Eindhoven University of Technology

MASTER

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van den Boorn, R.S.E.

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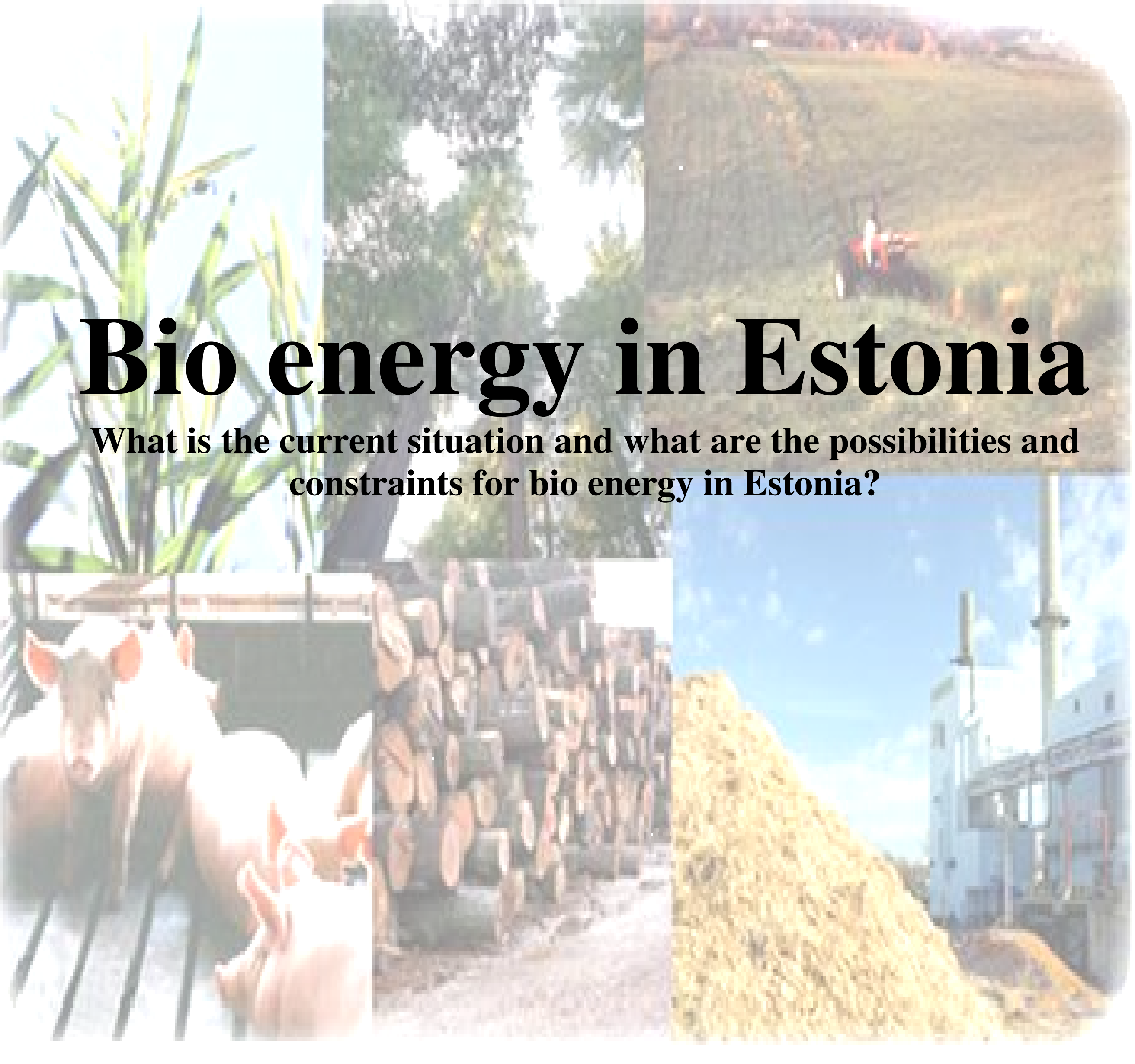

Bio energy in Estonia

What is the current situation and what are the possibilities and constraints for bio energy in Estonia?

September 2009

Master thesis of
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1. Introduction

1.1 Background

We use energy every day, we need energy for heating and lighting our homes, travelling to work and to power our businesses. Energy has become highly integrated in our daily lives and the demand for energy grows rapidly as shown in figure 1. Most of the energy generated is generated by the use of fossil fuels (oil, natural gas and coal).

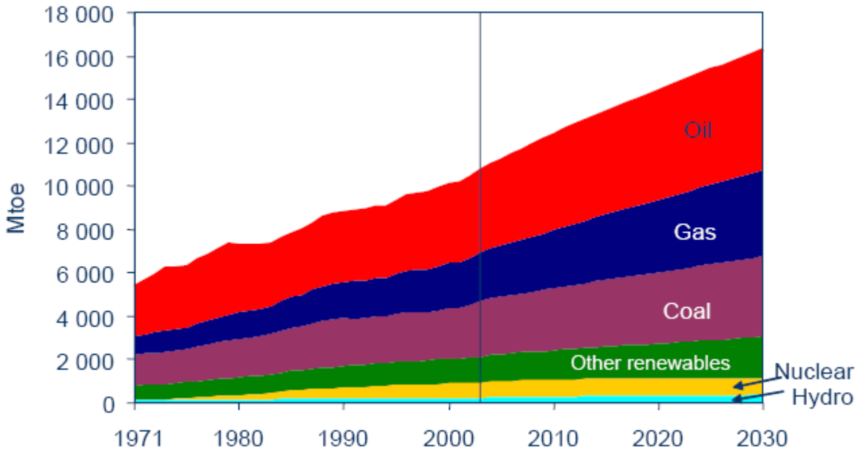

Figure 1: World Primary energy demand (International Energy Agency)

Fossil fuels are non sustainable fuels which have a big influence on the environment. This in combination with movies like: “An inconvenient truth” by Al Gore and “the 11th hour” in which Leonardo DiCaprio is one of the writers, make that climate change, greenhouse gases and CO_2 emissions are hot topics nowadays.

Climate change is an international problem and one of the biggest achievements so far is the creation of the Kyoto protocol in 1997. In the Kyoto Protocol industrialized countries agree on reducing greenhouse gas emissions in the period 2008-2012 with an average of 5% against the base year 1990.[1] Estonia ratified the Kyoto protocol in 2002. [2] The target for European countries is to reduce emissions by 8%. Estonia has also incorporated this target of emission reduction of 8%. At this moment Estonia has reduced its emissions by 56% and with the current policy a reduction of 63% will be reached in 2010.[3]

The most important reason for this big decline in energy consumption is that after Estonia gained its independence in 1991, it was not obligated anymore to provide the North-Western part of Russia with energy generated at the Narva power plants. Estonia was during the occupation period by the Russians part of the North-Western Russian electricity grid (more about the history of the electricity grid in chapter 5) and the Narva power plants needed to supply electricity for the regions of Leningrad, Pskov and Latvian SSR. After 1991 the supply to these regions fell away and the power plants had to generate electricity for domestic use which was a lot less then before and this decline in energy consumption can be seen in figure 2.

For energy security Estonia still largely depends on the use of oil shale. Oil shale is a sedimentary rock that contains large amounts of organic material. When this rock is heated to a temperature of around 500 degrees Celsius (low temperature processing) the oil comes free and can be used as fuel in the energy sector or it can be used to make shale oil. One of the reasons that Estonia depends so heavily on oil shale is the fact that the organic content of the mined oil shale is exceptionally high compared to rest of the world. In some cases the content is 50% while in the rest of the world between 5 and 25% is normal.[4]

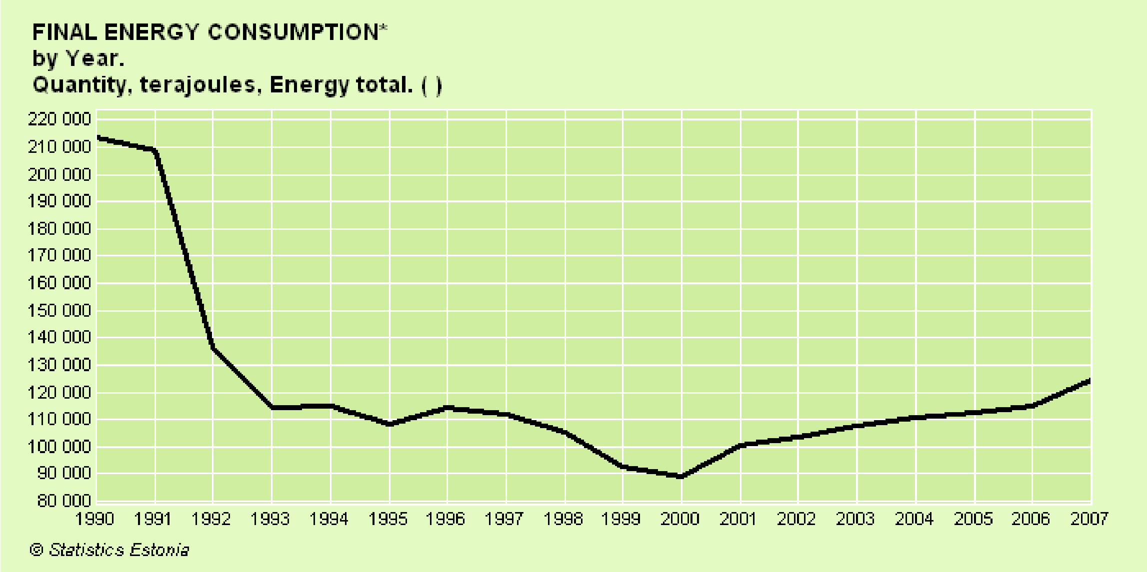

Figure 2: Energy Consumption in Estonia after independence (Estonian Statistical Office)

In 2007, 98,5 % of all fuel used for electricity generation in power plants was oil shale.[5] The biggest consumer of oil shale is the main electricity producing plant AS Narva Elektrijaamad (Narva power plant). AS Narva Elektrijaamad is part of the company Eesti Energia.

Eesti Energia is a state owned company in Estonia engaged in the production, sale and transmission of electric and thermal power. The company owns mines of which it gets the raw materials, “oil shale”, which is used to generate electricity and thermal power. Furthermore Eesti Energia is involved in the construction and maintenance of energy systems. The vision of Eesti Energia Group for 2015 is to sell energy to two million customers in the Baltic Sea region and to become the undisputed world leader in producing liquid fuels from oil shale. [6]

AS Narva Elektrijaamad owns two of the world’s largest oil shale fired power plants: Balti Elektrijaam and Eesti Elektrijaam.[7] AS Narva Elektrijaamad generated 96,2% of the total amount of electricity generated in Estonia in the financial year 2007/2008.[8] The other 3,8% is made up by 35 hydropower stations, 18 electric wind mills (together around 2%), and the use of natural gas for electricity production.[9] In 2009 two new biomass combined heat and power plants (CHP) (the first substantial use of bio energy in electricity generation) and a new wind turbine park will be operational. Together with the already existing hydropower stations and windmills the share of renewable energy will exceed the target of 5,1% for the year 2010 that is set in the “National Long-term Fuel and Energy Sector Development Plan until 2015”.

Oil shale is the number 1 air polluter in Estonia[10] and to transfer the current energy production process into a more environmental friendly one will take decades. It is not only a technical process but also policy plays an important role in the transformation of the energy regime. The biggest user of oil shale Eesti Energia will reduce the CO_2 emissions of its electricity generation portfolio to 0,8 t/MWh in 2015, from 1,1 t/MWh in 2007, and by 2025 to 0,3 t/MWh or less.[11] To achieve this will require the maximum use of renewable energy sources (bio fuels, wind, biomass etc.), increase cogeneration of heat and power and increase the use of waste to produce heat and power. To reduce the environmental impact of production, Eesti Energia invests in increasing the environmental safety of ash handling, and removing sulphur and nitrogen emissions from exhaust gases. This is also necessary due to stricter environmental requirements that will come into effect in 2012 and 2016.

Another reason why Estonia uses oil shale is the fact that under the Russian occupation the Narva power plants had to generate for the regions of Leningrad, Pskov and Latvian SSR. After Estonia gained its independence in 1991, it was completely independent from foreign energy and could provide in electricity generation for the whole country.
The main challenge was rebuilding the basic structures and systems of the state. This included:

- **Constitution** (adopted and in force since 1992)
- **Government of the Republic Act** (adopted in 1995, in force since 1996)
- **Local Government Organisation Act** (adopted and gradually enforced since 1993)[12]

Internationally Estonia became a member of the World Trade Organization (WTO) in 1999 [13] and in 2004 Estonia joined the European Union (EU) and the North Atlantic Treaty Organisation (NATO).[14] [15]

1.2 Research Questions

The goal of the research is to get an insight into the renewable energy policy and possibilities of renewable energy in Estonia. More precisely the possibilities for bio energy to compete with the energy regime at this moment and maybe become the dominant regime in the future. The research questions of this master thesis research comprise of two main questions and three subquestions. The main questions are:

What is the current situation and what are the possibilities and constraints for bio energy in Estonia?

What are the possibilities for Eesti Energia for the development of bio energy in Estonia and the Baltic States?

To structure data collection and analysis a recently developed multi-level approach to technological transitions towards sustainability is used. To answer the two main research questions the following three subquestions will be answered first:

- What are the major relevant trends and events in the “socio-technical landscape”?
- What are the most important barriers and opportunities for bio energy in the current Estonian electricity regime?
- Which learning experiences have occurred so far in the bio energy projects already carried out?

1.3 Data Collection

Using the multi-level perspective (MLP), a working method has been established that will be used for the research. The working method will be discussed by answering the subquestions that will be used to answer the research questions. The multi-level perspective distinguishes three different levels: the landscape (macro-level), the regime (meso-level) and the niche (micro-level).

To answer the first subquestion - *What are the major relevant trends and events in the “socio-technical landscape”?* - focus will be on the important issues in the landscape level, namely environmental issues, environmental change, increase in energy, wars and oil price. (The basics and important issues will be elaborated on in chapter 2)

The data to answer this subquestion will mostly be collected from literature studies, a small part is gathered from interviews and meetings with local people and policy makers in Estonia. The literature data consists of journals, scientific databases and internet sites of the actors involved in the landscape level.

The second subquestion is related to the regime level of the multi-level perspective - *What are the most important barriers and opportunities in the current Estonian electricity regime for bio energy?-* This data is gathered by interviewing people connected to the different social groups in this regime. The multi-level perspective is used as a framework for the interview protocol, an overview of some of the questions used can be seen in box 1 at the end of chapter 2. A literature study will provide a secondary source of data and the focus in this study is towards legislation. The literature consists of legislations, policy reports and studies done by researchers working in the energy field.

Related to the last level of the multi-level perspective, the niche level, the third subquestion is formulated - *Which learning experiences have occurred so far in the bio energy projects already carried out?-* This question is addressed by a literature study of 3 feasibility studies:

- Kuressaare Soojus (CHP biomass)
- Energy efficiency in intensive livestock farming (biogas)
- Planning regional bio energy resource use (Põlva)

and two biomass projects (Väo power plant and Anne Soojus CHP (Fortum)) already carried out and interviews with people who participate(d) in these bio energy projects. These projects are selected after a careful study of the bio energy sector at place at this moment.

Strategic niche management can be described as the analysis of the internal niche processes. Related to the strategic niche management the following aspects are included in the interviews concerning learning processes[16]:

1. Design specifications;
2. Government policy;
3. Cultural and psychological meaning;
4. Market demands;
5. Characteristics of the production network;
6. Characteristics of the infrastructure and the maintenance network;
7. Nature of societal and environmental effects.

The second main question -“What are the possibilities for Eesti Energia for the development of bio energy in Estonia and the Baltic States?”- will be answered after consultation with the Director of strategies of Eesti Energia and other people related to the field of renewable energy at Eesti Energia. Also knowledge gained by previous interviews mentioned above will be used.

The following people have been interviewed:

Name	Function	Company/ Institute
Ando Leppiman	Head of the Renewable Energy Business Unit	Eesti Energia Renewable Energy Business Unit
Timo Tatar	Head of electricity production development department	Eesti Energia
Andrei Vuhk	Project manager	Eesti Energia Renewable Energy Business Unit
Jaanus Arukaevu	Director of strategy	Eesti Energia
Mihhail Lljin	Project manager	Eesti Energia AS Narva Elektrijaamad
Argo Normak	Head of the Centre of Renewable Energy	Estonian University of Life Sciences (Tartu)
Andres Taukar	CEO of the Väo Power Plant	Väo Elektrijaam
Siim Paist	Sales Manager	Fortum Termest
Ülo Kask	Scientist Member of the board	Tallinn University of Technology Estonian Biomass Association
Albert van der Molen	Sr. Specialist asset management	Stedin

1.4 *Outline of the thesis*

The outline of this report will follow the order of the subquestions. After chapter 2 where the conceptual framework will be explained, chapter 3 will give a short introduction into the main routes of bio technology. In the chapters 4, 5 and 6 three subquestions will be discussed in the order of chapter 4 landscape, chapter 5 regime and in chapter 6 the projects in the niche level. In chapter 7 there will be an overview of the results and conclusions of the subquestions and the main research questions will be answered. After this chapter there will be a chapter with recommendations for Eesti Energia (chapter 8) and the fourth subquestion will be answered.

1.5 *Relevance of this thesis in relation with Technological Innovation Sciences Study*

The scientific relevance of this research can be seen from the perspective that the multi-level perspective (MLP) will be used in a different context. While the MLP is normally used in one specific sector and in one country, in this research different sectors are combined and the country specific view is sometimes exchanged for a regional view and this addresses some shortcomings of the MLP. In chapter 2.2 these shortcomings will be pointed out more specific, they might be an inspiration for future research.

A second scientific relevance can be seen in the fact that there is not much scientific research done at this moment towards possibilities of using bio energy in Estonia. For instance the crops research is done mostly from an agricultural point of view while research could be done also towards the usage of crops for bio energy generation, so to research the energetic value of certain crops.

This research also has a social relevancy which can be seen in the fact that this research has been done for an energy company and the recommendations that come out of this research can be used in the company's strategy towards development of energy systems.

