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Techno-Economic Network in renewable energy:

A case study of sugarcane based energy in Cuba

Elisabeth Marie Cassidy Svennevik

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ICIDCA, Cuba. Photo: Elisabeth M.C. Svennevik

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Abstract

This case study investigates the interface between traditional agricultural sugarcane production and modern renewable energies generation in 21st century Cuba, a command economy in transformation. In the previous century Cuba was a world leader in sugarcane production. What roles do policymaking and innovation processes play in developing this natural resource into renewable energy, potentially providing the country with both fuel and electricity?

Qualitative data from interviews and documents obtained on a field trip to Cuba are used in this single case study. The theoretical framework of *Techno-Economic Network* is employed to describe the current state of sugarcane-based energy and to explain the governmental interventions.

It is argued that sugarcane-based energy is affected by the decreasing agricultural sugarcane production. Further it is found that energy production faces challenges in transforming from research into useful products due to obstacles within implementation of the technology and lack of connections to the consumers. Cuba's main policy and strategic objectives focus on independence, including control over resources combined with sustainable development. Paradoxically current policies aimed at sugarcane-based energy are found to be limited. This research argues that current governmental policies are largely segregated, with the sugar production industry on one side and renewable energy on the other.

Keywords: Techno-Economic Network, Strategic Evaluation, policy making, innovation process, renewable energy, sugarcane, Cuba.

Acknowledgement

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I owe my deepest gratitude to all informants and interviewees in Cuba for sharing their important knowledge and diverse opinions. I was met with some skepticism and some difficulties, but after meeting those challenges, I got the possibility to learn from interesting, enthusiastic, welcoming and highly knowledgeable people.

It has been a very interesting and rewarding time conducting the research for this thesis. When spending time alone on the field trip to Cuba I felt as if years of studies in economics were wrapped up in exciting conversations followed by reflective thoughts around capitalism, socialism, technology and culture. This has forced me to think, study and act differentiated according to changing surroundings and with a more open approach. This whole process has provided me with great knowledge and I am thankful to everyone who has been involved.

I would also like to express my gratitude to my family and friends for their encouragements and support and of course to my fellow students at the ESST program.

Finally, I want to thank uncle Roger for proofreading.

The responsibilities for any inaccuracies or shortcomings in this thesis are completely mine.

Elisabeth Marie Cassidy Svennevik

Oslo, October 2014.

Abbreviations

Abbreviation	English	Spanish
ANT	Actor-Network Theory	
ATAC	Sugar Technologists Association of Cuba	Asociación de Técnicos Azucareros de Cuba
CEEC	Study center for the Cuban Economy	Centro de Estudios de la Economía Cubana
CEPEC	The Center for the Promotion of Foreign Trade and Foreign Investment in Cuba	El Centro para la Promoción del Comercio Exterior y la Inversión Extranjera de Cuba
CETER	Study center for the technologies of technologies	Centro de Estudio de Tecnologías Energéticas Renovables
CITMA	The Ministry of Science, Technology and Environment	El Ministerio de Ciencia, Tecnología y Medio Ambiente
FLACSO	The faculty of Latin-American studies of social sciences.	Facultad Latinoamericana de Ciencias Sociales
ICIDCA	The Cuban Research Institute of Sugarcane Derivatives	El Instituto Cubano de Investigaciones de los Derivados de la Caña de Azúcar
ICINAZ	Cuban Sugar Research Institute	Instituto Cubano de Investigaciones Azucareras
ONEI	National Office of Cuban Statistics and Information	Oficina Nacional de Estadística e Información de Cuba
PCC	The Cuban communist party	Partido Comunista de Cuba
SE	Strategic Evaluation	
STS	Science and Technology studies	
TEE	Techno-Economic Evaluation	
TEN	Techno Economic Network	

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1 Introduction

Cuba was for centuries one of the world leaders in sugarcane production. The country has recent years experienced success in its emerging biomedicine sector and is currently developing its petroleum sector. Other countries such as Brazil, and the more similar country Mauritius, have emerging renewable energy sectors engaged with producing energy from sugarcane. Cuba has developed the techniques in sugarcane harvesting during the last 50 years from to hand cutting to mechanized harvesting, with great success in mechanical loading in the 1960 (Edquist, 1985). The Cuban sugar industry is considered well-positioned to participate in the growing global movement towards the development of sugarcane as a viable alternative source of energy (Alonso-Pippo, Luengo, Koehlinger, Garzone, & Cornacchia, 2008). Thus, Cuba could have good prospects to developing sugarcane-based energies. But currently, the tendencies to emerge are not corresponding with its potential. Cuba is presently ongoing an economic reform and the changes include reconsideration and renewal of policies to insure economic sustainability. Concerning these changes, could this natural resource and existing technology be appreciated differently in Cuba? How this renewable energy being implemented in to possibly provide Cuba with both electricity and fuel? Can a sugarcane energy sector in Cuba be developed?

1.1 Objective and research questions

This thesis seeks to create an understanding on how innovation processes and policymaking, described with the concepts of Techno-Economic Networks, are part of implementing the utilization of sugarcane as a renewable energy source. By investigating this, the thesis seeks to create comprehension about the current Cuban situation.

Does Cuba have an appropriate environment for establishing this innovation of renewable energy? What is the current state for this energy? Within a setting characterized by what seems to be a governmental eager for change and interest in renewable energies– how can this innovation take place?

The general objective of this thesis is to understand policy making and innovation processes in renewable energy in an industrializing country.

To achieve this understanding the sugarcane based energy in Cuba is chosen as the case and three specific research questions are asked:

1. What is the current state of Cuban sugarcane production and downstream bioenergy industries?
2. What are the current strategies and policies for sugarcane-based energy production in Cuba?
3. What are the main challenges facing the industry, national policymakers, and other stakeholders?

1.2 Cuba then and now

This research is investigating what is currently occurring in Cuba at the intersection between the 400-year-old agricultural sugar production, a newly increased focus on renewable energies and a country in economic transformation. The research does not focus on the actual economic transformation itself, but rather takes into account the fact that the country is engaged in an important phase of constant economic reform. The changes include reconsideration and renewal of policies to insure economic sustainability. Therefore it is interesting, but also challenging, to investigate this topic at this time. By presenting some of the main events in the recent history of Cuba, the following paragraphs will provide an overview of a background that affects the current situation for sugarcane-based energy in Cuba.

1.2.1 A phase of economic reforms

Cuba suffers from lack of hard currency material resource shortages. The social welfare system provides free education and medical care, but aside from this the Cuban people are experiencing great challenges. Most people are living in poverty as the salaries of public employment do not cover basic needs and "*the majority of Cuban families that depend on public salaries only are living far below the poverty line"*(Bye, Chaguaceda, & Tønnessen-Krokan, 2014, p. 26). The reasons for the current changes are undoubted, as the country has suffered decades of economic difficulties. But the future prospects of the economy is still uncertain, as the country faces challenges with continuing with the communistic idealism; "*Cuban society is currently engaged in defining its future direction, whether toward a better-organized state-led society, a more market-based one, a more democratic one, or – more likely – a combination of the three"* because *"After more than twenty years of hardship,*

Cubans are first and foremost interested in increasing their incomes in order to satisfy basic needs"(Brenner, Jiménez, Kirk, & LeoGrande, 2014, pp. 55–56).

Currently Cuba is in an economic transformation and there is consensus that how the country has been governed in recent decades needs to be changed, or at least modernized. This is why Cuba recently has started the most *"ambitious plan for economic transformation since the Revolution over 50 years ago. The Cuban model as it was once conceived does not work in today's context, neither domestically nor internationally. Cuba is at a crossroads and something radical has to be done"* (Brundenius, 2013, p. 1)

Currently the economy is in a phase of complex change, moving towards a state that accepts a bigger private sector.

> *"Cuba is in the process of undergoing significant – perhaps fundamental – economic reforms. Although the pace is not always very fast, and the direction is more characterized by zigzagging that by a straight line, there is little doubt that the state-dominated economy is about to give way to more non-state actors"*(Bye, 2013, p. 5)

After the Revolution in 1959 Cuba gradually became a socialist state ruled by the Communist Party of Cuba with Fidel Castro as the leader. Fidel Castro governed Cuba with communistic idealism since the Revolution in 1959 with strict restriction of the private sectors[1]. With support from the Soviet Union, Cuba´s international economic relations were radically transformed, their previous dependency towards the US was eliminated (Brenner et al., 2014, p. 117) Cuba became a close ally with the Soviet Union and this insured beneficial trading conditions, which had positive repercussions for the whole Cuban economy. This continued until the collapse of the socialist-trading bloc in 1989. *"Faced with the worst economic crises in the history of the Revolution, Castro announced the beginning of the "Special period in a Time of Peace" in 1990"*(Brenner et al., 2014, p. 119). The special period is "*mainly a result of the collapse of the Soviet Union, the Cuban economy entered a freefall in 1989 and did not reach bottom until 1993"* (Henken, 2008). The crises caused a need for change in how the country was governed and led to an "opening up" approach. Due to the crises, the Cuban

[1] This needs to be understood as a very limited and simplified description of the Revolution. For more information about Cuba's history see Brenner, Jiménez, Kirk, & LeoGrande, (2014).

government began in 1993 to do policy actions to stabilize the economy. *"Cuba took some steps to reduce the state's role in the economy by legalizing the use of foreign currencies, liberalizing and expanding self-employment, reforming the structure of agricultural production and allowing the creation of some private marketplaces"* (Pérez-López, 2002, p. 514). But it was not enough to resuscitate the economy, and Cuba continued in economic decline. The country did not recover and remained in its "Special period" throughout Castro's regime.

In 2006 the Cuban government announced that President Fidel Castro had relinquished temporarily all of his government and party responsibilities due to illness. His brother Raúl Castro overtook and served as provisional president and later in 2008 officially elected president (Brenner et al., 2014). The country he overtook was in economic difficulties; *"Cuba's economy was in shambles, sclerotic and unproductive, and incapable of providing the citizenry with minimal goods and services"*(Brundenius, 2013). President Raul Castro predicts a radically different economic landscape than what he overtook in 2006, and has clearly stated that he acknowledges the challenges the country is facing. "*At the National Popular Assembly on August 1, 2009, for the first time Cuba's President, Raul Castro, explicitly referred to the need to transform the economic foundations of the Cuban socialist project* (Brundenius, 2013, p. 23).

In April 2011, The Sixth Congress of the Communist Party of Cuba, PCC, approved 313 guidelines *Los Lineamientos de la Polítíca Económica y Social del VI Congreso del PCC* (PCC, 2011) to update – not reform – the economy, "*for creating a path to gradually transform the Cuban economic model with the goal of greater long-term sustainability"* (Brundenius, 2013, p. 5). With these guidelines the new era of change was initiated that will affect the whole economy. The guidelines support the communistic idealism, but have also taken into account the fact that the country is in interaction with other countries and also needs to face the challenges they are having in providing social welfare for its people. Therefore there is a need of reorganizing key aspects of the economy. The guidelines and are further elaborated in Chapter 4.

These recent events affect the prospects of the sugarcane-based energy, to which extent and how will it be governed by the state? This thesis will not address the future prospects – but

the fact that the country is undergoing fundamental changes makes it interesting to investigate and understand the current status.

1.2.2 Trends sugarcane production

The production of sugarcane decreased from 82 million tons of cane harvested in 1990 to 23 million tons in 2004, and continued to decrease to the very low level of 11 million tons harvested in 2005. The downsizing has been so severe that since 2003 they even had to import sugar in order to meet domestic consumption and fulfill export contracts (Alonso-Pippo et. al, 2008, p. 2163). Figure 1 gives an overview of the Cuban sugarcane and derivate production and clearly illustrates the high production levels up until 1990, followed by a drastic decrease and then continues with lower yearly sugarcane production.

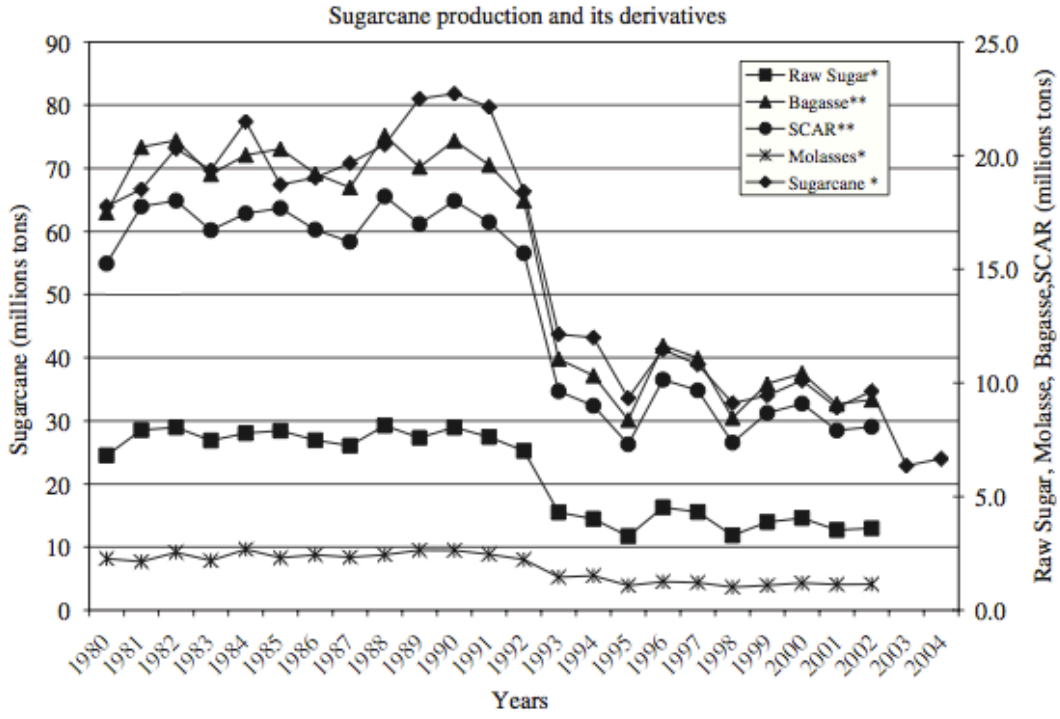

Figure 1: Cuban Sugarcane and derivate production (Alonso-Pippo et al., 2008, p. 2164)

Up until 1990 the Soviet Union had supported the sugar industry in Cuba by being part of their sugar-market:

> *"Cuba enjoyed a highly favorable commercial agreement with the USSR under which Cuba received 4 ton of imported oil in return for each ton of sugar it exported to the Eastern bloc countries. In addition to providing Cuba with energy security, this*

> *agreement effectively insulated the Cuban sugarcane agro-industry from the competitive price pressures of the world sugar market"* (Alonso-Pippo et al., 2008, p. 2164).

Briefly summarized, Cuba lost its customer that was paying over market price for the products and therefore they had to sell to a lower price to other countries within the international market. In addition, and perhaps more severe consequence, Cuba lost its access to subsidized oil.

The severe economic situation resulted in a drastic reduction in demand and multiple sectors throughout the country were affected. There were shortages of basic commodities such as food and fuel, the salaries were considerably lowered and the entire society entered an economic and social crises. The characteristics of the development of sugarcane industry are directly linked to these national and international historical events. Because of the general economic problems the country was experiencing, the derelict sugar mills were raided and all remaining parts were stolen "*Practically all of the closed sugar factories were plundered; parts, pieces of roofs, walls, hydraulic and sanitary facilities—anything which could be used—was stripped and carted away"*(Alonso-Pippo et al., 2008, p. 2169).

