point out that relations with the ouside of a system should be focused more on non-material flows or be limited to high value flows, in order to reduce the overall impact on the environment and enlarge the positive interconnections among systems and scale, which can generate reinforcing feedback loops. Finally criterion 9 is a sort of memorandum underlining that interventions in a context should take in full consideration the environment hosting them.

In the next chapter I am going to present three case studies, where a biogas system is in place. In Chapter 5 I will analyse the three by following the framework displayed above. Looking at the implementation and development occurred, I will highlight the main local actions to overcome barriers for biogas implementation and the consequences of these action for a Distributed Development in the three cases.

4 Three local biogas cases

4.1 The biogas system in Kristianstad

The system in Kristianstad illustrates how a change towards bioenergy can be implemented "trough shared vision", which acts like a glue in the system. Furthermore it displays some peculiarities of alignment to the DE concept; consequence of an intense and participated local process, still open towards the outside.

Kristianstad is a town situated in the region Skåne, in the South of Sweden. About 77,000 people live in the municipal area. Good farming conditions, high level of mechanization and investment in research and development have made this place one of the major food centres of Sweden. Today the town is hosting a complex and well-developed biogas system (Kristianstad Municipality, 2009a). The establishment and enlargement of the system has been strictly related to the Kristianstad municipality's declaration of commitment to become Fossil Fuel Free in 1999. Two of the most significant actions to fulfill such a challenging target have been to employ both biomass and biogas: the former for running the combined power and heating plant – CHP – in Allöverket, and the latter as a fuel for local buses and other vehicles.

4.1.1 Key features of the system

Biogas is produced in three different locations: the landfill, the waste water treatment plant and the biogas plant in Karpalund (Table 4-1).

Table 4-1 Yearly inputs and outputs in the Kristianstad biogas system.

Substarte (biogas plant)	
Source-sorted food waste	5,500 tonnes
Slaughterhouse waste	35,000 tonnes
Liquid manure	22,000 tonnes
Other	11,000 tonnes
Total	73,500 tonnes
Produced Biogas	
From the biogas plant	40,000 MWh
From the sewage treatment plant	6,000 MWh
Upgraded biogas	About 50% of the biogas & sewage plant productions
From the landfill	13,000 MWh
Bio-manure:	
Liquid bio-manure	63,000 tonnes

Source: SBGF & SGC (2008)

The landfill. Since 1989, the biogas generated by the Härvöv landfill has been collected by a pipe system (about 13,000 MWh/year). In the beginning it was flared off but since 1995 it has been incinerated in the district heating plant, together with some of the gas produced in

Karpalund (Kristianstad Municipality, 2006). Today the landfill is closed, thus the gas production is expected to decrease over time.

The waste water treatment plant. The biogas deriving from operations in the sewage plant (about 7,000 MWh/year) is mainly employed for internal heating production. Since the 1st November 1999 part of it (3,000 MWh) is upgraded to be employed as a vehicle fuel (Erfors, 2009).

The biogas plant. Here, anaerobic digestion generates approximately 40,000 MWh/year. Thanks to such an amount, a theoretical use of approximately 4,000 m^3 oil or gasoline can be avoided and 11,000 tonnes of carbon dioxide will not be emitted.

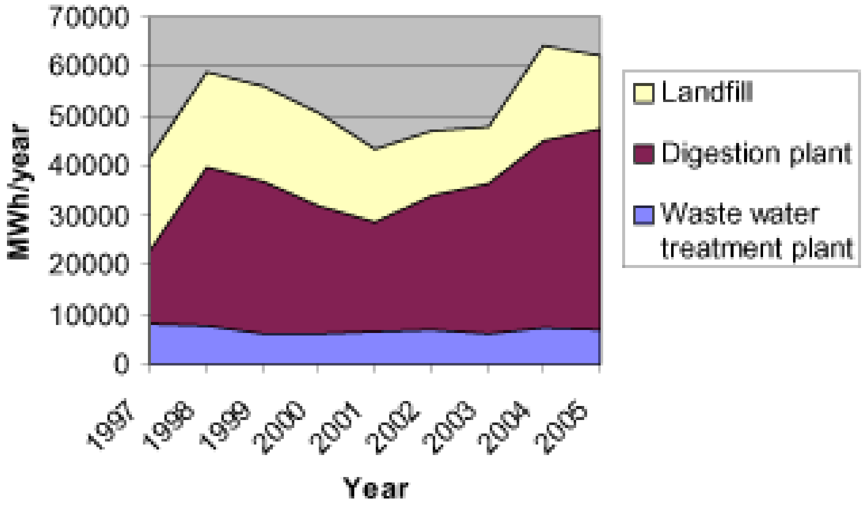

Figure 4-1 Biogas production in Kristianstad, 1997-2005

Source: Kristianstad Municipality (2006)

Production of biogas in Karpalund was started in 1997 by the Municipal Waste Management Company (Kristianstads Renhållnings AB, KRAB). Its capacity has been doubled in 2004 (Table 4-2). Nowadays, the co-digestion of a diversified feedstock takes place: sorted municipal solid waste from households (6%), food industry waste (from slaughterhouses, distilleries and dairies, 60%) and manure (34%) constitute the substrate in Kristianstad. Several and different actors jointly supply the input to the plant, namely, farmers, industry and citizens. Co-digestion occurs in two reactors where substrate is continuously mixed and processed. Retention time in the reactor is 22 days. The plant is able to process an amount of feedstock in the range of 80,000 and 100,000 tonnes yearly. The raw material is firstly treated with a magnetic separator and a fine mill, secondly moved in the mixing tank for 3-7 days, pasteurized at 70° in three parallel chambers and finally placed in the digester (SBGF & SGC, 2008). Since 1999 an increasing share of gas is further treated and upgraded to vehicle fuel. Today two water scrubbers upgrade the raw biogas by absorbing carbon dioxide – CO_2 – through pressurized water (Table 4-2). After the treatment, the content of methane – CH_4 – reaches about 97% of the volume. Biogas from Karpalund is moved through 10 km long pipelines to the upgrading plants.

Table 4-2 Data on the biogas plant in Karpalund.

Start year	1996
Digester volume	4,000 m^3 and 4,500 m^3
Process temperature	38° C
Start year Upgrading	1999 and 2007
Upgrading method	Water wash
Total investment costs	Approximately 11 million EUR (107 million SEK)

Source: SBGF & SGC (2008)

In 2009, 50% of the overall produced biogas was upgraded and used in the transport sector, while the remaining 50% was incinerated in the CHP plant. This share is progressively moving towards the use as a vehicle fuel. The reason is that not only the CHP system is relying on biomass as its dominating source, but also it is economically more profitable to use the produced biogas in the transport sector than for the heating (Erfors, 2010). The upgraded biogas is sold to the company E.ON. One of the main final users is the public transport company, Skånetrafiken, which has introduced buses running on it (the number of buses today are 26). 250 additional vehicles are running on biogas. Some of them are private companies and households' vehicles, whilst a car pooling fleet has been introduced by the municipality for its employees. Because the production exceeds the local demand, part of the biogas is exported to filling stations in nearby towns, like Ystad, Olofström and Hässleholm. Once out from the reactors, digestate is passed through two screw sieves where residues, like plastics, are removed. Water in excess is sent back in the production process. The bio-manure is stored in a tank where it is mixed. The certified manure is given back to the farmers that provide the raw material, and is used like a fertilizer. The substances enclosed in each ton of bio-manure are 55 kg of nitrogen, 4.5 kg of phosphorous and 16.5 kg of potassium.

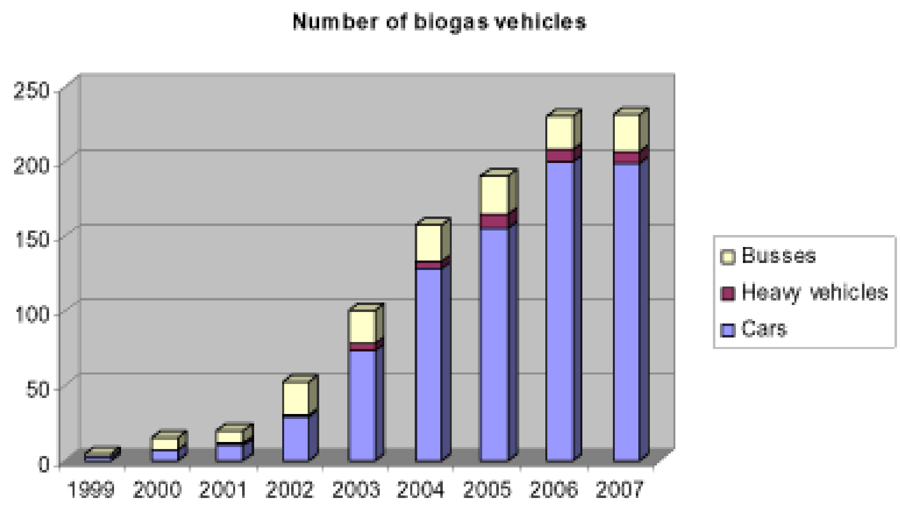

Figure 4-2 Number of biogas vehicles in Kristianstad

Source: Kristianstad Municipality (2009b)

The investment cost has been approximately 11 million EUR (107 million SEK), up to 2007. About 18% has been financed through state grants, within the Swedish initiative Climate Investment Programs KLIMP, and its precursor LIP. It is estimated that the plant will become economically viable in the long term, especially in parallel to a progressive expansion of the demand for the biogas as vehicle fuel (SBGF & SGC, 2008) .

Table 4-3 Stakeholders in the Kristianstad biogas system

Actor and networks	Role
Municipality of Kristianstad	Leading and supporting actor in the whole process. Creator of the fossil fuel free vision. Owner of key facilities, like waste water treatment plant and upgrading facilities, Directly taking care of car pooling, visits to the plant, participation in national and international conferences.
Renhållningen Kristianstad	The municipal waste management company has established the biogas plant in Karpalund (100% owned by the municipality)and collects the households' food waste.
C4 Energy	The municipal energy company (owned by the municipality) uses the surplus biogas in the CHP plant and takes care of extension of the district heating net.
The municipal department for technique	It is running the sewage treatment plant
Food industry	The main input supplier for the AD plant.
Farmers	They provide manure and collect digestate. The plant pays for transportation to and from farms, while farmers pay for bio- fertilizer. Nevertheless the cooperation is performing properly, still is quite expensive to spread the fertilizer on fields.
E.ON	The private energy company, owner of the filling stations and partner in biogas marketing
Skanetrafiken	The public transport company
Car dealers	Important in expanding bio-methane market
People	a) Some champions, like local visionary decision makers, promoting biogas within the institutions; b) Citizens positively reacting to the existence of such a system in their territory, by not opposing it or actively participating in the system (separating food waste and buying/using cars) both on the input and output side.
Municipality Ystad, Olofström and Hässleholm	Receiving part of the biogas
Krüger A/S	Biogas facilities contractor
Malmberg	Upgrading facilities contractor
Biogas Syd	A regional network aiming at increasing biomethane production, distribution and consumption.
Covenant of Mayors, Sustainable Energy Europe Campaign	International initiative the municipality has recently taken part
SEPA	Swedish Environmental Protection Agency providing financing , through LIP and KLIMP programs
Other national and local authorities involved in giving permits for plant construction	

Today, beyond being involved in some international initiatives, like Covenant of Mayors or Sustainable Energy Europe Campaign, Kristianstad is part of the regional network Biogas Syd. Biogas Syd is a joint project between private and public actors, whose purpose is working strategically and actively to increase both the production and use of biogas in Skåne Region.

Their objective is to increase opportunities for biogas both on production and demand side. In particular they promote use of bio-methane as a vehicle fuel. They organize meetings, seminars, educational and training courses and participate to regional fairs (Slatcher, 2009).

Kristianstad has been awarded many times for its efforts (Table 4.4). Receiving so many prizes is not just positively contributing to make known the case nationally and abroad, but is an aspect strengthening the vision and the development of the system from the inside, making everyone feel part of an effective change, from the workers in the local companies to the citizens collecting food residues in their paper bags or buying a "biogas car".

Table 4-4 Awards to Kristianstad

Campaign for take off award	2001
Climate star	2002
Energy Globe Award 3rd prize	2003
Best Climate Work in Swedish Municipalities (The Swedish Association for Nature Conservation) 2005	2005
Best work for environmental friendly cars (The Swedish association of Green Motorists)	2008

Source: Kristianstad Municipality (2009b)

4.1.2 How has the transformation been developed in Kristianstad?

The introduction of biogas in Kristianstad occurred within a broader change towards bioenergy. The oil crisis in the '70s and the introduction of a CO_2 tax applying to heat in the beginning of '90s were two strong drivers guiding the municipality towards the building of its own district heating running on biomass, here as in several further location in Sweden (Kåberger, 2002). The implementation of a biogas system in Kristianstad was triggered mainly by two local problems. On one side there was the exigency to deal with the by-product from the waste water treatment plant (plant started in the 1960s). Out of the energy generated in that plant, only 50% was used internally, while 50% was flared in the air. On the other side there was the need for the local food waste industry to have its waste treated. These, together with the will to introduce a separated collecting method for the household food waste and handle it properly, were the issues intensively discussed among the different stakeholders since mid '90s. The municipality, owner of the waste management company, was the actor that, having perceived the problem, triggered the process. Straight away, additional actors where involved in the analysis of the issue and investigation of feasible actions. Biogas production was considered as a possible solution, and a working group was established to investigate the idea. In parallel, the municipality started to investigate ways to use it. The option that became the solution at the time, and continues to be the way preferred even today, is using biogas mainly as a vehicle fuel. Contacts and negotiations with the energy company started already in mid '90 and constituted the premise to the creation of market for the biogas as a vehicle fuel (Erfors, 2010). Decision, building and start of the biogas plant in Karpalund were just first achievements for the system. Several following developments have been strictly related to the municipality's declaration in 1999 to become a Fossil Fuel Free Municipality by 2020. Later on the municipality's role was even more crucial because it became the mind of the vision within which the system then developed. To fulfil its executive committee's declaration of becoming Fossil Fuel Free, Kristianstad has embraced a Climate strategy, which includes the Energy and Waste Plans and a Strategy for Transports. The vision has represented the umbrella under which the different actions for realizing the biogas system have been developed and implemented. Biogas remains one leading area of action.