The relevance in relation to the Technological Innovation Sciences (TIS) study can be seen in two things, first it is closely related with the specialization energy and sustainable development inside the Technological Innovation Science study. The research is closely related to the TIS due to the fact that it gives an overview of the current situation and the constraints and opportunities towards the future for bio energy in Estonia. These subjects link back towards the specialization. The second relevancy can be seen in the use of the recently developed multi-level approach to technological transitions towards sustainability, which will be the guideline throughout this report.

2. Conceptual framework

In this chapter the basics of the three levels of the multi-level perspective and the basics of the strategic niche management model will be described. After this some shortcomings of the multi-level framework concerning this research will be briefly addressed and to end this chapter the methodology and how this framework is interconnected in the research will be described.

2.1 Multi-level perspective (MLP)

The multi-level perspective distinguishes three different levels: the landscape (macro-level), the regime (meso-level) and the niche (micro-level). The basic concept behind the multi-level perspective is derived from the sociology of technology, evolutionary economics and (later on) institutional theories. In this sociology there are three important interrelated dimensions:

- Socio technical systems (artefacts)
- Social groups (maintain and reproduce the elements and linkages of socio-technical systems)
- Rules (regulative, cognitive or normative)[17]

Rip and Kemp have widened these dimensions and introduced the term “socio-technical regimes” in which they broaden the technological regime aspect with the social aspect of rules and social groups. The interaction between these dimensions will be explained in more detail in paragraph 2.1.2. The socio-technical regime can be seen as the meso-level of the multi-level perspective.

The socio-technical landscape is the macro-level of the multi-level perspective. Landscape is a metaphor used to refer to the relatively hard material and immaterial context of societies. The characteristics of the landscape level are: slow change and high level of stability.

The third level of the multi-level perspective is the niche level or the micro-level. The niche level is the place where radical innovations occur. Niches can be seen as protected environments that act as “incubation rooms” for radical innovations. Niches are locations of learning and locations where you can deviate from rules of the existing regime.[18]

The relationship between the three conceptual levels can be seen as a nested hierarchy. The key point of the multi-level perspective (MLP) is that transitions come about through the interplay between processes at different levels. Several phases are distinguished, which will be elaborated on more in detail in paragraph 2.1.4.
In the first phase the emergence of novelty in the context of existing regime and landscape can be seen, no stable rules (e.g. dominant design), actors who improvise and the novelty has small and precarious networks. No threat to the existing regime.
During the second phase, technical specialisation that occur in market niches and new functionalities are explored.
In the third phase, the breakthrough phase, wide diffusion and competition with the established regime can be seen. In the fourth and last phase the new (niche) technology is gradually replacing the established regime, transformation and wider impacts can also be seen.

The multi-level perspective emphasizes that both internal niche dynamics and external developments at regime and landscape level are important for wider breakthrough and diffusion.[19] Figure 3 gives a good overview of the multi-level perspective on system innovation.

The multi-level perspective model can be used to analyse the bio energy developments in Estonia, due to the fact that there is a stable regime at this moment but there are also a lot of changes on landscape level and niche projects that start to expand all over the country.

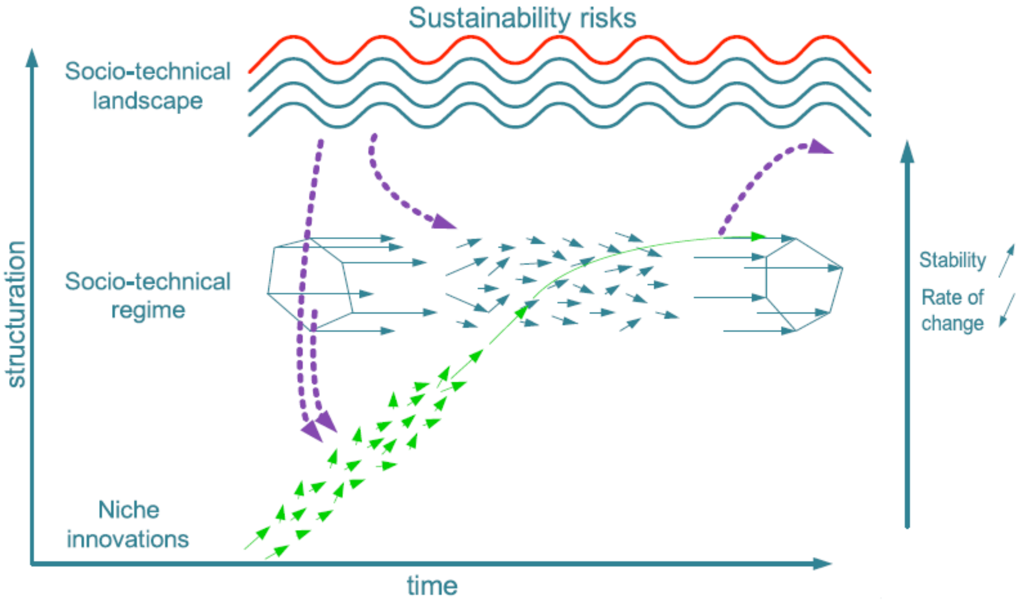

Figure 3: Multi-level perspective on system innovations (Geels, 2002b)

2.1.1 Landscape

The landscape is the macro-level of the multi-level perspective. Landscape is a metaphor used by Rip and Kemp to refer to the relatively hard material and immaterial context of societies, e.g. the material and spatial arrangements of cities, factories, highways, and electricity infrastructure.[20] The characteristics of the landscape level are: slow change and high level of stability. The slow changes can be seen in environmental issues, environmental change, increase of energy, but also quick reactions (change) can occur in this level for instance wars, oil price changes and disasters. The high level of stability can also be seen in figure 3 where the landscape level has a high level of structuration of activities. Landscape cannot be influenced by individual actors directly.

2.1.2 Regime

The regime is also called the meso-level of the multi-level model. Rip and Kemp (1998) introduced a definition of the socio technical regime in which they include the most important factors: rules and institutions, social groups and technological systems. They defined a socio-technical regime as:

‘the grammar or rule-set embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems – all of them embedded in institutions and infrastructures’.

With this definition Rip and Kemp broaden the technological regime aspect with the social aspect of rules and social groups.

Regimes are dynamic concepts. Geels makes a distinction between rules, socio-technical systems and human actors and social groups (see Figure 4).[21] These dimensions are always interrelated, for instance: actors in social groups act according to the socio-technical rules (cognitive, normative or regulative), so these rules guide their actions, but through these actions rules can be changed and reinforced. For analytical purposes it is easier to distinguish these 3 dimensions in order to investigate them. [22]

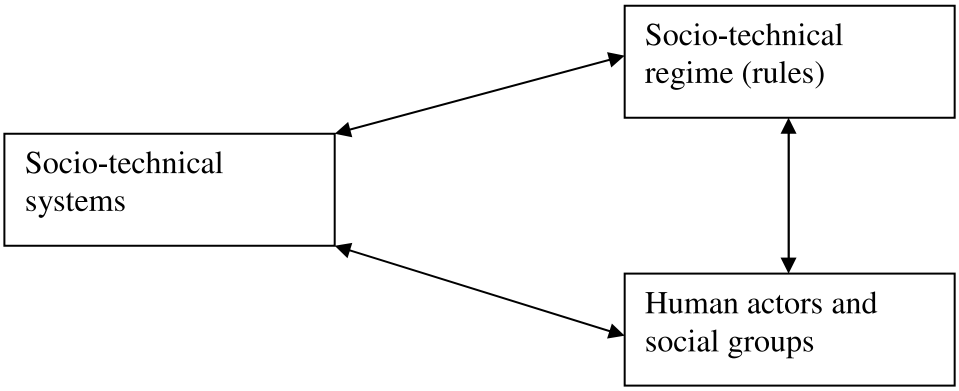

Figure 4:Three interrelated analytic dimensions. (Geels, 2002)

Rules and institutions

The rules mentioned refer to some sort of shared structure that guides behaviour. Scott (1995) distinguishes three pillars or dimensions in this rule set namely: regulative, normative and cognitive rules. *Regulative* rules refer to formal rules, which constrain behaviour and regulate interactions (laws and protocols are a good example of regulative rules).[22] *Normative* rules refer to what is perceived as appropriate behaviour, like norms and values, rights, duties and responsibilities. C*ognitive* rules give meaning to or make sense of the world, like belief systems. In accordance with these rules, Geels states that the interaction between these 3 pillars gives the regime stability and strength to coordinate activities.[22]

Social groups (human actors and organizations)

With the introduction of the social aspect, as mentioned above, Rip and Kemp also put the emphasis on social groups, human actors and organisations in the socio-technical regime. Technologies do not work without actors or institutions, technologies are invented, produced and used by humans. These actors and organizations are embedded in interdependent networks (with their own shared routines, rules specific to this social group and perceptions) and are mutually dependent on each other. This can be seen in figure 5.

The social-technical regime refers to the inner workings of this inter-social group which enables the fulfilment of a certain societal function. This societal function can for instance be personal transport or energy supply.

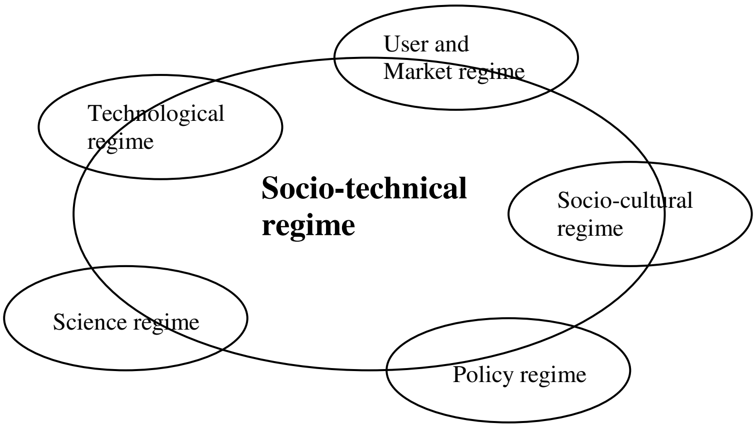

Figure 5: Meta-coordination through socio-technical regimes (Geels, 2004)

Technological system

The last group in this concept is technological systems. Artefacts, technical systems and infrastructures have a certain hardness which makes them difficult to change. Once one of these has been created it is not easily abandoned.

2.1.3 Niche

Niches form the micro-level of the multi-level perspective and the technology to be studied is included in this level. Together with strategic niche management they provide an intellectual framework which is among other things useful for the analysis of success or failure of the introduction of radical innovations.

Compared to the regime level, where incremental changes occur, the niche level is the part where radical innovations occur. Niches can be seen as protected environments that act as "incubation room" for radical novelties.[23] Protection is provided by subsidies but also strategic investments based on expectations of the future market are good examples of how these niches can be protected.

Geels states that niches are locations of learning (about technical specifications, user preferences etc.) and that niches are locations where you can deviate from rules of the existing regime (but also stay close to existing rules).[24]
This last part means that the rules are less articulated and clearly cut and give actors more space to learn and create more radical innovations compared to the regime level. Also there is space for a new set of rules to emerge and there is room to build new social networks.

The three analytic dimensions (rules, actors and system) of the regime level can also apply to niche but the difference is the degree of stability.[24]

2.1.4 Interaction of the MLP levels

In the previous chapters the different MLP levels have been discussed individually, in this part the focus will be on interactions between the different levels. Geels and Schot discuss five different possible transition pathways in which developments in the landscape and niche level might reinforce or disrupt the relationship with the regime. The five possibilities are: reproduction process, transformation path, de-alignment and re-alignment path, technological substitution and reconfigurations pathway.[25]

In the first pathway, the *reproduction process*, there is no external landscape pressure so the regime stays stable and can reproduce itself. Because of this dynamically stable regime radical niche innovations have little chance to break through. The landscape developments have reinforcing effects that help to stabilize the regime. Potential problems are solved within the regime and competition in markets occur within a stable rule set and proceed in predictable directions (trajectories).[26]

In the *transformation path*, the second possibility, the landscape puts moderate pressure on the regime (disruptive change [27]) at the moment that the niche developments have not yet been sufficiently developed. In this pathway an important task has been put aside for outsiders like social pressure groups and social movement, outside professional scientists or engineers, outsider firms, entrepreneurs or activists who draw attention to the negative aspects of the regime. This pressure from the landscape level together with the outsiders' criticism leads to reorientations by regime actors. New regimes grow out of the old one with cumulative adjustments and reorientation of trajectories as important difference compared with the old regime.[28]

The third pathway Geels and Schot mention is the *de-alignment and re-alignment path*. De-alignment and erosion of the regime occur when the landscape changes are large, divergent and sudden (avalanche change[27]). These changes cause increasing problems in the regime level and the regime actors lose faith in the regime to respond to these changes. These "avalanche changes" do not only cause problems, when these changes occur during the phase that no dominant niche innovation has evolved, multiple niche innovations will compete to become the dominant innovation. When this dominant innovation has been established it will form the core for the re-alignment of a new regime.[29]

Another pathway is the *technological substitution* pathway in which the landscape pressure is high and this pressure (avalanche change, disruptive change) puts major tension on the regime. This tension creates opportunities for the niche innovations to break through. The niche innovation can break through because it has been developed sufficiently (stabilized and gathered internal momentum) compared to the previous pathway. And when this niche innovation breaks through it can help to replace the current regime.[30]

The last pathway is the *reconfiguration pathway*. In this pathway the new regime grows out of the old one, similar to the transformation pathway, but with the difference that the basic architecture of the regime will be changed substantially. The architecture can be changed when the old regime adopts an innovation developed in the niche to solve local problems. These innovations leave most regime rules unchanged, but these adopted innovations can cause more adjustments when the regime actors explore new combinations between old and new elements and learn about these innovations. This may create space for new adoptions of niche innovations and slowly the basic architecture is changed.[31]

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[27] Disruptive change: infrequent changes which gradually develop, but have a high intensity effect in one dimension.
Avalanche change: very infrequent, but with high intensity, high speed and simultaneously affects multiple dimensions of the environment.

2.1.5 Strategic Niche Management

Strategic niche management can be described as the analysis of the internal niche processes. For two purposes the strategic niche management has been used: the first one is understanding the process of technological development and the second is to influence this process into the desired directions. This approach was used as research model for historical case studies (e.g. Hoogma, 2000; Van Mierlo, 2002) and to formulate suggestions for policy makers, firms or other technology promoters. Raven refers to these two ways of using the strategic niche management as *policy tool* (influencing technological change) and *research model* (understanding technological change). [32]

A good overall definition of the strategic niche management is given by Kemp, Schot and Hoogma. Kemp, Schot, Hoogma define strategic niche management as:
“the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology.”[32]

In this definition we can see three important parts of the strategic niche management: learning processes, network building and expectations. Each part will be discussed separately before the interrelation between the parts will be discussed briefly.

Learning processes

Learning is the most important process in the niche phase. Technological performance, user expectancy and economic feasibility are all important learning aspects in the experimental projects that are being done in the niche phase. There are seven aspects that can be distinguished for actors to focus on while learning in experimental projects.[33]

1. Design specifications: for instance requirements of adjustments to the technology to overcome initial limitations.
2. Government policy: adjustments of the policy framework (e.g. fuel taxes, access regulations) needed to make the technology viable.
3. Cultural and psychological meaning: for instance the emotional relationship people have with the technology (e.g. introduction of the Solar cooker in Africa, food tasted different, took longer to cook so was not a success).
4. Market demands: topics like what are the preferences, needs of the user/ consumer are relevant in this aspect.
5. Characteristics of the production network: in this aspect the important issue is who is capable of producing and operating the technology at hand?
6. Characteristics of the infrastructure and the maintenance network: for instance what adjustments need to be made to the current infrastructure to make the technology work?
7. Nature of societal and environmental effects: this is one of the difficult learning aspects due to the fact that not everybody has the same opinion about the benefits of the technology, quite often debates about the advantages and disadvantages of the technology are the result.

Network building

Network building is another important process implemented in the strategic niche management. With the introduction of a new technology new networks might be required to be built. Old actors are not always willing to cooperate in the new technology due to the fact that this technology is a competitor to the technology they already use. While new actors who will participate can bring new and fresh ideas in order to further develop the technology. Committed partners increase the chance of project success. So a mixture of old and new actors would be preferable to build new networks in order to further develop the technology.

Expectation

Expectation is the last key part of the strategic niche management. Promises and expectations are important in niche development. They can be powerful if they are shared, credible (supported by facts and tests), specific (technical, social and economic aspect) and coupled to existing problems which the current technology (regime) is unable to solve.[34] Hoogma et al (1999) formulate this process as: “Niche formation merges with the development of a “market of expectations.”” In this they see that co-operation needs to emerge in order to develop activities and create expectation in which the niche can evolve.

Interrelation

The three parts mentioned, expectations, network formation and learning processes are interrelated and the interrelation part will be briefly elaborated in this paragraph.
On the basis of expectations actors might decide to participate in experiments. The network formation (composition, alignment) and the expectations of the actors are important in the set up of experiments. These experiments produce results which can contribute in learning processes (type of learning depends on network characteristics). Outcomes of these learning processes might prove the expectations right or wrong. These outcomes might change the expectations and promises which on their turn can attract new actors to participate in the experiment. So changes in network and expectations can lead to new experiments which can consequently lead to new learning processes.

From this cycle of experiments four patterns of niche formations may emerge:
The first pattern, *technological niche proliferation,* is the outcome from a continuous process of new experiments. This niche pattern does not gain a substantial market share, the new technology cannot compete with the dominant one and protection stays necessary.
The second pattern, *development of market niches*, is characterized by the development of technology niches into one or more market niches. The most important characteristic in this pattern is the fact that only a limited number of actors switch to the new technology with the result that this change has limited effect on the dominant regime. *Regime transformation,* is the third pattern in which the new technology develops (through different stages in technological and market niches) into the dominant technology and transforms the regime. This regime is mostly a mixture between old and new elements but oriented around the new technology. The last and fourth pattern is *technological or market niche extinction*. In this pattern the new technology fails to attract further support and falls back into R&D option instead of staying the dominant technology.[35]

Throughout these patterns some important mechanisms in development patterns (interrelation) of niches can be seen:

- Changing level of protection (technological niche versus market niche);
- Niche branching from one application domain to another;
- Geographical niche branching from one location to another;
- Growth in size (absolute number or market share).[35]

2.2 *Shortcomings of the Multi-level perspective*

When using the multi-level perspective as the conceptual framework for my research I experienced some shortcomings or limitations. The multi-level perspective is a good tool to use when a regime is analysed, but quite often new niches are related to more than one regime. In this research the electricity regime and the heating regime are separated at this moment, but in the niches the use of bio energy appear mostly in combined heat and power (CHP) plants. The produced heat is used in the district heating networks. In this case the electricity and heating regime are combined and a multi regime analysis would be a better approach.