Since the start of the special period with its fall in production and loss of markets the sugar industry has not recovered nor managed to increase production to the previous levels, even though other industries such as the biomedicine and tourism have experienced growth. The government has made several attempts to recuperate the sugar industry, national strategies have been planned and the changes have been implemented. These efforts have lead to a shift rather than to a recovery. In short, the strategies have led to a closure of the small sugar centrals, and a focus to improve the larger centrals. The restructuring started in 2002 and has led to the shutdown of half of the industry's sugar-production capacity. Two-thirds of the land previously used to produce sugar now supports other products or is simply abandoned, covered in the weeds called Marabou. The sugar centrals in Cuba in 2013 are shown in figure 2 and although the industry has been downsized, it is still a big industry in Cuba with 56 sugar centrals. The attempts to recover the production have been characterized as follows:

"The restructuring plan was intended to reallocate resources to the agro-industrial complexes with the most productive sugarcane lands and the highest industrial yields. The production objective was to achieve low-cost, stable production volumes that met domestic demand needs and export commitments plus an exportable surplus intended to generate hard currency when world market prices justified it. To date, the restructuring plan has failed to stabilize sugar production, with output levels not seen since over a century ago" (Alvarez & Pérez-López, 2006, p. 55).

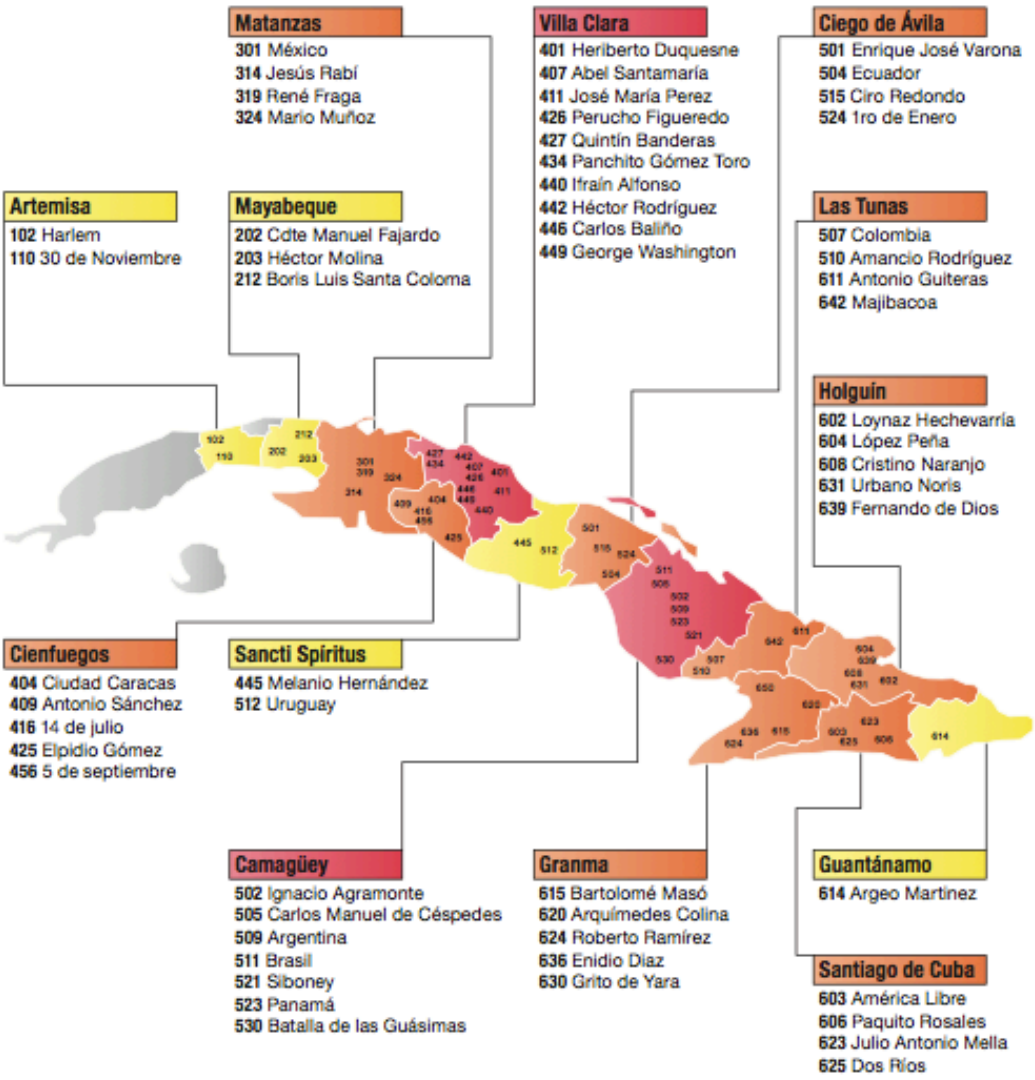

Figure 2: Sugar centrals in Cuba in 2013 (ATAC, 2013).

1.2.3 Trends energy

The consumption and production of energies are affected by the same historical events as the sugarcane industry. The sugar and oil trade deal with the Soviet Union caused an increase in energy consumption and energy production, i.e. electricity generated by imported oil.

Before the Revolution in 1959 only 56% of the country was electrified. By 1989 this had increased to 95%, a development made possible mainly due to the cheap oil accessed through the sugar for crude deal with the Soviet Union. With the introduction of the special period energy consumption and production were severely reduced. The production of electrical energy in the country did not develop much until 2006. Up until this year only 11 large and quite inefficient thermoelectric plants provided Cuba with electricity. These were mainly 25 years old and were not functioning 40% of the time. Events such as devastating hurricanes, difficulties to obtain oil and increased focus on climate change led to the Energy Revolution in 2006, according to "*La Revolucion Energetica: Cuba's Energy Revolution*" (2009). The country started to develop programs that focused on efficient use of energy, introducing initiatives to significantly renew household appliances as well as exploiting the development and use of renewable energy sources (Sulroca, 2011) (Moreno T. C., Hugo V. V., Fariñas E.W., y Delgado Y. T, 2013).

The Cuban government decided that one of the best ways to provide for energy security was to move towards decentralized energy, and thus it began the move towards distributed generation. In 2006, 1854 diesel and fuel oil fuel micro-electrical plants were installed across the country according to "*La Revolucion Energetica: Cuba's Energy Revolution*" (2009). This was an important initial step towards using renewable energy sources, as the facilities employed in the system can be powered by other fuel sources, e.g. sugarcane.

The four main sources of renewable energy in Cuba are solar, wind, hydro and biomass/bioenergy. The government's stated aims are to develop these energy sources (Sulroca, 2011). However in 2009 Cuba still relied on imported oil for more than 54% of its energy in production processes and 94% of its electricity generation (Sulroca, 2011). Presently Cuba is highly dependent on oil imports for providing energy and thus they are faced with global challenges concerning energy production and consumption. The contemporary global scenario is characterized by problems that have led to simultaneous,

interrelated crises in the worldwide social, economic and political sphere. Cuba is part of these crises and the crises in turn are directly related to the current development of sugarcane-based energy. This entails the energy crisis concerning an increasing trend in the price of fossil fuels, the environmental crisis concerning climate changes and the food crisis concerning unequal distribution of resources, which threatens the food security of the population in many countries (Sulroca, 2011). Figure 3 provides an overview of the energy sources in Cuba in 2009. Imported oil was 54%, national oil 25 % and energy from sugarcane biomass 8%.

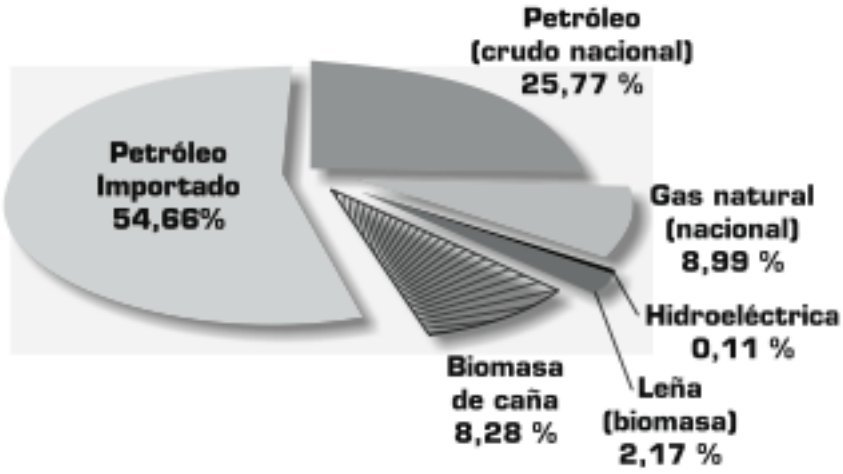

Figure 3: Energy Sources in Cuba. (Sulroca, 2011)

1.2.4 Future perspectives sugarcane based energy

Sugarcane-based energy is currently the largest supplier of renewable energies in Cuba. Statistical information from '*Oficina Nacional de Estadística e Información de Cuba*' provides up to date information and states that the total aggregated supply of renewable energies in 2013 was equivalent to 1 211 000 tons oil and of this, 993 000 tons (82%) came from sugarcane residuals (ONEI, 2014).

Cuba is by considered to be *"Well-positioned to participate in the growing global movement toward the development of sugarcane as a viable alternative source of energy"*(Alonso-Pippo et al., 2008, p. 2180). However, the current economic situation creates obstacles for this development as "*the main weakness to the introduction of ethanol fuel production and sugarcane biomass power generation in Cuba continues to be the lack of hard currency required to modernize Cuban sugar mills*" (Alonso-Pippo et al., 2008, p. 2180).

Cuba also has advantages in this development due to its established experience and knowledge in sugar production and its sugar agro-industry infrastructure. Cuba is regarded to be in good position to become an important producer of sugar-based bioenergy due to its natural resources. "*No other source of renewable energy in Cuba has the potential that sugarcane has"*(Alonso-Pippo et al., 2008, p. 2179).

Cuba, a country with natural resources in sugarcane and an need for energy - combined with encompassing governmental control with a desire for change to provide economic sustainability – could this be a setting suited for the development of sugarcane-based energy?

1.3 Contribution

The current situation in Cuba is strongly affected by the fact that public bodies dominate all economic sectors. In the command economy in Cuba the government has an overall encompassing role and this is different from other economies. This thesis takes this into account to some degree. Therefore it can only in limited extent contribute to provide useful information regarding policymaking and innovation processes in renewable energy.

Why examine a communist country in constant crises in the midst of ongoing economic reforms to create knowledge about policymaking and innovation processes in renewable energies? This thesis seeks to, in limited extent, to contribute to current public debates and to the theoretical framework.

1.3.1 Contribution to current public debates

This thesis is relevant to current global and national discourse about the development and application of renewable energies. Environmental concerns and the current energy crises are global issues, but nations are facing different challenges in regards to this.

Cuba was one of the world leaders in sugarcane production, but does this mean that they can achieve success in developing renewable energy from this natural resource? It is far from obvious that it is feasible to develop this energy production, just because of previous success in sugarcane production. It requests investments, infrastructure, technology and not at least coordination of governmental policies. And even in a country where the State has such an encompassing control there are great challenges.

There are more than economic measures that need to be taken into account when developing and implementing a renewable energy technology. Policies and strategies need to consider all these measures and this creates diverse challenges for the policymakers and other stakeholders. This case study uses an interdisciplinary approach that can be useful in comprehending and communicating the challenges in the development of a renewable energy in industrializing countries. Although the Cuban situation is unique, the case can provide useful information about the development of a renewable energy.

1.3.2 Contribution to theoretical framework

The thesis argues that the network perspective provides important information about the dynamics of the innovation process and policymaking within renewable energy. The paper evaluates the prospects of possibly using the conceptual framework to understand implementation of renewable energies in similar industrializing countries by looking at the policymaking and innovation processes. The thesis seeks to establish a point of departure for identifying and discussing opportunities and challenges in policy making for renewable energies in similar industrializing countries.

1.4 Thesis outline

This chapter presents the general objective and specific research questions and gives a presentation of the context of the case.

In Chapter 2 the theoretical and conceptual framework provides an overview of the concepts of Techno-Economic Networks. This included a presentation of the literary context. Thereafter the concepts of TEN are presented; the three Sub-Networks and the Intermediate Sub-Networks, their dynamics are explained, and the concepts Techno-Economic Evaluation and Strategic Evaluation are presented as tools for policy development process analysis.

In Chapter 3 the methodology used in the research is presented. This includes information about the research design and strategy of the case study and with this the whole process of the study is explained. The data collection process by is elaborated by presenting the fieldtrip to Cuba, the interviews and the documents obtained. The chapter ends with an explanation of the quality of research with its limitations and ethical considerations.

In Chapter 4 the case of sugarcane based energy in Cuba is presented. The concepts from the theoretical framework are used to describe the current state and the governmental policies and interventions are explained.

In Chapter 5 concluding remarks are presented. This includes a discussion and implications for theory and policymaking.

2 Theoretical and conceptual framework

This chapter starts with a literature review that presents the background for theories and explains how the theory of Techno-Economic Networks emerged. Then it is argued how the concepts of TEN are used in research and how it is applicable for the objectives of this thesis. The concepts are then presented by explaining the three sub-networks, the intermediate sub-networks, their dynamics and how they can be described. The concepts Techno-Economic Evaluation and Strategic Evaluation are presented as tools for policy development analysis.

2.1 Literature review - the theoretical context

The section on the literature on TEN begins with the development of Science and Technology Studies, continues with the development of ANT, which then culminates in the development of the theory about Techno-Economic Networks. Figure 4 gives an illustration of this. A literature review on these topics will provide a presentation of the theoretical context.

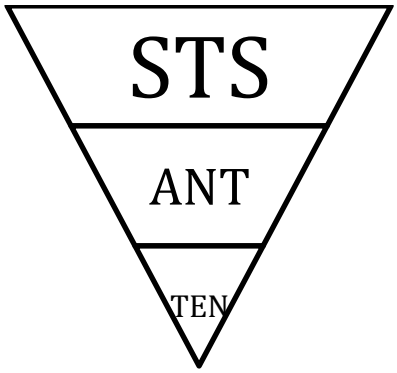

Figure 4: Theoretical context of STS, ANT, TEN

2.1.1 Science and Technology studies

Science and Technology studies are considered an interdisciplinary approach addressing the interaction between science and technology and a central part of the approach is the social. It addresses the social shaping of technology, and vice versa, how technological development shapes the society. How are science and technology created, and how is the social part of this? A main argument is that neither science nor technology is created naturally. It does not develop on its own, by itself, thus the social has to take part no matter what. Because of these

arguments STS has an interdisciplinary perspective that takes into account how the social, e.g. policies and culture, affects the technological development and scientific research, and also how the technology and science influences the social.

In the early stages of the evolution of STS these relationships were considered a new way of analyzing knowledge and expertise. The prehistory of STS can be considered to be connected to earlier social and scientific theories such as the development of Merton's arguments about science and society, in which he argues that also the social has to be considered inside the research environment (Merton, 1942) and the developments of the arguments about the role of the social within history and philosophy of science and sociology of science (Kuhn, 1977)(Polanyi, 1962).

The further development of STS can be considered to be radical, but it is not new. It can be *"described as a philosophically radical project of understanding science and technology as discursive, social and material activities that starts from an assumption that science and technology are social activities"(*Sismondo, 2010, p. 11). When STS examines how things are constructed it has a perspective that focuses on the action more that the structure. This makes it possible to study, as this thesis seeks to address, the relationship between actions as policies and technological development on the macro and micro level; *"The field makes it possible to see macro-level structures as constituted by and having their effects in micro-level action"* (Sismondo, 2010, p. 200).

"*STS starts from an assumption that science and technology are thoroughly social activities"* (Sismondo, 2010, p. 10) and because they are active processes, they also need to be studied as such. The STS field investigates how scientific knowledge and technological artifacts are constructed. With the expansion of arguments about these relationships several different approaches have been created. STS can be considered as having one perspective with several approaches. Among the main approaches are Sociology of Scientific knowledge (SSK) (Bloor, 1973)(Collins, 1975)(Collins, 1981), Social construction of technology (SCOT) (Pinch & Bijker, 1984), and Actor-Network Theory (ANT) (Latour, 1987b)(Latour, 2009)(Law, 1992) (Michel Callon, 1986).