Table 4-5 Milestones in the Kristianstad process

Year	Milestone
1965	At the waste water treatment plant, biogas is generated and flared off
1989	The biogas extracted at Härlöv landfill is collected by a pipeline system
1991-1993	Discussions, working group and studies on biogas as vehicle fuel
1994	The combined power and heating plant (CHP) fuelled by biomass is established in Allöverket by the municipally owned company Kristianstad Energy Ltd (C4 Energi).
1995	The biogas extracted from the landfill is used as fuel in the district heating plant
1997	The biogas plant production using organic waste is established in Karpalund by the Municipal Waste Company (Kristanstads Renhållnings AB, KRAB).
1999	The executive committee of Kristianstad municipality unanimously declares the ambition to become Fossil Fuel Free Municipality
1999	The first upgrading plant is started. The facility is provided by the company Malmberg The private gas company Sydkraft Gas (today E.ON) is partner and co-investor
1999	The first public filling station is opened
2001	Kristianstad receives the first awards because of efforts in the biogas issue
2004	The Karpalund biogas capacity is doubled
2007	The second upgrading facility is built

The initial sub-process made possible to individualize not only the main actors but also two leading challenges in the constitution of a biogas system. The first one is the necessity to have a secure feedstock supply. The facility at the sewage plant had not this problem, because it was re-using its by-product. On the contrary, this was an issue for the biogas plant. As it has been already shown, the industry and the waste company were two key actors that developed the negotiations. A partial security of the supply was already possible because the latter had the waste monopoly and the first agreed to sign long term contracts. In order to secure additional supply, farmers were involved too. A good cooperation was started with them and contracts have been set up, which specified that they deliver manure and receive digestate as fertilizer back. The agreements take place directly with the biogas company and till now has not constituted a difficulty for the system (Erfors, 2010). The second challenge deals with the reliability of a secure and stable demand. It is possible to use the biogas in the CHP plant (as still happens for the excess) but it is more profitable to sell it as vehicle fuel. This was the reason of looking at the private energy company and requiring its involvement. Having the energy company as partner has been important even for sharing the financial effort in some parts of the project, for example the delivery system (European Commission, 2009). Today E.ON buys the whole amount of upgraded biogas. It owns the filling stations and the facilities where the gas compression takes place. Even the public transport company, Skånetrafiken, has become a partner. Both of them have been involved in the project, invested in it and also received governmental grants for filling stations and bus purchases. Finally, the municipality is directly supporting purchases of cars running on methane through local grants providing.

About communication, the system has its internal way to interconnect. At the very beginning, the most common approach was informal discussion and meetings. Over time further tools have been used, such as the municipal council and statements, contracts, documents containing strategies and plans or even the web site. A further step has been the joining of local, national and international networks, which represents a way to communicate even towards the outside of the system. An example is represented by the regional network Biogas Syd. A first reason to have entered such a network has been sharing what is happening in Kristianstad. But the crucial motivation has been to work for the expansion of biogas demand, today considered the main challenge for the system (Erfors, 2010). Furthermore the municipality is making a big effort in directly marketing the biogas in the local market and promoting it as a vehicle fuel, in a joint venture with the private company E.ON and the local car dealers. These and additional initiatives, like "opening their gates" to visitors and providing information to citizens, or running several mobility management projects, aims at spreading knowledge, acceptance and thus enlarging the potential market, and in turn the system itself.

In Kristianstad, the change towards biogas happened within a broader change in the whole energy system. The fossil fuel free vision promoted a whole change within the municipality and the several stakeholders. The vision steered and enabled the development of the transformation towards biogas.

4.2 The biogas system in Västerås

The Västerås case shows how a "strategy through networking" can work in practice in facing local challenges to the development of a biogas system. It also illustrates several of the DE features, deriving *in primis* from the cooperation among many actors and the participation to a large, and even external, know-how network.

Västerås municipality is situated in Västmanland County, central Sweden, about 100 km inland from the capital Stockholm. It is the sixth biggest town of the country, with a population of 107,005 inhabitants (2005) out of the municipal total of 133,623 (2007) (Wikipedia, 2010). The town is hosting one of the more complete biogas system in Sweden. It is constituted by several components. Besides a sewage treatment plant, upgrading facilities, filling stations for vehicles and storage facilities for ley crops and digestate, its core is represented by the "mechanical cow", that is, its anaerobic digestion plant (SBGF & SGC, 2008). Thanks to synergies that have been built among several interests, today the system is successfully providing renewable energy and organic fertilizer to the local community by handling households' waste and crops grown by local farmers. The project is a demonstration of a sustainable eco-cycle and relation between the city and the countryside that benefits the environment, community and economy (European Commission Energy, 2006).

4.2.1 Key features of the system

Figure 4-3 The Eco-cycle in Västerås. Eco-cycle means that the resource flows creates a closed loop, with the biogas plant representing a crucial part in the cycle. Hoseholds and farming activities provides the input (waste and crops) to biogas plant. The latter provides energy to be implemented in several uses and by-product to be used as fertilizer in agricolture. The cycle can go indefinitely on.

Source: www.vafabmiljo.se

Table 4-6 Yearly inputs and outputs in the Västerås biogas system.

Substrate (biogas plant)	
Source-sorted food waste, from households and institutional kitchens (30% dry matter content)	14,000 tonnes
Sludge from grease separators (4% dry matter content)	4,000 tonnes
Silaged ley crops (35% dry matter content)	5,000 tonnes
Total	23,000 tonnes
Produced Biogas	
From the biogas plant	15,000 MWh (150-250 Nm^3/h)
From the sewage treatment plant	8,000 MWh (250-350 Nm^3/h)
Upgraded biogas (total)	23,000 MWh
Bio-manure:	
Liquid bio-manure	13,000 tonnes
Solid bio-manure	3,500 tonnes

Source: SBGF &SGC (2008)

There are two locations producing biogas in Västerås (Table 4-6). Every year about 8,000 MWh come out from the Kungsängens sewage treatment plant. In addition, since 2005 the

AD biogas plant at the Gryta refuse station, in the North of the town, produces 15,000 MWh yearly (VafabMiljö, 2007). The biogas plant anaerobicly digests several inputs: food waste coming from households and institutional kitchens, grease from grease separators in institutional kitchens and restaurants and dedicated ley crops (Table 4-6).

Svensk Växtkraft is the company owning and running biogas production and upgrading plants. 17 local farmers are responsible to grow ley crops (at least 25% of clover) and perform the harvesting, chopping and silage-making operations following the Svensk Växtkraft's guidelines on sowing, fertilizing and management. The guidelines aims at making the process to achieve efficiency and preserve in the substrate the intended properties for digestion. About 300 hectares are dedicated to these activity. The fields are at the most 15 km far from the plant. The crops are harvested 2-3 times a year, dried, chopped, transported by trucks at Gryta and here stored in plastic bags long up to 90 metres.

Table 4-7 Stakeholders in the Västerås biogas system

Actor and networks	Role
Växtkraft	The company owning and operating the biogas and upgrading plants
VafabMiljö AB	The Solid-Waste Company owned by the municipalities in Västmanland, is the food waste supplier to the system. The population of the region is about 300,000.
Mälarenergi AB	The local energy company, shareholder in the Växtkraft company. It uses surplus biogas in the CHP plant
Farmers	17 farmers nearby the town of Västerås are the ones providing the system with ley crops and taking back the digestate. At the beginning they were shareholders.
LRF	The National Federation of Swedish Farmers supporting the process directly as a shareholder
Municipality of Västerås	Giving permits and supporting creation of biogas demand
Västmanlands Lokaltrafik	The Västmanland local transport company, biogas user
Municipality of Växjö	Coordinator in the Agroptigas project.
Households	Biogas users and bio-waste providers
Ros Roca International AS	Biogas facilities contractor
YIT Vatten och miljöteknik AB	Upgrading facilities and filling station contractor:
Lindesberg Grus och Maskin AB	Gas pipelines and storage tanks contractor:
Agroptigas partners: JTI: The Swedish Institute of Agricultural Engineering; SDU: University of Southern Denmark; FAL: Federal Agricultural Research Centre, Germany; BAI: Bulgarian Association of Investors	
Biogas Öst (Biogas East)	Regional network for biogas promotion

VafabMiljö, the waste company, is in charge to collect bio-waste from houses and restaurants and deliver it at the biogas plant. The source-separation of bio-waste is done by 90% of the 144,000 households in the region. Households can choose if practicing waste source-separation, mixed collection or home composting. Because of the voluntariness of adherence to the system, mistakes done by not concerned households are minimized, and in turn, contamination in the bio-waste. The collection system is done in paper bags, temporarily stored in ventilated plastic bins once filled. Grease is gathered by slurry-exhausted vehicles and transported directly at the digesting facilities (VafabMiljö, 2007).

A receiving hall and a bunker welcome solid and liquid inputs at the plant. Before entering in the one-step continuously-mixed mesophilic digester, the substrate is pre-treated and pasteurized at 70°C for one hour. Heat exchangers are employed for heating the suspension and recovering the heat before the digesting step. Mixing inside the digester is done by compressed air (VafabMiljö, 2006). The digester works continuously 24 hours/day, digesting 21,000 tonnes of inputs a year (Table 4-8).

Table 4-8 Växtkraft's biogas plant data.

Start year	2005
Digester volume	1 x 4,000 m^3
Process temperature	37° C
Retention time	20 days
Start year Upgrading	2004
Upgrading method	Water wash

Source: SBGF &SGC (2008)

Since 2004, when the upgrading process was established in Gryta, the raw gas is purified and made suitable to run vehicles. The gas coming out from the plant has a 65% methane content. It is stored, pressurized and moved to the upgrading facility. Here, a water scrubber raises the methane content to 97%, reduces CO_2 from 30-35% to 2% and cuts hydrogen sulphide concentration from 1,000 ppm to 0 (a small amount is later added to give it an odour for safety reasons) (VafabMiljö, 2010). Even the biogas obtained at the Kungsängens sewage treatment plant is led to Gryta through 8.5 km long pipeline and purified.

Afterwards, the total amount of purified gas is delivered to the bus depot. Here it is pressurized and stored. There are three stations for quick refilling, one for buses and refuse collection vehicles, and two for private cars outside the depot (SBGF et al, 2008). Recently a filling station for mobile gas containers has been added to transport gas to public filling stations in Stockholm (Pettersson, 2010). At the bus depot a reserve tank has been installed as a back-up in case of lacking of supply from the system.

Today the biogas is enough for running 40 city-buses, 10 refuse collection vehicles and 500 cars and light transport vehicles. What is not sold as vehicle fuel, is moved through a 900 m pipeline, and used in the CHP plant, which serves the town district heating system (VafabMiljö, 2010).

Once out of the reactor, the digestate is dewatered employing no polymers, in order to fulfil Swedish Organic Farming Quality regulations. It is centrifuged and separated in solid and liquid phase. Out of the total digestate going out from the plant, 3,500 tonnes are solid (dry matter content 25%) and 13,000 tonnes liquid (dry matter content 2%) (Table 4-9). It is given back to farmers in proportion to hectares dedicated to ley crops to be use like a fertilizer. The solid residue has a high content of phosphorous while the liquid of nitrogen. The farmers apply the digestion residuals according to their fertilizing plan as a replacement for mineral fertilizer. It is expected that the digestion residuals can replace mineral fertilizer on 1,500 hectares of cereals (VafabMiljö, 2010). The digestate is accepted as organic fertilizer, respecting EU and KRAV rules. Inspections and analysis are carried out on inputs and outputs at the biogas plant. Further, controlling is done on households who separately collect the waste.

In 2003 the project was selected as EU demonstration case within the 5th framework program, Agropti-Gas. Several national and international partners joined the project. The Swedish Institute of Agricultural Engineering, the University of Southern Denmark, the German Federal Agricultural Research Centre and the Bulgarian Association of Investors represented new members of a broadened network.

4.2.2 How has the transformation been developed in Västerås?

Table 4-9 Milestones in the Västerås process

Year	Milestone
1990	Farmers start thinking about a biogas plant to treat ley crops
1993-1994	Municipalities adopt their waste management plans
1995	First ideas on a co-digestion biogas plant
1995-1996	Study and tests for starting with handling the bio-waste
1998	The main planning work begins
1997-2001	System for households and institutional kitchen is introduced in all the municipalities in the region
1997-2005	Collected bio-waste is treated in 3 regional small composting plants
April 2003	The Company Svensk Växtkraft AB is established
September 2003	End of planning phase. Svensk Växtkraft AB is ready to implement the project
November 2003	The project is selected as EU demonstration case within the 5th framework program, AGROPTI-gas. Several national and international partners join the project.
October 2004	Use of biogas from the sewage treatment plant to produce vehicle fuel
July 2005	Biogas plant starts its operations
2006	Biogas plant reaches full operation
2008	Filling station for load mobile gas containers to transport gas to public filling stations in Stockholm
July 2009	Second public filling station
2010	Conclusive decision: process residual can be an organic fertilizer

Source: elaboration on Pettersson (2010); VafabMiljö (2010 & 2007)

At the beginning of the '90s some of the farmers cultivating fields nearby Västerås were facing a problem: because of cultivation of only cereal crops for many years and scarcity of animal manure, the cultivated soil was progressively depleting. The idea to cultivate ley crops started to be thought as a proper possible solution and in turn the digestion of them in a biogas production facility. Even the regional waste management company and the municipalities had an issue to solve: they were looking for an alternative way to treat organic household waste. The Västmanland County municipalities and the waste company agreed to cooperate in planning and finding a common solution. The problems were different, and so the interests. Just one's action would not have properly solved all of them. A crucial step was to make them visible to everyone. A search-and-learning process involving a considerable number of actors was started. In 1995 they decided to start a joint project for the creation of a co-digestion plant. The regional waste company played the role of project leader and provided expertise and most of the resources for planning. Even the municipal energy company joined the process since this phase (Khan, 2005). Different solutions were investigated and a specific working group was formed by representatives of VafabMiljö, Mälarenergi, the National Federation of Swedish Farmers and the bus company. The working group managed to perceive the complexity of the project, due to many issues, actors and interests involved. As a consequence, the planning phase was characterised by high flexibility. (Khan, 2005). Many design features were changed and adjusted during the explorative process. For example, it was crucial when the energy company opted for the construction of a different district heating system. It was decided to move from the original location and thought about a new use of the produced gas. It was at that point that was decided to investigate and then employ the biogas as a vehicle fuel (Raven et al., 2007).

The problem formulation was useful for a rough identification of main potential actors to be involved in the project and their possible role: the waste management company as expertise and household waste provider; farmers as ley crop suppliers and digestate consumers; the municipal energy company as responsible for distribution and sale of biogas. During the exploring phase all of them interacted informally. In 2003 the informal network was formalized through the establishment of the Company Svensk Växtkraft AB, with the aim of just undertaking the project. The shareholders were the VafabMiljö owning 40% and additional three actors with 20% each: Mälarenergi, the National Federation of Swedish Farmers and 17 farmers (Figure 4-4).

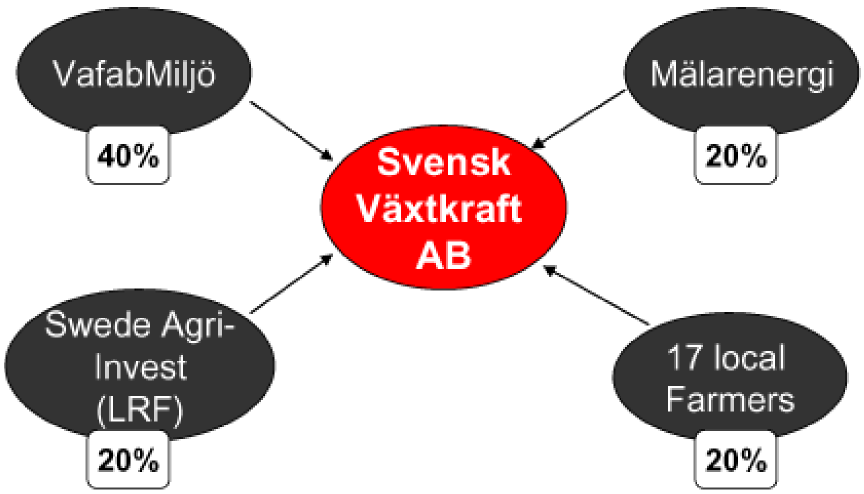

Figure 4-4 Svensk Växtkraft AB's ownership distribution

According to Khan (2005) negotiation among actors involve to a certain extent both cooperation and bargaining, because common and conflicting interests are coexisting. Interaction can result in value creation (joint gains for everybody) or value claiming (gains at expense of others). In Västerås the former kind of relation prevailed. The creation of Växtkraft embodied the choice for value creation. Everyone benefitted from the cooperation that represented a meeting point of shared interest and differences. The company was the way to effectively activate the participants. It was crucial not just in finding solution to some major issues like location, permitting process, financing, inputs sources and outputs markets, but also a way to aggregate and share expertise and information. Over time every participant has fulfilled its task under the common shared project. The network has worked as a strong connection, that further planning has strengthened even more. It has made develop a certain loyalty to the project (Heiskanen, 2006).