Another shortcoming is the fact that analyses using the multi-level perspective as framework are mostly related to one country, so at a national level. In this research Estonia is the country to be researched and with 1,3 million inhabitants it has one of the smallest populations in the EU. This results in a small electricity market and small bio energy market. As a country on its own it will be really difficult for Estonia to get a leading role in the bio energy technology, but when looking from a regional point of view and when taken the Baltic States as one area the market for electricity and bio energy market expands. So a more transnational approach would be better when looking at future possibilities.

In the multi-level perspective there is limited room for history in the content of occupation. In the content of occupation the country is exploited by conqueror and this can last long time so the sudden impact of for instance war fades and with this the impact on the landscape level. History is important when looking into the Estonian electricity regime due to the fact that the network and most of the power plants have been built in the time that Estonia was occupied by Russia. So the occupation period had big influence on Estonia but focus in the multi-level perspective is mostly on the changes (independence, occupation, war etc.). This is the third shortcoming in using the multi-level perspective as conceptual framework for this research.

All three shortcomings have had some influence on the research but the consequences for the multi-level perspective as conceptual framework for this research are limited. For instance: Estonia is the emphasis of this research but other (mostly Baltic) countries are also included in the regime and landscape level to overcome the shortcomings of the multi-level perspective to focus on one country/nation. The shortcoming related with the occupation has been overcome by taking it as an introduction for the landscape level (chapter 4) and regime level (chapter 5). By doing this the multi-level analysis can be done including the occupation part as if it is done by the country itself.

2.3 *Methodology*

This paragraph gives an overview how the conceptual framework of the multi-level perspective and the strategic niche management are intertwined with the research.

2.3.1 Landscape

The first subquestion is related to the landscape level of the multi-level perspective and is as follows:

What are the major relevant trends and events in the “socio-technical landscape”?

The important issues in the landscape level which are valid for Estonia are war, environmental issues, economical growth and increase in energy.

War
Estonia has a rich history of war and occupation. These wars did not only leave a big mark on the country but also shaped the country. Especially the last occupation of Russia from 1944 till 1991 left a big mark, but it shaped the energy sector also drastically. In chapter 4.1 the history of these wars and the shaping of the energy sector will be elaborated in more detail.

Increase in economic growth and energy
Another important characteristic in the landscape level is economical growth. Estonia has a growing economy chapter 4.1.5 elaborates more on the economical aspects of the landscape level.

Environmental issues
Environmental issues can be seen clearly in Estonia with the ratification of the Kyoto protocol in 2002 and the linkage to the former Russian electricity network.
Chapter 4.2 will elaborate in more detail about the environmental issues that are relevant for Estonia.

Estonian policy
The liberalisation of the electricity market is related to the landscape level. The Estonian regulations will be discussed more in detail in the regime level, the long term development plans:

- Long Term Public Fuel and Energy Sector Development Plan until 2015
- Development plan 2007 – 2013 for enhancing the use of biomass and bio energy

will be discussed in chapter 4.3.

2.3.2 Regime

In chapter 2.1.2 the basics of the regime level have been explained and what can be seen from that is that there are a lot of factors involved (rules, technological systems and social groups). Not all factors are included in this research in order to answer the second subquestion:

What are the most important barriers and opportunities for bio energy in the current Estonian energy regime?

Rules
In this research the focus is on the policy towards the current oil shale based energy generation regime and then especially the regulative rules, subsidy and taxation, export and import. There are a lot of regulative rules related to energy use, energy generation and energy transport, these can be seen in the Electricity Market Act, The Grid Code, Natural Gas Act etc. By focusing on the regulative rules a good overview of the current situation and barriers and possibilities in the energy sector can be gained.

Also towards the future (niche analysis and recommendations) this focus is the best in order to stay in line with the energy policy.

Social groups

The user and market (national or international) and policy are the most important social groups in this research. The government is related with the policy issues and Eesti Energia as the biggest energy company in this regime. A national perspecitve as well as an international perspective will be used to look into the regime developments. The reason to do this is that not all energy generated at this moment can be consumed in Estonia itself and needs to be exported. For future purposes it might also be a better point of view to look at it internationally instead of nationally because regionally the Baltic States together can play a more important role in securing energy supply from Russia towards Europe, but this will come back later on in this report.

Technological system

A clear overview of the electricity sector at this moment will be given in chapter 5.1, this overview is closely related to the third important group in the regime level, technological systems. Oil shale is the most important fuel in this regime concerning electricity generation but natural gas plays an important role in the heating sector. The heating sector is included because these two sectors will be intertwined in the niche level when electricity is generated with the usage of combined heat and power plants.

2.3.3 Niche

In this section of the multi-level perspective the focus will be on one of the three internal processes of the strategic niche management in order to answer the third subquestion:

Which learning experiences have occurred so far in the bio energy projects already carried out?

The seven aspects mentioned in chapter 2.1.3 are used as a guideline for my interviews (interview protocol can be seen below) in order to get a good understanding about the learning process that is strongly implemented in the niche level. The feasibility studies are used to complement the technical aspects that are difficult to capture during the interviews.

Box 1:Interview Questions

Landscape:
How is the involvement of the government affecting the experiments?
Do changes in legislation have to be made in order to stimulate the development of the experiments? (e.g. subsidy, tax reduction)

Regime:
What possibilities are there to enter the current electricity regime, because current generated electricity using oil shale is cheap?

Niche:
What experiences resulted from the implemented experiments?
What was learned from the experiences and did these effect future developments?
Who were the important actors in the experiments?
What were the crucial factors for the experiment to succeed?
Which visions or expectations did the actors have?

Which development can be a competitor for the experiment?
Do changes have to occur in the infrastructure in order to use generated (bio) energy?
Which fuel source is used and why especially this source?
Where do the fuel sources come from? (market, private owner, company, State)

3. Main routes of bio technology

Bio energy is seen as one of the most important options to reduce greenhouse gas (GHG) emissions and to substitute fossil fuels in the future.[36] In this chapter the main routes of bio energy technology (most important technologies) will be described briefly. There are a lot of options for energy production using biomass as fuel, this can be used to generate electricity, generate heat and it can be used as transport fuels. In figure 6 is an overview of the main conversion options. These conversions can be divided in two groups related to thermochemical conversion and biochemical conversion and separately the extraction process. Thermochemical conversion has three main technologies: combustion, gasification and pyrolysis. The biochemical conversion has two main technologies: biogas production (digestion) and fermitation. Fermentation and extraction will not be discussed in this report due to the fact that they are used to produce fuels from biomass for the transport sector and this sector is not relevant for the research, because the focus is on the electricity sector.

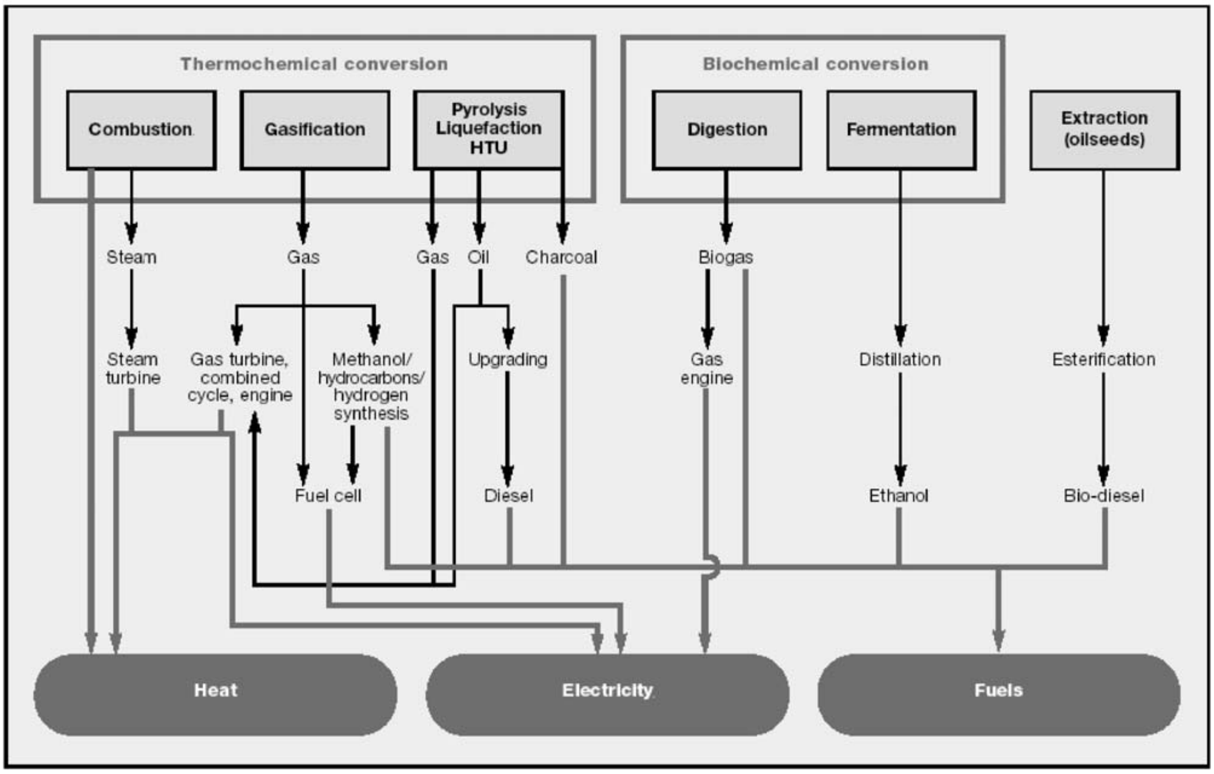


Figure 6: Main conversion options for biomass to secondary energy carriers (Turkenburg et al., 2000). Some categories represent a wide range of technological concepts as well as capacity ranges at which they are deployed, which are dealt with further in the main text.

3.1 Biogas production

Anaerobic digestion

Anaerobic digestion of biomass is a controlled process in which a variety of feedstock (organic waste, manure, sludge etc.) is broken down in an oxygen free environment by bacteria that are already naturally present in the feedstock. The feedstock needs to be mixed very well in the digester and needs to be heated between 20 and 65 degrees in order to promote bacterial activity.[37] This process creates biogas that consists of, depending on the feedstock, approximately 60% methane (CH_4) and 40% carbon dioxide (CO_2).

More gas will be produced if the feedstock is more liable to decompose. The energy content of sewage and manure yields less biogas as the animal which produced it already has taken out some energy.[38]

The biogas can be used to generate electricity by running it through a gas engine or to generate heat. The overall electrical efficiency is rather low for anaerobic digestion, varying between 10 and 15% depending on the feedstock used. Anaerobic digestion is especially suited for wet biomass materials.[39]

Anaerobic digestion does not only produce biogas but also a solid and liquid residue. This residue is called digestate and can be used as fertilizer for land use.

Landfill gas
Biogas can also be obtained as byproduct in landfills. Landfill gas is a methane rich gas that is produced captured during the storage of municipal waste. Solid municipal waste is stored and the landfill gas is produced during decomposition of organic materials in an oxygen free or nearly oxygen free environment under influence of anaerobic bacteria. This way of producing biogas, that can be used for generating electricity and heat, has many benefits.
Some of the benefits are:

- Reduction of greenhouse gas emissions;
- Replacement of fossil fuels;
- Gas produced by municipal waste in landfill is usable energy.

3.2 Combustion

Domestic heating
Biomass has been used for centuries for domestic applications as generator of heat. A classical application is the heat production through wood combustion. The wood is used in fireplaces or furnaces. In this case the wood has low efficiency and a lot of emissions e.g. dust and soot.[40] Nowadays through technological development the efficiency can be improved considerably compared to the fireplaces and emission can be reduced by 70-90%.

District heating and CHP
District heating is the heating of industrial, residential or commercial buildings from one centralized place. Heating can be space heating or water heating. District heating has been used already a long time. The oldest commercial district heating network still operating descends from 1880. The heat that comes from the centralized places can be provided from a variety of sources, including geothermal, cogeneration plants, waste heat from industry, and purpose-built heating plants.[41]

In Scandinavia and other Nordic countries biomass fired Combined Heat and Power (CHP) plants are mostly used to generate the heat for the district heating networks. One of the biggest advantages of using CHP is that it generates electricity and heat in one single process. In figure 6 and 7 can be seen that both heat and electricity are generated and transported. More advantages of using biomass CHP's are reduction of emissions and cost savings due to CHP's high efficiency.

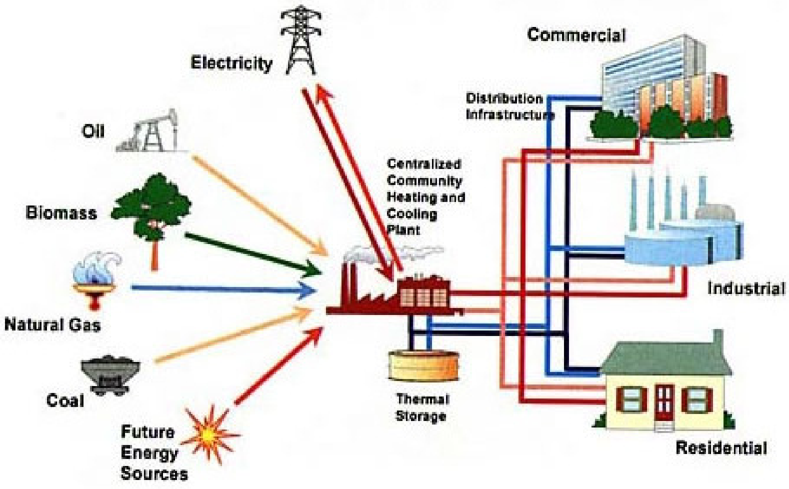


Figure 7: District heating network (Solvay plumbing)

District heating networks can mostly be found in colder climates, this makes it economically more attractive to use the generated heat from CHP's. Important players in CHP plants and district heating networks are forest owners, energy companies, feedstock owners and municipalities. Municipalities are important due to employment and expenditures that benefit the community.[40] Forest owners are important for supplying the feedstock.

District heating: water

Low-temperature district heating systems are used in urban areas. They use low-carbon heat sources such as combined heat and power plants with heat accumulators, waste-to-energy plants, geothermal plants, biomass boilers, large-scale heat pumps and large-scale solar heating plants. Even for small urban areas, district heating with thermal storage can be the key component of a cost-effective, carbon-neutral heating system for existing and new buildings.

District heating: super-heated water and steam

Special district heating systems that use super-heated water or steam are used for industrial processes in the main but are also used by some cities and hospitals. Experience in this area includes the design of pipe systems with a proven lifetime of more than 50 years and experience in the transformation of such systems into more efficient, low-temperature ones.

District cooling

Decentralised electric chillers in district cooling systems can often be replaced by less expensive systems that use cold seawater, groundwater or carbon-free thermal energy. Experience in district cooling includes chilled water storage, district heating absorption heat pumps and centralized cooling plants.

CHP plants not connected to heating networks

A good example is the application of combined heat and power in the pulp and paper industry in which heat and electricity produced is consumed at the factory. The pulp and paper industry has several waste heat sources that can be used in the CHP plant. Some examples of these waste heat sources are: waste heat from the process (e.g. black liquor recovery) and heat from the gas turbine (also electricity generator).[42] Typical capacities for these biomass combustion plants (typically using wood such as forest residues, as fuel) range between 20 and 50MWe, with related electrical efficiencies in the 25–30% range. These plants are economically viable when biomass fuels are at low costs or when subsidy is provided (e.g. carbon tax, feed in tariff).

Co-combustion

The easiest definition of co-combustion is the burning of more than one fuel. In most cases biomass is combined with coal, oil shale or other fuels. The purpose is to reduce CO_2 emissions. Other advantages are:

- Higher thermal efficiency of the biomass
- Higher overall electrical efficiency due to economies of scale
- Investment costs are low if high quality biomass (e.g. wood pellets) are used
- Avoiding, reducing emission (GHG, sulphur etc.)
- Low co-firing shares have limited consequences for boiler performance and maintenance. [43,44]

3.3 Gasification

Gasification is the process in which biomass, coal or another solid fuel is transformed into carbon monoxide and hydrogen (syngas) using high temperatures with a controlled amount of oxygen, water vapor and carbon dioxide. The key is to reduce the biomass to charcoal and then convert the charcoal at suitable temperatures into CO and H_2. After the production of the H_2 and CO, the syngas is pumped through a filtration system and into an engine or CHP plant that generates electricity and heat.[45] The syngas can also be used for the production of methanol or hydrogen (liquid fuels) that can be used as fuel for transportation. Another possibility is to upgrade the syngas to natural gas quality so that this "green gas" can be injected into the natural gas networks.

3.4 Pyrolysis

Pyrolysis can be defined as chemical decomposition of biomass by heat (temperatures around 500 °C) in the absence of oxygen. With this reaction gaseous, solid (charcoal) and liquid (bio-oil) fractions are formed. These products can be used as replacement of fossil fuel products, for example bio-oil can be used for firing engines and turbines. Pyrolysis is seen nowadays as an important pre-treatment step for long distance transport of bio-oil which can be used again in further conversion (e.g. efficient power generation).[46]

4. Landscape-a closer look at Estonia

There are three types (varied set of factors) that can be distinguished in the landscape level namely:

1) Factors that do not change or change slowly, like climate change;
2) Long term changes such as the transition from a communistic economy to an open market economy in Estonia and other former Soviet Union countries;
3) Rapid external shocks such as wars or fluctuations in the price of oil.[47]

These types are the guideline through this chapter and will be discussed in paragraphs 4.2, 4.3 and 4.4, but first a general overview of Estonia will be given in order to get an insight in the geographical location, history, population, religion and economy of this country.

4.1 Estonia

The official name for the Republic of Estonia is: Eesti Vabariik.

4.1.1 Geographical location

Estonia is a country situated in the North East corner of Europe bordered by Russia to the east and Latvia to the south, the other borders are the Baltic Sea and Gulf of Riga to the west, and the Gulf of Finland to the north.