2.1.2 Actor-Network Theory

The Actor-Network Theory was originally developed by STS scholars Michal Callon, Bruno Latour, and John Law (Michel Callon, 1986) (Latour, 1987) (Law, 1992) and their work contributed to the early development of ANT. The approach is different from other STS approaches because of its material-semiotic approach (Law, 2009), which means that that the objects give meaning to the network because of the relationship between the material and the semiotics. Some of the concepts, e.g. translation, in the above mentioned original papers have been further elaborated (Michel Callon, 1986). Over time there have been different varieties of ANT. This thesis will not assess this, rather merely relate some of the developments. New concepts and debates have been included and contributed to the theory's development in different directions. Some of the concepts have been assessed and new branches of the theory has been created; e.g. research in the wild (M. Callon & Rabeharisoa, 2003), hot and cold situations (Venturini, 2010), framing and overflow (Michel Callon, 1998), expertise and technical democracy (Michel Callon, Barthe, & Lascoumes, 2009) and the Techno-Economic Network (M. Callon, Laredo, Rabeharisoa, Gonard, & Leray, 1992). This thesis will employ the Techno-Economic Network.

2.1.3 Techno-Economic Networks

The Techno-Economic Network is presented by Callon in his article 'Techno-Economic Networks and irreversibility' (Michel Callon, 1990). There the heterogeneous processes of social and technical changes are investigated and the dynamics of Techno-Economic Networks are explained. The article considers how actors and agents are constituted and define one another within networks in the progress of translation. The translation is used to explore how the networks converge to create incorporated linkages of the heterogeneous elements. When the linkages are shaped by the processes of translation the networks ensure future durability. With this seminal paper, Callon can be considered the main contributor to the theory of TEN. In a later paper, 'The management and evaluation of technological programs and the dynamics of Techno-Economic Networks: The case of the AFME', Callon et al. (1992) uses the theory of TEN to address an empirical case study of the French Agency for Energy Management (AFME) (M. Callon et al., 1992). The article presents a series of concepts and tools that are designed to describe the morphology of TENs and to analyze their dynamics. Callon uses the Techno-Economic Network to address issues about policymaking, innovation and technological development. The theory has further been used in other case

studies to address environmental policies (de Laat, 1996), R&D strategy (Penan, 1996) and also more specific policy issues regarding the Cuban biotech sector (Plahte, 2010).

There is literature that theoretically discusses the use of TEN, e.g. in comparison to paradigms (Green, Hull, McMeekin, & Walsh, 1999) (Hull, Walsh, Green, & McMeekin, 1999), with the theory of standards (Loconto & Busch, 2010), and in connections with the field of systems of innovation studies (Plahte, 2010)(Geels, 2004)(Geels, 2005). This thesis will not address these theoretical discussions. The literature on TENs has focused mainly on describing the emergence and stabilization of specific innovations and is used to analyze the wider context of an innovation, embraced by social, economic and technical elements. The policy processes are fundamental in this context. Therefore TENs is applicable for use in this thesis.

2.2 Techno-Economic Network in research

2.2.1 Innovation processes and policymaking

Innovation and economic performance are linked. By examining innovation in the making, the innovation process of the actors and within the networks, we can get an overview of a continuous interaction among actors and within organizations (Fagerberg,Mowery, & Nelson, 2005). Innovation, and how it performs, has broader social and economic consequences, thus innovation processes are associated with policy issues. These issues are interdisciplinary and the conceptual clarification of the term 'innovation' therefore varies in the literature. Fagerberg et al. (2005) has concluded that there is no universally valid definition of innovation (Fagerberg et al., 2005). Since the term 'innovation' differs, it is necessary to specify that in this thesis the concept of innovation is used in terms of innovation processes, and not as objects or concrete systems. Innovation is understood as a process that treats both technological change and economic development. (Andersson, Å. E., Batten, D. F., & Karlsson, C.,1989).

2.2.2 Relations and Interest

This thesis uses theory of Techno-Economic Network. Some the general ideas and assumptions within the ANT that the TEN builds upon will therefore is presented here. ANT builds on the ideas that social relations are effects of the participation and existence of actors within a network, and that objects as different physical material also are actors as parts of this

social network. (Law, 1992). Furthermore ANT posits that all these actors should be studied symmetrically, i.e. equally included when analyzing a network (Law, 1992). The ANT rests upon the assumption of symmetry, that all actors are included, as well as upon the theories of ethnography within sociology (Latour, 1987) (Latour, 2009). By following the actors in their roles in their environment it is possible to reveal information about the actors, understood as the technological and the social, their intentions, their interests, their aims and the distribution of power. ANT thus can be used to tell stories about ongoing processes that include technological as well as human actions and will contribute to reveal information about this. Law (2009) emphasizes that the Actor Network Theory is more of an approach than a theory, as the approach is descriptive and *"tells stories about "how" relations assemble or don't"* (Law, 2009, p. 141).

The TEN is a suitable approach for the Cuban case of sugarcane- based energy because it takes into consideration the aspect of interest. Interest is in the Cuban case is affected by their history and culture. There private market is limited and the policymaking thus has a distinct direction towards the publicly owned and operated industry. By including the interest aspect of this it is possible to understand the development and implementation of this innovation. The approach is applicable because it takes into account the different reasons for interest, where, why and how the interest is situated and how the different actors articulate it. By taking into consideration interests as independency and self-sustainability the approach makes it possible give a more complete presentation of the current Cuban situation, both in terms of policymaking and innovation processes.

2.2.3 Limitations

In this thesis ANT and the theories of TEN are used pragmatically with an acceptance of their limitations. ANT can be criticized for how it includes the material objects by giving them interests. The symmetry can also create obstacles because does not take into account the uneven distribution of power among the actors. In this paper the use of both ANT and TEN concepts are limited and the thesis does not employ all aspects of the theories. The research is limited the use of ANT, e.g. it does not handle the interest of the sugarcane fields themselves. Therefore the theoretical framework presented here needs to be understood as a tool used in order to generate a description of the current state and reach the general objective of the thesis.

2.3 Definition and application of TEN concepts

The concept of Techno-Economic Networks (TEN) is based on ANT and was developed by Michel Callon and his colleagues (Michel Callon, 1990) (M. Callon et al., 1992). The concept was created in order to study government interventions that aim on transforming the results of science into socially useful products and processes and seeks to provide a solution for the linking of the social and the economic (Plahte, 2010). On one hand, such interventions differ from traditional public R&D funding programs in that the government would have much more of an operational role. On the other hand, they differ from large public R&D projects aimed at developing a specific object, such as a nuclear bomb or a military aircraft, in that a full range of products and processes would be developed (Plahte, 2010, p. 149).

The TEN concept is suitable to identify the actors and interests that are involved in and have influence on the policy-making processes for strategic technologies. What are the strategies and policies? In what way is the government part of the technological innovation process? What challenges are the policymakers meeting when intervening in the development? By using these concepts in this analysis, the current situation of the sugarcane industry will be mapped out, and the policies regarding sugarcane as energy and the challenges that are met by policymakers when intervening, will be elaborated.

2.3.1 Definition

Science, Technology and Market can all be involved in the development of the innovations and these elements are part the Techno-Economic Network. To understand the current situation of the sugarcane industry and downstream industries one has to understand who and what are involved in using the innovations and implementing the technologies and which relationships are created. Callon et. al (1992) provides the following definition of a techno-economic network:

> *"What we define as a techno-economic network is a coordinated set of heterogeneous actors - public laboratories, technical research centers, industrial firms, financial organizations, users, and public authorities - which participate collectively in the development and diffusion of innovations, and which via numerous interactions organize the relationships between scientific-technical research and the marketplace"*(Callon et al., 1992, p. 220).

Callon explains that the networks evolve over time and may vary according to the different actors involved. He stresses that the term 'actors' is used in a complex, heterogeneous and dynamic manner. Actors include humans, natural objects, artifacts and texts, as well as networks made up of these actors, e.g. documents, knowledge, technical artifacts. This is not a static situation but will vary over time (Callon et al., 1992, p. 220). Callon et al. (1992) further elaborates how the dynamics of the variation of the actors involved in the network causes a continuously changing web.

The dynamics are characterized by the significance of relationships and how the actors act together; *"relationships between institutions (or between heterogeneous organizations) are more important than the institutions or organizations themselves"* (M. Callon et al., 1992, p. 222). These interactions emphasis the complexity of TEN because the relationships open the possibilities for creation of new knowledge and skills, which in turn makes it possible for an innovation to occur anywhere within the network "*The dynamics of the techno-economic network is tied to that of the innovation process"*(Callon et al., 1992, p. 223).

Therefore, in order to understand the current situation both in terms of technological innovation processes within sugar and energy industries, policymaking and the challenges met by the policy makers, the concept of Techno-Economic Network will be used.
Callon has as mentioned used this framework in an empirical case study of the French Agency for Energy Management (AFME).

2.3.2 Three sub - networks

In order to comprehend the Techno-Economic Network the networks needs to be further subdivided. To understand the network more completely, to comprehend the dynamics of the relationships and what the government actually intervenes into, Callon presents the three categories, labeled as sub-networks or poles[2]: "*These are the scientific, technical and market poles"* (Callon et al., 1992, p. 220).

The Scientific sub-network (S) is categorized by the production of certified scientific knowledge (Callon et al., 1992, p. 220). In the Cuban context this can be found in articles in

[2] Callon uses the words "pole" and "sub-network" interchangeably.

journals and research produced by universities' research institutions. These will also be part of a transfer because they can be considered outcomes of research and inputs to technological development. This will be further elaborated later in the paper. Research is the core of what Callon regards as the scientific sub-network.

The Technology sub-network (T) includes the items and associated features, such as patents, models and prototypes that contribute to the production (Callon et al., 1992, p. 221). Thus the main products of the technical sub-network are artifacts, e.g. it describes how the sugarcane plant converted into energy production.

The Market sub-network (M) corresponds to the universe of users and is not considered in purely economic terms such as supply and demand. Rather the concept grasps the entire environment surrounding the users, as stated; "*the identity of consumers, the nature of their "needs", their hierarchy of preferences (or, more prosaically, purchasing criteria), their organizational forms and so on"* (Callon et al., 1992, p. 221). The users provide information about themselves through expressing their needs and desires: "*The market, and this is the origin of its force as a mode of organization and coordination, is a gigantic machine producing more or less explicit information about identity of users and their expectations"* (Callon et al., 1992, p. 221). Callon's conception about the market is particular appropriate for the Cuban context, to consider the whole environment around the users because of the lack of market economy.

Dynamics and intermediary sub-networks

S, T & M are all part of the TEN and in different ways connected to the other sub-networks. Figure 5 shows these dynamics. Callon determines these connections as intermediary sub-networks and presents the transfer pole between science and technology (ST) and the commercialization and development pole between the technology and the market (TM). Callon details these connections by explaining that the ST consist of *"large number of organizations that are exclusively devoted to bringing science and technology into relationship with each other"* (Callon et al., 1992, p. 221). And the TM "*consists of the production and distribution activities that lie between technology and the marketplace"* (Callon et al., 1992, p. 222).

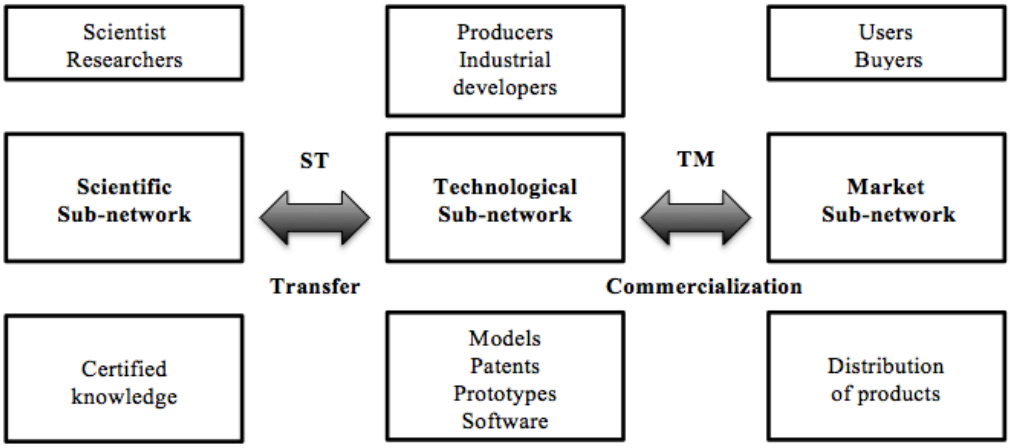

Figure 5: The Techno-Economic Network. Adopted from (Callon et al., 1992, p. 222) and (Plahte, 2010, p. 51)

The contemporary state of the sugarcane industry and downstream bioenergy industries can be explained by elaborating the current state within the three categories of the sub-networks Science, Technology Market. The intention is not to divide the network; rather, by using the sub-networks concepts it is possible to provide an explanation of the topics and argue how they are related to one another as well as how they are interdependent. It is neither possible, nor desirable to completely separate the elements, because of the fundamental meaning of the interconnections and dynamics of the network. But some separation and systematization is necessary in order to provide a coherent explanation of the dynamics of the current state. These connections are what the theory emphasizes: technology is created in interaction with other artifacts and human objects. The connections go in both directions and are should not be understood as moving as the linear model in some early innovation theories.

2.3.3 Three structures of Techno-Economic Networks

Callon et al. (1992) presents concepts that are designed to analyze the dynamics of the TENs and to describe their structures - how they are incomplete or chained, convergent or dispersed, long or short (M. Callon et al., 1992, p. 215). By employing these concepts it will be possible to give a more detailed explanation of the status of the TEN. The application of the descriptions will be presented in the analysis. These concepts will therefor be further elaborated in chapter 4.

2.3.4 Strategic Evaluation

> *"The strategic evaluation is preliminary to any intervention, and constitutes a real and necessary stage. It can draw on criteria which are not purely economic, and can take into consideration national independence (in terms of resources or technology), impact on the environment, the satisfaction of a desire for social equity (for example, the availability of energy resources in isolated regions) and so on"* (Callon et al., 1992, p. 218).

I interpret Callon et al. (1992) characterization to mean that the Strategic Evaluation is an evaluation that uses multiple measures and criteria. This enables the inclusion of the different preoccupations the government has concerning this technology. The outcome of the evaluation is a list of products and processes that are identified by the function they are able to perform. Their development or replacement is considered strategic – they will be measured and compared on the basis of the government's missions. Thus the term Strategic Evaluation entails which considerations the Cuban government makes – and included in these considerations are their reviews of the plans for what can be developed. Strategic Evaluation results in a specification of a range of products that represent the interest of the public and the objectives they have for intervening, "*it is a continuous, reiterative process and it is suitable to use the evaluation to analyze the strategic choices and their underlying assumptions, interest and considerations"* (Plahte, 2010, p. 149).

2.3.5 The Techno-Economic Evaluation

The Techno-Economic Evaluation is also the articulation of the interest of the public, but rather positioned on the tools for intervention. When evaluating what they can develop in the Strategic Evaluation, the Techno-Economic Evaluation treats how this can be developed. The Techno-Economic Evaluation is the process of identifying the actors and other resources that are needed in order to create the desired products, and how to organize them. (Plahte, 2010, p. 184) (Callon et al., 1992). How the government elaborates this evaluation will not be employed in this paper because it is not feasible determine to this degree how the actors can be organized. Therefore the governmental evaluation about this will be presented in this paper as an evaluation the government needs to consider and what they can take into account in this consideration.