Beyond the company constitution, other tools have been used to mobilize resources.

One was the existence of a system for source separated bio-waste in place before the starting of the biogas digester. Broad education and economic incentives have been provided to households, to make them joining the project through the source-separation of organic waste. The system in place, even if still voluntary, makes the mixed-waste option significantly more expensive. Their responsiveness to the project was "tested" from 1997 to 2005, when the gathered bio-waste was brought to three small composting facilities. As mentioned above, 90% of households sort their waste. Anyway, a gradual introduction to the biogas facility operations was positive to investigate the stability of a critical substrate.

Biogas use as a fuel for local buses was a strategic decision in the city of Västerås as start of replacement of diesel fuel to more environmental friendly alternative. City of Västerås is a major owner in the local bus company. A triangular agreement between the city, Västmanland lokaltrafik (the bus company) and Svensk Växtkraft was established for the supply of biogas to run the buses. It has represented a crucial step for biogas demand development (Pettersson, 2010).

By having been chosen as a demonstration case within Europe, the biogas introduction in Västerås received support. New partners contributed both in a material and immaterial way. That is, they supported the project being consultants and evaluators. Moreover, the Växtkraft project received an additional financial support from Europe because of its belonging to the Agroptigas, 2.4 million EUR. Additional help came from the Swedish government through the Local Investment Programme – LIP (about 7.19 million EUR). The residual (about 7.29 million EUR) has been financed by ordinary bank loans and capital share invested in the company by the owners.

After such a coordination and mobilization, the biogas plant started its operations in 2005. Well-established organisation and continuous networking have made possible the biogas system development still moving forward today. The project in Västerås has been an economically viable project(SBGF & SGC, 2008).

Within the Västerås process, communication has been essential for many purposes: in highlighting the chain of problems and the systemic solutions, building the network and emphasizing its importance internally and towards the outside and showing the opportunities for the different stakeholders in relation to it.

Communication has been carried out in several ways. Media included: informal discussion, the working groups and partnership, the international seminars, conference seminars, education to households (functional to the gathering of a high quality and sufficient input), guidelines and contracts with farmers and study visits by various groups from Sweden and abroad.

The Växtkraft project was launched mainly as a solution to local issues, even though the receiving of Swedish government's grants revealed that spreading awareness and know-how within the nation had to be one of the project purposes. By becoming a European demonstration case, the project has been linked with many national and international partners. They have co-operated in demonstrating, evaluating and disseminating the project and its outcomes. Research institutes and consultancies have been relevant in analysing and solving technical issues as well as finding out and assessing socio-economic consequences.

Even the BiogasÖst network has been joined. But it was after the establishment of the biogas system, thus has not played a role in the first implementation phase (Pettersson, 2010) Nevertheless, the participation can be useful in spreading know-how, legitimizing the technology and enlarging the future market for bio-methane.

Since the Växtkraft case is even a demonstration project, communication has constituted a decisive aspect, not just to establish a connection within the different actors directly involved in it but especially to establish a tie towards external actors both in the national and international arena.

4.3 The biogas system in Camposampiero

The case from Camposampiero helps to understand how a "strategy through management culture" has developed in facing local challenges to the development of a biogas system. It also facilitates a better understanding of some peculiarities typical of the Italian national context.

Figure 4-5 Camposampiero, North Italy

Source: www.maps.google.it

Camposampiero is a municipality of 12,118 inhabitants, situated in the province of Padova in the Veneto Region, North of Italy. Veneto is one of the richest region of Italy, producing alone 9% of the national added value. Agriculture and breeding activities are relevant for the regional economy. They are mainly practiced following intensive and high-mechanized methods (Regione Veneto, 2010).

4.3.1 Key features of the system

One of the few co-digestion plants existing in Italy is operating nearby Camposampiero (CIT, 2006). The overall system seems already well established. The digester was started quite recently (in 2005) and is working without relevant technical problems.

Table 4-10 Features of the facilities in Camposampiero

Start year	2005
Digester volume	3,300 m^3
Process temperature	50-55° C
Retention time	15 days
Cogenerator power	2 * 500 kW

Source: CIT (2006)

It receives two inputs. One is the household organic waste produce by 200,000 citizens from 26 municipalities, source-separated and delivered at the plant through the ordinary waste transport (Rifiutinforma, 2009). The other is the sludge coming from the proximate sewage treatment plant. The total substrate digested in 2008 was 30,000 tonnes.

Table 4-11Yearly inputs and outputs in the Camposampiero biogas system (2008)

Inputs (tonnes)	
Households organic waste	12,255
Sludge (from the sewage plant)	17,408
Other	361
Total	30,024
Outputs	
Biogas (Nm3)	2,190,200
Digestate (t)	3,083
Residue to landfill (t)	1,927
Residue to landfill (% input waste)	6.5%
Electricity production (kWh)	3,393,748
Electricity to the grid	347,693
Electricity purchases	1,409,504
Electricity used in the waste water treatment plant	3,190,051
Electricity used in the AD plant	1,265,508

Source: Etra (2008)

The biogas generated in the anaerobic process is entirely converted into electricity and heat by two cogenerators (500 kW each), also set up within the "Camposampiero Bio-treatment Centre" (Table 4-10). In 2008 the total electricity produced was about 3,400 MWh, mainly employed to cover internal uses of the AD and sewage plant. Just 350 MWh were put in the electricity grid (Etra, 2008). Also the produced heat is partially used to supply energy to offices and water process. Nevertheless the surplus is wasted, because there is no district heating receiving it. The solid digestate is sent to composting facilities external to the waste company, which treat and commercialize it. Etra S.p.A – Energia Territorio Risorse Ambientali- is the company managing and owning the Centre. The company, responsible of both sewage and waste treatment, is 100% owned by the municipalities.

Table 4-12 Stakeholders in the Camposampiero biogas system

Actors	Role and responsibility
Etra	The waste management company, managing the process towards biogas, owner of the "Bio-treatment Centre". It is managing also the waste water treatment. It directly produces electricity and heating and is even the main utilizer.
Camposampiero municipality	Municipality hosting the plant,
Other Municipalities	Etra's shareholders
Cattle breeders	Provider of the manure, not successfully involved
Neighbours	Surveillance Committee
General public	
Linde	Provider of the technology
Enel	Buyer the surplus electricity

The investment has been about 10 million EUR, out of which 6.4 million EUR for the AD plant. Veneto Region has financed 90% of the total amount, for reasons explained in the following section (Bacchin, 2010). Already in the planning phase, estimations preannounced profits for the Centre. Running cost were expected to be 1.13 million EUR, against revenues of 1.29 million EUR (CIT, 2006). The plant is actually producing profits (Bacchin, 2010).

4.3.2 How has the transformation been developed in Camposampiero?

Though the production in Camposampiero started in 2005, conjectures about anaerobic digestion already took place at the end of '90s. (Table 4-13).

Table 4-13 Milestones in the Camposampiero process

Year	Milestone
1996	Beginning of Separated collection system
1998-2000	First ideas about biogas option
2000-2006	Project and authorization
2005	Test of the biogas plant
2006	Biogas plant starts working
August 2006	Agreement with Enel
December 2006	Surveillance Committee

The waste company had to find a solution to treat households' bio-waste, since a separated collection system has already been working for some years. Landfill option had to be abandoned, because of national legislation limits. Diversion from landfill started to be introduced by the "Decreto Ronchi" in 1997 (implementing the European Directive on waste 91/156/CEE). Once quitted the organic waste delivering to the nearby landfill in Campodarsego (10 km far), the waste company shifted to composting. Since those facilities were belonging to external operators, the option did not appear a rewarding activity to be sustained in the long period. Already in 1998, members within Etra's staff started to think about anaerobic digestion like an option (Bacchin, 2010). An additional aspect emerged. There was the necessity for a new sewage treatment plant. This need strengthened the digester idea. In fact, household waste and sludge from the water treatment were seen as large amount of inputs capable to feed in a stable way a digester. Moreover, many additional advantages would have originated from the joint construction of the two facilities. The digester would have benefitted by sending the liquid digestate to the adjacent plant, whilst the sewage treatment plant both by sending the output sludge to the previous and using a large amount of the electricity internally produced. Synergies represented a strong economic driver for the company (Bacchin, 2010). There is a further relevant element. The breeder farmers of the area were looking at an alternative for dealing with manure produced in their farms, than directly spreading it on fields. They were pushed by the "Nitrogen Directive", 91/676/CEE, implemented in Italy by the D.Lgs. 152/1999, which imposes a limit in spreading manure on fields, especially within areas classified as "sensitive zones to nitrogen". Even if in normal condition manure is a good fertilizer, in excessive quantities it causes problems to the environment, like eutrophication. The area has been classified sensitive to nitrogen (contained in manure). The political concern in the region is particularly high because the lagoon of Venice is directly affected. Thus farmers, pushed by legal limitations, saw in delivering manure to a dedicated digesting facility a positive option for their activity. An attempt to involve them in the project occurred, since the design phase. Etra commitment in this direction can be motivated by the regional grants Veneto Region was providing to the treatment of materials, first manure, provoking eutrophication in Venice. The plant was even tested with the manure. Anyway technical and organisational problems emerged. First, with the manure nitrogen load for sewage treatment plant would have been excessive. Second, the external composting facility were not available to accept the mixed digestate. Third, farmers were not available to take responsibility on the manure transport to the plant (sustaining costs and getting required authorizations). Even if the Veneto grant was received and covered 90% of the plant financing (which in total was around 10 million EUR), the collaboration with farmers in practice did not work (Bacchin, 2010).

On the use side, a CHP facilities employing the self-produced fuel would have produced energy to mainly cover internal uses of electricity and heating. Clients would have been necessary just for moderate surpluses. Electricity could have fed the electricity grid. In this way, complexities and efforts to build a biogas local distribution system and market, like in the analysed Swedish cases, could have been avoided.

In contrast with the situations in Västerås and Kristianstad, the waste management company here has been less dependent on other actors' support, both on demand and supply side. The mentioned peculiarities mean that most of the project-specific planning could have been carried out within one single entity: the waste company. And this occurred. Decisions and planning have been mainly performed within the company, without creating any specific project body. The great benefit has been taking advantage of already existing and well established management structure. Central in planning the change have been investment project, costs, evaluation of future savings. Those documents represented the basis for presenting the project even to external institutions, like the municipalities.

An additional incentive to change came by the Green Certificates, introduced in Italy in 2002. The economic tool and the complementary requirement for large conventional energy importers and producers to provide a share from renewable, aimed at boosting the renewables diffusion. These rules were introduced by the D.Lgs 79/1999 (receiving the European Directive 96/92/CE) and further developed by the D.Lgs. 387/2003, implementing the EU

Directive 2001/77/CE. The effect, even in the Camposampiero case, is not only that the whole production of electricity from renewables would have originated a gain per kWh, additional to the electricity market price (equals to 0.16 EUR/kWh), but even that a space in the market for that kind of production was created. An additional enabling feature was the guarantee (by law) of GC over 12 years.

However dialogue was begun with some stakeholders. Effort has been made in the dialogue with the municipalities belonging to the "Consorzio Bacino Padova 1"(the territorial authority in charge of administrating and controlling waste management), which represented 100% of Etra's shareholders. Furthermore communication was towards provincial and regional institutions, since the project has to be approved by them (Dlgs 152/2006). Before the request of the official judgement, many steps were already been done to inform all the different institutions.

Nevertheless, most of the discussion has taken place with the local government of Camposampiero, the location that would host the Bio-treatment Centre. The "lobbying" action towards the local administration has been continuous. The clever Etra's staff action, together with further compensation for the municipality, have been the relevant conditions that managed to convince Camposampiero administrators. Two of these forms of compensation are a financial reimburse for every ton entering the AD plant (5 EUR/ton, which in 2007 generated a total amount of 75,000 EUR) and the building of new roads in the plant areas for local people's benefit (Busolin, 2007). Recently the new administration does not appear anymore so collaborative. Even if there is no definitive decision, nor a definitive official position, the local government is hesitating in giving its positive opinion on the enlargement of the digester at the Centre. There are negotiation going on. According with a municipal engineer, it is mainly a matter of "giving-and-receiving back" between the company and the municipality. Some of the negative impacts the Bio-treatment Centre is producing on people living nearby it cannot be forgotten, like odours and increased traffic, even though actions have been done by Etra to balance the drawbacks (Martini, 2010). Unlike in Västerås, here it seems to emerge more what Khan (2005) defines "value claiming" (gains at expense of others), where different interests are seen in a competitive way instead of a collaborative one (Khan, 2005). The current municipality interest towards renewable looks for developing options other than biogas, for example PV plants (Martini, 2010).

Finally, direct dialogue with citizens has been promoted. Local citizens support is often vital for such a kind of plant (Roos et al., 1999). Etra has strived to be as much as possible transparent since the beginning. It is welcoming a Surveillance Committee, led by local councillors, allowed to ask for information and clarification on the activities at the Centre. In collaboration with local administration, Etra has opened several times its gate to the public (Busolin, 2007). Moreover, the management company keeps on informing households, to make them more and more involved in source-separating organic waste. Several meetings with local people have been promoted. Efforts are paying back, considering the high the amount of organic waste the company manage to gather (Etra, 2008). Etra has shown to be engaged, even by promptly fixing the facilities when problems were claimed by neighbours (vibrations and odour). Nevertheless it is significative that the plant is still mainly perceived by people more like a plant treating waste than a plant producing renewable energy (Martini, 2010).

5 Analysis of the three case studies

5.1 Distributed alignment of Kristianstad, Västerås and Camposampiero

The implementation of biogas systems came along with several changes for Kristianstad, Västerås and Camposampiero. The change has made them more aligned with some of the DE features, as illustrated in the following paragraphs. The aim of this section is to give a qualitative illustration of some of aspects that have been modified. For some of the features a dedicated research would be needed, in order to draw a complete picture in terms of environmental, economic and social effects. Under each of the 9 DE criteria there are considerations related to each of the three cases. This and the next section contain many references to data already presented in the previous chapter, which will not be repeated here again.

1. *Increasing the share of renewable resources in local economic activities*

The amount of biogas produced and collected in Kristianstad is increasing over time (Figure 4-1). The share of transport relying on it is also growing. The number of buses, cars and other vehicles is steadily enlarging since 1999 (Figure 4-2). Moreover biogas gives a contribution to district heating: it represents 8% of the total input feeding the CHP plant. Both uses have reduced more and more reliance on fossil fuels over time.

Also in Västerås biogas is used as a vehicle fuel and substitutes fossil fuels. Today 40 buses, 10 refuse vehicles and 500 cars and light transport vehicles run on it. The surplus constitutes an input for the local district heating. An annual production of 2.3 million Nm^3 biogas allows buses to cover 3.8 million km by bus, which would require 1,900 m^3 diesel.

In Camposampiero, 3,400 MWh of electricity and a larger amount of heating are produced from biogas. This lessens the purchase of both natural gas and electricity from the national grid. The further composting step, which requires a large amount of energy, reduces part of the general improvement (CIT, 2006).