Figure 8: Map of Estonia

The total area of Estonia is 45.226 km^2. The biggest part of the country is covered by forest, 48% or 21.000 km^2.
37 % is agricultural land and around 10% of Estonia's territory is made up of 1520 islands.[48]
Furthermore 7% of the total area of Estonia is marshland and moor and 5% are inland water bodies which consist of more than 1150 lakes and reservoirs of which Lake Peipus (Peipsi Järv) in the east and lake Võrtsjärv, in the center of Estonia, are the biggest two.[49]
Estonia has also a number of rivers of which Võhandu (162 km), Pärnu (144 km) and Põltsamaa (135 km) are the longest. In the north-east, the Narva river is not the longest but it is the largest river in Estonia with an average discharge bigger than all the other rivers combined.[50] The Narva river forms the border between Estonia and Russia.

Estonia can be compared with The Netherlands and Denmark in area size but also in geographical viewpoint. The highest point is 318 meter above sea level, so Estonia can be described as a low country.

The climate in Estonia is characterised by long winters and short summers. The temperature is influenced by the Atlantic Ocean and the Gulf stream and due to this the weather is considerably milder than that of the Nordic countries and countries at the same latitude. The average temperature in summer (June-September) is between 15 and 18 ˚C, in winter the temperature is average between -4˚C and -7˚C.[51] These temperatures are averages and can differ between coastal area and inland. The annual precipitation is also related to which part of the country you are looking at and varies from 510 mm on west islands to 740 mm in highest parts of the south-east.[52] The longest day in summer is over 19 hours and in winter the shortest day does not last longer than 6 hours.

4.1.2 Population

With 1.34 million inhabitants Estonia has one of the smallest populations of Europe. The capital of Estonia is Tallinn which has approximately 396.000 inhabitants. Other cities are Tartu (98.700), Narva (67.200), Kohtla-Järve (47.100) and Pärnu (38.700).[53]

In 2008 almost one third (31%) of the population of Estonia consists of minorities. The biggest minority group consist of Russians with 26%. The other 5% consists of Finns, Ukrainians, Belarusians, Germans, Latvians, Lithuanians and other ethnic nationalities.[54] (In appendix 1 you can find an overview of the different minority groups)

The Estonian language is a Finno-Ugrian language which is closely related to Finnish, and distantly to Hungarian. The Estonian language has no relations to Russian, Anglo-Saxon or any of the Indo-European language families (e.g. Spanish, Polish, Lithuanian, Norwegian, Albanian, Romanian, Greek or Welsh).[55]

4.1.3 Religion

Most people in Estonia are atheist, of the people who are religious Evangelical Lutheran and Eastern Orthodox communities are the biggest and most important religions. Religion is closely related to the historical wars and occupation that Estonia has had. An overview of the different religious communities and their members can be found in appendix 2.

4.1.4 History

Estonia has a long history of occupation and wars. A brief overview of the history of Estonia will be given starting from the Russian period in 1710. The period before 1710, Estonia was occupied by Danes, Swedes and Germans but it is not relevant for this report to cover this part of history. One nice fact stems from this period. The Danes conquered ancient Tallinn (derived from *Taani linn*, meaning "Danish town")[56] in 1219 and established their own fortifications on Toompea (German: Domberg, or "Cathedral Hill").[57] Tallinn is the capital of Estonia and Toompea is the place where the parliament is settled.

1710-1918 Russian period

The ending of the Swedish period came in 1697 when the young and inexperienced Charles XII came on the throne. By battling Poland he left not a lot of armies in the Baltics to protect the country from the Russians and they could easily reach Tallinn. With the surrender of Tallinn to the Russians in 1710 a new occupation was a fact.

During the Imperial Russian rule, the Estonians had for the first time since the Middle Ages a peaceful era. In the first 150 years of this occupation there can be seen three periods. The first period 1762-1796 the Estonians recovered from the effects of the Great Northern war and one of isolation from the rest of the Russian empire. The period 1760 to 1820 was dominated by an activist state policy, leading to formal emancipation of the Estonian peasantry. The final 40 years were characterized by agricultural crisis leading to culminating in a more meaningful rural reform in the countries Livland and Estland.[58] After the crisis education was spread over the country and contacts with countries outside the Baltics increased. These developments contributed to the emergence of an Estonian national movement and the beginning of a growing Estonian role in Baltic political life. This period 1860-1880 can be seen as the "national awakening".[59] The most distinctive feature of this "national awakening" period is the birth of an Estonian national culture, Estonian literature and all Estonian song festivals.

The period towards independency (1900-1917) can be seen as a period of revolution and war. The rise of liberalization in Russia and the lack of modernization created the turnover in Russia that resulted in the February revolution in 1917 (this revolution was the follow up of the Revolution in 1905).[60]

Figure 9: Estonia in 1920

1918-1940 Independent Republic of Estonia

The February revolution of 1917 was the starting point of the collapse of the Russian tsarist regime. Non Russian nationalities began to pursue the realization of political autonomy. This was not easy because of World War I. The Germans defeated the Russians and took over the Baltic States. This occupation temporarily halted the activities of Estonian political forces. In November 1918 the first World War ended and the struggle for independent Estonia was renewed. Russians tried to occupy the lost territory but with the help of English weapons and Finnish soldiers Estonia pushed the Russians back. After a lot of fighting a peace treaty was signed in February 1920.[61]

The Republic of Estonia improved living conditions and restored private property that was framed in the previous period, but not all was positive. The policy was unstable and fragmented and with the collapse of the world economic order in the 1930's the weakness of the constitution of 1920 became apparent.[62] After some big changes in the constitution the mid and late 1930's were a period of recovery and rapid expansion of the economy.

In 1939 the threat of Nazi Germany could be felt in the Baltics. But with the signing of the Molotov-Ribbentrop Pact Finland, Estonia, Latvia and Lithuania came under Russian rule again and this ended the first period of independence. [63]

1941-1944 German occupation

In 1941 Germany started to occupy the Baltics and pushed the Russians back. In Lithuania and Latvia the occupation by the Germans was celebrated and in Estonia, Estonian partisans fought with the Germans against the Russian troops. Estonia was kept occupied by Nazi Germany until August 1944, then Russia overwhelmed the Germans and by October Estonia was occupied again completely by the Soviet Union.[64]

1944-1991 Occupation Soviet Union

The Soviet Union under leadership of Stalin took over Estonia in 1944. Estonia became part of the Soviet Union as well politically as economically and was called: Estonian Soviet Socialistic Republic (ESSR). The central government was placed in the Kremlin in Moscow which gave orders to the ESSR government.[62] This first post war era can be seen as a period of transformation into the big Soviet Union empire. In this period the current Estonian electricity regime was founded (more about the current regime in chapter 5). After Stalin's death in 1953 again a lot of administrative changes were made but now the Estonian government had some influence. Also the people got more freedom, they were able to travel to Helsinki by ferry for instance. But it took until 1985 when Mikhail Gorbachev was leader to change the life of the Estonians drastically. Gorbachev predicted that "perestroika" (restructuring) and "glasnost" (openness) were needed. In Estonia this era of "perestroika" and "glasnost" brought broadly based cultural renewal. This whole period of Soviet occupation ended in 1991 with the "singing revolution", a non violent revolution. It was called the Singing Revolution because of the role singing played in the protests of the mid-1980s.[65]

1991-….. 2nd time Independence

20 August 1991 is the day that Estonia regained its independence. This period of independence is a period of change again. In 1992 the Estonian constitution was adopted and the Russian Ruble was changed by the Estonian Kroon.[66] Furthermore internationally Estonia joined the United Nations in September 1991, Estonia became a member of the World Trade Organization (WTO) in 1999 [67] and in 2004 Estonia joined the European Union (EU) and the North Atlantic Treaty Organisation (NATO).[68] [69]

4.1.5 Economy

Economical indicators

Estonia has a modern market based economy that is rising quickly. The growth rate of real Gross Domestic Product (GDP) has been 6% or higher the last four years. Even with this growth rate Estonia is still not half as wealthy as the Western European countries.

Figure 10 gives an overview of the real GDP growth from 2003 and table 1 gives the numbers and data about the change in GDP, Purchasing Power Parity (PPP) and ERDI.

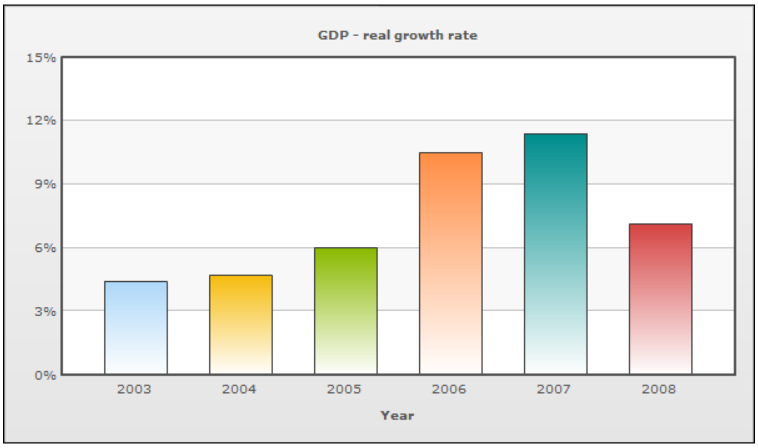


Figure 10: GDP real growth rate Estonia (CIA World Factbook)

The Central Intelligence Agency (CIA) uses the following definition for GDP per capita (PPP): "the sum value of all goods and services produced in the country valued at prices

prevailing in the United States". Economists prefer to look at this when they compare living conditions or resources across countries. [70]
ERDI is a measure of hardness of the currency, so the closer the value to 1 the harder the currency and with this more and relatively cheaper export. If the value is lower than 1 the currency is undervalued and when it is higher than 1, the currency is overvalued. [71] Estonia has an undervalued currency which helps create relative equilibrium in the current account by boosting export income and by moderating import expenditure.

Estonia	**1995**	**2000**	**2004**	**2005**	**2006**
GDP nom. (Euro mln)	2.906	5.940	9.582	11.210	13.234
PPP adj.	7.608	11.346	16.648	18.924	21.429
GDP per capita in Eur (PPP)	5.249	8.245	12.193	14.052	16.162
ERDI	2,62	1,91	1,74	1,69	1,62

Table 1:overview economical performance Estonia (CIA, Wiiw)

Labour market

In 2008 the Estonian workforce, people between the 15 and 74 years old, had an unemployment rate of 5.5% .[72]The wages in Estonia are still lower than the average wages in Europe but they are rising as can be expected in a rising economy. The gross wages more than doubled the last 8 years (table in appendix 3) to approximately 700 euro.
The minimum wages in Estonia remain in the first half of 2009 at 4.350 EEK (around 278 euro (1 EUR =15,65 EEK)) and the minimum hourly wage rate is 27 EEK (1,73 euro).
The minimum wage rate may rise as of July 2009, but no specific figures were discussed at the negotiations between the Board of the Confederation of Estonian Trade Unions (EAKL) and the Estonian Employers' Confederation (ETKL).[73]

Foreign Direct Investment (FDI)

Estonia is a very attractive country to invest in, the last 15 years Estonia has been one of the leading countries in East and Middle Europe in terms of inward investment per capita. Some of the reasons why Estonia is attractive for foreign direct investment are:

- Labour is cheap.
- Quality of work is high.
- Estonia is attractive for small businesses due to flexible production processes and it is possible to quickly change the range of the manufactured goods should the need arise (e.g. clothing articles, interior design products etc).
- There is a relatively low income tax for enterprises and the possibility not to pay income tax on the invested profits.[74]

Table 2 gives an overview of the countries that have investments in Estonia.

Country	Million EUR	% of total
1. Sweden	4.651,9	39,9
2. Finland	2.610,7	22,4
3. Netherlands	795,9	6,8
4. Denmark	431,8	3,7
5. Russia	395,6	3,4
6. Norway	392,8	3,4
7. Cyprus	276,1	2,4
8. Great Britain	273,6	2,3
9. Germany	227,8	2,0
10. Luxembourg	208,2	1,8
Others	1.383,5	11,9
Total	11.647,9	100,0

Table 2: Foreign direct invesment position in Estonia by countries as of 31st of December 2008 (Bank of Estonia)

4.2 Environmental issues

The environment is an important factor in the landscape level. In this paragraph the national and international regulations concerning reduction of environmental pollution will be discussed.

4.2.1 Heritage from Soviet Union

The independence Estonia gained in 1991 (see previous history part) is widely spread and can be seen in different parts of society like the high level of education and the basic institutional infrastructure.

Concerning primary energy Estonia is, since its independence, still relatively independent. About 70 % of its primary energy is of domestic origin. First of all oil shale, but also firewood and peat are the main domestic energy carriers. Estonia “inherited” a considerable dependency on natural gas imported from Russia after the totalitarian system disintegrated that was controlled by the former Soviet Union. In addition to gas pipelines, Estonia is connected to the electric energy systems of North-West Russia and Belarus.[75]

With the heritage of dependency on oil (shale) and natural gas imported from Russia, Estonia also inherited technology that was relatively old compared to the technology of the West. This technology, used in civilian industries, was heavily polluting and natural resource consuming.[76] The energy sector is the most polluting sector and the most polluting activity is the burning or processing of oil shale for electricity production. In the next chapter, chapter 5, the current electricity regime with the use of oil shale and the environmental risks that arise from that will be discussed more at length.

In figure11 the CO_2 emissions (in tonnes) per capita in 2007 are shown and as can be seen Estonia is ranked number 2 in Europe. (An overview of CO_2 emissions per country in the EU till 2007 can be found in Appendix 4)

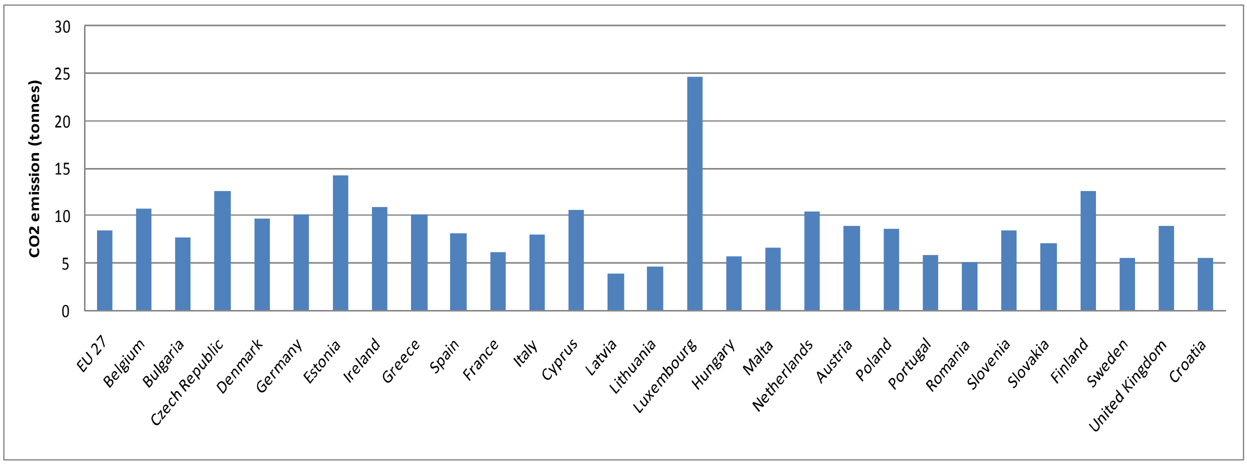


Figure 11: CO2 emissions (in tonnes) per capita in 2007 (World Research Institute)

4.2.2 Kyoto Protocol

Already in 1989, two years before gaining its independence, Estonia started with political and administrative transformations. In 1991 Estonia became a member of the United Nations (UN) and in 1994 it ratified the UN Framework Convention on Climate Change. One of the big achievements of this convention was the approval of the Kyoto protocol in 1997.
In the Kyoto Protocol industrialized countries agree on reducing the emission of the six greenhouse gases in the period 2008-2012 with an average of 5% against the base year 1990.[77] Estonia ratified this Protocol on September 3, 2002. The Government of Estonia has the right, as stated in the Act of Ratification of the Kyoto Protocol, to transfer emission reduction units.[78]
Estonia joined the EU in 2004 and the target for European Countries (EU) is to reduce the greenhouse gas emissions by 8%. Estonia has also incorporated this target of emission reduction of 8%. At this moment Estonia has reduced its emissions by 56% and with the current policy a reduction of 63% is possible in 2010.[79] [80]

The decline of energy consumption is the most important reason for the emission reduction and can be seen in figure 12.

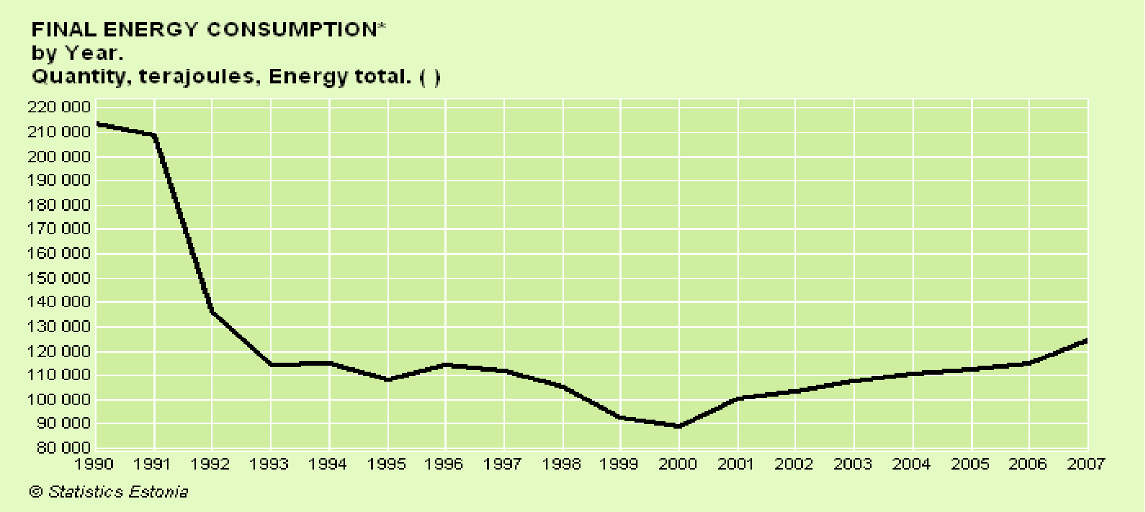


Figure 12: Energy Consumption in Estonia after independence (Estonian Statistical Office)

4.3 Strategic objectives

To decrease climate change and dependence on unstable countries in the world for oil, national and international legislation has to be made in such a way that it secures energy supply and does not affect the competitiveness of a country. In this paragraph legislation and strategic goals as well for Europe as for Estonia itself is discussed. The underlying thought is to decrease the environmental issues discussed in the previous paragraph.