2.3.6 Techno Economic Evaluation and Strategic Evaluation

The Techno Economic Evaluation and Strategic Evaluation are presented separately, but this does not mean that they should be treated separately. The evaluations are interconnected, they build upon one another and are two aspects of one process. Figure 6 illustrates the dynamics of this. Callon elaborates the importance of this, by stating that:

> "*How could a strategic evaluation not draw on information about a sector, and for example on prior knowledge about markets and technologies involved in linking one's goals to these products? How could one carry out a techno-economic evaluation without having first analyzed the technological, economic and geopolitical environment of the sector concerned? These two types of evaluation and analysis are of course closely linked to each other. There are successive iterations, redefinitions resulting from information acquired at one level working to modify the analysis made at another level"*(Callon et al., 1992, p. 219).

Thus, when analyzing the network of sugarcane based energy and trying to comprehend the strategic and Techno-Economic Evaluations taking place, it is necessary to consider both and how they affect one another.

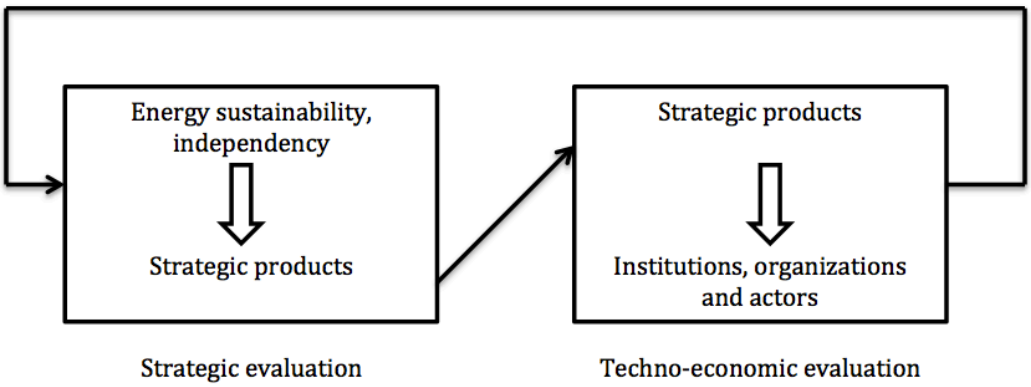

Figure 6: Dynamics of Techno Economic Evaluation and Strategic Evaluation. Adopted from Callon et al., 1992, p. 219 and Plahte, 2010, p. 49.

2.4 Summary

This chapter presents the literary context of Techno-Economic Network and explains how it is developed within Science and Technology Studies. It further argues how the theoretical concepts can be used in research by explaining concepts of innovation processes, policymaking, relations and interest. Limitations of the theoretical framework are also explained.

The concepts of the Techno-Economic Network are presented and it is explained how these can be employed in order to create an understanding of how policymaking and innovation process are part of the implementation of a renewable energy. By using the concepts of the Sub-Networks, Intermediate Networks and description of the network it is possible to present information about the current state of sugarcane production and downstream industries. And by further employing the concepts of Strategic Evaluation and Techno-Economic Evaluation it will be possible to comprehend the current policy making process regarding this and the challenges that meet the policymakers and other stakeholders.

3 Methodology

This chapter provides an overview over the research design and strategy of the case study. The case study approach and the data-collecting methods are explained. The quality of the research is clarified and ethical considerations are presented.

3.1 Research design and strategy of the case study

The research strategy defines different terminologies and clarifies assumptions. This explains why the methods used in this paper are suited to the case of sugarcane-based bioenergy in Cuba and achieving the main objectives of this paper. A qualitative single case study approach will be used in order to answer the specific research questions and fulfill the general objectives of this thesis. The case study approach is *"a way of investigating an empirical topic by following a set of pre-specified procedures"* (Yin, 2009, p. 21).

3.1.1 Research strategy

The research strategy consists of an explanation about why the concepts used in the research are suitable for the case of sugarcane-based bioenergy in Cuba. The strategy includes the definition of the terminologies, clarification of assumptions and evaluation of alternative approaches. In this thesis the development of the sugarcane-based bioenergy technology is studied in its present context. A case study approach makes it possible to investigate the case in this time perspective, including other processes happening simultaneously. Yin (2009) gives this clarification when a case-study approach is appropriate *"In general, case studies are the preferred method when (a) "how" or "why" question are being posed, (b) the investigator has little control over events, and (c) the focus is on a contemporary phenomenon within a real-life context"* (Yin, 2009, p. 2)

Using the case study approach means excluding other research approaches such as experiments and sample surveys. The case study method is suitable for this study because the answers sought to the research questions are going to be descriptive. Very briefly expressed, Schramm (1971) explains the difference between case study, experiments and sample surveys: *In contrast to experiments, which analyses the effect of a on b, and sample surveys, which ask "what is out there?" the case study asks "what happened" and is both descriptive (unlike the experiment) and free of time (unlike the sample survey)* (Schramm, 1971, p. 5).

3.1.2 Research design

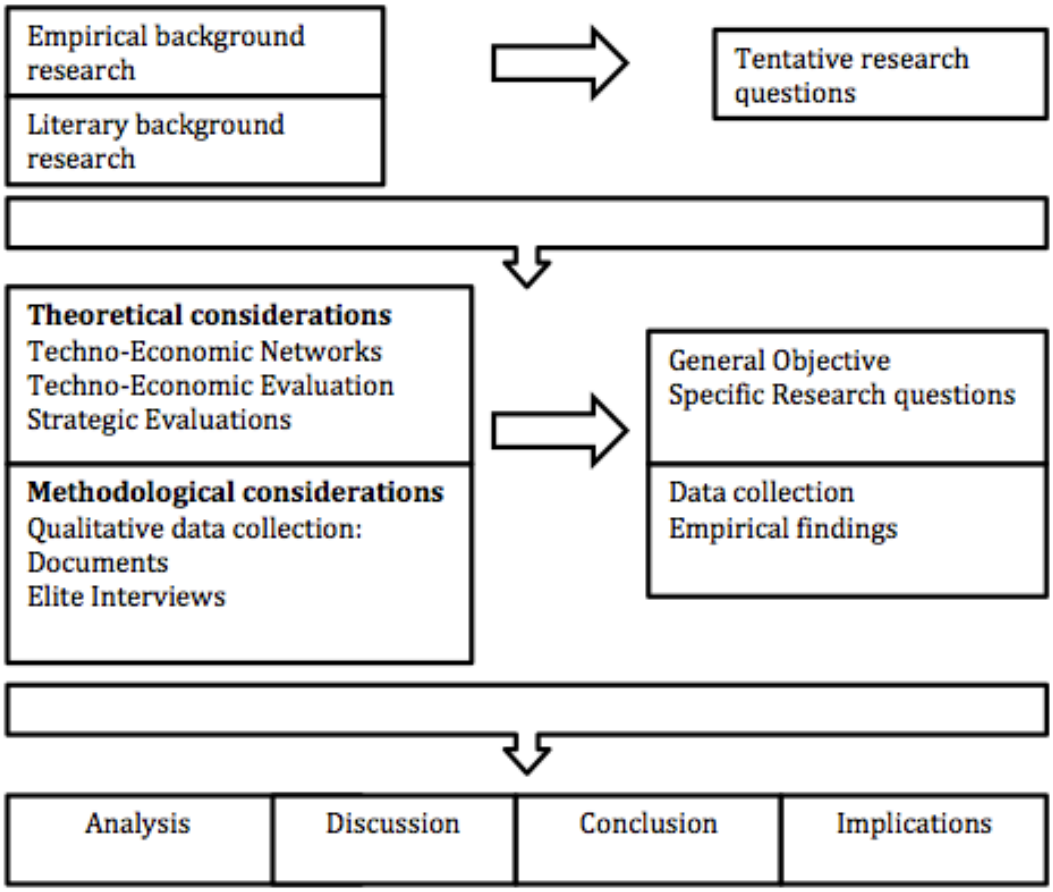

Figure 7: Research design.

The research design explains how the research is managed, it gives a clarification of how the study was planned and conducted. The process from the defining the research question, through finding the appropriate approaches and data collecting methods and the results created when analyzing and interpreting the data collected. Figure 7 shows an overview of this process. Yin (2009) gives this explanation of the research design "*A research design is a logical plan for getting from here to there, where here may be defined as the initial set of questions to be answered, and there is some set of conclusions (answers) about these questions"* (Yin, 2009, p. 26).

The case study approach includes the entire research process; it *"comprises an all-encompassing method – covering the logic of design, data collection techniques and specific approaches to data analysis*"(Yin, 2009, p. 18). The design therefore includes a clarification

of the process from the idea to the conclusion and the possible implementations; from finding the case, determining the research questions and shaping the process of how to collect, interpret and analyze the data.

3.2 Sources of information - data collection

The case study approach as a research method involves using multiple and various sources of information. The sources of evidence used to find the desired information can be *"observation, analyzing texts and documents, interviews and recording and transcribing"* (Silverman, 1993, p. 9). In order to find the sources and obtain the data I embarked on three different data-collecting expeditions. On the first journey I attended the World Bio Markets (WBM) seminar in Amsterdam, March 4th – 6th, which provided essential background information about the international environment for renewable energies and policy processes and inspired the preparatory work for this thesis. The second trip, Havana, from May 28th until June 16th, provided the key data collection, consisting of interviews and documents. During the third trip to The Regional Student Energy Summits (RSES) in Aberdeen, Scotland on June 19th – 20th, current international energy issues were highlighted.

3.2.1 Fieldtrip to Cuba

In order to collect the data for the research it was crucial to conduct the field trip to Cuba. It was a complex, time consuming and complicated process to obtain the necessary data in this research. During the background research I identified some Cuban governmental institutions involved in the development of the sugarcane-based bioenergy, but the online resources and literature were limited. It was difficult to get official information and the information on several sites proved outdated.

I established contact with Jens Sörvik (Sörvik, 2010) and Claes Brundenius (Brundenius, 2002 and 2013) both of whom had previously conducted research in Cuba. They generously provided me with details of possible informants. With this information I mapped out potential interviewees and their locations. I contacted them by email prior to my departure. I received only one response from one of these potential interviewees. In addition, I had a telephone conversation with Even Sandvik Underlid (Underlid, 2012) who provided me with historical background and oriented me to the possible obstacles inherent in conducting research in the Cuban culture.

I was prepared for difficulties of fieldwork such as limited access to Internet, limited access to phones and general obstacles with getting in touch with experts on the topic. Therefore I prepared a document consisting of maps and directions to selected institutions, potential informants and their contact details[3].

I arrived in Havana late Thursday night on May 29th and the next day I met with the first and only pre-arranged interviewee, Alejandro Perez Malagon from CETER. The following week I visited several institutions and tried to establish contact with informants. This proved a difficult process, as it was hard to get in contact due to obstacles with telephoning and Internet access[4]. Therefore I chose to visit the institutions in person. This too was challenging due to the communication difficulties. But once I made contact with the informants and explained the research, some were interested in being part of the research and accepting to be interviewed. I also asked each informant if they knew of other experts on the topic whom I might contact. In addition, the institutions often had their own in-house specialized libraries that I gained access to and from which I could obtain documents.

During the first week in the field I visited different institutions to map out the possibilities for interviews and to obtain documents. Due to time constraints I started eagerly on Monday June 2nd to visit the institutions which I had already prepared the directions for. On Monday, I visited CEEC and accessed their library, located CEPECs office, visited their library and mapped out possibilities for gathering information there. I visited AZCUBA and ICIDCA where I asked for the possibility to talk with informants. Based on my background research, I asked to speak with key elite informants, but I was also open to suggestions about other suitable informants.

That day I was not able to speak with any of them directly, but I did establish contact with the institution that later led to two interviews with experts. I had a telephone conversation with Jose Bell at FLACSO. I also called ICINAZ, but they were not interested in meeting and stated they were only a laboratory and could not contribute to the research.

[3] The institutions will be presented in Chapter 4.
[4] I rented a phone from a Cuban person in order to have a Cuban phone number during the fieldwork. But it was often several problems with obtaining contact due to the telephone system there.

The data-collection continued like this throughout the weeks, with numerous phone calls and visits and no lack of obstacles during the stay. When visiting CEPEC, ONEI and ATAC the electricity suddenly went out, lights and computers went black and I had to abort the visit and reschedule. These incidents enhanced my general understanding of the Cuban energy situation, as I understood they still experience severe problems with providing secure, constant electricity. I invested a considerable amount of time in visiting several anonymous sources that ultimately decided that they could not accept because of the risk related to being interviewed. Nevertheless, it was possible to navigate these obstacles and I used the time find other informants or to obtain documents other places.

The data-collection was conducted using the methods of single case-study and included interviews with specialists, downloading of statistical data, receiving articles and journals both on paper and downloaded onto a memory stick, buying literature in local bookshops and making copies in libraries. The institutions often had their own libraries with official documents and books that I got access to, and it was possible for to get access to their specific literature[5]. The informants are listed in Table 1. Table 2 contains an overview of the interviews conducted in Havana.

[5] A case study diary was written during the fieldwork that provides information about all the visits and communication throughout the fieldwork in Cuba and is kept by the researcher.

Informant	Data collection relevance	Profile / Company	Date Place
Jens Sörvik	Emails about informants in Cuba	Research Policy Institute, Lund University, Sweden	20.05.2014 Oslo/Spain
Claes Brundenius	Emails about informants in Cuba	Research Policy Institute, Lund University, Sweden	14.05.2014 Oslo/Sweden
Even Sandvik Underlid	Telephone conversation / informal interview	University of Bergen	19.05.2014 Oslo/Bergen
Alejandro Perez Malagon	Conversation / informal interview	CETER	30.05.2014 Vedado, 23 G, Havana
José Bell Lara	Obtained documents and conversation about informants	FLACSO	12.06.2014 Miramar, Havana

Table 1: List of informants.

3.2.2 Elite interviews

Marshall et al. (1995) presents "elite-interviewing" as a specialized case of interviewing. This is defined as "elite individuals are considered to be the influential, the prominent, and the well-informed people in an organization or community and are selected for interviews on the basis of their expertise in areas relevant to the research" (Marshall & Rossman, 1995, p. 83). I chose this specific method for this case and did the interviews with selected, informed and influential people to collect the data needed.

With information provided at the office of CITMA I got more information about Cuba Energía. I visited their visited their office and I conducted the first interview with a known expert in sugarcane energy, Antonio Valdes Delgado. He has works within the Division of Industry and Energy Science and Technology and is a renowned expert on sugarcane-based energy with decades working within the field. He became a key informant providing information. Later I visited the offices of Cuba Solar. I managed to get in contact with Julio Torrez Martínez who is Vice president of Public relations at Cuba Solar and conducted two interviews with him. At AZCUBA I conducted an interview with Armando Alvarez Dozágüez, Senior specialist in sugarcane production and with with Jorge Tomas Lodos Fernández, business manager in international relations from Zerus at Azcuba.

Interviewing as a data-collecting method differs in how they are prepared and how they are conducted, *"interviewing vary in the terms of a priory study structure and in the latitude the interviewee has in responding to questions"* (Marshall & Rossman, 1995, p. 80).
In this case study the questions were not entirely set in advance as with surveys, but rather had an open approach, giving the opportunity to the interviewees to decide what is important and relevant to include in their answer. An interview guide containing the questions was used, and I let the interviewee shape the dialogue during the interview. This method has several labels, such as in-depth interviewing and the focused interview, "*qualitative in-depth interviews are much more like conversations than formal events with predetermined response categories. The researcher explores a few general topics to help uncover the participant´s meaning perspective, but otherwise respect how the participant frames and structures the responses (Marshall & Rossman, 1995, p. 80)*

The interviews were conducted in Spanish and English and the interviewees all accepted that the interviews were audio recorded. By recording the interviewees it was possible to obtain an open approach, and allowed for a natural conversation interview style (Hay, 2010, p.119). The interviewees told their stories and I had the possibility as the researcher to ask questions and be part of the conversation without having to write simultaneously.