Biogas itself represents a renewable resource. Every case scores a positive result.

2. *Decreasing pollution and waste generation (shorter distances and prosumers)*

The three cases are characterised by use of local waste as an energy source. Carbon dioxide emitted from combustion of biogas does not contribute to a net greenhouse effect, giving it an environmental advantage over fossil fuels (Swedish Biogas Association, 2010). Nevertheless, a detailed assessment would be needed for the different cases to evaluate the specific overall contribution (direct and indirect) of the diverse practices to the several environmental aspects.

The use of upgraded biogas as a vehicle fuel, avoids on an annual basis the use of 4.4 million liters of petrol and diesel in Kristianstad (Erfors, 2009). This leads to important environmental benefits in term of air quality and GHG emissions. Waste (food and sludge) is diverted from landfill and employed locally as a energy source. By reducing the amount of dumped waste, the CH_4 (a gas with a Global Warming Potential 21 times higher than CO_2) emissions from landfill are lowered. Even an amount of manure is processed. This contributes to reduce nitrogen leakages from arable soils and thereby reduces eutrophication (Berglund, 2006). The output digestate is not sent to landfill, but employed on fields. This practice contributes to reduce the use of chemical fertilizers, which require huge amounts of energy to be produced, and finally to close the material loop. Nevertheless, the impact of the overall growing of dedicated crops should be assessed.

Every year the Västerås AD plant turns 18,000 tonnes of waste in valuable and local source of energy and fertilizer. This avoids the use of inorganic commercial fertilizer and the emissions of GHG connected with their production. Moreover, by running vehicles on biogas instead of diesel or petrol, an improvement of the air quality and a reduction of emitted CO_2eq take place. As above, diesel replacement reduce GHG emissions. In addition, the environmental impact both of fossil fuel extraction and ley crops should be evaluated. However, the latter is the way farmers wanted to practice regardless of the anaerobic digestion project, in order to improve the soil nutrients in their fields.

The local production of electricity and heat allow not to buy natural gas and electricity from the national grid in Camposampiero. Since in Italy the emission factor for electricity production in 2007 is 0.496 kg CO_2/kWh (Enel, 2007), net avoided emissions are approximately 1,680 tonnes CO_2 eq yearly. Furthermore, the amount of waste sent to landfill represents 6.5% of the initial input (Table 4-11).

3. *Increasing the 'sustainable use of' and 'value addition to' local resources in economic activities*

There are some advantages in using digestate as a fertilizer. All the nutrients of raw material are preserved after the anaerobic process and furthermore some qualities of the raw materials are improved. The digestate contains a higher proportion of plant-available nitrogen, i.e. ammonium, than the raw materials, which can improve the nitrogen efficiency. This occurs because of the mineralization within the digestion, where organic-bound nitrogen is converted into ammonium. For example, digestion of pig manure has been estimated to higher the share of ammonium from 70% of the total content of nitrogen to 85% in digestate. Anaerobic digestion consents an improved management of plant nutrients and a better precision in application of fertilizer. It can be useful in decreasing nitrogen leakages from arable soils and thereby reduce eutrophication (Berglund, 2006).

In Kristianstad local waste becomes an energy source and digestate becomes fertilizer compatible with organic agriculture methods. Considering some of the practices within the facilities, a contribution to a sustainable use of local resources is given by the re-circulation of water and hot air, and by using the surplus of biogas in a CHP plant, which is more energy efficient than a conventional condensed cycle unit.

Digestate applied to lands helps to reduce the required amount of inorganic commercial fertilizers also in Västerås. The solid phase is employed in the autumn cultivation as a phosphourous-rich fertilizer, whilst the liquid one in the spring cultivation as a nitrogen-rich fertilizer. In 2006 the amount of plant nutrient was: 60 tonnes of nitrogen, 10 tonnes of phoshourous and 20 tonnes of potassium (Swedish Biogas Association, 2010). Ley crops (mainly clover), on a long term basis improve the soil structure, increasing soil organic matter (Berglund, 2006). They are a good preceding crop for cereals. Moreover, they are revalorized because they constitute one of the input for the digester. Also within this plant water is re-circulated, reducing the need of fresh water and the amount of digestate to be transported.

In Camposampiero the exploitation of synergies, mainly with the sewage treatment plant are giving a contribution to a sustainable use of resources. Compost as a fertilizer is an additional element. Heat production allows to reduce purchases of natural gas from the grid and the likely use of a boiler. This entails some benefits, like the increase of energy efficiency thanks to the CHP facility. The profits the facility is producing belongs to Etra, which is 100% municipally owned.

4. *Increasing the share of added value benefits retained locally*

Several local stakeholders, like local farmers, industry and car dealers, directly benefit from the implementation and running of the system in Kristianstad. Some of them benefit of an alternative waste management, some have a new business opportunity. For the community is beneficial to have the possibility to rely on a local fuel that is cheaper than oil, even because the higher cost of buying cars running on methane are partially balanced by the subsidies provided by the municipality through governmental funding.

Västerås. The diffused financing and ownership, especially in several farmers' hands, strongly contributes to retention of system benefits in the area.

Camposampiero. The system is indirectly benefitting the whole regional community because of the 100% municipal ownership. The Camposampiero municipality is directly receiving a compensation of 75,000 EUR every year and also new roads and cycle lanes. However, there are no direct relevant benefit for citizens, farmers or industry.

5. *Increasing the diversity and flexibility of economic activities*

Kristianstad. Biogas represents an alternative to other fuels, both for vehicles and the CHP plant. The diversification it brings in the whole local economy means higher overall system resilience. Biogas today covers 10% of local energy supply.

Västerås. The above statement is valid even in this context. Furthermore, farmers are shareholders in the company, thus for them the participation in Växtkraft project represent a new activity, additional to their core business.

Camposampiero. Biogas is a relevant additional energy source for the sewage plant, and also contributes to satisfy the electricity demand in the region. Unfortunately part of the heat is not recovered.

6. *Intensifying connections through non-material vertical flows*

Kristianstad is considered a model case, contributing to biogas know-how and awareness, both in Sweden and abroad. It is "benefitting and receiving back" from the several conferences and regional, national and European networks it has joined. It even opens its gates to visitors. Biogas Syd, the regional network, is further amplifying the phenomenon among all the biogas producers within Skåne.

The project in Västerås represents an international project, many actors are looking at. It was launched as a solution to local problems, but it has become a link among several national and international partners.

Camposampiero can embody a way to expand biogas awareness and know-how in the region and nation. But no dedicated initiatives have been started.

7. *Intensifying connections through added value material outbound flows*

Kristianstad. The town is a sort of *prosumer*. In addition, it even exports the surplus of upgraded biogas, a valuable energy source, to nearby municipalities, like Ystad, Olofström and Hässleholm.

Västerås is exporting part of its production too, for example, towards Stockholm.

Camposampiero confers to the electricity national grid part of the local production.

8. *Engaging diverse actors in material and non-material flows within the system*

Looking at Kristianstad process, it clearly emerges how material and non-material interconnection both enabled the system and were intensified by it. A sort of self-reinforcing feedback loop has been established (Meadows, 2008). Energy industry, food industry, farmers, transport company and public institutions are interconnected. Many actors are involved on supply and use side of resources. There are multiple feedstock and biogas supplier in the system. More than one actor receive the two outputs of the system (biogas and digestate). Even people are directly involved, because in charge of sorting biowaste within their houses or even buy cars running on the biofuel. A large number of local and external actors is affected by the information and non-material flow. More than one supplier of biogas is present in the system.

Västerås. Like in Kristianstad, several stakeholders provide their expertise and resource to the project, and as many demand the outputs from it. One relevant example is represented by the seventeen local farmers which not only are involved in the resource chain but even in the ownership of the company managing the project. More than one supplier of biogas is present in the system.

Camposampiero. Interconnections with political and administrative activities, energy company and citizens. Not successful connection with farmers. Lack of further links.

9. *Contributing to satisfy local needs*

The systems started expressly to answer local problems in the three locations. The primary one was to find an alternative way to deal with biowaste. AD was considered a proper method to solve issues at the landfill and sewage plant, and because of this, synergies were created among the different activities. It is regarded as a way to produce renewable energy, even if in Camposampiero this aspect looks a less strong driver.

5.1.1 Summary of biogas contribution to Distributed Development in the three cases

The following table is going to visually summarize the former observations. It is a schematization of the fulfillment with the DE criteria. It should be remembered that it is a qualitative assessment and a simplification of some of the main occurred changes.

Table 5-1 Biogas contribution to Distributed Development characteristics in the three case studies

DE criteria	(1) Kristianstad	(2) Västerås	(3) Camposampiero
1) increasing the share of renewable resources in local economic activities			
2) decreasing pollution and waste generation (shorter distances and prosumers)			
3) increasing the 'sustainable use of' and 'value addition to' local resources in economic activities		 (?)	
4) increasing the share of added value benefits retained locally			
5) increasing the diversity and flexibility of economic activities			
6) intensifying connections through non-material vertical flows			
7) intensifying connections through added value material outbound flows			
8) engaging diverse actors in material and non-material flows within the system			
9) contributing to satisfy local needs			

The "very happy" level indicates a configuration where most of the opportunities look to have been grasped, the "happy" level a state where they seems to have been partially grasped, the "sad" level to under-exploited opportunities.

5.2 Boundary conditions, drivers and strategies in the implementation process

5.2.1 Boundary conditions, drivers and strategies in Kristianstad

Upper level drivers represented important factors for the implementation of the biogas system in Kristianstad. Oil prices, oil dependency and energy security have been issues that made the energy system depart from reliance on fossil fuels in the whole Sweden since '70s. Since '90s, it was added the diffused alarm on climate change. Those concerns have been embodied in the national policy framework through the 15 environmental quality objectives issued in 1999, and consequent economic incentives, like LIP (and KLIMP) grants since 1998, CO_2 tax since

2001 or Green Certificates. Moreover, the EC landfill directive in 1999 has led first to a landfill tax in 2000 and then to ban landfilling for organic waste. On the other side, local drivers played an equally important role, namely the need of solutions for the flaring of biogas at the sewage treatment plant, and a proper waste treatment. Even the fossil fuel free vision was a strong driver.

According to Erfors (2010), the most challenging issues for the municipality have been mainly two. At the beginning, it was a matter of getting everything in place and all the actors working together especially in creating a market for biogas as a vehicle fuel. Many stakeholders had to cooperate: the public transport company, the gas selling company on the market, the production company. The presence of many participants can be considered both a strength and a challenge for the process. Nowadays, what is challenging is the further development of the vehicle market. It is an important achievement because it is more profitable to sell biogas as vehicle fuel than to the district heating system. In 2009, 50% of biomethane has been given to the district heating company. The future challenge is to sell 100% of the biogas as a vehicle fuel.

Table 5-2 How challenges have been tackled in Kristianstad

Challenges	Ways to face the challenge (pre-existing or undertaken)
Economic viability and economic gains for each stakeholder	- Incentives and grants; market conditions, like a lower price for gas than for petrol - Sharing risks and financing burden through the network - (already existing) municipally owned facilities - Use (and availability) of cheap resources
Available but scattered resources	- Since the beginning: long term contracts with farmers and food industry; monopoly of waste
Need of a stable and secure demand	- At the beginning: the CHP plant and involvement of energy company and public transport company
Stakeholders involvement	- Vision, municipal coordination
People's awareness	- Vision, information campaigns, visits
Local decision makers commitment	- National policy and commitment, awards
Enlarging the biogas demand	- Ways to make biogas spread as a vehicle fuel (marketing, information, public procurements, economic incentives to final users…)
Biogas vehicles more expensive than traditional ones	- Municipality's procurement - Local grants for gas vehicle

At the **local level** a crucial role has been played by:

- political agreement and commitment expressed and reinforced through an explicit and shared **vision**
- collaboration among stakeholders under the municipality coordination
- municipality procurement and local grants

- increasing awareness and involvement of citizens and stakeholders (enhanced by communication within the inside and towards the outside of the system)

- cheap resources availability in the area

- municipality's partial ownership (some facilities)

- **formal agreements and long term contracts** among stakeholders (both on supply and demand side)

Building a biogas plant is just a step in the path towards a biogas system. Afterwards, effort is needed in maintaining and updating it. The links that were established and developed over time have helped to find solutions to several aspects (especially dealing with supply and demand), to create a working market in the long term, to share financial burden and risk of the investments. The municipality has largely contributed to find financing for the investments. Triggered by the initial local exigencies, the process was started. Then a steering vision was added. Many stakeholders seeing in the biogas an opportunity important both for themselves and the others, have collaborated and originated an ongoing work under the vision "carbon free". Along the process, the vision has been established and broadened. It seems that it has taken place what Mårtensson & Westerberg (Mårtensson & Westerberg, 2007) argue: "the companies are part of the same vision-based network and are part of each others' value chains". The vision as guidance for the local network looks like a possible reason of the broadening of the biogas system over time. New investment and additional initiatives, especially on the demand side, have continuously been added.

5.2.2 Boundary conditions, drivers and strategies in Västerås

According to Pettersson (2010), several issues have been challenging in the Västerås project. Among them, the financial one has been crucial for the initial pronouncement on starting the project. Also the organisation and incorporation of the farmers into the project, who were essential for the use of bio fertilizer, was a decisive step. Like in the other two cases, also for Växtkraft it is possible to observe how both local as well as external drivers have been important in creating a suitable setting for the change towards biogas. National legislation and policy asking for more renewables and "less landfill" together with the existence of local needs to be satisfied (think to the farmers' need to improve soil) have been the trigger. In addition, some factors have helped since the beginning in facing some of the general challenges. These are:

- National (LIP and KLIMP) and European grants available

- Feedstock availability

- Already implemented and working source-sorting waste when the biogas plant started operations, thus a close integration with this system occurred

- Additional source of biogas already existing (sewage treatment plant)

- Municipality, though not directly involved in the process, not opposing the process as such

- No opposition of great importance at stake (nor from people or environmental organisations)

In addition, some **local actions** have provided a relevant contribution.

- Willingness to cooperate was formalized through the **Växtkraft constitution**. It was useful to face some barriers, or at least partially simplify some of them, like the financial and organisational ones. Moreover, Växtkraft managed to successfully coordinate supply-demand issues providing guidelines to farmers, signing contracts and agreements (like the one with the local transport company), thus created the basis for both digestate and biomethane markets.

- It was important to have provided additional economic incentives to induce households in source separating their bio-waste.

- The gradual introduction of the biogas system was wise. At the beginning composting facilities were used then AD was introduced. The procedure was useful to test the system and the existence of a secure input supply, thus lower the risks of failure

- By joining an international network, not only financial but also further know-how entered the system. The "immaterial flow" was useful in solving technical issues and analysing the development and consequences of the process. Belonging to network, included the regional one, has been important in creating awareness among the broad public, thus enlarging biogas acceptance and legitimization.

- By locating the facilities within pre-existing activities dealing with waste, the system met less opposition from neighbours, already accustomed to similar activities in their vicinity.

- By showing continuous openess in solving technical problems, like odorous, and maintaining a constructive dialogue with citizens, the project gained acceptance.