4.3.1 EU objectives

The EU strives for a leading role in the reduction of climate change and the emission of greenhouse gases.

High on the agenda are:
- Reducing the dependence on (unstable) nonmember countries;
- Reducing the emissions of carbon sources;
- Decoupling energy costs from oil prices;
- Energy security and competitiveness.

To achieve this, the use of renewable energy sources is seen as a key element.[81]

The EU has accepted quite a lot of directives in the last years in which the use of renewable energy sources and the reduction of climate change were central. (A brief overview can be seen in table 3.) In 2007 the European Commission adopted the “COM (2007) 1” proposal which has a set of long term goals and is used as the EU energy policy.[82]

These goals are:
- reducing overall greenhouse gas emissions to at least 20% below 1990 levels by 2020;
- improve energy efficiency by 20% by 2020;
- increase the share of renewable energy in energy consumption to an average of 20% by 2020;
- derive 10% of transport fuels from biofuels by 2020.[83]

Directive/communication	Date of publication	Purpose
Directive 2002/91/EC on the energy performance in buildings	Published on 16 December 2002	Measures the energy performance and the use of renewable energy in buildings.
Directive on the Promotion of the use of biofuels and other renewable fuels for transport (biofuels directive) 2003/30/EC	Published on 17 May 2003	This directive aims at promoting the use of biofuels or other renewable fuels to replace diesel or petrol for transport purposes in each Member State.
Directive 2004/8/EC (CHP)	Published on 11 February 2004	Directive has the aim to the promotion of cogeneration based on a useful heat demand in the internal energy market
Biomass Action plan COM (2005) 628 final (BAP)	This Commission communication was adopted 7 December 2005	Designed to increase the use of energy from forestry, agriculture and waste materials in three sectors: heating, electricity and transport.

EU Forest action plan 2007-2011	Published on 15 June 2006	Aims at promoting the use of forest biomass for energy, particularly by developing the pellet and wood chip markets.
Renewable Energy Road Map COM(2006)	Published on 10 January 2007 and accepted by the European Spring Council on 8-9 March 2007	The aim is to increase the share of renewables in the current energy mix to 20% by 2020.
Proposal of directive on the promotion of the use of energy from renewable sources COM(2008) 19 final 2008/0016 (COD)	Published on 23 January 2008	The aim is to implement the Councils decision to reach the 20% RES target by 2020. The directive fills the gap of unexistent directives for heating and cooling.

Table 3: Overview EU directives (bioenergy in motion)

4.3.2 Estonian objectives

In accordance to the EU regulations the Estonian government has made some regulations and strategic goals for the Estonian energy sector. These regulations are compliant with the regulations and strategic goals of the EU and are necessary to improve energy efficiency and renewable energy in Estonia. Energy security and competitiveness that are high on the EU agenda can be found also in the Estonian long term development plans or directives. The Estonian government wants to provide a reliable source of energy at the lowest possible cost.

There is one important development plan covering the energy and fuel sector at this moment and that is the: **National Long-term Fuel and Energy Sector Development Plan until 2015.** This development plan was adopted by the Estonian Parliament on 15 December 2004 and is based on the Sustainable Development Act. The development plan describes the current situation in the energy sector and the issues set out by the Directive 2003/30/EC.

The strategic objectives of the Estonian fuel and energy sector include:

- ensure that by 2010 renewable electricity forms 5,1% of the gross consumption;
- ensure that by 2020 electricity produced in combined heat and power production stations forms 20% of the gross consumption;
- ensure compliance with the environmental requirements established by the state;
- increase the efficiency of the energy consumption in the heat, energy and fuel sector.[84]

The **Development Plan for Promoting the Use of Biomass and Bioenergy 2007-2013** was approved by the Estonian Government on 25th of January 2007. This development plan is based on the Order No 429 of 3 August 2006 and has taken account of the European Commission's communications on the "Biomass Action Plan" and the "EU Strategy for Biofuels". The main objective of this plan is to reduce Estonia’s dependency on imported resources and fossil fuels. By diversification of the sources used in the energy production and the development of domestic biofuel and bio energy production the pressure on the environment will be reduced and the land resources will be used more efficiently.[85]

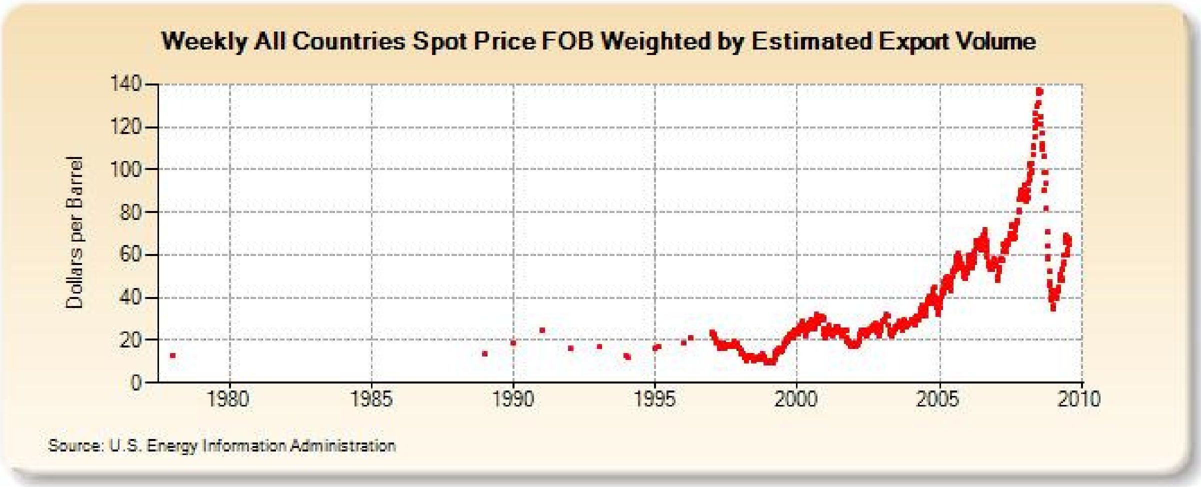
This development plan should be implemented in two phases.
In the first phase (2007-2008) studies will be done to analyse the market, resources, technologies, market measures and other factors related to the use of biomass. In the first phase a strategic assessment of the environmental impact of the implementing measures in phase II will also be carried out. The second phase (2009-2013) will start to promote the use of biomass (subsidies, taxes, standards, knowledge acquisition, etc.) based on the outcomes of the studies in the first phase.[86]

4.4 Influence of oil price

The last of the three landscape variables is the influence of a rapid external shock. Estonia has as already previously explained almost 20 years of independence so the influence of war is not relevant at this moment. Another influence that can cause rapid external shock is the influence of fluctuations in the price of oil. The electricity price is connected with the oil price, so when the oil price increases the electricity price increases (in normal conditions). The main use of fuel for electricity production in Estonia is oil shale. Oil shale is mined in the north east of Estonia. So do fluctuations in oil price also effect Estonian electricity price when the main use is not oil or coal?

AS Eesti Põlevkivi is an oil shale mining company that delivers oil shale to the Narva power plants. The price for oil shale has been the same for 10 years already. A circumstance facilitated to achieving that goal has been the good oil price in the world market, which increased oil shale mining for the purpose of shale oil production. The price has been set to a limit of 133 EEK per ton. [87] (1 EUR = 15,65 EEK)[88]
With the rising of the oil price (see figure 13) also the price of oil shale increased. AS Eesti Põlevkivi can sell its oil shale to the Narva Power plants at a price of 165,10 EEK per ton and the heating value of the oil shale is 8.37 MJ/kg (price in 2008).[89]

The fluctuations in the oil price do not have a big influence on the oil shale price. There are two reasons for this, the first one is that the price of oil shale is more influenced by the environmental taxes. The second reason of this limited relation to oil price, even with opening of the electricity market in 2013, is that the oil shale price is regulated by an agreement between the oil shale mining companies and the government. The electricity price is not regulated anymore and can or is expected to follow the oil price which results in the increase of the price (double almost).[90]



Source: U.S. Energy Information Administration

Figure 13: oil price in dollars per barrel (US Energy Information Administration)

4.5 Conclusions

In this chapter the first subquestion is answered:

What are the major relevant trends and events in the "socio-technical landscape"?

The most important conclusion that can be seen in the landscape level is that Estonia ratified the Kyoto protocol and incorporated the European Union targets, but already from the start Estonia met its and the EU targets. The CO_2 emissions have dropped remarkable as could be seen from the statistics and this takes away the pressure to from the landscape level to change the electricity regime.

Furthermore it can be clearly seen that after Estonia gained its independence one important trend has been to join and acknowledge international treaties and organizations. Directives and objectives from the European Union are important for Estonia and limitations and restrictions can be seen in Estonian objectives. A nice example is that in 2010 5,1% of the gross electricity consumption should be produced by the use of renewable energy sources. Another example is the objective to ensure that by 2020 electricity produced in combined heat and power production stations forms 20% of the gross consumption. These objectives are in line with the 20% by 2020 objective from the EU.

5. Estonian electricity regime

In this chapter the current energy regime will be discussed. The following subquestion will be answered:

“What are the most important barriers and opportunities for bio energy in the current Estonian electricity regime?”

The electricity network was built more than 50 years ago when Estonia was occupied by the former Soviet Union. Estonia was part of the North Western Russian electricity grid. The beginning of this chapter gives an overview of the birth of the Estonian electricity regime. After the historical overview of the birth of the electricity regime the current situation will be discussed with the three dimensions, social groups, technological systems and rules and institutions of the multi-level perspective as guideline. To end this chapter the subquestion will be answered which gives an overview of the most important barriers and opportunities for bio energy in the current electricity regime.

5.1 Historical regime

After World War II, Estonia was occupied by the former Soviet Union (see also chapter 4). The Baltic States (Estonia, Latvia and Lithuania) became part of the all-Union high voltage electricity grid, the North-Western (sub) system of the USSR, which tightly integrated the new member states with the Soviet Union. In 1955 the construction of the first large oil shale fired power plant started in the North East corner of Estonia (Narva region). The plant had a capacity of 1600 MW[91] and this was needed for local use, for the regions of Leningrad and Pskov and Latvian SSR. The power plant was ready in 1965 and between 1969 and 1973 the second enormous power plant with the same capacity went into operation. [92] Also in the other Baltic States the Soviet Union built electricity producing plants. In Latvia this was mainly hydropower and in Lithuania nuclear power. In late 1983’s the first reactor of the nuclear power plant, Ignalina nuclear power plant, went in operation and the second block in 1987. The reactors had a huge capacity of 1500 MW per block.[93]

In order to make it possible for the transmission of these large amounts of electricity to the Russian Soviet Federated Socialist Republic (SFSR), the capacity exceeded the demands of Estonia and Lithuania, a new high voltage transmission grid was constructed. In the late 1950’s the construction of this new transmission grid started which formed a circle round the North Western part of the USSR. The transmission grid consisted mostly of 330 kV electricity lines.[93]

In the period 1987-1991, towards the ending of the occupational era, the Baltic States started to resist against new power plants. In Estonia there were debates and demonstrations against a third oil shale fired power plant, in Latvia the construction of a new hydropower plant was stopped and in Lithuania the third and fourth block of the nuclear power plant were cancelled due to the fact that they were the same type of reactors as used in Chernobyl. The oversized power plants were a symbol of the power of the USSR in the Baltic States but at the same time it secured the energy supply when gaining their independence. [94]

After gaining its independence mostly the trade towards the East dropped away in Estonia and this led to a decline in electricity production, consumption, export and import as can be seen in figure 14. The data round the year 1992 for import are not included due to the fact that the statistical office did not have them available (estimated amount is 0 in 1992)[95]. The overcapacity was transported to the other Baltic States as can be seen in the figure. The difference between production, export and consumption can be explained by losses in electricity networks and equipment.

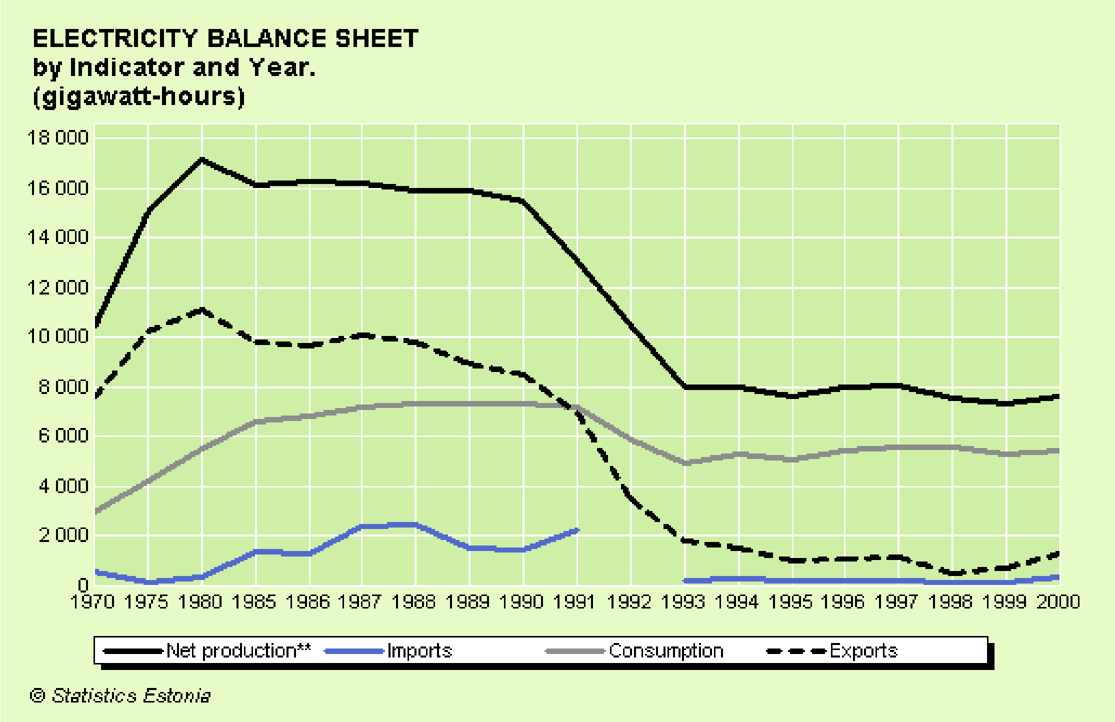


Figure 14:Estonian electricity production, consumption, import and export, 1970-2000 (GWh) (Estonian Statistical Office)

The next question (for Estonia and/or the Baltic states) was: delinking from the North Western Russian electricity grid or not?
The power generated was more than enough for domestic use and from a political standpoint this would mean that a symbol of Soviet occupation and Moscow dominance would disappear, but the energy companies were afraid of the reduction of the load factor and the possibilities to export electricity in the future with the loss of income was the most important reason to keep connected to Russia and other Baltic States.

After this the focus went from East to West, because the Baltic States where only connected to the West through Belarus and Ukraine. In 1993 the electricity grid between Ukraine, Belarus and central Europe was disconnected and the Baltic States became an electricity island in Europe. After several studies throughout the Baltic ring only one connection has been made so far and that is Estlink, a submarine cable between Estonia and Finland. There are several other options to connect the Baltic States with other Nordic countries or Baltic ring countries but none of these projects have been realized yet.

5.2 *Rules and institutions*

After this short historical overview the three dimensions in the regime level of the multi-level perspective will be used to help get a good overview of the electricity regime as it is currently in use. The first dimension that will be used is: rules and institutions.

The rules mentioned refer to some sort of shared structure that guides behaviour. As explained in chapter 2 three different pillars (types) of rules can be distinguished: regulative, normative and cognitive. The focus in this report will be on the regulative rules, which give a good overview of the current situation in the electricity sector. Also towards the future (niche analysis and recommendations), this focus is the best in order to stay in line with the energy policy.

5.2.1 Electricity Market Act

The most important legislation document concerning the electricity sector is the Electricity Market Act. The act came into force in 2003 and was last amended in 2007 (RT I 2007, 23, 120). This Act regulates the generation, transmission, sale, export, import and transit of the electricity and the economic and technical management of the power system. The diversity of energy sources is essential for security of supply in the electricity regime. In the Act is further stated that there is a lack of suitable power stations to balance out the use of wind power (for regulation purposes generator units are used in Narva power stations burning oil shale, which means that instead of saving fossil fuel it is burnt simply to keep the generating plant in the spinning reserve), it is particularly important to promote also the other renewable sources of energy (e.g. biomass or landfill gas).

The amended Act that came into force in 2007 helped promote the use of other renewable sources.

Before this change (in the Act before 2007) the subsidy scheme used was not sufficient enough to promote the use of renewable energy sources. The old scheme required network operators to purchase (in a trading period) all the electricity generated by a producer of renewable energy to the extent of the operators' network losses. The main problem was when the network operator did not have a permit to sell electricity, he could not buy more than the amount of electricity that was lost in the network. This problem was clear in summer periods when electricity consumption was low and network losses small.[96] This was one of the two important reasons to change the subsidy scheme, the other reason was the fact that in the period 2005-2006 the electricity consumption increased faster than the generation of renewable energy. The electricity consumption increased from 6.022 GWh in 2005 to 7.904 GWh in 2006[97], the increase in renewable energy can be seen in table 4. The share of renewable energy sources in total consumption even fell, from 1,8% in 2005 to 1,6% in 2006.