The recorded interviews create so much data that they should be transcribed and converted into text in order to make it possible to analyze and recorded interviews should be transcribed as soon as possible and it is very time consuming (Hay, 2010, p.120). But because it was difficult to charge the computer in Cuba and because of strict time schedule the interviews were transcribed in Norway after the fieldtrip. All interviews were transcribed by me and are written exactly as they were recorded, which included both Spanish and English language[6]. Due to the oral statements, and a combination of Spanish and English in the written in the transcriptions of the interviews, I have tried to avoid direct statements in the paper. Therefore, in some instances a presentation of the statement is done in order to create a better text for the reader. Some statements are still presented, and the author of this paper has done these and all other translations throughout the paper.

[6] Transcriptions of the interviews are not part of the appendices, but are kept by the researcher.

In Cuba the Sir name is the name in the middle, and not the last name. Therefore, in this paper the names are expressed in their full name or Surname, which then will be the name in the middle and not in the end[7].

Informant	**Data collection method**	**Company & Profile**	**Date & Place**
Antonio Valdes Delgado	Interview, recorded and transcribed	Cuba Energía, Specialist in sugarcane energy	04.06.2014 Miramar, Havana
Julio Torrez Martínez	Interview, recorded and transcribed	CubaSolar Vice president of public relations.	11.06.2014 13.06.2014 Miramar, Havana
Armando Alvarez Dozágüez	Interview, recorded and transcribed	Azcuba. Senior specialist in sugarcane production.	11.06.2014 ATAC, Vedado, Havana
Jorge Tomas Lodos Fernández	Interview, Recorded and transcribed	Zerus, Azcuba. Business Manager, international relations.	13.06.2014, ATAC, Vedado, Havana

Table 2: List of interviews in Cuba

3.2.3 Documents

Documents are used in this research as sources of evidence and forms empirical data that can confirm and supplement the interviews, "for case studies, the most important use of documents is to corroborate and augment evidence from other sources" (Yin, 2009, p. 103).

At CEPEC I had a meeting with specialist in commercial information, Elaine Pérez Sanchidrian, and got statistics about the market for ethanol, energy, and general market information. I visited ONEI and got assistance from a specialist in interactive information and got official statistics about the Cuba and official publication about renewable energies and environmental issues. At ATAC I got access to their library and downloaded articles and their magazine dating back to the eighties. And at Cuba Solar I met with Julio Torrez and got issues of their journal "Energia y tú, and downloaded copies of national strategies.

[7] This explanation is given here because the uses of Sir names are different in Cuba than in Norway. In Norway the last name is used as the Sir name.

At local bookstores and at the University of Havana I bought several books about the specific history of the sugarcane industry and the general economic and political situation.

During the field trip in Cuba I collected a considerable amount (769 items) of documents such as journals, newspaper articles and official statistics from the Cuban government. This data was then reviewed, relevant papers and statistics selected and then all these documents were systematized thematically. Of all these documents a case study database was created. It exists of 179 documents that was studied[8].

Yin (2009) gives an overview of the strengths and weaknesses of using documents as source of evidence. The strengths are that they are stable - can be reviewed repeatedly, they are unobtrusive – not created as a result of the case study, exact – contains exact names, references and details of an event and broad coverage – long span of time, many events and many settings. The weaknesses are retrievability – can be difficult to find, biased selectivity, if collection is incomplete, reporting bias-reflects (unknown) bias of author and access – may be deliberately withheld (Yin, 2009, p. 103). In this case it can be problematic to find some the same documents again and there is a potential limitation as documents might have been deliberately withheld.

3.3 The quality of the research

To establish the quality of empirical social research and to judge the quality of the research design, Yin (2009) determines four criteria: validity, internal validity, external validity and reliability. These concepts consider the challenges as to whether the findings in this case study are generalizable.

3.3.1 Construct validity

The research design in this thesis strives to create credibility, to help justify why the readers can trust the findings. The research design includes the description of the whole research process and explains how the reader can trust the findings of the investigator. The data-collection process is documented and the explanation of theoretical framework is used to comprehend the data collected. The theoretical and conceptual framework thus becomes a tool to use the data to construct validity, *"identifying correct operational measures for the concepts being studied"* (Yin, 2009, p. 40). Tactics that can be used to construct validity

[8] An overview of the case study database is not included as an appendix, but is kept by the researcher.

include that the data collection employs multiple sources of evidence and establishes chain evidence (Yin, 2009, p. 41). In the data collecting for this master thesis I am using interviews and analyzing documents, which means that multiple sources of evidence are used, and also that chain evidence are established.

3.3.2 Internal and external validity

Internal validity refers to the internal logic and consistency of the research, the extent to which the findings faithfully represents and reflect the reality which has been studies (Punch, 2005, p. 254). In this theses the internal validly seeks to be is ensured through the data analyses, that the data-collection and analyses of this is done in order to provides adequate information to represent the actual occurrences.

External validity considers the issues surrounding whether the findings can be generalized, *"knowing whether a study's findings are generalizable beyond the immediate case study"* (Yin, 2009, p. 43). Can the findings and the conclusions in this analysis be used in other settings? This research seeks to find the answers to what is going on in the Cuban context. By discovering this, the research can also be used in finding answers in other contexts. In this research I will emphasis the external validity to the transferability of the research. Are the conclusions transferable to other settings and contexts? *"Survey research relies on statistical generalization, whereas case studies rely on analytic generalization. In analytical generalization, the investigator is striving to generalize a particular set of results to some broader theory"* (Yin, 2009, p. 43).

This research can be generalized in a limited extent to provide understanding on how policy making and innovation processes are part of the implementation of a renewable energy in an industrializing country. Limited because, the findings are affected by Cuba's command economy model with its strong regulations of the private market, limited autonomy, strong regulations and centrally governed decisions.

3.3.3 Reliability

Yin (2009) presents the reasons why reliability has to be considered and how to obtain it. The goal of reliability is to minimize the errors and biases in a study. Furthermore, if a later

investigator were to follow the same procedures as described by the initial investigator and conduct the same case-study all over again; the later investigator should arrive at the same findings and conclusions (Yin, 2009, p. 45). Yin outlines two tactics to achieve reliability: a case study protocol that pertains to documentations issues and development of case-study database (Yin, 2009, p. 41). This approach has been adopted in this research. A case study diary was written during the fieldwork which provides information about all the visists and communication throughout the fieldwork in Cuba. The case-study database consists of all the data that has been collected. These are available on request along with transcriptions of the interviews.

3.3.4 Limitations

When the criteria for quality of research is thoroughly assessed the chances for weaknesses in the case-study approach are minimized. Yet there will still be limitations that need to be taken into account when employing a case-study approach. For example, there are few specific restrictions concerning what is included in the case-study. Therefore one potential weakness is that such a holistic approach, itself a strength, could become too extensive thus turning a potential strength of the case-study method into a weakness (Meyer, 2001, p. 329).

3.3.5 Ethical considerations

When doing research there are several ethical dilemmas to consider. In particular this is a concern during the data-collection phase because one is dealing with humans beings, but challenges are to be found throughout the case-study process. Ethical considerations will be informed by the investigator's values that in turn affect choices and actions taken throughout the research. *"It is important to consider because in research on human subjects there is often an ethical dilemma produced by a conflict between the fact that we value obtaining new knowledge and also value the individuals right to privacy* (Jones, 1985, p. 364). This is especially important in an interview-based data-collecting process as *"interviews involve personal interaction; cooperation is essential. Interviewees may be unwilling or uncomfortable sharing all that the interviewer hopes to explore*" (Marshall & Rossman, 1995, p. 81).

In Cuba the interview process had to be conducted with great attention to ethical considerations. Interviewees were approached with carefully, cautiously. Cuba has a history of limited freedom of speech and people in general exhibit a fear of contradicting the State.

This context can cause people concern about expressing themselves freely. As public employees they also represent the Cuban state and this may limit their ability to express themselves freely.

I presented the interview guide together with information and confirmations about the research to the potential interviewees. I was met with doubts and some speculation about my research and my intentions. A few interview candidates were concerned about and rejected my proposal. Some were so anxious that they contacted other interviewees warning them about my research. These were provided with confirmed documentation about the research. Although I met with them several times at their offices they concluded that they could not accept to be interviewed. They felt they could not share their knowledge and professional opinions with a non-Cuban researcher.

The concern was that by accepting to be interviewed they could risk their positions in the company and in general. Given this setting, those who accepted to be interviewed were risking professional repercussions at a minimum within their institute. In this context it was challenging to identify subjects and conduct interviews. The interviewees who accepted my request were treated with strict adherence to ethical concerns. Having fully informed the interviewees about the research, I asked for permission to record or take notes. In all the cases we agreed on this as well as the necessity of discretion and protection of the sources.

3.4 Summary methodology

This chapter has presented clarifications of the considerations concerning the methodology employed in this thesis. The qualitative single case-study approach has been elaborated and the data-collection by elite interviews and review of documents has been explained.

These explanations ensure that the reader can evaluate and understand how the conclusions and implications in this thesis are researched. Explanations are given in order to ensure validity, reliability and that the research is conducted in keeping with ethical considerations and protection of the sources. Given the object of the study and the theory, the chosen methodology contributes to answering the research questions in a satisfactory manner. This is because it creates the possibilities to follow and understand the whole research process: how the data is obtained, how it interpreted and how conclusions and implications are created.

4 Sugarcane based energy – the Cuban case

The first chapter has provided a presentation of the historical context and current trends of the sugarcane industry and renewable energies. This chapter will provide a description of the current state and address the specific research questions.

4.1 Current Techno–Economic Network

The current Techno-Economic network is presented by using the concepts presented in Chapter 2. Figure 8 gives an illustration of a suggestion of the network by showing the current Sub-Networks and Intermediate Networks. The illustration does not take into account the interactions as explained in figure 5, but is presented only in order provide an overview of concerns included in this analysis.

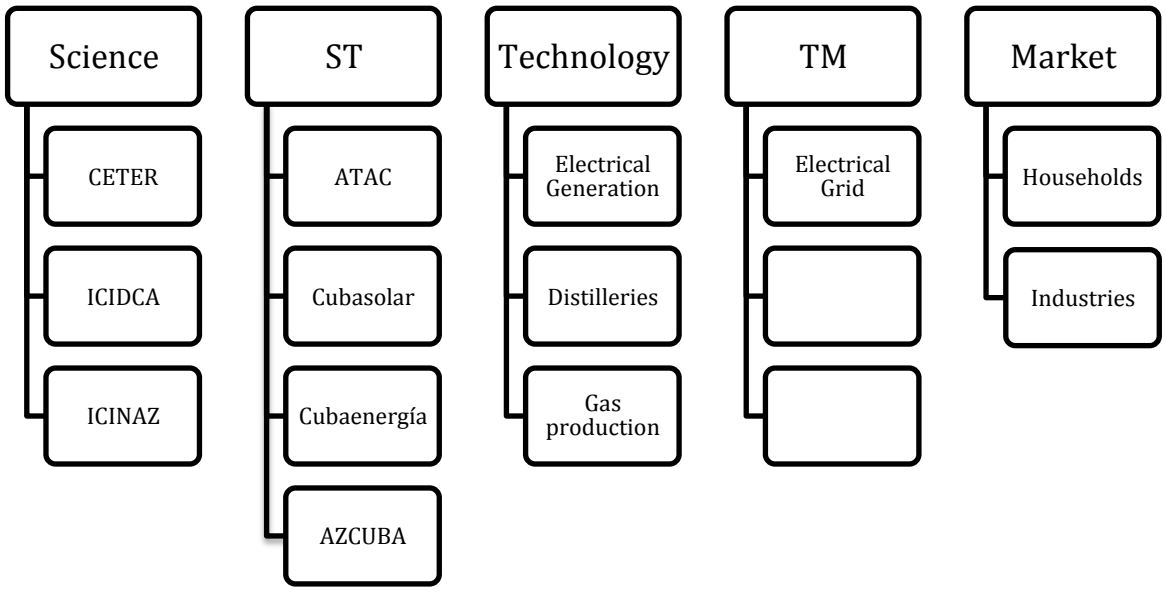

Figure 8: Current TEN of sugarcane-based energy.

4.1.1 Technology

By using the concept of the Technology Sub-Network it is possible to provide an overview of the technologies used to transform the primary material sugarcane into energy end products such as ethanol and how using sugarcane and its residuals can generate electrical energy.

As noted, current sugarcane production is in decline. Alongside tobacco, sugarcane is considered the most important industry in the Cuban culture; yet the industry is suffering from the fact that it having great difficulties operating cost-effectively. Today's Technology is characterized by high costs, out-of date equipment and difficulties to obtain necessary inputs such as fertilizers. These problems have led to the closure of several sugar mills during the two decades and a severe reduction in the sugarcane cultivation. The potential of utilizing the natural resources to produce sugar is represented in the historical high production numbers.

The current status of the Technology in energy production from sugarcane in Cuba is directly linked to the present low level of agricultural sugarcane production. The low level of the primer material sugarcane has an impact on the types of and amounts of energy produced from this basis. The main Technology to produce energy from the primer material sugarcane is electricity generated at the sugar centrals. In addition there are some Technologies used in the production of ethanol and alcohol in distilleries and other Technologies used in production of the biogas methane from sugarcane residuals.

Electricity- thermal energy

Electricity is produced using a Technology of generation by burning the left over parts of the sugarcane at the centrals, as part of the sugar production. Jorge Tomas Lodos Fernández, at Zerus, Azcuba states, "*The sugarcane industry, the general sugar industry, all over the world, generates its own energy."* (Jorge Tomas Lodos Fernández, personal communication, June 13, 2014). And this is comprehensively stated throughout the empirical data, e.g.: "*Sugarcane biomass has been used as an energy source for hundreds of years, to produce heat, and later electricity. When both processes are combined it is known as cogeneration"*(Moreno, 2013). The bagasse is the waste, a surplus, dry fibrous material that remains after sugarcane stalks are crushed to extract their juice as part of the process of producing the actual sugar. The bagasse is burned and this process creates thermal energy at the production site. The heat generates steam and the pressure in the boiler is used to create electricity. This electrical energy is then directly used as energy for the sugar production initially.

Thus there are two basic aspects that need to be taken into account when considering the Technology of electrical energy production from sugarcane. I believe these two facts create a general interest to use this technology to generate electricity from sugarcane bagasse.

Firstly, electrical energy is required to operate the machinery in order to produce sugar from the sugarcane. If there is a lack of equipment, such as boilers, for producing electrical energy from the actual sugarcane, the sugar mill needs to provide this energy from other sources, such as burning fossil fuel to create electrical energy.

Secondly, the production of sugar from sugarcane creates bagasse regardless of the possibilities to use it in energy production. It is a byproduct that will occur no matter what. Thus the sugar mill needs to get rid of this waste, normally by burning it. This then creates the undesirable situation of having to burn or in other ways dispose of the bagasse without harvesting its potential energy dividend.

By taking into account these two aspects it is evident that the sugar centrals are interested in developing the Technology of producing electrical energy from the bagasse. What is not clear is the amount of energy the sugar centrals are interested in producing. They can produce less than their required needs, the exact amount to meet said needs or potentially produce an energy surplus. The alternatives of producing enough to be self-sufficient or of producing a net-surplus of electricity available for distribution are of interest to more actors than merely the sugar centrals themselves.