In Kristianstad, the municipality was the supervisor of the process. In Västerås, it is just one of the participants. The Växtkraft company plays the role of the hub whose specific purpose is to put in place the biogas system. It is like a "spider in the web", enhancing a general cooperation essential for the establishment of the project. The case study shows how in practice a strategy can work similar to the one that Mårtensson & Westerberg (2007) call "transformation through networking". In the problem formulation a common solution to several actors' problems is pursued. In mobilizing resources, many partners are activated and involved in the process. And when it comes to the communication step, an intense effort is set up in order to make evident the opportunities for change. The Växtkraft case study suggests that, in facing the process organisation, all the stakeholders should be involved from the beginning and legally binding contracts should be signed to create a secure and stable supply source and output market. Willingness to exploit synergies among different activities indeed contributes to the economic viability and environmental impact of the system. Partnership, like Växtkraft in itself, represents a method to tackle financial, perceptual and organisational constraints, and allows to share risk and benefits deriving from the activity.

5.2.3 Boundary conditions, drivers and strategy in Camposampiero

More attention has been played to Camposampiero, being an implementation case in the Italian context. The transformation towards biogas in Camposampiero has been both pushed by several drivers and impeded by a number of challenges. Some of them come from the outside, while some were embedded in the system and possible to be handle within it. As noticed previously, conditions in favour of biogas has first to be created at upper levels. The Italian legislation on waste and energy, mainly accomplishing with European directives, can be considered one of the main drivers for the change. Nevertheless, someone has to locally trigger the change. In Camposampiero this role was played by the waste company that perceived the biogas idea as a way to improve waste management. Furthermore, the company kept the leadership in the process implementation and still holds it during the system development. Thus, it is the waste company action that has faced many of the constraints. They had been taken into account during the problem formulation step, when solutions were looked for and a potential project had to be defined, the mobilization phase of actors and resources, when the plant had to be executed, and finally the communication step, when the project had to be disclosed to a broad audience.

Some enabling conditions, at local and upper level, have facilitated the starting of such a kind of process. Some of them can be listed:

- Green Certificates lasting for 12 years
- Grants from the Region
- Regional concern on eutrophication
- Committed people in Etra
- Support from regional waste authority
- Etra been assigned the management for a long term
- Etra's household waste monopoly, thus cheap (no cost) input available
- Etra managing both sewage and waste
- Use the biogas to produce (mainly) electricity give the possibility to easily exploit an already existing infrastructure (electricity grid)

Local actions have helped in facing some of the barriers. Among them:

- Creation of synergies with the sewage treatment plant, which have improved the economic feasibility and environmental impact of the plant.
- Negotiation and discussion to develop political support.
- Collaboration with citizens' Committee to increase neighbours acceptance.
- Information, "open gates" and educational initiatives in collaboration with the municipality to engage households.

- Good planning performed by Etra, in consideration with the context was operating within. For example, it has been opted for 2 inputs, one with an already existing supply chain (biowaste), an the other one, near and under control of the same company (sludge). They guarantee a stable and secure feedstock to the plant.

- Agreement with the energy company useful on the demand side; it lowers market risks.

- Compensations (financial and alternative roads), more jobs and financial (direct and indirect) benefits from the plant have granted benefit to the local community;

- Broad communication (even through a Sustainability Report), especially about benefits, like CO_2 reduction, attempt in addressing the Venice lagoon eutrophication, reduction in electricity and natural gas needs, can have improved general public opinion

From the case emerges that not only economic viability is crucial. Perceptual challenges and coordination of the supply chain are largely affecting the implementation process. Some issues have not been solved. The local administration seems not ready to give its support to a digester enlargement. The digestate is sent to composting facilities before being used as a fertilizer, mainly because of restrictive and not clear regulations. Even though composting is a zero cost action for Etra, for the system it means higher energy consumption. The system is not completely closed: part of the heating is not used. Furthermore, farmers are still not included in the system and their problem with manure still exist. According to the engineer Bacchin (Bacchin, 2010), if you want to use manure or residues from agriculture, farmers should be involved from the beginning, be partners in the project, and even the planning of a dedicated plant would facilitate the whole process. In several of the interviews emerged that in Italy there is a strong division among the “agriculture” world and the “waste” world, and it is complex to make them converge somehow (Confalonieri, 2010, Moretti, 2010, Boicelli, 2010, Mattirolo, 2010). In Italy, since there are large legislative differences (meaning different laws, authorities, permits to be required, etc…) affecting action within the waste and the agriculture sectors, it can be a careful and wise decision to select the area you want to work in and keep going in that (Moretti, 2010). Even the public opinion on them is slightly different. Moreover, one should be aware that ventures with public institutions means to go through longer processes. According to Moretti (2010) it can take almost ten years to get started, as the experience in Italy shows. Nevertheless, a potential drawback is to miss the benefits deriving from partnerships. For example, many participants are able to offer different expertise.

By analysing the problem formulation phase in Camposampiero, it emerges that the transformation was started within the waste company, a key stakeholder. The evaluation of the process predominantly occurred looking at internal financial aspects. The change towards biogas was made official and legitimate simultaneously to the internal regular activity of the waste company. Biogas option was dealt with as part of ordinary way to operate. Nevertheless the process had to be made acceptable, first, to the political board of the waste company and second, to the local government and people. Like the formulation phase, the mobilization occurred mainly internally the waste management company. However, even if the project has been led by a small project group, the effective operationalization has involved not just the whole organisation but also external stakeholders. An example is the financing coming from the regional government. Communication has been primarily a tool of internal coordination, performed through formal and informal methods. Equally important are relations with the shareholders, namely, the municipalities. The local government, though not leading the process, remains a crucial building block in the change process. Also communication towards neighbours and broad public has been important, especially to update the internal process that is going to impact on external stakeholders. The strategy developed in Camposampiero turns out to be close to the picture that Mårtensson & Westerberg (2007) draw on the "transformation through management culture".

5.3 Summary of the three strategies

Table 5-3 Strategies in the three case studies

Municipality	Problem formulation	Mobilization	Communication	Strategy Pattern
	What sets off a process: one's own situation linked to the surrounding→possibility for change; idea of a project	All the actions activating everyone and everything	All the activities where the process and its results are made visible	
Kristianstad	Sewage and food waste problems/municipality triggers the process/ initial study/ municipality creates a vision	Through a vision/ Municipality coordinating the process/ Through the waste management company (municipally owned)/Contracts	Internally and towards the outside/ to create and make the vision spread	**Transformation through shared vision**
Västerås	Farmers' idea/ Waste management company triggers the process/ Studies and tests/ Concerted solution	Through a network/ Constitution of a multi-participated company/joining of Agroptigas project	Within the company, among partners, towards people	**Transformation through networking**
Camposampiero	Internal managerial exigency of the waste management company/ EU and national policy on waste and energy	Through the waste company	Primarily internal communication/ municipal and regional council resolutions/ informal meetings with authorities/meeting with the citizens' committee/websites and reports	**Transformation through management culture**

Overall we can appreciate that in the three cases the project implementation was triggered by different problem formulation and involved different level of mobilization and communication.

6 Umbertide

Umbertide is a town of almost 15,000 people, situated in the central part of Italy, in the small and cosy Umbria Region. The population density in the area is low, about 76 inhabitants/km^2 (Istat, 2001). It belongs to a territory named Alto Tevere Umbro (Upper Tiber Valley), which is 990 km^2 large and for 90% constitutes the river Tevere basin. 80% of it is covered by woods and lands for grazing and farming. Eight municipalities (75,000 inhabitants with a density of 46 inhabitants per km^2) belong to the sub-region: Città di Castello, Citerna, Lisciano Niccone, Monte S.M. Tiberina, Montone, Pietralunga, S. Giustino and Umbertide. Umbertide is the second largest city, after Città di Castello. All together they have set up the Alto Tevere Umbro Mountain Community (Bidini & Servili, 2008).

Umbertide started to be committed towards sustainability about 20 years ago. Among the main activities are the promotion of organic agriculture, local products, and renewables. Today, the lines of intervention are mainly two: one sees Umbertide as coordinator within the eight Mountain Community municipalities to work at the Agenda 21, and one sees the town directly planning and performing municipal actions, especially on renewable energy (Ciarabelli, 2010).

Among the several energy projects, Umbertide has decided to establish an anaerobic digestion plant for biogas production in close proximity to the municipal slaughterhouse. The plant is still a project, but the process toward its introduction in the area has already been launched. The pilot project could represent the beginning for the implementation of a broader biogas system in the city.

In the following sections I am going to present both the pilot project and the current actors, networks and institutional setting related to sectors linked to biogas: energy, waste and agriculture. The aim is identify drivers and barriers for a biogas system implementation in the area and the opportunities in term of a more distributed development that such a system could generate.

6.1 The context in Umbertide

6.1.1 Local economy

The economy in Alto Tevere Umbro – ATU – was mainly relying on agriculture and forestry. Since the '60s people started to shift towards occupation in small and medium industries. Nowadays agriculture is a marginal activity with respect to others, except for tobacco farming (Alta Umbria, 2007).

There are about 2,100 **farms** in the area, with an availability of 35,000 ha arable land, out of which 5,400 ha dedicated to tobacco. The other main plantations are sun flowers, wheat, corn, sugar beet, olive trees and grape. Several of them are small activities, integrating other revenues and employing large share of people belonging to a same family. In average they are dealing with surfaces below 5ha. In the ATU 434 farms are breeding cattle, 476 sheeps and 164 horses. The total amount of animals in the territory is 6,000 beeves, 20,000 sheeps and 717 horses (Guerrieri et al., 2006). Livestock breeding is practiced extensively and in small scale, with meat and milk mainly for the local market. The interest towards organic agriculture is high and increasing. About 10% of breeding activities operate with organic methods (Alta Umbria, 2007).

The picture of farming activities in Umbertide is specifically shown in the following tables (Table 6-2) The total land available – SAT – is 15,000, and 7,650 is use for farming – SAU (Istat, 2000). In 2009 the number of farms is 394 with 675 people working in the sector (Ufficio Programmazione e Sviluppo Economico del Comune di Umbertide, 2010)

Table 6-1 Main farming and breeding activities in Umbertide (hectares)

Tobacco (ATU)	Wheat	Corn	Other cereals	Sunflowers	Olive trees	Grape	Grassland
5,000	1,360	410	950	900	270	150	1,470

Beef (farms)	Sheeps (farms)	Pigs (farms)	Poultry (farms)
1,185 (57)	4,400 (88)	3,000 (116)	9,000 (22)

Source: Istat (2000)

Tobacco is a peculiarity of the Umbertide and ATU landscape and economy. More than 5,000 ha and 2,200 people are in the tobacco business. Tobacco was introduced in the area at the end of XVI century. In 1911 a huge consortium-farm was founded in Città di Castello. Today in the whole area there are activities that cover the entire chain, from harvesting machines to treatment and storage. About 500 farms with an average extension of 8 ha are cultivating it. There are five producers' associations and three consortia dealing with the first phase of tobacco. In Umbertide the ratio of employees in the tobacco sector to total food industry is much higher than in rest of the territory (30%)(Alta Umbria, 2007). The tobacco activities are not anymore at their flourishing stage. The overall competitiveness is highly connected with CAP support. The sector has started to suffer because of CAP reform and decoupling system (see section 2.3) that has been introduced. The Region Umbria itself is recognizing the necessity of a restructuring in the sector. The tobacco farmers, deeply connected with this kind of plantation, have often opposed alternative ideas to their core crop. However, they and their association, namely CIA and Coldiretti have started to be aware of the necessity on finding further solutions (Confederazione Italiana Agricoltori, 2010).

Between 1990 and 2000 grassland diminished (– 20%), because of support to crops like cereals since 1993. But the decoupling introduced by the CAP reform had changed course. It has made lowered wheat and corn farming, and even sunflower crops, which still remain important in the area (Alta Umbria, 2007).

Wine and olive oil production are significant activity in ATU. There are local oil-mills but some of them rely on facility outside the region. Several wineries, many even of new construction, produce good quality wine, in part biological (Ciarabelli, 2010). Even a relevant part of olives is biological and high quality (certified) production.

Within the local **industry** it is pretty relevant the production of **machines for agriculture**. Though, the sector is facing a period of crisis, especially because of lack of investment, innovation and excess of reliance just on tobacco (Alta Umbria, 2007). The **food industry** is constituted mainly by small handcraft activities producing high quality products. Honey, marmalades, cheese, truffles, bakery and butchery products, all relying on peculiar goods from local agriculture. No strong marketing or branding and lack of strong vertical supply chain are main weakness of the sector (Ciarabelli, 2010). In all the industry sector the peculiarity is the low number of employees: 82% of businesses has less than 10 people.

In Umbertide food industry encompasses 23 activities employing 250 workers. In the whole industry sector there are 640 businesses providing jobs to 3,100 people (Ufficio Programmazione e Sviluppo Economico del Comune di Umbertide, 2010).

The natural landscape, medieval towns and villages, cultural and artistic heritage are reasons of the existence of sustained **tourism** in Alto Tevere Umbro.

6.1.2 Waste

The main environmental threat from biowaste is the production of methane in landfills, which accounted for some 3% of total greenhouse gas emissions in the EU-15 in 1995. The Landfill Directive 1999/31/EC requires Member States to neatly lower the biodegradable waste that they landfill to 35% of 1995 levels by 2016, to contribute in reducing the environmental problem (EC Environment, 2010). In Italy, according to the national Decree 152/2006 (changing the previous rules contained in the Ronchi's Decree 22/97), regions are in charge of dealing with waste management. Umbria has accomplished with the law requirement on the 5th May 2009 with a Regional Decision instituting the Regional Waste Plan (the first plan was in 2002), that aims at ruling in a systemic way on technical and administrative aspects of waste management. The objective is boosting waste separate collection, reusing and recycling, and optimizing energetic uses of residues. More in details: prevent waste production, enhance material reuse, expand infrastructure for energy recover and minimization of landfilling, improve the waste management performance in environmental and energy terms, promote a cost-efficient management, enlarge public awareness on waste sustainable management, support waste treatment nearby its waste production site. In order to use source-separated biowaste in an alternative way than landfill, the Plan suggests first to start with composting facilities and integrate the recycling chain with anaerobic digesters. Ato are the bodies in charge of putting into operations Regional Plan indication. They are even supposed to define how to intervene for reusing and increasing waste value in agriculture and energy sectors (Umbria Region, 2009).

Umbria is divided in 4 Ato. Umbertide and the Alto Tevere Umbro, belong to Ato 1 constituted by 2 sub-areas. D.Lgls 152/2006 art.205 introduces important objectives for differentiated collection: 35% in 2006, 45% in 2008 and 65% in 2012. The Regional Waste Plan introduces an additional intermediate target: 50% in 2010. Today, the share of differentiate collection in Ato 1 is 32% of the total waste, while in Umbertide 41%.

Table 6-2 Produced waste in Umbertide and its region

	Inhabitants	Total waste (t)	Total waste/inhabitants (kg)	Source separated waste (t)	Source separated waste/inhabitant (kg)
Umbertide	16,784	11,968	713	4,949	295
Ato 1	137,407	75,413	549	23,800	173
Umbria	943,475	555,092	588	165,500	175

Source: Arpa Umbria (2009)

Umbertide produces 16% of the total Ato waste (Arpa Umbria, 2009). The amount per inhabitant is higher than the regional and Ato average. It is 713 kg per inhabitant. In 2008 the amount of biowaste (including garden waste) collected per person was approximately 60 kg, and in total 1,061 tonnes. In the same year, the source separated biowaste in the Alto Tevere Umbro was about 2,500 tonnes, out of 8,000 tonnes in the whole Ato 1.