Energy source	Production, GWh 2005	Production, GWh 2009
Wind energy	53,9	76,3
Hydropower	21,5	13,5
Other	33	38
Total	108,4	127,8

Table 4: Renewable energy production 2005-2006 (Ministry of Economical Affairs and Communications)

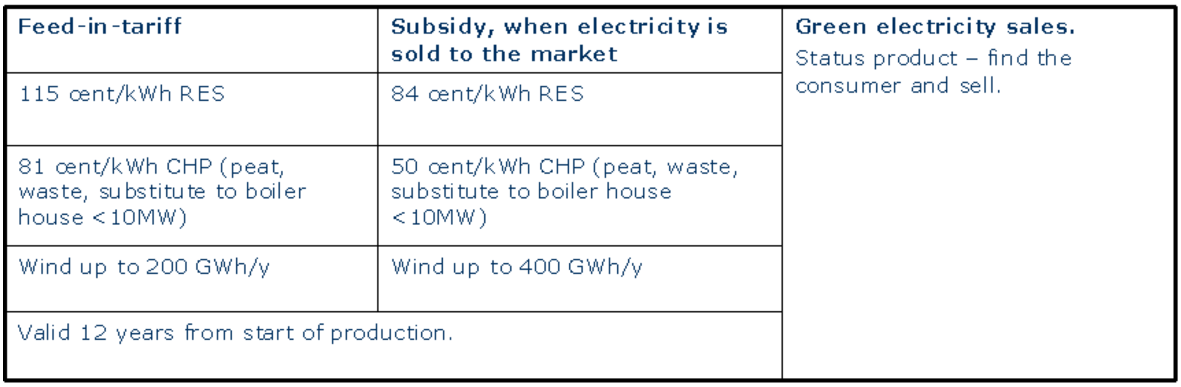
Changes have been made and in the amended Act can be seen in paragraph 59 that:" a producer has the right to sell electricity as a fixed supply to a seller designated by the transmission network operator or to receive support from the distribution network operator for the electricity supplied and sold to the network." So this allows producers to use the purchase obligation as before, but adds the possibility for a producer to sell the electricity produced itself and be given aid for the electricity sent to the grid and sold.

There are three different subsidy schemes for electricity producers to choose from: the feed in tariff scheme, a more open one which is called the subsidy scheme and a green electricity sales scheme which has not been used since it was implemented. A brief overview can be found in table 5 (prices are in EEK).

The feed in tariff has a purchase obligation at fixed feed in tariffs, the right to sell electricity from renewable energy sources (RES-E) as a fixed supply at ± € 0,073/kWh. This tariff is only applicable to generation installation with the capacity not exceeding 100 MW and within 12 years of the start of the production. Furthermore a limitation can be seen towards the amount of wind that can be generated. The right to sell at fixed tariffs until the total annual amount of electricity generated from wind in Estonia is up to 200 GWh, after this amount the Transmission System Operator (the TSO in Estonia is OÜ Põhivõrk) is not obligated to pay the fixed price or to buy the generated electricity.

The other possibility is the subsidy scheme which gives the right to sell RES-E at market price and apply for a subsidy (paid by the Transmission System Operator) of ± € 0,053/kWh. The market price in April 2009 was approximately 40 cents, so adding the 84 cents subsidy the seller gets 122 cents EEK per kWh (about € 0,078/kWh). The same as with the feed in tariff, the subsidy is applicable only to generation installation with the capacity not exceeding 100 MW and within 12 years of the start of the production. Also here a limitation for the generation of electricity by wind is included but this is higher than with the feed in tariff. The limit until which the TSO is obligated to buy the total annual amount of electricity generated from wind in Estonia back is up to 400 GWh. After these amounts the TSO is not obligated to buy generated electricity.

The last possibility, the green electricity sales, is only a possibility on paper because nobody uses this, because the buyer offers a higher price for the electricity than the other two subsidy schemes and the profits that can be made are less due to the relatively low price of electricity that is sold to households and industries.



Feed-in-tariff	**Subsidy, when electricity is sold to the market**	**Green electricity sales.** Status product – find the consumer and sell.
115 cent/kWh RES	84 cent/kWh RES	
81 cent/kWh CHP (peat, waste, substitute to boiler house <10MW)	50 cent/kWh CHP (peat, waste, substitute to boiler house <10MW)	
Wind up to 200 GWh/y	Wind up to 400 GWh/y	
Valid 12 years from start of production.		

Table 5: Subsidy scheme (Electricity Market Act)

In the two first subsidy schemes mentioned no distinction between renewable energy sources is made. The definition in paragraph 57 of the electricity market act states that renewable energy sources are: water, wind, solar, wave, tidal and geothermal energy sources, landfill gas, sewage treatment plant gas, biogases and biomass.

Liberalisation

The Estonian electricity market has been open for eligible customers whose annual consumption exceeds 40 GWh since 1999. These consumers (ca. 10% of total consumption) have the right to buy electricity from any seller in the market and have an obligation to pay for network services.[98] Estonia and the EU have reached a compromise solution for opening the rest of the market. At least 35% of it must be opened before December 31, 2008 and for all non-household consumers (ca. 77%) before December 31, 2012. The market will operate according to the rules of the new Electricity Market Act and the Grid Code.

Opening the electricity market has some risks and possibilities, the main risks are:

- market will not be open in practice if there are insufficient independent producers and sellers (no competition with Eesti Energia Ltd.);
- shortage of generation capacity can occur and prices rise if the market participants (also in the neighbouring countries) want just to sell and buy, but not to invest – it is the most important risk;
- Estonia is so small that large-scale cheap import can destroy local production and investments, and make the country dependent on neighbouring states;
- new power plant investments can increase the share of imported fuels (natural gas technologies are cheaper, more efficient and environment-friendly than the other fossil technologies) and cause supply security and price risks, and worsen foreign trade balance;
- low interest of big customers in small producers and the cheap electricity import can slow down the development of cogeneration;
- the pressure to increase the electricity prices of the closed part of the market (especially households) will increase;
- considering the small size of the Estonian electricity market, the complication of the power system control, costs of operating the market, volatile prices and possible lowering of supply security and reliability due to insufficient investments in the whole region can easily surpass the expected positive effect of liberalization.[98]

For Eesti Energia the liberalisation means that production, network and sales activities have to be separated.

5.2.2 Long-term fuel and energy sector development plan until 2015

This development plan is briefly mentioned in the previous chapter and will partly overlap but the plan will be elaborated more on in this paragragh. This development plan is based on the Electricity Market Act.

The strategic objectives include:

- Ensure that by 2010 renewable electricity forms 5,1% of the gross consumption;
- Ensure that by 2020 electricity produced in combined heat and power production stations forms 20% of the gross consumption;
- Ensure compliance with the environmental requirements established by the state;
- Increase the efficiency of the energy consumption in the heat, energy and fuel sector.[99]

In order to implement these strategic objectives the state may use the following measures:

- Regulative or legislative measures (including price formation mechanisms);
- The tax system;
- Investment support;
- National programmes (including education, research and technology development).[99]

The Estonian government has also committed itself to making oil shale a less dominant part of its energy resources. In 2005 oil shale based power constituted over 90% of electrical power production in Estonia. By the power section development strategy adopted by the Estonian Parliament in 2006, it should decrease to 68% by 2015.[100] This reduction of usage of oil shale was quite hard to realize due to the fact that no law or regulations to refuse permits for mining had been enacted. In October 2008 the National Development Plan for the Use of Oil Shale 2008-2015 was approved.

5.2.3 National Development Plan for the Use of Oil Shale 2008-2015

This development plan examines for the first time the mining and use of oil shale primarily in terms of national and environmental interests.

Minister of Environment, Jaanus Tamkivi said about this development plan:
"Oil shale is Estonia's national wealth and a strategic resource, thanks to which we are able to supply ourselves with the electricity we need. We have to do everything we can to make sure that our oil shale lasts, because if it does it will ensure our energy security and sustainable development. It is crucial that the state is able to direct its mining and use from the point of view of its own interests, and the development plan approved by the Riigikogu will make that possible." [101]

The Long-term Public Fuel and Energy Sector Development Plan until 2015 forms the basis for the production of the national development plan for the use of oil shale. As can be seen in the fuel and energy sector development plan also in the oil shale development plan a lot of different Ministries are involved: the Ministry of the Environment, the Ministry of Economic Affairs and Communication, the Ministry of Finance, the Ministry of Social Affairs and the Ministry of Education and Research.

The most important aspect of this development plan is that the government has a legal basis to refuse issued permits. For instance permits of 24 million or 26 million tonnes of oil shale a year had to be approved when they were all valid. This could lead to a situation that more oil shale would be mined than could be processed so the government approved an amendment to the Earth's Crust Act to halt the processing of applications for permits to mine oil shale until this development plan was approved. [102]
In the development plan no specific reduction amounts for emissions of greenhouse gasses can be seen (Kyoto target has been reached, see chapter 4). However one annual limit is included and that is the amount of oil shale that can be mined in a year, namely 20 million tonnes. Step by step this amount will be reduced, with the annual target set in 2015 at 15 million tonnes of oil shale.[103]

5.2.4 European Union Regulation

Estonia is a recent entrant into the European Union as already mentioned in the previous chapter. In order to give Estonia time to meet the norms that are applied in the European Union, oil shale had been given a temporary status, thus postponing implementation of some relevant EU directives.[104] Step by step Estonia has to meet the European standards.
By 2009 the reconstruction of ash handling systems and bringing ash landfills in compliance with landfill directives have to be ready. By 2012 the sulphur dioxide total emissions have to be decreased to 25 kton/year and by the year 2016 the Large Combustion Plant directive requirements have to be applied to power plants.

The boilers at the AS Narva Elektrijaamad (Narva power plants) are based on pulverized combustion of oil shale and they are at the end of their life cycle.[105] By European Union directives all old pulverized combustion boilers have to be closed by 2015.[106]
So the most critical time for Estonian electricity system is the year 2016. By this time all power production has to be in compliance with the European Union norms. At this moment (2009) two new fluidized bed boilers have been installed in the Narva power plant with a capacity of around 450 MW. According to OÜ Põhivõrk's information in addition to the projects that are currently implemented and those capacities that will be added in the future (Väo power plant, Anne Soojus and Pärnu CHP plants, the reserve plants of the transmission network) the following extra production capacity has to implemented, in order to secure required production reserve: 22 MW by 2013 and approx. 1500 MW by 2023. [107]

These capacities can be implemented by the use of renewable energy sources and are a good opportunity for bio energy.

5.3 *Social groups*

The second dimension in this regime that will be discussed is social groups, human actors and organisations. Technologies do not work without actors or institutions, technologies are invented, produced and used by humans. These actors and organizations are embedded in interdependent networks (with their own shared routines, rules specific to this social group and perceptions) and are mutually dependent on each other.

The focus in this report is on the user and market (national or international) and policy regime, two of the five social groups in the socio-technical regime discussed in chapter 2. The government is the most relevant actor related to the policy issues and Eesti Energia as the biggest energy company is the most relevant player in the regime for supplying energy (user and market).

5.3.1 Eesti Energia

Eesti Energia is state owned, vertically integrated and the dominant company in the electricity sector. Eesti Energia has 97% of the production capacity and an 88% retail market share, while it also controls all of the transmission (OÜ Põhivõrk) and 85% of the distribution networks in Estonia (OÜ Jaotusvõrk).[108] The strategy Eesti Energia follows to maintain their success in generating electricity is:

- investment in new power generation capacities in Estonia, Latvia, Lithuania, Finland or Scandinavia;
- reducing CO_2 emissions from power generation and diversifying its electricity generation portfolio;
- to lower the environmental impact of production, Narva Elektrijaamad (Narva Power Plants) ;
- reduction of the CO_2 emissions of its electricity generation portfolio to 0,8 t/MWh, from 1,1 t/MWh in 2007, and by 2025 to 0,3 t/MWh or less. [109]

To achieve these strategic goals will require a significant holding in a nuclear power plant, the maximum use of biofuels and waste to produce heat and power, generation of electricity in wind parks, and an expansion of co-generation of heat and power. Investment decisions are taken one by one, dependent on the legislative environment and the electricity market.

Eesti Energia's long-term goal is to own enough power generation capacity to cover at least Estonia's electricity consumption and help ensure Estonia's energy security. Eesti Energia has recently (May 2009) introduced the term "green energy" in its sales portfolio. All the people who have joined the Green Energy participation system support, with a targeted donation, the Estonian Institute of Sustainable Development, Stockholm Environment Tallinn Centre (SEIT), the amount of the donation being 10 EEK cents/ kWh of consumed Green Energy. The objectives of the cooperation agreement between SEIT and Eesti Energia, within the framework of the Green Energy participation system, are to increase the volume of electric power generated from Estonian renewable sources and to improve people's awareness of the importance of energy produced in an environmentally friendly manner. In two months since introduction Eesti Energia has sold 6 GWh in advance for this year.[110]

Eesti Energia wants to sell energy to two million customers in the Baltic Sea region. To achieve this Eesti Energia states that the strength and uniqueness of the company lies in the integrated value chain from *oil shale mining, production of electricity, heat and oil, to electricity transmission, sale and various service enhancements* (figure 15). Eesti Energia consists of different companies, in order to bring together these different companies a new brand name has been created: Enefit. The name Enefit – derived from the words *energy–benefit, fit for your needs* – will help Eesti Energia establish its brand name in international markets.

In Latvia a subsidiary from Eesti Energia, E Energy obtained permission from the Latvian regulatory body in September 2006 to sell electricity. In 2009 Eesti Energia claimed more than 5% of the Latvian retail market. In Lithuania the subsidiary Lumen Balticum was founded and entered in the Lithuanian open electricity market.

Eesti Energia does not have many competitors in Estonia, Fortum is the biggest competitor in the field of renewable energy (chapter 6 will elaborate more about Fortum), but in the field of oil shale there are no competitors. In the Baltic States Eesti Energia has more competitors. From Latvia the stated owned company Latvenergo which has around 70% share of the Latvian electricity market.[111] From Lithuania, Eesti Energia has a competitor in Lietuvos Energija and three public suppliers Rytų Skirstomieji Tinklai AB, VST AB and Visagino Energija VĮ. These energy companies can compete with each other but also strengthen co-operation and collaboration with the electricity systems of Latvia and Estonia and conditions for the functioning of a common electricity market can be tried to be established. These energy companies can strive to optimally use the potential of the electricity systems of the Baltic States. This cooperation will lead to a common market for trade in electricity. [112]

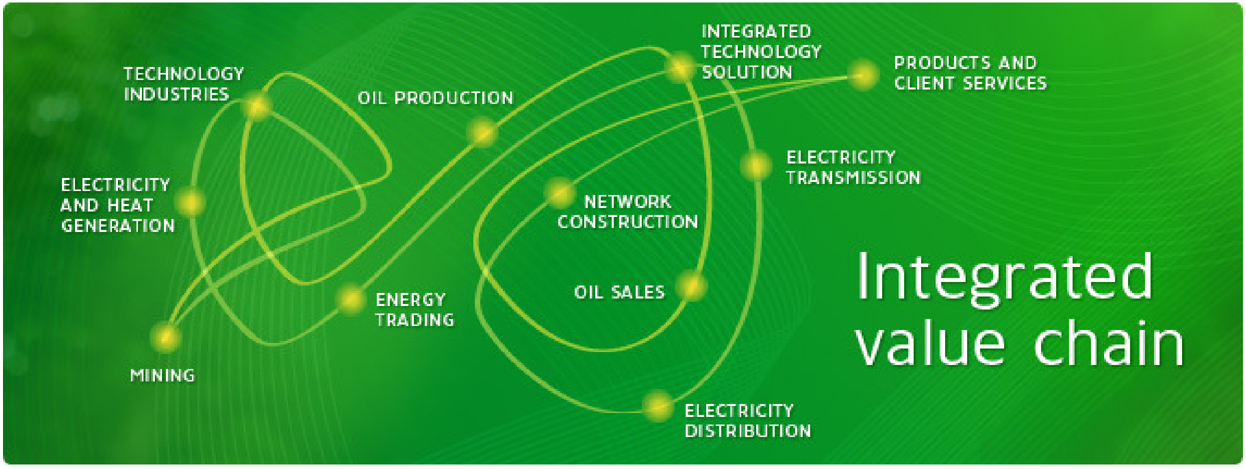


Figure 15: Eesti Energia's companies connected in one brand name Enefit (Eesti Energia)

5.3.2 Ministries

Ministries are important in the electricity regime for guidance, regulations, legislation etc. so the policy part of the regime. Ministries are committed to environmental protection and other social goals. When looking at the electricity regime and more specifically the bio energy niche, it is clear that a lot of Ministries are involved and have broad but often common goals:

- The Ministry of the Environment has as mission to create such preconditions and conditions for Estonia's development that would guarantee the preservation of Estonia's natural biodiversity and clean environment and ensure that natural resources are used economically.[113]
- The Ministry of Economic Affairs and Communications general objective is to create conditions, via the development, implementation and evaluation of the national economic policy, for promoting the competitiveness and a balanced and sustainable development of the Estonian economy. Especially for the energy department the main tasks are to elaborate national development plans focused on the efficiency, competitiveness and environmental sustainability of fuel and energy management and to ensure their implementation, to arrange the formation and administration of the minimum stocks of liquid fuel and to prepare draft legal acts for regulating the field.[114]
- The main functions of the Ministry of Finance of Estonia are to plan for and supervise the implementation of the Government's macroeconomic, fiscal and economic reform policies. This is carried out by preparing legislation, planning state revenues and expenditures, managing and supervising the state budgetary spending process and preparing a framework for economic policy and development. [115]
- The area of government of the Ministry of Social Affairs shall include the drafting and implementation of plans to resolve state social issues, the management of public health protection and medical care, employment, the labour market and working environment, social security, social insurance and social welfare.[116]
- The Ministry of Agriculture has as main objective to provide conditions for the sustainable and diverse development of Estonian rural development, agriculture and fishing industry, to ensure safe and proper food and feeding-stuffs, and a good state of animal health and protection and plant health and protection fields through evolvement, implementation and assessment of rural development, agricultural, and fisheries policies and elaboration and implementation of food safety, animal health and protection, and plant health and protection requirements.
- The main tasks of the Ministry of Education and Research are to guarantee the expedient and effective development of education, research, youth and language policies and the high level and competitiveness of research and development activities. This ministry is directly involved with the energy regime due to studies on for instance oil shale, but also education for future employees in the energy regime. [117]

All these tasks and objectives of the different Ministries have some common goals like health, environment and economical feasibility. But the view for the future is not always clear due to the number of different ministries that are involved in the regime. This creates uncertainty in the development of investments, markets and the direction in which the technology is going.