The amount of electrical energy produced depends on the technology of distinctive pressure in the boilers. In other words, the distinctive types of boilers generate different amounts of energy and determine the possibility for producing and distributing the electricity. A particular amount of pressure in the boilers will produce enough electrical energy to run the sugar production at the mill. Lodos explains this process and rounds the measurements to fit American standard measures of Bar, a metric measurement unit of pressure. He explains that when using a boiler of 10 Bar the turbine does not create sufficient energy for what the sugar mill consumes and it is necessary to purchase/import the electricity needed for the production. However when using a boiler that reaches 18 Bar it creates enough electricity to supply the mill with sufficient energy. By increasing to a boiler that reaches 28 Bar, surplus electricity is generated which can be distributed in addition to fact that the mill is self-

sustainable in energy production. The possibility of developing and increasing the energy production from the bagasse in order to distribute the a net-surplus of electricity thus depends on the boilers; it is the boilers that actually will produce extra electrical energy. (Jorge Tomas Lodos Fernández, personal communication, June 13, 2014)

Cuba Solar representative and "*Energía y tú*" writer Julio Torres explains the possibilities of developing the Technologies to produce more sugarcane with an aim to generate electricity as part of the Cuban electrical energy system. He explains the current situation about the amount of sugarcane produced in terms of the accumulated amount of tons per year and also in terms of the production performance, tons per hectare. Furthermore Torres states that it is possible to produce more primary material from the natural resources in Cuba, and subsequently the potential to produce more electrical energy. He states his personal opinion:

> "*I think that we could manage and we must manage the situation in the country in order to breed more sugarcane in all of the country. We are now producing yearly around 22-25 million tons of sugarcane yearly. But for producing the whole electricity demand of the country, and besides what is produced for the ethanol industry, we could need around 90-100 million tons yearly. It is maybe a very big quantity, but during the eighties, from 1981 to 1990 we produced yearly, every year, more than 70 millions tons of sugar"* (Julio Torrez Martínez, personal communication, June 11, 2014).

Torres' vision does not take into account the technological concerns about access to boilers and mechanical equipment, fertilizers etc. From his perspective he only addresses the potential latent in the natural, renewable resource sugarcane.

Biofuels and alcohol

Although the informants represent both the energy and the sugar production interests, they generally give alternative energy generating Technology. At present distilleries employ Technology that are producing different types of alcohols from the sugarcane. The production of rum from sugarcane has a long tradition and has a central place in Cuban culture. However the Technology of producing alcohol such as ethanol for energy production is limited. A Cuba Solar article states that the Technology of producing ethanol for energy to use in ethanol-gasoline mixtures is currently only at the stage of R&D. "*Biofuels is mainly used in*

transportation. In Cuba ethanol is traditionally produced from sugarcane. The use of ethanol-gasoline blends in Cuba is not widespread, and technology is at the stage of research and development" (Moreno, 2013).

The Technology has difficulties to develop due to the lack of financial resources and equipment for implementing the technology. An ATAC article states that the technology in the distilleries is characterized by old equipment, but the production methods are gaining attention and there is some interest in modernizing it. "*Cuba has been working on a program for the development of ethanol production in the country. This program aims to increase the efficiency and production of alcohol in the 11 existing distilleries, in order to be able to take advantage of the growth, demand and prices for this product"(*Sáenz, 2009).

Biogas

Biogas is an energy produced with Technology utilizing the activity of living microorganisms. It is mainly a mix of methane and carbon dioxide, and has the character of fuel gas. It is principally possible to obtain biogas from a variety of materials that can be subject to anaerobic digestion (fermentation in the absence of oxygen) and sugarcane leaves are suited. This Technology requires specific conditions, such as the right temperature, lack of oxygen etc. (Moreno 2013).

In Cuba the first attempts to develop this Technology were made in the beginning of the eighties and continued in the 1990s with some development of the technology based on cow excrement. The Technology was further developed near a sugar mill using sugarcane as material and, "*After several years of operating the plant became a compelling example of the demand and possibility of using this renewable energy source, especially in places that have a stable source of supply of organic matter"*(Moreno 2013).

The US embargo.

The US embargo[9] is a highly discussed and controversial topic in Cuba. The sources state that the blockade is a major obstacle that hinders the development of the Technology. Lodos states that the embargo is fundamental for the development of the Technology because of the great concerns with US interests and ownership of related industries and agriculture (Jorge

[9] The Embargo will not be further explained in this paper, for more information see Brenner et.al 2014.

Tomas Lodos Fernández, personal communication, June 13, 2014). In the magazine '*Energía y tú*' there are several articles that relate widely held opinions about the blockade and there are clear statements against the embargo with its resultant negative effects on the development of energies (No al Bloqueo, 2010)(Nada ha cambiado, 2011)(Declaración final del IV 2006). Antonio Valdes Delgado from Cuba Energía explains that it leads to higher prices for importing equipment from e.g. China and of course the loss of a potential large market. The blockade is one of the reasons for the particularly high costs of Technology in Cuba, thus forming an important reason why the current sugar industry is not able to operate cost-effectively (Antonio Valdes Delgado, personal communication, June 04, 2014).

Lack of hard currency, technical equipment & obstacles for foreign investments

Another challenge for the Technology is the lack of hard currency and this hinders the availability to technical equipment. Alvarez clearly states that there are great potential in the natural resources of sugarcane, but one of the main challenge to increase the sugarcane production is lack of financing. And he also states that developing the Technology of sugarcane based energy demands excessive financing, and this needs to be organized by the government (Armando Alvarez Dozágüez, personal communication, June 11, 2014). The lack of financing affects the whole network, but mostly the Technology because of two reasons. First of all because the high cost of investments required within the Technology, the amount of currency that is needed is decisive and hard to obtain by the government. And secondly due to the lack of governmental interest towards investing in the mechanical equipment, the Technology is given lower priority than for example the education within the Scientific pole.

Lodos expresses the possibilities and obstacle with foreign investments. Because of the US embargo commercial trade with the US is not an option and also creates challenges to negotiate with other countries. But could there be possibilities to provide financing through investments from for example China or Brazil? Lodos explains that there are potential to provide mechanical equipment to develop the Technology by trade agreements with China. And there are possibilities that this can be part of solving the financial challenges that creates obstacle within the Technology (Jorge Tomas Lodos Fernández, personal communication, June 13, 2014).

4.1.2 Science

Cuba has a large Scientific sub-network that provides research for both the sugar industry and the renewable energy sector. As previously mentioned, the elites interviewed in the data-collection are experts from both of these directions of research. According to the informants the educational system within this field is considered a good producer of knowledge. The research institutes create science and knowledge needed for the technical professionals within agricultural sugar production, within the technologies of renewable energies and also within management.

The statistical information provided by ONEI gives some indications about the current state of how the government is involved in funding the Sciences. In 2010 the expenditures in science and technology were CUP758 million (Cuban pesos), of which CUP613,1 million (81%) were financed by the state, CUP86,9 million (11,5%) from corporate funding, and CUP58 million (7.5%) from other sources.

The Scientific pole is characterized by large research institutes. The Center for the Study of Renewable Energy Technologies (CETER) is the main research institute within energy and renewable energy. ICINAZ (The Cuban Institute for Sugar Research) and ICIDCA (The Cuban Research Institute of Sugarcane Derivatives) are the main sugar research institutes in Cuba.

The Center for the Study of Renewable Energy Technologies (CETER) is a university organization belonging to the Faculty of Mechanical Engineering of the Polytechnic José A. Echeverría (Cujae) Institute. Its main purpose is to contribute to sustainable development of society through education, research and implementation concerning renewable energies, energy efficiency and its interaction with the environment and society. The center works with all types of technologies employing renewable energy sources (fuel cells, wind power, biomass, engines, bio-fuels, etc.) and develops analysis and designs tools to provide comprehensive solutions to current technical problems (CETER, 2014).

Perez from CETER expresses his concern about the lack of focus on sugarcane-based energy within the research of renewable energies. He states that the study center concentrates on solar energy and other renewable energies and that the general low interest towards the

sugarcane-based energy may be a result of the decline in sugarcane production during the last two decades (Alejandro Perez Malagon, personal communication, May 30, 2014).

The ICIDCA (The Cuban Research Institute of Sugarcane Derivatives) belongs to AZCUBA and is also part of the West Havana Scientific Pole, which brings together some 53 institutions and about seven thousand scientists (ICIDCA 1, 2014). Throughout its 45 years of work ICIDCA developed, assimilated and adapted a considerable number of applicable technologies which exploit the byproducts of sugarcane for use in different sectors of the economy. Many of these technologies have been implemented commercially in Cuba and other countries (ICIDCA 2, 2014). ICIDCA has 115 university graduates, including 12 PhDs and 35 masters, as well as 151 technicians. The institute consists of sub-study centers, 50 laboratories and 4 pilot plants (ICIDCA 3, 2014).

ICINAZ (The Cuban Institute for Sugar Research) is a laboratory research institute that addresses industrial processes, promotes the development of new technology, and adopts technology from other countries, to be fitted into processes in sugar mills. ICINAZ's work includes: feasibility studies, capability building through education, technical assistance both domestically and internationally. ICINAZ also develops boilers and co-generation systems to increase the use of harvest waste and develops software for management processes (Sörvik, 2010, p. 129).

The general systems of public education of several other universities are also involved as they provide different general knowledge about the topic. Scientific knowledge captures the breadth and depth within the current research base that provides expertise to the agricultural sugar production and downstream industries such as electrical energy production machinery and distilleries.

These impressive institutions indicate that the Scientific sub-network is strong and has substantial governmental attention.

4.1.3 Market

The Market concept found in Callon is suitable to describe this Cuban case because it takes into consideration the users and the environment surrounding them. Due to the command

economy in Cuba Callon's definition makes it possible to emphasis the role of the government in the market and thus in the network. But the open approach also makes it challenging to explain how the Market is part of the network. This needs to be taken into account. The description of the Market will seek to explain how the users, both household and industry, create, or do not create, demand for the mentioned energy technologies and products.

The current environment around the users is a result of historical events, as well as the present political and economic situation mentioned in Chapter 1. Cuban society creates limited possibilities for demand of energy products. The command economy, currently in the doldrums, creates a Market that does not give the users the possibility to use or request the energy products. Cuba has an environment in which people and organizations do not express their energy demands. Though, this should not be interpreted that there is no need for the energy.

Because the electricity is produced from a natural resource with harvest seasons, it can cause uneven production of electricity during the year. In Cuba the optimum harvest period usually goes from December through April – July and in Cuba this whole period is called Zafra (Edquist, 1985, p. 16). Lodos expresses his concerns of the lack of potential buyers of the electricity because of the uneven production throughout the year. He states that the domestic households have a constant demand of electricity, but the government will not be the buyer on behalf of the people. He states that this could be partly due to the uneven distribution of energy due to harvest season and the current concerns of the distribution possibilities[10](Jorge Tomas Lodos Fernández, personal communication, June 13, 2014). Thus, in this Market there is an environment that has the need for constant electricity throughout the year. This causes challenges for the implementation of the renewable energy of sugarcane.

There is a need for energy, but the Cuban people and Cuban institutions have limited possibilities to actually obtain it. For the people, their state salaries are insufficient to provide for their living costs. This results in limited demand for some of the energy products such as biofuel. Few people own their own cars and there are strict regulations for those who do.

[10] The distribution problem could in this network also be expressed within the Technology sub network.

Thus there is limited demand for fuel, and the market potential cannot be compared to for example Brazil.

Cuban organizations are state regulated thus the state determines the possibilities to request a product and how it should be financed. In general, industries, with the exception of tourism and biomedicine, are severely outdated due to lack of hard currency and financing opportunities. There is a potential Market of industries that requires both fuel and electricity, but in general these industries currently suffer in economic struggles.

There are also impediments confronting the distribution of the electrical energy generated. This hinders the creation of potential consumers of electric energy. Although electricity can be understood as the energy source with the greatest current potential for use, it faces challenges reaching end-users.

The Market is characterized by limited choices and possibilities to demand this product. Cubans lack the cash to pay for it and the equipment to use it. It is shown that there is a lack of an environment that creates a Market that can demand the energy products. But this does not implicate that introducing market economy should solve it.

Torres explains that there is need and consumption of electrical energy, but currently this is generated with the use of imported oil. (Julio Torres Martínez, personal communication, June 13, 2014). Thus here it is room for misinterpretation when using the theoretical framework of TEN to describe the reality and it is necessary with a clarification. There is a Market for energy – especially electrical energy. But is there a Market for sugarcane-based energy? This is a very important concern in this description. There is an environment around the users that creates a demand for energy – but not the energy products that the renewable energy source sugarcane creates.

4.1.4 Intermediate Networks - Connections

The Market, Technology and Science Sub-Networks are in different ways in interaction with other sub-networks and this interaction is described as the intermediate networks. An explanation of these will provide a description of the actions and processes linking the network together.

The relationships and connections run in both directions: Science affects Technology, but Technology also affects Science. As with the Sub-Networks, these connections are generally characterized by limited autonomy, strong regulations and centrally governed decisions.

Interconnecting public bodies – the change from MINAZ to AZCUBA

Cuba's Ministry of Sugar, MINAZ, was for more than 45 years the sole governmental body responsible for directing, executing and controlling state politics/policies regarding the sugar industry, sugarcane agricultural activities, and its derivatives. The Cuban government announced the closure of MINAZ in September 2011. The following month the state group AZCUBA was created and tasked to perform many of the same functions of the defunct ministry (AZCUBA 1, 2014). Explained by Bye: *"the previously so powerful Sugar Ministry has been abolished, giving way to a holding company (Grupo Empresarial de la Agroindustria Azucarera) with its 26 subsidiaries replacing the ministry's previous 139 companies"* (Bye et al., 2014, p. 23).

The Ministry of Sugar had been a part of linking the network of sugarcane energies. It served many functions and possessed power in the industry in addition to the normal functions common to all agencies of the central state administration authority. According to their own Internet pages AZCUBA's mission is to produce quality sugarcane and sugar, electricity and animal feed at competitive costs, by applying science and technology and protecting the environment. Their functions are to guide, direct and control the sugarcane sector are similar to the ones mentioned for MINAZ (AZCUBA 1, 2014).

Science and Technology connection

Some examples of how Science and Technology are connected include the research results created at ICINAZ that affect how the sugarcane is seeded and harvested, research at ICIDCA that affects the bioenergy production, and research at CETER influences the technology development of renewable energies.

However, several organizations exist that are exclusively devoted to bringing science and technology into relationship with each other. There are renowned institutions that I would position within this intermediate sub-network, such as ATAC, Cuba Solar and CubaEnergia.

These institutions are not purely scientific. They also engage in scientific research and distribution and implementation of new technologies.

ATAC, Association of Sugar Technologists in Cuba, is the oldest organization of professionals Cuba. It was founded 1927 to promote the development of science and technology among the men who made the sugar agro-industrial process possible. Their mission partly is to contribute, through training, consulting and project management to local sustainable development associated with the sugarcane agricultural business (AZCUBA 2, 2014)

CUBASOLAR is a NGO created in 1994 as a non-profit organization that aims to promote the use of renewable energy sources to replace non-renewable and polluting sources and to promote savings, energy efficiency and respect for the environment with emphasis on educational work. They have 800 members organized in provincial delegations. They focus on introducing the use and knowledge of renewable energy sources in all its manifestations in the national secondary school education system for training purposes, with the participation of students and teachers, with special emphasis on the pedagogical institutes, Preuniversitarios of Sciences, technological and polytechnic institutes (CubaSolar, 2014).

'*Energía y tú*' is Cuban popular science publication aimed to contribute to the formation of a sustainable energy and environmental awareness on issues related to the development and use of renewable energy sources (photovoltaic, hydro, wind, solar, biomass and science related), energy efficiency, bioclimatic architecture, environmental effects and environmental education (Torres, 2007).