The greatest of Ato1 biowaste is treated aerobically in the Pietramelina facility, 13 km far from Umbertide but within the Purugia municipality. The output compost is certified to be used in organic farming. The plant is even authorized by the Region Umbria to treat animal by-products (Regulation CE 1774/2002). The whole household biowaste is directed there. Nevertheless, a small part of the garden waste has to be send out of the region. The not source-separated fraction is mechanically sorted. The final fate of the residual is the Pietramelina landfill. The landfill in Pietramelina has 310,000 m^3 of volumes still available (30 June 2008). There are permits to use 568,000 m^3. Once the site will the maximum capacity, the landfill will be closed. The site in Pietramelina has a system gathering biogas from the dump and producing electricity of it (Arpa Umbria, 2009).

The Umbertide waste water treatment plant, is placed within the municipal territory, in Montecorona. The sludge today is send to the landfill.

The company dealing with waste management in Umbertide is GE.SE.NU. Biowaste is collected both by the ordinary collecting system and garden waste even by a specific call service citizens can avail of (Arpa Umbria, 2009). In the others municipalities of Alto Tevere Umbro SOGEPU company is managing waste.

The company Umbria Acque was assigned to manage the waste water by the Ato, an authority responsible for water management over a sub-regional territory.

Table 6-3 Normative context affecting biogas in Umbertide

Field	**Laws, Plans and Incentives**
Energy	National laws implementing EU Directives (see section 2.3): Renewable Directive 2001/77/EC, Biofuels Directive 2003/30/EC, ETS Directive 2003/87/EC, Cogeneration Directive 2004/8/EC.
	Green certificate and feed-in-tariff
	PER – Regional Energy Plan
	PEC – Territorial Energy Plan Alto Tevere Umbro
Agriculture	CAP – Common Agriculture Policy
	PSR – Rural Development Plan 2007-2013, promoting: (one aim is promoting sustainable agriculture, quality of life and diversification of farms activity) (Umbria Region, 2007)
	PSL – Local Development Plan Alto Tevere Umbro
Waste	Directive 1999/31/EC on landfilling
	National Decree 152/2006
	PGR – Waste Management Plan

6.1.3 The energy context

Current energy supply and demand The total energy consumed yearly is 1,550 GWh in Alto Tevere Umbro. Transport sector needs one third of it (530 GWh), heat 700 GWh and electricity 320 GWh (Guerrieri et al., 2006).

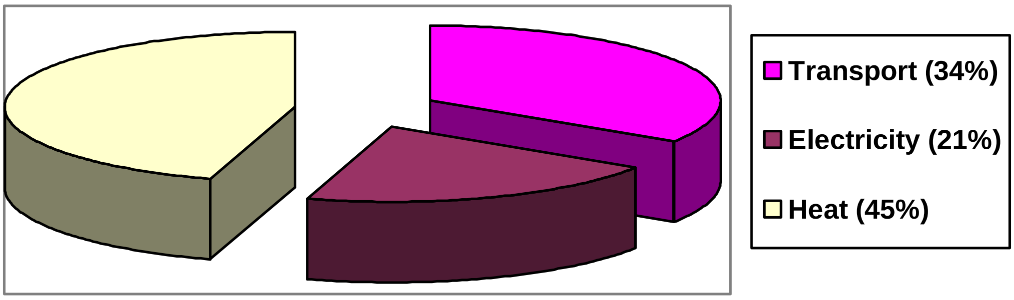

Figure 6-1 Energy consumption in Alto Tevere Umbro

Source: Guerrieri et al. (2006)

Electricity: The electric consumption in the area is slightly lower than the national average. 44% of electricity is used by industry (142.7 GWh), 25% for services, 23% by households and 8% in agriculture. Almost 80% of 321 GWh consumed in one year is produced from oil and natural gas. Umbertide needs about 78 GWh/year of electricity.

Transport: Umbria is one of the regions in Italy with the highest ratio cars/inhabitants. The sector source are almost completely constituted by products deriving from oil. It is estimated a consumption of 177 GWh of petrol and 351 GWh of diesel. The estimated consumption for transport in Alto Tevere Umbro is about 20,000 tonnes of petrol and 40,000 tonnes of diesel. Data on actual consumption exists for tractors and other farming vehicles (12,000 million litres) and for waste lorry vehicles (380,000 litres).

Heat: half of the total energy (340 GWh) is necessary for households needs, the remaining for industry and services ones (360 GWh). About 600 GWh are covered with natural gas, whilst 100 GWh by wood and other fuels (for example, oil).

In Italy the largest part of electricity is provided by large operators from conventional sources. In Umbria there is a similar situation, with 3 main operators producing more than 85% of the total electricity (AEEG, 2010).

The institutional energy context. Within the framework designed by the Regional Energy Plan 2004, Alto Tevere Umbro has established its **Territorial Energy Plan** – PEC. PEC is consequence of an agreement "Sustainable Energy Alto Tevere" among the eight municipalities of the Alto Tevere Mountain Community. In ATU renewed interest towards renewables emerged again during the last three years, led to the agreement in 2007(Berna, 2010). It promotes sustainable development, renewable energy and energy efficiency. The parties commit themselves to consider and implement initiative and trying to encourage a bottom up approach and establish synergies between public and privates stakeholders. Beyond mapping the area, PEC encloses objectives and action plans for different renewables. It suggests both viable and pilot plants. The viable initiatives have been studied by the University of Perugia and the energy consultant Gianni Berna.

PEC includes biomass, in particular supports plant up to 1.5 MW installed power. Biomass has high potential considering the importance of farming and forestry for ATU. Beyond by-product originating from the ordinary farming and breeding activities, in the ATU there is availability of fields that could be used for energy purposes. Just to sum up, today 3,000 ha are set aside, 9,800 ha are growing cereal crops, 3,500 ha sunflowers and about 5,000 ha for tobacco (Istat, 2000; to make a comparison, see also Table 6-1). About 64,000 ton/year of manure is available in the Alto Tevere Umbro, out of which 18,000 in the Umbertide municipality (Bidini, 2006).

PEC mentions the realization of some biogas pilot projects with an installed power below 1 MWe, which could rely on local inputs. Unfortunately, political and organisational reasons are still impeding the actual implementation of the Territorial Energy Plan. Once established a Coordination Committee, the process is supposed to start (Berna, 2010). Everything should be ready at the end of this year (Ciarabelli, 2010). National policy and laws promoting renewable, together with the 2004 PER, have represented important incentives for the local commitment.

6.2 Energy actions in Umbertide

The main biogas project in Umbertide has been planned to be established in proximity to the municipal slaughterhouse. It is passing through the planning phase. After almost 2 years from the official technical-financial evaluation that the Sereco company delivered to the Municipality offices, the project is still under discussion.

Within the context described in section 1.1, an external **energy consultant**'s concern and steering activity represented a key factor triggering the local process of introducing the biogas technology in Umbertide. Gianni Berna was the one striving to convince the municipalities to work together in promoting an energy system alternative to the incumbent one, largely relying on fossil fuels. He has been crucial even for the specific pilot biogas case in Umbertide.

Table 6-4Renewable plants in Umbertide

Type	year	Power	Annual production (KWh)
PV (municipally owned)	1998	15.4 kW	27,500
PV (municipally owned)	-	16.2 kW	19,233
Mini Hydro (municipally owned)	2004	635 kW	2,850,000 (In 2009)
Several PV and solar thermal small plants			
Several small geothermal plant: many private and one public			
Biodiesel plant (private)			Not working today

Source: Ciarabelli (2010)

The **municipality** has been open to suggestions. It is committed to the renewable energy promotion since the beginning of ‘90s, when there was no specific incentives like the GC. The reason was local politicians concerns (Ciarabelli, 2010). Through realized or planned projects they aimed at exploring different technical solutions and discovering the ones more suitable for local privates and public needs and geographical features. Two sectors have been the leading lines of interventions: mini-hydro and PV (Table 6-4). Furthermore, a biogas plant is going to be started in Città di Castello. The farm Fattoria Autonoma Tabacchi is planning a facility of 1MWe power running on silomais (Berna, 2010). An additional project had to be set up within Umbertide municipality. It was supposed to digest manure and dedicated crops for electricity production (installed power of 450 kWe). But the company had financial problem and the project has not been started yet.

About three years ago Berna was the one suggesting the municipality to introduce the further technology of anaerobic digestion. Beyond the research of additional renewable resource, there was the need to reply a local need: a more sustainable way to handle waste generated by the slaughterhouse activity. The local government agreed to study the new option. Sereco company was given the responsibility to draw a first technical-economic evaluation.

6.2.1 The network

Umbertide municipality is making efforts in two directions: on one side is directly promoting interventions, on the other is working together with the near municipalities. In the following are presented the most important initiatives it has joined.

Agenda 21. In 2002 some of the Alta Val Tevere municipalities decided to work together to Agenda 21. Additional towns joined the existing group in 2004. Today all the municipalities belonging to the Mountain Community work together, under the Umbetide’s coordination. Till now the main Umbertide’s action has been writing the “Environmental Accountability Report”, which contains evaluation of natural resources and their flows and changes over time, together with costs of main environmental actions.

Aalborg+10. To implement its Agenda 21 program, municipality of Umbertide joined the national working group of small-medium towns. In order to contribute to the working group activity, Umbertide decided to sign the Aalborg Commitments (dealing with strategies and actions for a sustainable development). One first intervention is to compile a list of activities that both the public and the privates are undertaking within the issues mentioned in the Aalborg Commitments.

Covenant of Mayors was joined on the 23rd March 2009. The aim is reduction of CO_2 emissions in the municipality through “enhanced energy efficiency and cleaner energy production and use” (EC Energy, 2010). The municipality declares to fulfill its commitment by compiling an Action Plant for Sustainable Energy (Umbertide Municipality, 2010).

Climate Alliance international associations of cities and municipalities committed to protection of global climate. Milestone of commitment is halving per capita emission at latest in 2030 (baseline 1990) (Climate Alliance, 2010).

Twin towns. It is planned to build a network among the 8 Alto Tevere Umbro municipalities and their twin towns in order to further promote sustainability issues, included renewable energy.

UNESCO week in November 2009. A discussion on sustainability projects took place. Citizens joined the debate.

6.3 The pilot biogas project

The future small biogas plant in Umbertide will be built nearby the city **slaughterhouse**. It is situated in the proximity of a residential area, which is planned to be soon renovated (Ciarabelli, 2010). Slaughterhouse by-products and garden waste (grass, branches etc…) are the inputs. The digestion will take place in two reactors. The obtained biogas will be then sent to a co-generation facility (Table 6-5). 213,000 kWh of electricity will be produced yearly, out of which 13% will cover internal uses. The total heating is 290,000 kWh/year. It will be useful within slaughterhouse and AD process steps and for the composting phase. Surplus will be sent to nearby greenhouses. Digestate will be centrifuged. The liquid phase is planned to be processed through Sermap device (Sereco's patent to produce struvite) that takes away ammonia from the liquid before being sent to the sewage treatment plant. The solid part will be composted and then sold as fertilizer (Poletti, 2009).

Table 6-5 Estimation of yearly inputs and outputs in the Umbertide biogas pilot plant

Start year	Still a Project
Digester volume	130 m^3 and 600 m^3
Inputs	
Slaughterhouse waste	(Small amounts of several kind of residues from 100 pigs and 30 beeves per week)
Residues from maintenance of gardens	1 tonnes/day
Outputs	
Biogas (Nm^3)	230 (m^3/day)
Power (kW)	25
Electricity production (kWh)	213,000
Heating production (kWh)*	290,000
Electricity consumption within the plant	13%

Source: Poletti (2009)

**Not the whole potential of heating seems will be exploited.*

6.3.1 Some of the benefits from the pilot project

What now is just waste, causing large financial costs for the handling operations, can become a valuable energy source for electricity and heat generation. To give just two examples, the municipality spends 12,260 EUR to treat the gardens residues while the slaughterhouse 14,000 EUR to get rid of its waste, which is mainly going to the sewage treatment plant and landfill. Anaerobic digestion can change these costs in revenues, making them become a feedstock free of charge. Production of electricity and heat will allow not to buy them from the grid. Today (in 2009) the slaughterhouse spends 14,000 EUR/year for electricity and 6,400

EUR/year for methane. Thanks to the feed-in-tariff each KWh will produce a revenue of 0.22 EUR/kWh for a 15-year period. The investment for the new plant, included the digestate treatment, is between 300,000 and 350,000 EUR. The payback period has been estimated in 9-10 years without including some opportunity costs, like the methane, electricity and waste cost of the slaughterhouse. Including them it is about 8-8.5 years. The estimated cost to produce 1 m^3 of biogas is 0.65-0.70 EUR, whilst the estimated revenue from 1 m^3 of biogas is 1 EUR (including selling to the grid, savings for and alternative waste handling).

Table 6-6 Stakeholders involved in the biogas pilot plant in Umbertide

Actor	Role
Umbertide Municipality	Owner of the slaughterhouse and of the future pilot plant
Gianni Berna	Energy consultant
Sereco Biotest	Not just an evaluator. The research company is playing the role of supporter and promoter of the new project. Moreover Sereco is trying to promote innovation, for example by introducing its patent Sermap (Poletti, 2010 a&b)
Butchers' cooperative	They manage the slaughterhouse. They will get the direct benefits because less purchases both for energy supply and waste handling will be needed.
Cooperative with social mission	(employing "disadvantaged" people) it will receive the surplus heat for free. It will serve farming activities in greenhouses nearby the future biogas plant
Farmers	Not directly involved in this project. Nonetheless, municipality and project promoters are thinking the pilot case will beneficial for them and their activity.
Facilities contractor	Still not defined
Energy company	It will buy the electricity surplus
Investors	Still not identified
Public	Still no meetings (soon after got a positive judgment from regional authorities)

Many synergies among different activities and facilities, namely, the slaughterhouse, the management of gardens residual, the anaerobic digestion and composting facilities, will be exploited. Biogas use in the CHP plant represents an alternative to electricity (produced mainly from fossil fuels) and methane purchasing from the national grids. Even if the Umbertide's small pilot case entails small amounts of resources and energy, it represents a contribution to reduce fossil fuels use (and imports).It benefits the private activity at the slaughterhouse, the community and indirectly issues like energy security. Moreover, maintenance will be done by local companies and an additional worker will be recruit. The savings for key actors, like the slaughterhouse cooperative and the "social cooperative", could create a small but significant cascade effect in the local context. Finally, the biogas introduction through this first pilot plant will contribute and is already contributing to the enlargement of general awareness and local know-how among stakeholders.

6.3.2 Main findings about the current pilot project

The municipality is currently leading the biogas introduction through the starting of an owned small biogas facility. A managerial approach is leading the planning and design phase of the new plant. High-quality and sustainable service delivering is the rationale (reduction of energy costs and alternative way to treat the waste). In addition, local administration and consultants aim at testing a new technology and show it to other local actors. Enabling factors are the location and features of the plant. The small scale and the proximity to the slaughterhouse is likely to enable both the supply chain organisation as well as people acceptance. Furthermore, after meetings with member of regional and provincial agencies to acquire preventive judgment about plant permits, which will take place this fall, the municipality intends to start dialogue with citizens (Ciarabelli, 2010).