5.3.3. Users

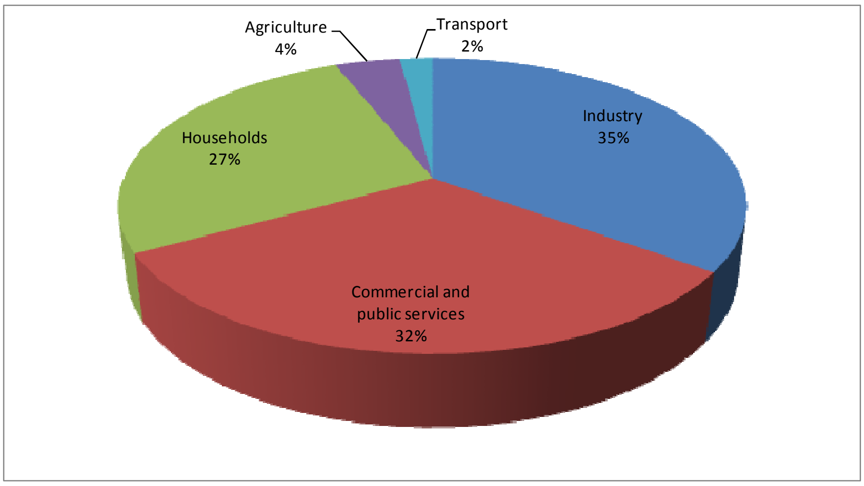


Figure 16: Final energy consumption by sector (2005)

Industry, commercial and public services and households consume the most of the generated electricity (see also figure 16). The households have got the possibility to choose a basic tariff or a day and night tariff. The electricity price is made of four parts: 1) the electric energy price (so oil shale cost and mining fees); 2) network services; 3) renewable energy fee; 4) the excise tax for electricity (from the government). Furthermore Eesti Energia gives the households the possibility to buy green electricity which has a higher price than the normal electricity price. The electricity price is made up the same for the industry sector , commercial and public services sector as it is for households. An overview of the electricity prices for businesses, and usage below 63 Ampere and above 63 Ampere can be found in appendix 5. The prices are for oil shale generated electricity, green electricity prices are more expensive due to a targeted donation, the amount of the donation being 10 EEK cents/ kWh of consumed green electricity (see paragraph 5.3.1. about Eesti Energia for more information about the green electricity). So the users have to pay an renewable energy fee for all the electricity they buy whether it is oil shale generated or green electricity. Furthermore they have the opportunity to buy green electricity besides the normal oil shale generated electricity. This green electricity price and amount sold is explainedn.

5.3.4 Universities (research)

In Estonia two universities are closely involved in the research and development of bio energy. These two universities are: Tallinn Technical University (TTU) and the Estonian University of life sciences in Tartu (Eesti Maaülikool).

At the Estonian University of Life Sciences, the Centre of Renewable Energy was founded in March 2006 and its main focus is on bio energy. The main goals are to start, coordinate and develop interdisciplinary scientific and developmental co-operation in the field of renewable energy.

Main research themes and workgroups:
•Bio energy from grasses and agricultural crops;
•Biogas;
•Short rotation forests;
•Biomass from the forestry;
•Technological solutions for production and use of renewable energies;
•Economical and social aspects of production and use of biofuels.[118]

At the Tallinn Technical University the Department of Electrical Power Engineering is engaged in optimal and safe production, transmission and distribution of electrical energy. New priorities are: planning of power system development, energy market, use of alternative energy sources, and optimization of large systems. Traditional programs of technical and economic problems and optimal control of power plants, high voltage engineering, networks and systems are pursued. The main topics of the research activities of the Department of Thermal Engineering of Tallinn University of Technology are mainly associated with the issues of energetic use of low calorific solid fuels (including oil shale). Also energy sector development plans and use of renewable energy sources in Estonia are on the agenda of being researched.[119] [120]

Both universities are cooperating with other companies and organizations in order to further develop and research bio energy in Estonia. Tallinn Technical University cooperates with for instance: AS Narva Elektrijaamad, Ministry of Economic Affairs and Communications, Ministry of Environment and the Scientific-Technical Journal: Oil Shale.
Estonian University of Life Sciences cooperates for instance with: Eesti Energia, Tallina Vesi (city waste water treatment Tallinn and Tartu Veevärk (city waste water treatment Tartu). Overall the research is still in an early stages (due to projects that just have been started or the recent foundation of research departments) and the cooperation with Eesti Energia (the biggest energy company) is rather limited.

5.3.5 Non Governmental Organizations (NGO's)

Two non governmental organizations that are closely related with the field of bio energy in Estonia are: Estonian Biomass Association and Bioenergy in motion.
Estonian Biomass Association (EBA) is a non-profit association, which was founded in May 1998 in Tallinn. EBA is engaged in biofuels research, resources estimation, development of renewable types of energy and promotion of the use of environment friendly fuels on both state and individual level.[121]

The main objective of Bioenergy in motion is to increase the uptake of new and innovative biomass heating and cooling technologies and systems in the EU, by strengthening the market confidence of specific target groups (end-users, investors, government authorities) in the EU in general and in three target countries (Bulgaria, Czech Republic and Estonia) in particular. Projects in Estonia that are included in a promotion and information movie made by this organization are: Pääsküla Landfill, Paide boiler house, Leie basic school and Liiva boiler plant.[122]

5.4 Technological systems

The last dimension in the electricity regime is the group technological systems. Artefacts, technical systems and infrastructures have a certain hardness which makes them difficult to change. Once one of these has been created it is not easily abandoned.

Oil shale is the most important fuel in this regime concerning electricity generation but natural gas plays an important role in the heating sector. The heating sector will be explained because these two sectors will be intertwined in the niche level when electricity is generated with the usage of combined heat and power plants.

5.4.1 Oil shale

The main fuel used to produce electricity in Estonia is oil shale, figure 17 gives an overview of the fuels used in the power generation.

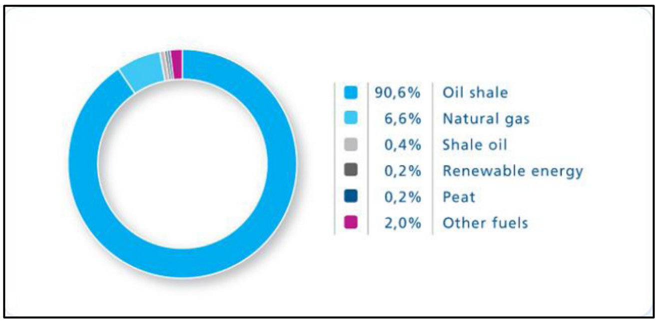


Figure 17:Power generation based on national resource (Ando Leppiman; Eesti Energia)

Oil shale is: ”Any fine grained, sedimentary rock that contains large amounts of organic matter and that yields substantial amounts of oil upon destructive distilling or pyrolysis”.[123]

Oil shale has been deposited under conditions that prevented the oxidation of the organic matter (often poorly ventilated, oxygen-depleted water masses). The organic content of the oil shale mined in Estonia is exceptionally high compared to the rest of the world. In some cases the content in Estonia is 50% while in the rest of the world between 5 and 25% is normal. The organic matter in oil shale has a high oil and gas-generating potential, but because the sediment did not experience temperatures that where high enough to liberate the oil and gas the oil and gas stayed in a solid rock. By heating them at high enough temperatures the oil and gas come free and can be used to generate electricity, heat or make shale oil.

5.4.2 Power plants

The main electricity producing plant is AS Narva Elektrijaamad (Narva power plant). AS Narva Elektrijaamad owns two of the world’s largest oil shale fired power plants, Balti Elektrijaam (765 MW_{el}, 400 MW_{th}) and Eesti Elektrijaam (1615 MW_{el}, 84 MW_{th}).[91] AS Narva Elektrijaamad generated 96% of the total electricity generated in Estonia in the financial year 2007/2008.[124] Two units of this power plant have been renewed and can be used for co-generation with biomass as secondary fuel.

The third biggest power plant when it comes to electrical capacity is OÜ Iru Elektrijaam (Iru power plant) and this plant is the largest heat producer in Estonia. The Iru power plant is a combined natural gas fired heat and power plant in Tallinn (190 MW_{el}, 648 MW_{th}, incl. 398 MW_{th} in CHP mode).

The Kohtla-Järve power station is an oil shale fired CHP plant which is a subsidiary between Eesti Energia (60%) and VKG Energia OÜ. The thermal capacity in 2003 was annually 154,82 GWh and the it had an electric capacity of 25,3 GWh. This plant supplies heat to a part of the town Kohtla - Järve.[125]

Other electricity is generated by small power plants which use oil shale as their main fuel. At the moment that this report is written two biomass CHP plants, which will be discussed more detailed in the next chapter, are built but they are not yet in full operational mode. They will start producing heat and power at normal operational process in the course of 2009.

In table 6 below you can find an overview of the amount of electricity produced in 2006 by the different power plants and different fuels they use.

Power plant	Net Capacity, MW	Electricity produced, TWh	Fuel
Narva TP	**2120**	**8,8**	Oil shale
Iru CHP	**158**	**0,45**	Gas
Other TPP-s	**80**	**0,1**	Oil shale, gas
Wind turbines	**29**	**0,076**	Wind
Hydro PP-s	**5**	**0,027**	Water
Total	2392	9,5	

Table 6: Electricity production by type of fuel used in 2006 (Elering)

Electricity prices for households in Estonia are currently the second lowest among member states (higher only than Bulgaria) and about 43% below the European averages prices, see also figure 18). The prices for industrial users have remained relatively constant over the last five years; they are the second lowest among member states and are currently about 32% below the European averages (see figure 19).[126]

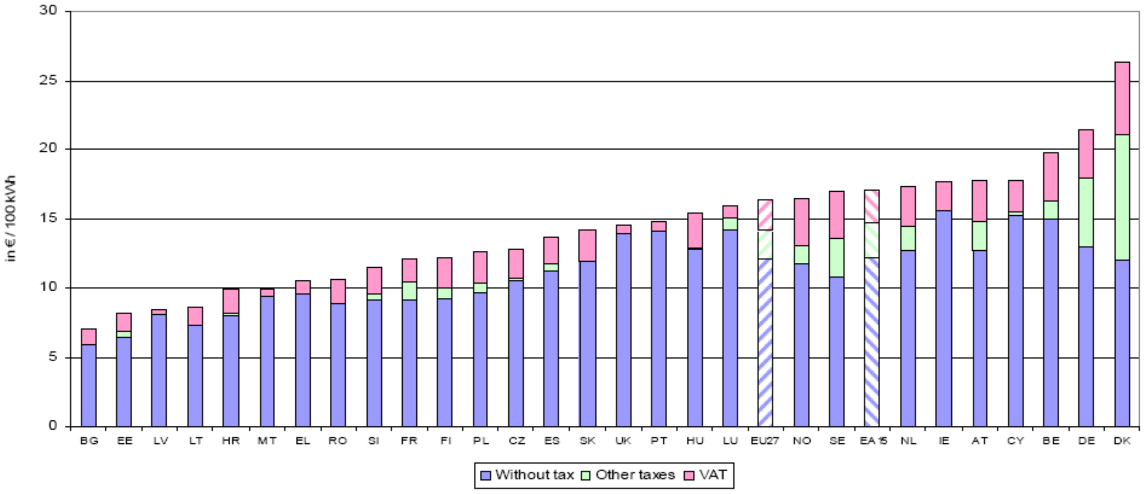


Figure 18: Electricity prices for household consumers ('Household consumers' refer to consumer band Dc (annual consumption between 2500 and 5000 kWh)) (Eurostat)

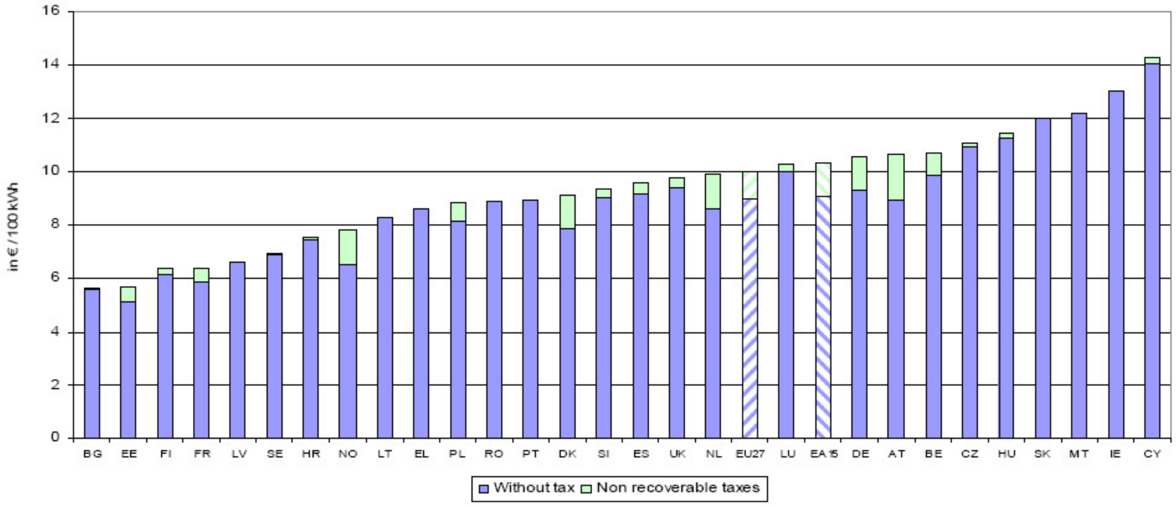


Figure 19:Electricity prices for industrial consumers ('Industrial consumers' refer to consumer band Ic (annual consumption between 500 and 2000 MWh)) (Eurostat)

5.4.3 Infrastructure

The Estonian electricity grid is part of the Baltic grid constructed under the former Soviet Union as explained in chapter 5.1. This Baltic electricity grid can be seen as an island in the European Union. The Estonian Foreign Ministry stated in June 2006:

“Estonia considers matters of energy security very important. As a complex issue, energy security will remain a matter of concern in the foreseeable future and continue to have an increasing impact on the overall security of the European Union. For Estonia as well as for Latvia and Lithuania the need to connect the Baltic gas and electricity grids with the rest of the EU internal market remains an important issue of energy security.”[127]

In the same year the first submarine cable between Estonia and Finland was realized. Estlink, as the project was called, is a 350 MW HVDC submarine cable that connects the Finnish transmission network with the Estonian one. In this project the three Baltic power companies Eesti Energia, Latvenergo, Lietuvos Energija; and Pohjolan Voima and Helsingin Energia from Finland cooperate. [128]

Despite years of planning to connect the Baltic States with the rest of the EU, through a sea cable that connects Lithuania or Latvia to the Swedish grid or the so-called “Baltic ring” that connects all the countries around the Baltic Sea, the only tangible result so far is the cable connection with Finland. The only tangible project that is in the planning is a second sea cable, Estlink 2, between Finland and Estonia with a capacity of 635 MW. Estlink 2 should be ready in 2013.[129]

Estonia is not only linked with the other Baltic States (Latvia 750 MW connection) or Finland (350 MW connection) but the biggest and most connections are with Russia (see also figure 20). Two lines connect the Estonian grid with the Russian one, having a total capacity of 1500 MW (in both directions).[127] With this link comes one big problem: Estonian producers are not allowed to trade on the Russian electricity exchange and therefore direct imports of Russian electricity to Estonia have stopped (but electricity exchange takes place). The main reason for this is to protect the “small” electricity market of Estonia from being run over by cheap Russian electricity in order to secure supply, regulate prices and remain independent. [128] These connections with Russia are a good opportunity to sell the cheap Russian electricity to the European electricity market once more connections with EU countries will have been established. Estonia and the Baltic States can become the roundabout of Europe in order to import and sell cheap Russian electricity.

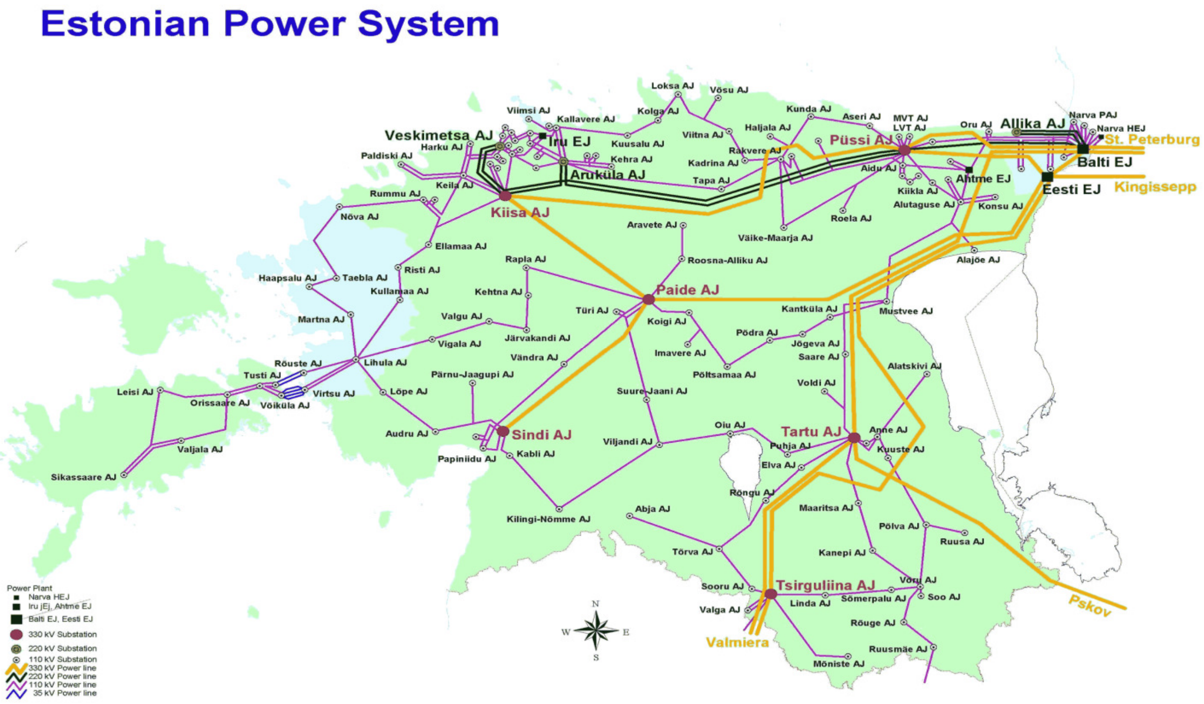


Figure 20:Estonian electricity grid

5.4.4 Natural Gas

Natural gas is used mostly for industrial purposes and heating and only a small amount for electricity generation. The reason to include this paragraph although it is not part of the electricity regime is the fact that in the bio energy niche, which will be discussed in chapter 6, biomass will be used in combined heat and power plants. Besides electricity also heat is produced and this heat can replace the use of natural gas as energy source for heating purposes.