Cuba Energía is The Centre for Information Management and Energy Development and belongs to the Ministry of Science, Technology and Environment (CITMA) and is an institution for research, development and scientific and technical services on energy and environment. Since its creation in 2000, Cuba Energía conducts research-development and technological innovation projects that contribute to decision-making in the energy sector, the communication of science and technology, energy education and the implementation of renewable energy sources for electricity generation. The organization strives to promote information technologies and sustainable energy development (CubaEnergía, 2014).

The descriptions of these institutions implicate that there are great governmental interest in integrating Science and Technology. But it can be questioned weather or not it leads to actual technological development that the innovation process actually develops from Science to Technology. It might actually be a sign of poor integration or governmental implementation force. There is great attention towards this link, but there are limited actual action with implementing and diffusion of the technology. This could might be due to the mentioned lack of hard currency and limited investments possibility within the Technology Sub-Network.

Technology and Market connection

The empirical findings suggest that there are weak connections in both directions between Technology and Market. Commercialization and development are not linking the two sub-networks strongly together. The technologies are not developing in order to meet the environment in the market, and the current market is not able to commercialize the technology.

The informants in general show little interest in these relationships and there is little general focus on institutions or enterprises in this interconnecting-network. It cannot be stated that there are no institutions within this intermediate sub-network, but the data-collection indicates a lack of focus and interest within this area. The fact that the actors do not show an interest in this intermediate-network is important concern within the ANT theory. By following the actors we reveal information, the actors do not gravitate towards the areas that connect the technology and the market. In general the actors are less interested in this area of the network, compared to the science-technology relationship.

In the current Market there is a general demand for energy, but not a demand that is applicable to the energy products from sugarcane. The environment around the users confirms that there is an actual demand in the market for energy, but there lacks linkages that make the market prepared and equipped for using the different energy technologies from sugarcane. There are deficits in proper electricity grids and an absence of cars and machinery that can use the type of fuel produced from sugarcane.

Within the generation of electrical energy there are some attempts to develop the electrical distribution possibilities. Lodos emphasis the challenges connected to the lack of a

functioning electrical infrastructure. This leads to the low interest and limited possibilities for producing electrical energy from sugarcane. He mentions that there are possibilities to improve the electrical grid so that it could serve as an electrical system with power plants in order to receive and distribute electrical energy from the sugar centrals. If this were to be organized, the sugar mills themselves or other stakeholders might have incentives to invest in developing the energy production facilities at the sugar centrals. Lodos also emphasizes the challenges with distributing the energy due to the different harvesting seasons of the cane during the years and the added-cost of boilers that reach the desired pressure (Jorge Tomas Lodos Fernández, personal communication, June 13, 2014)

4.1.5 Distinctive description of TEN

Because of the explanations of the sub-networks based on the empirical findings the network of sugarcane-based energy in Cuba can be described as an Incomplete, Dispersed and Long network. As stated in Chapter 2, these terms will be explained in this section.

Incomplete

Plahte (2010) reviews Callon's concepts and summarizes, if all the sub-networks are complete and developed, the TEN is characterized as Chained. When one or more of the sub-networks are not developed or underdeveloped, the TEN is characterized as Incomplete. I consider the current network Incomplete because of the underdeveloped Sub-Networks.

The environment surrounding the users forms an underdeveloped Market Sub-Network. The Technology Sub-Network cannot be categorized as developed either because of the deficits in equipment, methods and procedures to produce the energy products. There are procedures present, but they are expensive and it is difficult to obtain the necessary equipment. I would consider the scientific network to be developed in sugar research, but I would not consider the scientific sub-network of sugarcane-based energy as developed yet, because of the lack of research in this area. Thus the combined scientific network of sugarcane-based energy is considered as underdeveloped as well.

Dispersed

The difference between a Convergent and Dispersed network is the degree of distribution of resources between the Sub-Networks. In a Dispersed network the links are weak because the translation of phenomena from one sub-network to another is cumbersome and problematic.

In a Convergent network the links are strong and well developed and the various actors may mobilize resources from other Sub-Networks (Plahte 2010). I consider the network in this case to be Dispersed because of the weak interaction between the Sub-Networks.

The ST Intermediate-Network has connections because the research at the sugar and energy research institutes are distributed to the technology. I believe the relationship is strengthened by the fact that both the T and S sub-network are centrally governed and the technology sub-network can communicate what is needed from research and vice-versa; the scientific research are able to produce research about relevant topics and solve problems. R&D is predominantly governmentally funded and I have the impression that the relationship is strong due to the command economy, yet the incentives and possibilities for actually implementing the scientific research are weak in this relationship due to the lack of equipment, hard currencies and possibilities for investments.

The network is largely regarded as dispersed because of the lack of interaction between the technology and the market. It is shown that the technology would, if funded and managed correctly, be able to provide energy products from sugarcane. The Cuban government and people desire to be self-sustainable energy-wise, but it appears as if the marked is not ready for these energy products. The Cuban case differs from other market environments due to the extensive control in the command economy where government agencies and companies dominate all economic sectors. The commercialization process of the technology thus is more directly controlled by state-owned companies. But as noted, although they are all state-owned and have the *similar aims*, they have challenges with the commercialization and distribution of the energy products.

Long

Long networks embrace the whole chain and include S, T and M, and a short network may exist of only two of them. It should not be confused with the term 'incomplete'. Plahte (2010) provides an explanation of this: "*the difference then between a short and an incomplete network is that a short network would not be improved by adding the "missing" sub-network, because the missing part is considered redundant for meeting the strategic goals in the first place"* (Plahte 2010).

I label the network long because the network is dependent on all sub-networks to exist. I believe that the network needs all three Sub-Networks in order to be established and to develop. A short network would not be improved by adding the missing part; because the missing part is considered redundant. Callon argues that in some cases a network may function without one of the sub-networks. This could possibly also be argued in this case, some might state that it is not crucial with a market for the development of the technologies. But the market is not only considered for the marked mechanisms that create demand, competition and sets the price; there is also a need for a market in the sense of an environment that creates the need and possibilities for using the energy technologies. Therefore, in this network none of the sub-networks are considered redundant. They are all needed and the lack of one would hinder the establishment and development.

4.2 Policymaking

The sugarcane centrals have limited interest in producing energy in addition to the sugar. The sources state that the sugar production industry lacks incentives to improve its electric energy production. Lodos formulates the challenges with lacking incentives in the sugarcane agricultural production industry associated with producing extra amount of energy as follows: *"What if there is extra electricity? The sugar industry is economically interested in nothing more than electricity and steam for its own consumption";* and later, *"The power plants and boilers are part of the sugar factory. And its object is to produce sugar, and in addition it can sell some amount of electricity to the national grid. Its objective is not producing electricity. If they succeed (applause) is awesome. But it is not their objective. Their objective is that sugar is produced"* (Jorge Tomas Lodos Fernández, personal communication, June 13, 2014).

With these statements it is illuminated that it is neither the objectives to the sugar centrals to produce energy nor it is their responsibility. This thesis address the governmental concerns. Is the government interested in developing the energy products? And if they are, how can they intervene? The Strategic Evaluation and Techno-Economic Evaluation employs these questions.

4.2.1 Strategic evaluations

Cuba is, as explained in Chapter 1, ongoing an economic reform and the government is reconsidering how the country is economically organized. The development of sugarcane-

based energy technology could be a part of this. The government evaluates, in limited degree, the energy products as desired products that could be developed by a governmental intervention. This evaluation is described as a strategic evaluation.

What is the desired state of producing energy from sugarcane?

A Strategic Evaluation, the process of identifying a range of desired products to be developed by an intervention by the government takes into account the interests and considerations of the Cuban government. The concept Strategic Evaluation is used to describe how the government includes these concerns and by this it can be explained how their evaluation is not purely economical. Environmental, legal and cultural concerns are involved in the development of producing energy from sugarcane.

National policies and concerns

Policies concerning the development of sugarcane-based energy are diverse and complex as they involve both the development of renewable energies and the sugarcane production industry. The empirical findings show that currently, there is an absence of national policies directed directly at these two as one coherent object. There are policies that give attention towards the development of renewable industries and other towards the sugar industry. The guidelines *Los Lineamientos de la Política Económica y Social del VI Congreso del PCC* from the only political party Partido Comunista de Cuba (PCC, 2011), mentioned in Chapter 1, and national environmental policies from Ministry of Science, Technology and Environment elaborated below have limited policies covering sugarcane and energy production together (CITMA 2007) (CITMA 2011).

Although though sugarcane as a renewable energy is it not specifically stated in the documents, it does not mean it is not treated. By stating that they should focus on renewable energy, the policies indeed include sugarcane. Sugarcane is, as stated in Chapter 1, the biggest renewable energy source in Cuba. Therefore this needs to be taken into account when considering the policies. And as argued earlier in this chapter, the sugarcane energy production is directly affected by the actual sugarcane production. Thus, lack of policies directed towards the sugarcane production are therefor linked to the energy production.

Torres explained that the main policies for sugarcane-based energy are created on the bases of the national environmental strategy from the Ministry of Science, Technology and

Environment for the period 2007-2010 and 2011 – 2015 (CITMA 2007) (CITMA 2011) (Julio Torres Martínez, personal communication, June 13, 2014). In the strategy 2007-2010 the sugar industry are considered important in regards to the development of the Cuban economy and is given great attention, but this in only in regards to the development of sufficient food production and not for the energy generation. Renewable energy is also given attention. The strategy states that the use of renewable energy is part of the transformations in the Energy Programme of the Country. This is involved in the significant changes in the key sectors in the Cuban economy (CITMA 2007). The strategy also includes a concrete goal. It is stated that energy from renewable sources should represent at least 20% of the national energy mix in 2010. As part of reaching these goals concrete actions are mentioned. The actions focus on continuing the search for technologies, to create greater efficiency in the generation and develop the use of renewable energy (CITMA 2007).

In the 2011-2015 strategy the sugar industry is not mentioned, but the strategy contains policies that promote the use of renewable energy sources. These are concerned with climate change and independence as it states that efforts should be pursued regarding the increased energy efficiency and the development and use of renewable energy sources. And subsequently, that this would also contribute to the energy independence of the country (CITMA 2011).

PCC has power as the only political party in Cuba. As elaborated in Chapter 1, their guidelines launched in 2011 treat the Cuban economy. Number 209 and 212 in the guidelines treats the sugar industry and states that the sugar industry will have its primary objective to steadily increase the cane production. It also states that the sugar production should diversify and take into account the demands of the international and domestic markets. The guidelines also suggest that the industry should advance the creation, recovery and exploitation of the plants and derived products, prioritizing the objectives to obtain alcohol, animal feed, and other bio products (PCC, 2011). The guidelines number 113, 131, 247, 267 treats the use of various renewable energy sources and development of the technologies. Number 247 within energy politics states that the use of various renewable energy sources, mainly the use of biogas, wind energy, hydropower and biomass should be promoted. And further that those energies that have the greatest economic impact should be prioritized.

Further elaboration of these national policies will not be presented in this thesis. The information here should only be understood as presentations of the concerns. Thus the descriptions of these documents and other national policy documents are very limited. The thesis argues that there is a lack of coherent policies, and this is mainly due to the statements of the informants found in the interviews. In Chapter 3 the use of interviews as sources in the data collection are elaborated. The opinion of the informants and their expressed concern about the lack of coherent policies are therefor important in the consideration of the national policies. The informants expresses that they are aware that the government are positive towards the implementation of renewable energies, but that there is lack of policies that creates a strong connection to the sugarcane industry.

Alvarez states that he thinks the state need to increase the sugarcane production and the general salaries. And he is not sure if these guidelines address these issues and therefor he is unsure of the future implementation of the technology. His opinion is that it should happen and there are possibilities, but the guidelines lack strategies of concrete actions (Armando Alvarez Dozágüez, personal communication, June 11, 2014)

Independence and energy sustainability

The sources strongly valuate the importance of independency for Cuba, to be able to provide sufficient energy to their own country. While other countries may focus on the revenue or labor possibilities, the Cuban interest is more toward self-sustainability and self-control of the resources. I got the impression that they are not interested in selling the rights to their natural resources. This is considered particular policies in terms of for example land properties and foreign investments and has an emotional aspect; the Cuban soul is not for sale. This interest is strong and creates policies that support the development of renewable energies, but on their own terms.

The great attention of independency in Cuba also affects the strategic products because they are very concerned with owning their own resources, working on their own terms and they state quite determinately the fact that no other country should control their resources. Torres explained that this is linked to their history of strong dependency of Spain and later the US. "*I think that the main thinking behind the plan and behind this strategy must be ours. Not everybody from abroad that says to us: you must do that. I know what I must do; the only*

problem is that I don't have the resources for doing" (Julio Torres Martínez, personal communication, June 11, 2014)

Environment

Policies for developing the technologies are affected by the national and international environmental concerns and the development of renewable energies is considered an important tool to meet the environmental issues. All the informants explicitly express their concern on this area and the documents are in great extent about environmental concerns, covering the aspects of pollution and climate change. It is a widespread concern of the informants and a major topic in the documents. With the environmental concern there is a desire to develop renewable energies, but as is does not concentrate on developing the renewable energies of sugarcane (Julio Torres Martínez, personal communication, June 11, 2014).

Food Vs. Fuel

Using sugarcane to produce energy is a controversial topic because of the concerns about using food to produce energy. The informants explain that it has been a major debate in Cuba to use an important nutrient resource to make energy. The government has earlier expressed concerns about using sugar to produce energy instead of producing food. It is also important within the communist reasoning that it is more important with nutrition and producing food to the masses than e.g. proving fuel to the few who are so privileged to have a car (Julio Torres Martínez, personal communication, June 11, 2014).

But this debate is two folded because the energy can be produced simultaneously as sugar by using left overs from sugar production, or producing energy can be *instead* of producing sugar. This debate has been calmed down lately as there is consensus that electrical energy, biofuel and biogas can be produced simultaneously as there are technologies that insures that energy is produced together with the sugar production using the bagasse and other residuals from the production. *In all cases, biofuel production in Cuba is governed by ethical principles such as biofuels can not be developed at the expense of the nutritional needs of man, must be environmentally sustainable and should contribute to reducing emissions of greenhouse gases"* (Moreno, 2013). Alvarez Supports this and states the energy produced does not affect the food production negatively (Armando Alvarez Dozágüez, personal communication, June 11, 2014).

4.2.2 Techno-Economic Evaluation

What are the tools for reaching the goals of the creation of the energy products? As explained in Chapter 2, the Techno-Economic Evaluation is the process of identifying the actors and other resources that are needed in order to create the desired products, and how to organize them. This thesis will not provide a description of this evaluation to this extent. It is not the aim of the research and would not be possible. Understandably, the researcher does not provide sufficient data about this and the amount of words would also be beyond the limitations for the thesis. Therefor, only a limited presentation on how these interventions can be perceived will be presented in order to understand the dynamics in the TEN.

How the government is currently organizing the actors is elaborated earlier in this Chapter within the Sub-Networks and Intermediate Networks. The current Techno-Economic Evaluation considers how this could be organized to reach the goals of energy products. Therefore it is directly linked to the fact that the current Strategic Evaluation of the sugarcane-based energy is rather weak. With the Strategic Evaluation it is explained that there is governmental interest to develop renewable energies. But in the specific sugarcane energy products the interest is shown to be limited. Therefore, there it is a potential for the government to intervene in organizing their resources into developing sugarcane-based energy. But, because of the weak request on the sugarcane based energy products, the plan for how to reach them naturally also becomes weak.

Nevertheless, what is interesting is that there was great success in production of sugar a few decades ago and a severe improvement in electrical production grid in 2006, as elaborated in Chapter 1. The country has the potential within the natural resources, and was able to organize in order to achieve successful production. Thus, the government already could have knowledge about how to intervene in the sugarcane network: How to organize the actors to create the products. They could use experience from this in their evaluation on how to intervene in the energy production of sugarcane.