What emerge from this small initial experience and the Umbertide history is that a change towards biogas is not a matter of technology (Berna, 2010). The challenges are mainly two. **Administrative**: a major constraint that still risks to become the definitive barrier to the plant building and starting is related to getting permits. Remaining from slaughterhouse activity are classified special waste and its treatment is regulated by meticulous rules. The regulation is different from region to region and even in relation to the different provinces. Moreover, agencies and authorities involved in the permitting procedure are several. The resulting framework is particularly unclear and complex, thus often not adequate to rule on newer topic, like anaerobic digestion. Local government has still to understand if they will be allowed to treat that kind of waste. It is still possible that the project will not be approved. In that case the plant will not be built. The municipality would be interested to keep going in the biogas introduction but at the moment does not know which could be an alternative. The politicians are not so in favour of plants running just on maize or crops that could be used as food. Nonetheless a good news is represented by a recent development of law. Digestate will be classified no more waste, and this will favour its use directly on fields.

Financial: because of restrictive limits imposed by the national law on municipal expenses, the local authority has to find external financing. It is likely they will contact an energy service company (ESCO). ESCOs usually take care of analysis, design, installation and maintenance of a system to ensure energy savings to pay back the capital investment. Financial and technical risks are assumed by ESCO (Gordon, 1999). The feed-in-tariff over 15 years represents a good financial support and even a guarantee for banks.

6.4 Potential stakeholders in the future biogas system

Umbertide Municipality is a crucial actor. Pulled and persuaded by local committed consultants, it is attempting to enlarge know-how on a new "renewable technology" in the region through the small scale biogas plant. It is the project decision maker and owner of both the slaughterhouse and the land where the digester is going to be built. It has already started to work through formal and informal channel to make the project be accepted by authorities and citizens. Local government's environmental commitment started already in 1990 and has progressively developed over time. The current administration is receiving this heritage and wishes to give its contribution to move forward. The political support on those actions is pretty unanimous, today. (Ciarabelli, 2010)

Gianni Berna is a key figure in the process leading Alta Val Tevere towards bioenergy exploitation. He is an energy consultant, actually partner and administrator of Maridiana s.r.l., a demonstration breeding farm with the goal of extending the concept to rural areas that can benefit from raising alpaca. He has successfully organized and managed innovative agricultural projects in Umbria and in numerous third-world countries.

Sereco Biotest is not just an evaluator of the biogas plant at the slaughterhouse in Umbertide. Beyond the accountability, the research company is playing the role of supporter and promoter of the new project together with the consultant Berna. Through its work, it is making evident which is the best alternative in economic and technical terms. Moreover Sereco is trying to promote innovation, for example pushing for introducing its patent Sermap (Poletti, 2010 a&b).

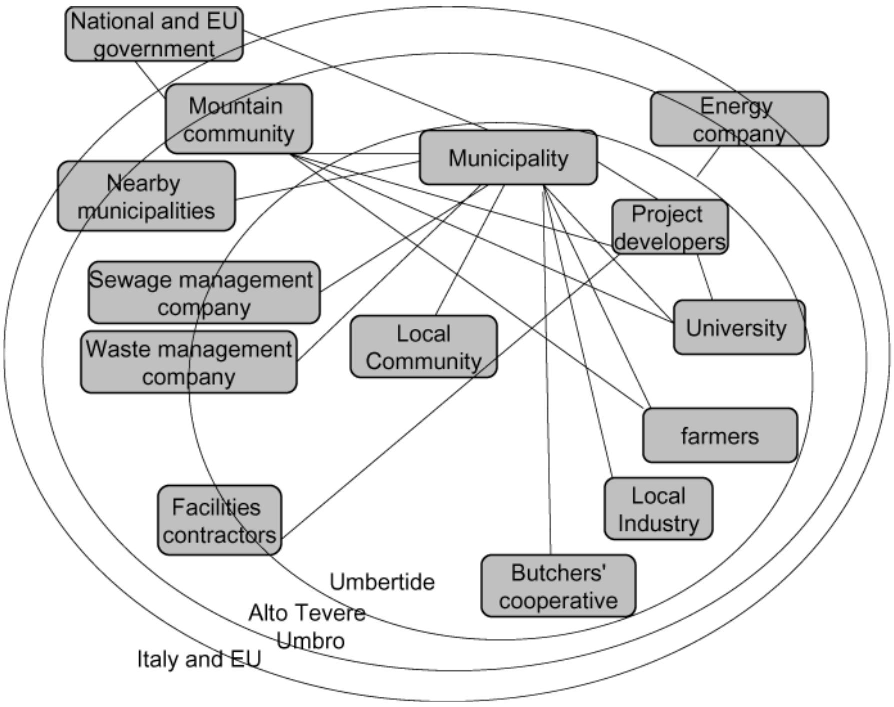

Figure 6-2 Stakeholders in Umbertide

University of Perugia is supporting the introduction of renewable in the area, for example, by doing research and performing studies together with consultants. University of Perugia was the institution compiling the study which led to the municipalities agreement on Renewable Energy Plan

Nearby municipalities, belonging to Mountain Community Alto Tevere Umbro and working together at the Agenda 21.

Mountain Community Alto Tevere Umbro it is a body aiming at increase the mountain areas value. It has been constituted by eight municipalities, Citerna, Città di Castello, Lisciano Niccone, Monte Santa Maria Tiberina, Montone, Pietralunga, San Giustino and Umbertide, which have delegated some of their functions. (Mountain Community Alta Umbria , 2010).

Farmers, their **associations** and **consortia** are not directly involved in the pilot project. Nonetheless, municipality and project promoters are thinking the pilot case will beneficial for them and their activity. Currently the tobacco business, a peculiarity of the area, is in crisis. Biogas and renewables could represent a diversification of farming activity and revenues. One consortia is already trying to start a biogas plant in Città di Castello.

Butchers' cooperative is part of pilot project. They will get the direct benefits because the they will need less external contribution both for energy supply and waste handling. They have been completely delegated the service.

Food industry could provide inputs to a future biogas system, while locally developed industry producing machines for agriculture could think to convert its technology.

Not many **NGOs** in the territory, even if people are members of national ones, like Legambiente, WWF and Italia Nostra. Though, there are small associations with specific environmental aims like promotion of the Tevere river, disagreement against a possible incinerator and concern for electromagnetic pollution, namely, "Amici del Tevere", the committee "Inceneritore Zero" and a further committee that want to move a telecommunication antenna. A notable NGO has its head quarter in Città di Castello, it is Climate Alliance (Cirabelli, 2010).

Table 6-7 Umbertide's milestones towards biogas

Year	Milestone
1990-1995	Umbertide's commitment in a sustainable development begins
1995	Biodiesel plant started operation, but after few years it closed down.
1996	Study for a biomass plant. Never realized
1998	The first PV plant is started, at the municipal high school
2002	Umbertide joins the Agenda 21
2004	PER – Regional Energy Plan
2004	A mini-hydro plant starts its operations
2007	Alto Tevere Umbro municipalities and Mountain Community agree on a Sustainable Energy Plan
2007	PEC – Territorial Energy Plan
2008	Consultants and experts suggest the municipality to take into consideration the biogas option
2008	The municipality asks Sereco to develop a first study
2009	Umbertide joins the Covenant of Mayors
March 2009	The technical – economical assessment is concluded
July 2010	The municipality has decided to follow up with the biogas project.
(FUTURE) Autumn 2010	Planned informal consultations with the agencies and bodies responsible to release the authorization
Straight after	Consultations and involvement of citizens

Local Action Group (GAL) implementing locally projects under the European Leader Programme.

GE.SE.NU is the company managing waste in Umbertide.

Cooperative with social mission (employing "disadvantaged" people) will receive the surplus heat from pilot project for free. It will serve farming activities in greenhouses nearby the future biogas plant

Umbria Acque is the company managing the waste water treatment, being assigned by Ato, the authority responsible for water management over sub-regional territory. The plant is placed in the municipal territory, in Montecorona. The sludge today is send to the landfill.

Facilities contractor, Investors

Broad Public in the past had a negative attitude towards some of the bioenergy project (Berna, 2010).

Energy company buying the electricity surplus from the pilot plant.

6.5 general drivers, barriers and opportunities connected with biogas

Local Drivers:

- Available supply: already source separated biowaste, manure and by-products from farmers, food industry and slaughterhouse waste, sewage sludge;
- Available land to be used for dedicated crops
- Available demand: national natural gas grid and national electric grid;
- Available technology
- Crisis of tobacco and interest from some of them and their associations
- Visionary experts and engaged people in local institutions
- The start of a pilot project
- University support
- Some interest from the farmers associations

Upper level drivers:

- Energy and waste legislation and planning in favour of renewables and biowaste treatment other than landfill
- International concern for climate change
- Green Certificates or feed-in-tariff for new and relatively small plants running on renewables.
- Subsidies from EU for energy crops and possibility to get support within the implementation of some plan, like the Rural Development Plan.

Local barriers:

- Available supply is scattered in the territory and in many stakeholders' hands, in turn the supply chain can be complex

- No district heating; nevertheless, part of the town is going to be restructured, thus a net for the heat use could be planned there

- Lack of experiences of connection to grid or use as vehicle fuel in Italy

- Need of a coordinator to make stakeholders cooperate;

- Broad public fear. The local community has had a negative attitude towards some of the bioenergy projects that were supposed to be implemented or started in the area (Berna, 2010). In general in Italy there is not a positive approach towards innovation (Boicelli, 2010). There is even an unconditioned fear for solid waste incineration, which risk to be extended to "similar" project (Gold et al., 2005).

- Some of the potential stakeholders are not awareness of opportunities and can lack the know-how. For example, famers have a deep and specialized expertise on tobacco, and they risk to be lock-in the current situation. The same can be said for the industry producing machines for agriculture.

Upper level barriers:

- Laws and regulation are unclear, often contradicting themselves and have been frequently changed in the past (Moretti, 2010; Poletti, R., 2010). Consequently, many stakeholders perceived them as uncertain. Current legislative interventions, even at regional level, seems to make an attempt to clarify the situation

- Long permit processes, even stricter when the treated material is classified waste (and this happens every time some of the agriculture by-product leave the farm)

- No dedicated programme financing the construction of kind of plants.

- Oligopolistic market for electricity and natural gas, in Italy. There are large and powerful companies detaining a large share, which in turn have a great lobbying power against political and institutional environment.

Biogas can be an **opportunity** for making the region further develop. It could represent a new way to deal with energy, waste, and other issues within the local economy. It can be a way to reduce the amount of imported fossil fuels in the region. By making the region more rely on local and renewable energy, the energy security in Umbria and Italy can be improved. Biogas can represent an additional way to treat by-products and biowaste, for private and public participants. For example it is an opportunity for waste companies for sustainably handling already source-separated biowaste and for the territorial authority dealing with waste (Ato) to comply with legislation. It can be a way for local farmers to differentiate their current revenue. Today agriculture and especially tobacco, which is a crucial farming activity for Umbertide, is in a not flourishing phase. The further European support towards bioenergy and energy crops can represent an additional facilitating aspect. In turn, even the local tobacco supply chain, and especially industry producing farming machines, could see in bioenergy a new way to reinvent its future.

7 Conclusive discussion

Distributed economies (DE) is still a concept in development that researchers are working on. Authors, mainly from the IIIEE and the Veil Institute in Melbourne, have worked on defining it for only a limited numbers of years. This thesis develops from some of the milestones the authors have provided. The use of DE concept has been the basis for understanding bioenergy, and the specific biogas contribution to sustainable development.

In order to reply to the research question "How can the implementation of a biogas system be tackled in Umbertide to enhance a Distributed Development?", it was a logical step to first address the question "what has been done in the other cases?". I decided to integrate two analytical models for the analysis of processes and characteristics in the three selected case studies. The application of the 9 DE criteria seemed too limited to well understand a context and the process that created it. The addition of a further framework that allows to consider the actual implementation of the transition has been useful to identify the mechanisms that make a system occur and further develop.

The **observation of empirical cases** has been an attempt to find both the existence of DE features in reality and understand how DE features can be concretized. I tried to see if, by adopting certain actions, it is possible to get a more DE-aligned system. I saw that many ways can be followed. The final outcome is a sort of meeting between what was implemented and what was pre-existing.

In all the three cases I found some common patterns:

- capable first mover
- attempt to solve local needs
- cooperation to address issues like supply, demand and know-how
- communication

One major finding is that **local actions** are important. It is true that without national or international support even local pioneers can have hard times. National grants and truly committed national governors were crucial both in Kristianstad and in Västerås. Even in Camposampiero I noticed the importance of national economic incentives, like the Green Certificates and the regional programme to save the Venice lagoon from eutrophication. But, without a local first mover and local committed people in private and public sectors, those interventions would not have produced what we see today, or similar results. Local actions are important to overcome several barriers, namely economic, perceptual, organisational ones.

A **bottom-up** and **participative approach** for intervention resulted to be essential in order to establish the system and obtain a more distributed outcome. Without starting from local needs and listening to them and, through these, finding solutions within the process, a true commitment is hard to reach. Without broad participation all the opportunities are not disclosed and remain unexploited, acceptance around new actions can still not be full, the loop risks to remain opened with relevant consequences in term of an actual distributed, and in turn sustainable, development. Participation is crucial both to make the system flourish, as well as further develop and "survive" over time. If the two Swedish cases show a successful implementation, in Camposampiero this issue seems solved only in part. There, the waste company managed to involve the broad public and local administrators in the debate, but was not successful with the farmers.

A **trigger** that starts the process is a basic condition. In the case studies there is always someone pushed by a need that makes a number of stakeholders converge, start a debate and find a solution. Then the process keeps on going both for someone's constant action, and even because of a sort of cascade effect, where the new structure seems to start living its own life. In Kristianstad the first mover was the municipality through its waste management company, while in Västerås and Camposampiero it was the waste management company itself. But the paths they took were different. In the first case it was opted to enhance a broad change and a vision was created. In Västerås a multi-participated company represented a first step towards the establishment of a network. In Camposampiero the company decided to move based mainly on its own resources. Further in the 3 cases different **engines** moved the process forward: in the first case it was the **vision** itself, which is enhancing a self-reinforcing loop towards the fossil fuel free status; in the **network** the interconnections themselves are "independently" linking and sustaining the whole process; in Etra the **internal** need to improve management is leading the process.

The importance of good and developed **communication** and the achievement of first good results were noticed. They can help in reducing the perceptual challenge. Communication **within** the system is fundamental. Information about the project has to be provided to system stakeholders. It allows exchange of expertise and awareness about system opportunities. It improves the general perception of the project. Communication with the **outside** is decisive. It allows external know-how to enter the system and enlarges the legitimization of a new technology at different levels, regional, national and local.

All the three cases worked and were more or less successful in relation to different aspects. In Kristianstad the key success was the ability to always include new actions and stakeholders in the process; in Västerås the key success was having managed to put in place a network directly benefitting many and local participants; in Camposampiero it is the economic viability, the exploitation of synergies and the partial acceptance of a pretty innovative technology that constitutes the successful part.

The following is an attempt to re-formulate the lessons provided by the three case studies, following the process structure.

Problem formulation is the moment when a systemic solution is looked for and attempts are made to make it prevail. It is crucial to identify the relevant stakeholders and local needs. The project planning should address all the potential barriers and keep in mind time and resource availabilities. The formulation of a vision embedding local values and the system's target can help. This can give motivation to the several stakeholders and leave room to further and new options.

Mobilization is the step when the process is set up. Usually it is started from what is existing and the revalorization of it. New networks are created in order to find new support and resources. The network, operating under the vision guidance, can represent a strong engine of the process. The connections should be solid and formalized enough to guarantee a certain degree of security, namely, partnerships, contracts, or other agreements. Involvement of many, even in the ownership, allows to retain locally value addition and to build a real diffused and interested involvement. The wider the partnership or network is, the larger are the generated renewable outputs, the actors that can enjoy the benefits deriving from the process, the level of acceptance around the system. Nevertheless this does not mean that the system has to be a large and fully operating net from the beginning. It can be started step-by-step (like Västerås shows with the gradual introduction of the collection system) and developed step-by-step (for example in Kristianstad the capacities are increasing over time).

Communication is the phase where the process is disclosed to different stakeholders. Learning is made spread and system is keep open to listen to everyone that can supply new knowledge on different aspect of the process.

7.1 Five factors enabling a distributed energy system

The analysis of the cases has been useful to elaborate an attempt to convert the 9 criteria in "5 enabling factors to a distributed energy system". These criteria could turn out to be useful whenever local developer intend to develop a bioenergy system, but could, in the view of the author, also be useful when analysing any system from a distributed economy perspective.

Table 7-1 Summary of 5 factors enabling a distributed energy system:

5 factors enabling a distributed energy system		
1	**Supply**	• **Local** • **Multi-inputs** • **Multi-suppliers** • Prioritize **waste** use
2	**Demand**	• for bioenergy: **local or connected** through grids to wider markets • for by-products: local re-cycling in the system
3	**Technology/type of production**	• aiming at system's energy efficiency and closing the resources **loop** • exploiting **synergies** • **multiplicity** of sources and operation
4	**Actors**	• **several** public and private bringing diverse expertise and resources in the system • directly involved in the **supply or demand** of **material and non-material** flows • **networked**, within the local system and towards the outside
5	**Finance**	• **Various** external and local financial resources

7.2 Recommendations to Umbertide

In Umbertide, some good **preconditions** for diffusion of biogas have already been put in place, like the establishment of the Territorial Energy Plan, the local introduction of some renewables or even the participation in international networks. Recently the construction of a biogas plant has been planned. It is perceived as a pilot case to show additional local actors, like farmers, a new option for their future development. Biogas can represent an option of revenue differentiation in farming activities, especially for those segments in greater difficulty, like the tobacco one. Obviously the relevance of biogas in terms of contribution to issues like reduction of use and imports of fossil fuels, improvement of national and regional energy security, economic and social benefits, will expand if the pilot case will become a starting point of a true complete system, like it is happening in the other case studies. Already some participants are wishing and putting effort to make such a change happen.

The **municipality** is directly promoting several renewables, and in addition is collaborating with neighbouring municipalities for a wider introduction of energy alternative to fossil fuels. It is coordinating the local Agenda 21 group and participating to several initiatives, like Climate Alliance, even internationally, in order to share experiences on innovation and feel involved in a global commitment towards sustainability. The number of links the municipality is tied with recalls the Kristianstad municipality situation. There, the local administration is locally and internationally connected with many actors, because of the ultimate goal of realizing the fossil fuel free vision. Umbertide in the future could choose to adopt a similar approach. Instead of just signing an international or local chart of commitment, it could decide to elaborate an own individual vision, rooted in the local context. In case it is opted for such a strategy and the crucial actor, the municipality, should identify potential stakeholders and elaborate a shared vision. Then it should activate and coordinate the mobilization of the diverse actors and, finally, take care of making the vision spread among stakeholders.

Recommendations for the first mover, which are useful for anyone who wants to lobby for the creation of a biogas system aligned with distribute economies in Umbertide :

1) ***Start operating from local needs***

… identifying local stakeholders and problems.

2) ***Start from locally available resources***

….and cheap (waste), and even from existing structures and infrastructures, and revalorize them; create and exploit synergies among diverse activities.

3) ***Create an informal network among many actors and engage many of them in a formal common project***

… even through public-private partnerships and long term contracts. This can help the development of supply and demand of material and non-material resources.

4) ***Coordinate***

…the many participants under shared and known targets.

5) ***Adopt a participative approach***

…early in the process, to organize internally the system and to gain external acceptance.

6) ***Be open and transparent***

Make everybody know the steps and decisions adopted and the target that you want to be reached. Especially make known the opportunities the system can offer. Make known the achieved successes (this increases commitment). In addition enable the coming of know-how in the system from the outside (keep the system open). Communication is a bare bones of the system: formal and informal, internal in the organisation and toward the outside. It is crucial to get acceptance, to get know-how and share leanings.

7) ***Use several financial sources***

…in order to find them easier and distribute the achieved benefits among a large group. Provide (when possible) incentives to increase involvement and acceptance.

8) Develop the system step-by-step

…in this way, the several choices can be tested and the overall risk of failure (because of financial and perceptual reasons) is reduced.

9) Amplify the pilot plant experience

10) Favour a multi-digestion scheme, not limiting the system to a co-digestion configuration

The process does not necessarily have to take place in the same physical place. Multi-production or co-production can be equally important.

A process based on multi-digestion and step-by-step development increases modularity within the system. Even flexibility, and in turn, resilience to shocks can be enlarged. Everybody should be necessary, nobody indispensable: lots of participants on the supply and demand side help in reducing the potential of system failure.

Sometimes keeping distinct but interconnected units can help to enhance the system flexibility and even to avoid some time-consuming permit process. An interconnection forward in the chain can still be a strong connection for the system. This envisions a system where several small units produce biogas and are interconnected further, in the CHP or upgrading phase.

8 Conclusion

The distributed economies (DE) concept is a challenging and fascinating idea which reconsiders the incumbent pattern of development. It envisions small, local, diverse and synergistically interconnected systems of production and consumption, with the ultimate ambition to promote social well-being and quality of life. In this study biogas systems have been analysed in order to empirically find features of alignment to the DE concept and discern the implementation process which led to them. On the basis of the analysis and discussion developed through the previous sections, I am going to reply to the initial research question:

How can local actors tackle the implementation of a biogas system to enhance a Distributed Development in Umbertide (Central Italy)?

Local actions are important and a first mover is required to trigger the process. The implementation process has to pay attention to every sub-process, namely problem formulation, mobilization of actors and resources, and communication of the process and its results. The process or strategy should be able to include the local needs, stakeholders, resources and existing boundaries, and turn them in a precious base to create a project, which not only put in practices new actions, but even add value to the existing local context.

Any first mover, or anyone who wants to lobby for the creation of a biogas system aligned with distributed economies, should pay attention to some crucial design criteria, concerning supply, demand, technology, actors and finance.

In Umbertide, the municipality could continue in its role of first mover and coordinator, amplifying what has already been started. It could create and add in the system a shared vision in order to connect all the local actions. It could act as a hub in the net, mediating the relationships among various participants, namely, the companies managing waste and sewage, farmers, energy companies, local industry, the slaughterhouse cooperative, and even those agencies responsible to give authorizations.

A systemic view of the whole process and context (local and national/global) is required. Broad involvement, establishment of formalized partnerships, joining of networks, creation of synergies, effort in closing the resource loop are all elements that can help the establishment of a system and its progress towards a distributed outcome.

At the end of this research journey, looking back, I can see a long, experienced and sometimes challenging process that has led me to draw some conclusions. These findings remain connected with their premises and their scope. Nonetheless, many questions still remain unsolved. They concern both biogas in itself and the DE concept.

A concern of mine if whether a biogas system in the long run may incentivize the continued production of waste or further activities that will keep on enlarging the global footprint, even if in a lighter way. My question is: does biogas really represent one of the long term solutions to solve the sustainability issue? Are there alternative ways more sustainable that really improve the incumbent system, namely, other biofuels, other ways to deal with biowaste, or even other ways to address energy needs?

Further about the DE concept: can distributed economies represent an effective solution to global concerns in the short and/or long term ? Is it possible to globally catalyze a shift to the new paradigm?

Future research could look at these concerns and go deeper in the examination as compared to what was possible in the current work.

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Gianni Berna (2010) , Maridiana, Umbertide

Luca Poletti (2010), Sereco Biotest, Perugia

Martini Corrado (2010), officer at the Camposampiero Municipality

Mauro Moretti (2010), CEO at the CRCM, Terranuova Bracciolini

Philp Peck (2010b), Professor at the IIIEE, Lund

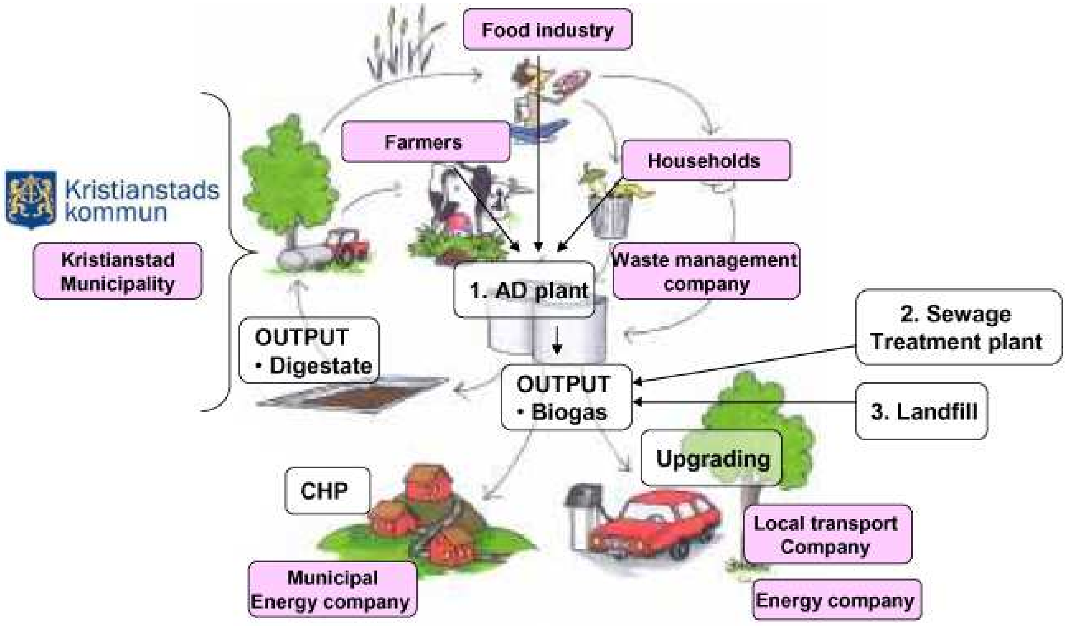
Piero Mattirolo (2010), Distretto AgroEnergetico Italia Nord Ovest

Roberto Poletti (2010), Sereco Biotest, Perugia

Viller Boicelli (2010), Consorzio Italiano Biogas

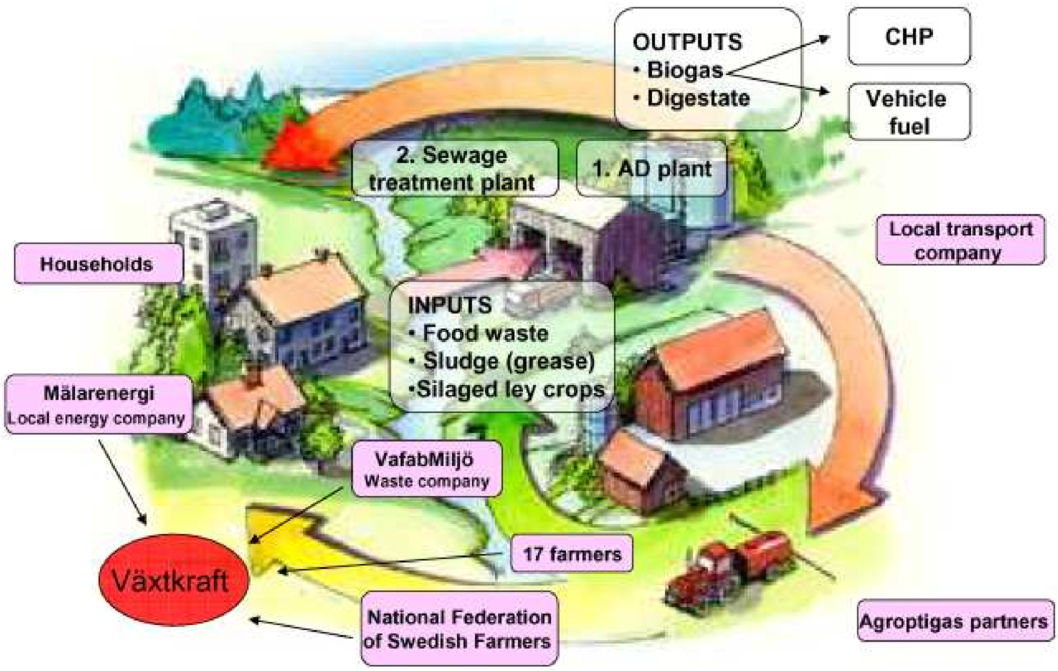
Appendix 1 A visual overview of the three case studies

A.1.1 Kristianstad biogas system



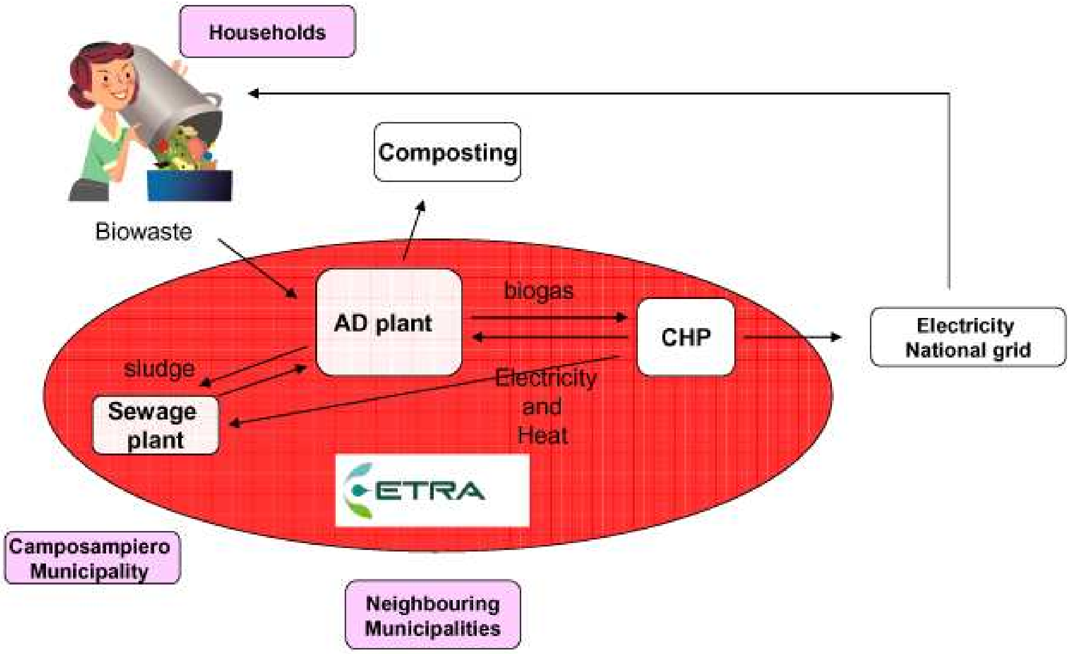
Source: elaboration based on a picture retrieved from Erfors (2009)

A.1.2 Västerås biogas system



Source: elaboration based on a picture retrieved from www.vafabmiljo.se

A.1.3 Camposampiero biogas system



Appendix 2 The Natural Gas grid in Italy

Source: Snam Rete Gas, 2008

Appendix 3 The Natural Gas grid in Sweden