Governmental interest in combining sugar production with renewable energy

The current evaluation on how to organize their resources is strongly effected by the interest by the government. The Strategic Evaluation makes it clear that there is interest in developing renewable energy, but it is not directly linked to the sugar cane production. Thus the first step

in organizing their actors seems to be to have the governmental interest in combining these strategies. Therefore the governmental interest in organizing a coherent strategy is considered an important tool in the organization of the actors, and therefore in the Techno-Economic Evaluation.

Also, the governmental interest is especially important in a command economy. If it was a free market, other stakeholder might express their interest by investing in the technology or by creating an environment that used the product. And in this way contribute to the development and implementation of the technology. But with the command economy and strict regulations this is within the power of the government.

Valdes thinks it is possible to develop the technologies for sugarcane based energy, but the problem is that it depends on the governmental interest because this determines what resources that are provided by the state. He states that there is sufficient technology, but there has to be interest and action to solve it (Antonio Valdes Delgado, personal communication, June 04, 2014).

4.3 Summary of main findings

The current sugar industry is not producing the amount of sugarcane that is possible from the natural resources. The production of sugarcane is in decline and at present it is only to a limited degree being used in order to produce energy.

The main Technology used to produce energy is generating electricity from burning the bagasse at the sugar mills. This electricity is currently limited into being used for the sugarcane production. It is challenging to produce electricity for additional utilization given the absence of distribution possibilities. There are other Technologies that convert sugarcane into energy products such as ethanol and methane gas, but in this case these are situated mainly within Science and Technology, not circulated to the Market. The Science Sub-Network has many research institutions and substantial governmental funding. But although all these initiatives, it does not inevitably contribute to a further technological development.

The Market has limited governmental interest. Also within the intermediate network between Technology and Market there are few initiatives. The governmental bodies do not focus their

policies towards these. Although the environment around the users creates need for electric energy, it does not provide possibilities for consumption. And there are obstacles with the distribution possibilities for the electrical energy. The environment is characteristics by poverty and therefore the Market do not have users that demand these energy products.

The policy attention has been directed towards the Sub-networks of Science and Technology and to the intermediate network between them. The Science within both sugar-production and renewable energies are strongly supported by several governmental initiatives. Given the descriptions provided in the chapter the current TEN of sugarcane-based energy is considered long, dispersed and incomplete.

The specific policy concerns about developing energy from sugarcane are part of a somewhat larger national policy development regarding energy sustainability, independence and environmental issues. These are addressed within the Strategic Evaluations conducted by the government. The developments of the energies are only a very limited part of the development of these larger national policies, but these policies affect how the government evaluates its desires for developing the energies. There are policies that support the development of renewable energies, but in little degree connecting this with the declining sugarcane industry. The Techno-Economic Evaluation provides a confined presentation of the possible governmental tools for intervening. It is stated that the government can use knowledge from how they organized the actors in for successful sugar production in the 1980 and transformation to distributed electrical energy in 2006.

5 Concluding remarks

5.1 Discussion

The theoretical network of TEN can be discussed in regards to the empirical findings. Callon's TEN framework is used to present one network of sugarcane-based energy to describe how the policymaking and innovation process are part of implementing a renewable energy. However this case study shows that the current governmental interventions could be described as three Techno-Economic Networks: the sugarcane TEN, the renewable energy TEN and the sugarcane-based energy TEN.

Science, Technology and Market are characterized by the separation into sugar on one hand and renewable energy on the other. A description of three co-existing networks is therefor suggested in order to provide a description on how the government currently intervenes differently within the three TENs. The Strategic Evaluation shows that the national policies are divided. A modified use of the TEN concepts can provide a description of combining several excising networks. This is illustrated in Figure 9. The thesis shows that in some cases innovation requires combining several co-existing networks.

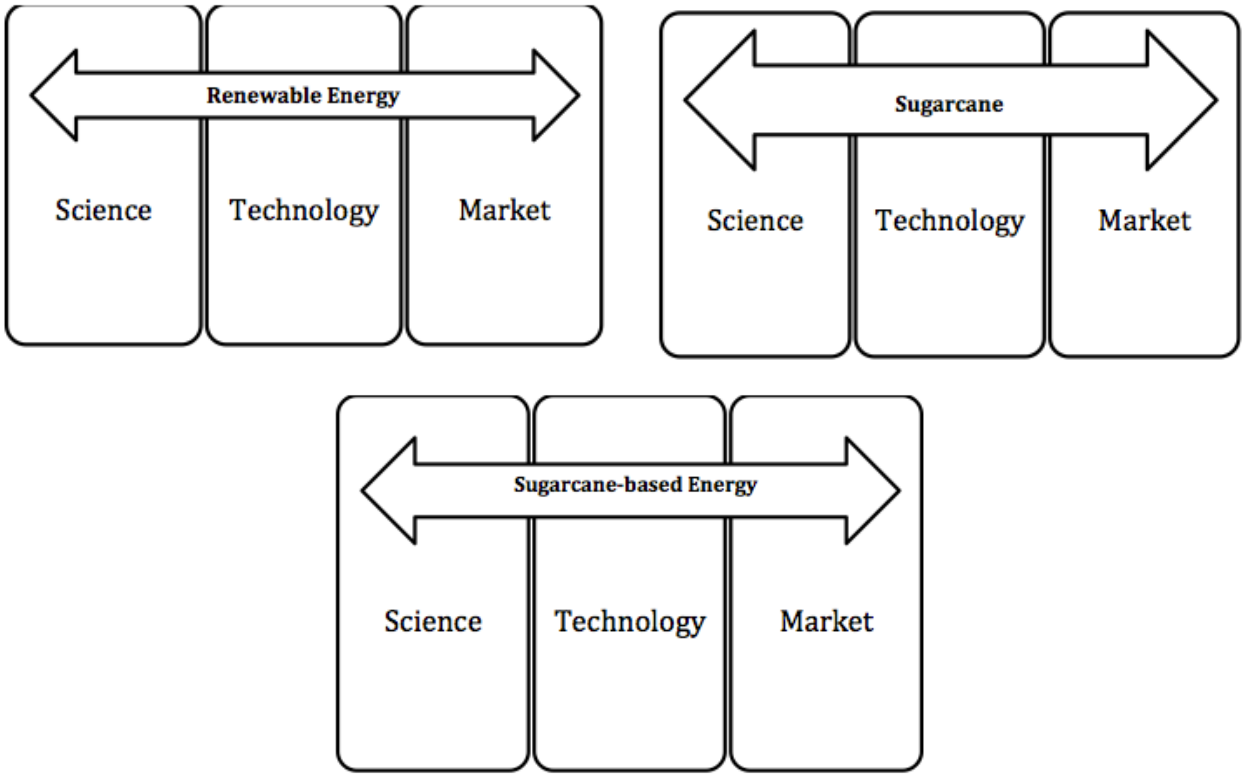

Figure 9: Sugarcane, Renewable Energy and Sugarcane-based Energy networks.

5.2 Concluding remarks

The general objective of this thesis is to understand policy making and innovation processes in renewable energy in an industrializing country. In order to achieve this understanding the sugarcane based energy in Cuba was chosen as the case and three specific research questions were asked. Answering these questions has provided an understanding of how the innovation processes and policymaking, described with the concepts of Techno-Economic Networks, are part of implementing the utilization of sugarcane as a renewable energy source.

When looking at one combined network for sugar cane based energy, the current governmental interventions are limited. They are mainly concentrated towards the Scientific Sub-Network and the ST Intermediate network. The technological innovation process is affected by Cuba's national policies directed towards a decreasing sugarcane industry and increasing renewable energy sector. The sugarcane industry has been in decline since the 1990s with different governmental initiatives trying to reverse this trend. However policy initiatives towards developing the sugarcane industry are severely reduced the last couple of

years. The current situation (2014) is that there are very limited specific policies earmarked to increasing the production sugarcane based energy. There are national policies and strategies for developing renewable energies, and to some degree it is stated that there is an interest in developing the electricity grid to distribute electrical energy generated at the sugar mills. The lack of policies and strategies, which combine the interest in renewable energies with the sugarcane industry, is an important implication of the current policy and strategic situation. The main object for the policies and strategies appears to be a focus upon independence, including control over resources combined with sustainable development.

By following the actors and relating their own experiences this thesis reveals information about who and what are involved and what their interests are in the development of using sugarcane as a energy source.

5.3 Implications

This study uses the Techno-Economic Network concept to describe the current state of sugarcane-based energy in Cuba in regards to innovation process and policy development. The research that has been done provides justifications on how to use the theoretical framework and also discovers current processes in Cuba and therefore this research might have implications for both theory and policymaking.

5.3.1 Theoretical implications

The thesis suggests that this theoretical framework can be used to achieve an understanding of the implementation of renewable energies in similar industrializing countries. This thesis shows that Callon's concept of Techno-Economic Networks can be used to provide descriptions of the implementation of renewable energies. Furthermore it suggests that the networks can be understood as the combination of coexisting Techno-Economic Networks.

Suggestion for further research

The thesis proposes a contribution to the theoretical framework of Techno-Economic Networks by suggesting that in some cases innovation requires combining several co-existing networks. Further research can be done within this suggestion.

5.3.2 Policy implications

The research shows that there are both potential and need for the development of sugarcane based energy in Cuba, but currently the focus on sugarcane production and development of renewable energies are divided. By developing policies aimed at the two networks as one object there might be possibilities to develop this renewable energy. The research suggest that when organizing the actors to create the products, the government can use its experiences from the development of electrical system in 2006 and its success in sugarcane production in the 1980.

This thesis also shows that there is interest within science and technology and lack of activities for connecting this to the market. This could be useful information to policymakers to direct policies towards the market and not at least towards the intermediate network that actually connects the technology to the market.

5.4 Limitations

The policy issues and challenges found in this analysis take into account that the government's significant role in Cuban sugarcane industry as well as government agencies' and companies' dominance in all economic sectors. Thus this can cause limitations in generalizing into other industrializing economies.

The conclusions and implications provided in this thesis need to be understood in connection with the methodological and theoretical limitations. The research has been done according to the research strategy and the methodological decisions seek solid reliability, internal and external validity. Still, the research is limited as it only contains a certain amount of information provided by interviews and documents. The theory provides a conceptual framework and there are many limitations to the findings as it only provides a narrowed description of the actual current state; in order to describe this reality, simplifications have been done.

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Appendix 1: Informants & interviews

Informant	Data collection relevance	Profile / Company	Date Place
Jens Sörvik	Emails about informants in Cuba	Research Policy Institute, Lund University, Sweden	20.05.2014 Oslo/Spain
Claes Brundenius	Emails about informants in Cuba	Research Policy Institute, Lund University Sweden	14.05.2014 Oslo/Sweden
Even Sandvik Underlid	Telephone conversation / informal interview	University of Bergen	19.05.2014 Oslo/Bergen
Alejandro Perez Malagon	Conversation / informal interview	CETER	30.05.2014 Vedado, 23 G, Havana
José Bell Lara	Obtained documents and conversation about informants	FLACSO	12.06.2014 Miramar, Havana

Informant	Data collection method	Company & Profile	Date Place
Antonio Valdes Delgado	Interview, recorded and transcribed	Cuba Energía, Specialist in sugarcane energy	04.06.2014 Miramar, Havana
Julio Torrez Martínez	Interview, recorded and transcribed	CubaSolar Vice president of public relations.	11.06.2014 13.06.2014 Miramar, Havana
Armando Alvarez Dozágüez	Interview, recorded and transcribed	Azcuba. Senior specialist in sugarcane production.	11.06.2014 ATAC, Vedado, Havana
Jorge Tomas Lodos Fernández	Interview, Recorded and transcribed	Zerus, Azcuba. Business Manager, international relations.	13.06.2014, ATAC, Vedado, Havana

Appendix 2: Audit diary

Audit diary of major decisions made during the research process:

Dates 2014	**Issue**	**Decision**	**Approach & Consequence**
March	Research topic	Sugarcane based energy Cuba	Did empirical background research, found technical information and general interest in other countries, e.g. Brazil.
April	Method and Theory	TIS and TEN theory Qualitative Case study method	Did theoretical background research and wrote draft, prepared for data-collection in coherence to the method. Made tentative RQ.
May & June	Data Collection	Field trip to Cuba and seminar Aberdeen	Organized for trip, found informants and prepared interview guide. Challenging to book interviews. Went on fieldtrip, conducted interviews, obtained documents and attended seminar.
July	Data analysis	Data collection analysis	Transcription of interviews, systematization of documents and analysis, got overview of findings and made outlook to empirical chapter.
August	Theory, methodology and empirical chapter	TIS + TEN + Data = theory, empirical findings and analysis	Wrote TIS and TEN theory and empirical findings on basis of combining both, then found out it was not possible. Had challenges due to formal limitations (words and time).
September	Theory, methodology and empirical chapter	TEN + Empirical findings	Rewrote theory and analysis/empirical findings, now only with TEN as theory.

Appendix 2: Interview guide

UiO : Centre for Technology, Innovation and Culture
University of Oslo

Working title	Policymaking and innovation in renewable energy technologies - The case of sugarcane as energy in Cuba.
Tentative Research Question	What are the current policy processes for the emerging sugarcane based bioenergy in Cuba and what is affecting these policy strategies?
Objective	With this research question I want to map out the policy process and understand the Strategic Evaluation of the Sugarcane Based Bio Energy in Cuba. I want to investigate the growth of sugarcane industry in renewable energy sector by looking at how the government is part of the growth of sugarcane based biofuel both as the policy making part, but also as the biggest actor on the demand and supply side. In the special case of Cuba I believe it is interesting to look at how this technology evolves without the market normalcies such as competition and profitmaking, but rather with the public sector as the main actor and little or no private sector. I hope I can use results from this case to generalize and say something about the growth of renewable energy sectors where the government has a significant role.

Data-collection

Method	Interviews and elite- interviewing through Skype and during fieldwork.
Language	Norwegian, English or Spanish.
Time	March – July 2014.

Fieldwork 1	**Cuba**
Time	May 28 – June 16 2014.
Place	Havana, Cuba.

Fieldwork 2	**RSES The Regional Student Energy Summits**
Time	June 19-20, 2014.
Place	University of Aberdeen in Aberdeen, Scotland
Homepage	http://www.studentenergysummits.com

Fieldwork 3	**WBM World Bio Markets**
Time	Attended March 4-6, 2014.
Place	Amsterdam RAI, The Netherlands.
Homepage	http://www.worldbiomarkets.com

Interview guide

(SBBE = Sugarcane based bio energy)

General introduction: Who believes what?
What is your role/part/function in this?
What is your task/assignment? How did you get involved?
Who is the initiator?
What dilemmas are you experiencing?
Castro has earlier mentioned that sugar energy is food to the cars – what is your opinion about this now?

What documents exists?
Is it possible to get access to these documents?
Who has made them? Who is the principal/contracting authority – why is it made?
What is the status of this report/document?
What is the impact of the document? What importance does it have for whom?
How is it used in the further strategic planning?

Policy development Cuba
Can you describe the policy process regarding the SBBE?
What is the current status in the policy development?
What changes have you seen?
Who says what?
Who has an opinion about SBBE? What is their opinion?
Who has expressed their interest in the SBBE either supporting or rejecting the development?
How does the industry of SBBE look like today?
What is the strategy of whom?
What has the department of energy/sugar/education done in terms of accepting and connecting SBBE with the current state?

Technological development and industry development
What is the current status in the technological development?
What changes have you seen?
How has the policy processes affected the technological development?
How is the development of the technology organized, R&D etc.?
How would you characterize the market of sugarcane-based biofuel?

Economical development and international energy policy
What trends are you experiencing?
How does the industry act according to these trends?
How do you deal with the international trends regarding energy prices etc.?
How do you deal with the challenges regarding food vs. energy production?