The same as the electricity market, also the Estonian gas market is small. Eesti Gaas is the sole importer and wholesaler of gas in the Estonian Market. The transmission company and the major distribution and supply business accounts for 97% of the market. There are no independent suppliers and, to date, no customer switching has taken place[130].

As for electricity, the gas supply network is historically formed part of the Soviet gas supply system. Estonia therefore only has cross-border connections with Russia and Latvia and the only source of supply is Russia.

5.5 *Conclusion*

In this chapter the second subquestion is answered:

"What are the most important barriers and opportunities for bio energy in the current Estonian electricity regime?"

One of the biggest barriers is the low electricity price in Estonia. The electricity prices for households and industrial users are the second lowest in Europe. The electricity is generated with oil shale as fuel, when switching to bio energy the price of electricity would likely increase due to new (imported) production networks, other fuel etc. When the electricity price rises a threat can be seen from the East. Russia as a neighbour produces cheap electricity that can be imported instead of using more expensive domestic electricity generated from biomass. The biggest risk when importing electricity is the supply security and that can be an opportunity for using bio energy generated in Estonia. This will be mentioned also in the paragraph about opportunities later on.

Another important barrier is the lack of competition. Eesti Energia is the biggest electricity generation company in Estonia. Eesti Energia has 97% of the production capacity and an 88% retail market share, while it also controls all of the transmission (OÜ Põhivõrk) and 85% of the distribution networks in Estonia (OÜ Jaotusvõrk). So there is not a lot of competition or pressure from other companies to change the way of electricity generation. One of the reasons for this lack in competition can be found in the late liberalization of the electricity market. The Estonian electricity market has been open for eligible customers whose annual consumption exceeds 40 GWh since 1999, but the market will be completely open to all customers in 2013. Until then Eesti Energia will probably not have a lot of competition from other companies in Estonia and with this no real pressure to change the company's strategy.

Estonia has got one of the smallest populations in the EU, related with this the gas and electricity markets are also among the smallest in the EU. This creates a barrier for implementing bio energy projects due to the fact that projects and plants can only be implemented with size restrictions (due to limited size of towns and district heating networks, discussed in the next chapter).

The last barrier that can be seen is related with the Electricity Market Act. In this act the subsidy scheme for renewable energy has been incorporated. The shortcoming of this scheme is that it does not support all possibilities of renewable energy production to its full potential. The scheme is valid for all renewable energy sources while not all renewable energy sources cost the same in developing, building and implementing them.

The opportunities for bio energy can be divided mostly into three areas: legislation, Eesti Energia and geographical opportunities.
In the Estonian as well as EU legislation, restrictions have been incorporated for the use of oil shale. Step by step Estonia has to meet the European standards. By 2009 the reconstruction of ash handling systems and bringing ash landfills in compliance with landfill directives have to be ready. By 2012 the sulphur dioxide total emissions have to be decreased to 25 kton/year and by the year 2016 the Large Combustion Plant directive requirements have to be applied to power plants. These restrictions give an opportunity for bio energy to replace oil shale in the electricity production because of the replacing of current technology.

Estonian Ministries support sustainable and environmental friendly energy generation and in that way promote the use of renewable energy.

Eesti Energia has opportunities to implement or develop bio energy projects due to the fact of diversification of electricity generation (sources) that is incorporated in the company's strategy. Furthermore with the sales of green energy, renewable energy is promoted by the company. Achieving its strategic goals will require a significant holding in a nuclear power plant, the maximum use of biofuels and waste to produce heat and power, generation of electricity in wind parks, and an expansion of co-generation of heat and power. So it can be seen that bio energy has got opportunities within Estonias biggest energy company.

The last area in which opportunities can be seen is the geographical area. As already discussed in chapter four, Estonia has a large amount of potential biomass. The country has a lot of forest, rivers and swamps but also agricultural land that can be used for growing energy crops. So in short a lot of potential biomass is available.

One opportunity that cannot be divided into these areas and that is previously mentioned is the supply security. The biggest risk when importing electricity is the supply security and that can be an opportunity for using bio energy generated in Estonia. The costs might be higher but there is no risk of getting no electricity because there are problems about price or other problems from the Russian side.

6. Bio energy (Niche)

In this chapter some of the current energy projects will be discussed in order to answer the following subquestion:

"Which learning experiences have occurred so far in the bio energy projects already carried out?"

Strategic niche management will be used as a guideline to find the learning experiences.
In the definition of strategic niche management given in chapter 2 can be seen three important parts: learning processes, network building and expectations.
Learning processes are the most important issue in the niche phase. Technological performance, user expectancy and economic feasibility are all important learning aspects in the experimental projects. In the learning process seven aspects can be distinguished for actors to focus on while learning in experimental projects and these will be the guideline in this chapter when analysing the projects. Focusing on the learning processes will help to construct recommendations for Eesti Energia. (chapter 8).

6.1 Background projects

Before starting with the seven aspects of the learning process in the strategic niche management a brief background overview of the projects that have been analysed is given.

6.1.1 Väo power plant


Figure 21: Väo power plant

The owner of the plant is the Dalkia Group company AS Tallinna Küte. Tallina Küte owns almost 400 km of the district heating network in Tallinn. Furthermore AS Tallinna Küte has three large and eight small boiler plants which are used for heating purposes (the fuel in these boiler houses is natural gas). The Väo power plant is located near Tallinn.

The capacity of the power plant is 25 MW_e and 49 MW_{th} with an additional 18 MW_{th} from the scrubber. The fuel that is used is woodchips (90%) and peat (10%). Concerning the used technology the power plant has 4 main contracts and 60 smaller contracts. The main contractor in the construction of the Väo heating and power plant is KMG Inseneriehitus; interior equipment is provided by Siemens and the Finnish companies Noviter and BMH Technologies. When the plant was started up in December 2008, 22 people were working at the plant. In the beginning of 2009 still some problems had to be handled but by the end of 2009 the plant will be fully operational.

Estimated costs from the beginning 1 billion EEK (64 million euro (EUR 1 = EEK 15,65)).[131]

Big advantage of the plant is that the owner Tallina Küte owns most of the district heating network in Tallinn so produced heat can easily be put into the district heating network.

6.1.2 AS Anne Soojus


Figure 22: Biomass CHP Tartu

AS Anne Soojus is a daughter company of Fortum Tartu, the owner of the biomass CHP plant that is located near the town of Tartu. AS Anne Soojus incorporates all the boiler houses of the enterprise (Luunja, Ropka, Turu, Tarkoni and all small boiler houses). Of great importance are the boilers at Luunja and Ropka boiler houses that operate on local fuels (saw dust, wood chips, peat), the total capacity being 55 MW. These boiler houses guarantee an essentially lower selling price of heat energy than do the boiler houses operating on natural gas and they are considerable competitors to the container boiler houses operating on gas. With the aim to achieve the economic goals of the company and proceeding from the environmental as well as the macroeconomic requirements, a combined heat and power production plant (CHP) operating on local fuels is built.[132] [133]

The capacity of the plant is similar to the Väo power plant 25 MW_e and 50 MW_{th}. The fuels used are woodchips and peat, which are all produced from local markets and the technology used is from Metso power (bubbling fluidized bed boiler). The CHP plant is in the testing phase and will likely be fully operational by the end of 2009. Overall estimated investment costs for the Tartu CHP plant are: 64 million euro. In 2010 a biomass fired CHP will be ready in Pärnu with the same capacity and fuel as the Tartu CHP plant and an estimated investment cost of 80 million euro.[133]

6.1.3 Other biomass projects

Narva

The power plants in Narva are owned by Eesti Energia, the biggest energy company in Estonia. At the big power plants in Narva 2 units have been made operational for cofiring with biomass (the oil shale will be mixed with biomass). These 2 units have each an electrical capacity of over 200 MW and are located near the town of Narva in the north east corner of Estonia.

Kohtla-Järve

Eesti Energia is building a biomass fired CHP plant near the town of Kohtla-Järve. The capacity of the plant is 22 MW_e and 50 MW_{th}, and as fuel 75% woodchips and 25% peat will be used. This power plant is built in order to replace the existing Ahtme thermal power plant. Ahtme must stop using oil shale as fuel in 2009 because its facilities fail to meet environmental requirements. The Kohtla-Järve power plant is expected to be ready in 2011. In the period between closing the old plant and opening the new one, 2 adjusted boilers (of the old plant) will produce the necessary heat. Electricity will not be produced because of the expenses that will be too high.

Paide

Near Paide a 5-6 MW_e woodchip fired boiler will be built by Eesti Energia.

Boilerhouses
Several boilerhouses like Põltsamaa have as base load fuel woodchips and peak load natural gas and oil shale oil are used to cover up the difference.

6.1.4 Biogas

At this moment three biogas projects are active in Estonia of which two will be used in this research. Some other biogas projects are on paper or in the planning but not put into practice yet. In appendix 6 is an overview of the biogas stations in Estonia.

Saaremaa economics
The project developer and owner is Estonian company OÜ Saare Economics, which has been advised on carbon issues by the Norwegian company ECON Carbon. This biogas plant uses the manure of pigs as fuel and is located on the biggest island of Estonia Saaremaa.

The entire heat production and most of the electricity (approx. 75%) is used to cover the digestion plants own demand for heat and power. The rest is to be sold to the grid under a guaranteed contract under Estonian law.

The project lifetime is 15 years of which 7 years are crediting period for emission reductions starting from 2006. The early Assigned Amount Units (AAU's) can be claimed in 2006-2007 and are estimated to be around 24.805 tonnes of CO2. The Emission Reduction Units (ERU's) can be collected starting from 2008-2012 and the amount of reduction is estimated to be round 63.711 tonnes of CO_2.[134]

At the plant the manure of 25-26 thousand pigs (7,2% of Estonian total) will be processed, this with a total capacity of 40.000 m^3 of manure per year.

Landfill gas
In 1994 the gas company AS Eesti Gaas and some private investors started a landfill gas (LFG) -producing project at Pääsküla landfill (near Tallinn). A new company AS TERTS was established with the purpose of utilizing landfill gas. The company has the preferential right to manage the landfill of Tallinn and produce biogas from the waste till the year 2014.

Until December 2001 the produced biogas was sold to two boiler houses owned by district heating utility AS Tallinna Soojus. During wintertime the consumption of gas has been approximately 600 nm^3/h. In summertime the process of gas production is more intensive, but the demand for heat energy, in opposite, is minimal, and so the most part of collected LFG was not used.

6.2 Design specifications

In this first of the seven learning aspects the focus is on which requirements are needed for the technology and what is the scope to overcome initial limitations. First of all the technology in use is mostly inherited from the former Russian occupation as explained in previous chapters. The technology is old and low efficient. With the new regulations, domestic and EU, the use of oil shale is put on a leach. In the Narva power plants two units have been rebuilt into fluidized bed boilers with ESP filter to filter the flue gasses and this is more than enough to meet the regulations. This technology is imported from abroad.

The same can be seen with the Väo power plant and Fortum power plant. Väo imported the technology from Finland and Germany while Fortum imported all the technology from Finland.

When looking at the biogas projects it is clear that most of the technology is imported and the director of strategy at Eesti Energia, Jaanus Arukaevu said about this: “small countries utilize technology and do not create technology.”

Bio energy projects are still in the beginning phase of development in Estonia and the technology needs to be imported first in order to adjust it to the Estonian climate. With cold winters and relatively mild summers the heating of the digester in biogas projects is an important issue that needs to be overcome. Another limitation that needs to be overcome is the fact that at the moment it is very difficult to analyse the production of biomass and bio energy because the statistical source data is inadequate.[135]

6.3 Government policy

In this part of the strategic niche management learning phase the role of the government is the central subject. For instance, are adjustments of the policy framework (e.g. fuel taxes, access regulations) needed to make the technology viable? A subsidy for the use of renewable energy sources, as discussed in the previous chapter, is in use at this moment. This subsidy scheme is equal for all renewable sources as can be seen in the definition in paragraph 57 of the electricity market act. This paragraph states that renewable energy sources are: water, wind, solar, wave, tidal and geothermal energy sources, landfill gas, sewage treatment plant gas, biogases and biomass. No taxes or subsidies are available for individual sources and this is one of the reasons why so few biogas projects are implemented at this moment in Estonia. Andrei Vuhk, project manager at Eesti Energia and responsible for renewable energy projects concerning biogas says that the price of investment costs are too high to start new projects . Without additional support from the government the development of biogas in Estonia will not get off the ground.[128]

Another problem can be seen in the forest resources. Problems include unstable extent of forest use, sometimes increment and low profitablity of developing biomass used for bio energy.[136] More than half of the Estonian forest resources have naturally developed through forestation of lands no longer used in agriculture. The land is now in hands of private owners. To prevent the owners from just cutting the trees down, the government set fixed cutting volumes. Cutting volumes are fixed in forestry development plans for ten years but the government could better set volumes on the basis of social economical objectives. When more biomass is to be used in CHP plants (Tartu and Pärnu) when they are fully operational and in the two units at the Narva power plant the amount of biomass (woodchips) needed can rise above the regulated amount. What will happen then? No more generation of electricty in CHP plants or less sales of wood to consumers (households) for heating purposes? This regulation would be better from the perspective of social economical objectives.

Energy companies focus on building medium sized CHP plants that are located near bigger towns. These towns have larger district heating networks, which can be used to deliver the generated heat to. The government has not yet put any specific development plan or regulation mechanism into work in order to stimulate micro and small biomass CHP plants. With the current regulations the micro and small CHP plants are economically not feasible and they are not capable to be competitive with other ways of producing energy.[137]

6.4 Cultural and psychological meaning

This aspect of the learning process is related to the symbolic meaning of bio energy for the people in Estonia (the users). For example can it be labelled and promoted as safe and environmentally benign?
In the development plan 2007-2013 for enhancing the use of biomass and bio energy is stated that consumers have a low awareness of the advantages of domestic renewable energy sources. They care the most about the costs and the security in supply of energy.

A small change can be seen when looking at the green energy that Eesti Energia is selling to its customers. The amount that has been sold in the first two months after its implementation shows that there is awareness among customers about origin of the energy they use. Eesti Energia gives certificates with the sales to show the customer that they really produced the amount the customer uses with renewable energy sources. Most customers are bigger companies due to the fact that they want to profile themselves as green and environmentally friendly. Among normal households the sales are not yet that big and the price is more important than the origin.[138]

When looking at biogas production, a lot of farmers are skeptical about using fuel (waste from vegetables, fruit and garden) not produced by themselves. In the fuel that comes from towns it is possible that plastic bags or other parts are included which could harm the process. So in this case the psychological meaning is more towards the trust of fuel they can get instead of the usage of the technology. Furthermore the problem is that energy crops are practically not cultivated.

6.5 Market demands

In this section topics are relevant like: who are the users of bio energy technology and what are the preferences, needs of these users?

The first users of “bigger” bio energy technology like the Väo power plant near Tallinn and AS Anne Soojus near Tartu are outsiders of the Estonian electricity regime. Eesti Energia is as already mentioned in previous chapters the biggest energy company in Estonia with a market share of 88%, but is a small player in the bio energy market. With the two units in Narva that can be used for cofiring, but without receiving subsidy and projects that will be ready in a few years only a few small biomass fired power plants are used in this market. This means that the outsiders “rule” the market at this moment with their 25 MWe capacity plants. Another reason why these outsiders use the possibility for bio energy and Eesti Energia not (yet) is the fact that the outsiders are the owners of the biggest district heating networks in the country. Tallinn, Tartu and Pärnu have got the biggest district heating networks in Estonia and the generated heat produced in the CHP plant can be applied in the networks because this saves other fuel sources, mostly natural gas.

A whole new market for woodchips has been established since the 2 “bigger” biomass fired power plants have been built. In the beginning of the Väo project shredding the wood next to the factory was considered the best option because there was no market at all. Fortum has several contracts with companies to buy woodchips from them, but in the near future they will switch to one supplier because of better prices and because the market has been established.

Problems related to growing and using energy crops are due to the fact that the marker has not yet fully been developed and another reason is the lack of experience the users have. The need for more research and better financial support can help this market to become better established.[139]

To shape the bio energy market it is important to have an integral overview of law as a market regulator and to supplement regulation based on analysis.[140]

6.6 *Characteristics of the production network*

In this aspect the important issue is who is capable of producing and operating the technology at hand?
Production networks for bio energy installations are mostly imported. Energy company Fortum imports technology from Finland and the Väo power plant has four main contracts with different suppliers from Finland and Germany. So the networks are mostly outside Estonia and this limits the opportunities for connection of sustainable energy with industrial development, job creation and economical growth.

6.7 *Characteristics of the infrastructure and the maintenance network*

The aspects that are important here are for instance what adjustments need to be made to the current infrastructure to make the technology work?
When looking at, for instance, the infrastructure for the transport of biogas more research has to be done, this is also the case for the construction of the infrastructure, training of youth and adults abroad to do research in Estonia. Furthermore the big district heating networks are most likely to be connected with biomass CHP then small networks. These smaller networks have another problem that they are not always in the best condition and they have large heat losses. So adjustments have to be made for sure into these networks.

When looking at the power plants already in use, switching over to cofiring or use of other fuel is not that easy due to the old technology in use. When biomass is to be used for cofiring like is possible in the Narva power plant new boilers had to be installed. At this moment 14 of the 16 boilers have to be replaced by new fluidized bed boilers or closed down, 2 have been replaced in order to meet the limitations discussed in previous chapter for oil shale all. So the state of technology and equipment used is in most cases old with a lot of losses in the district heating networks and inefficient burning in boilers. The heritage from Russia is the main cause of this and to change towards the future a lot of boilers, plants and networks have to be rebuilt to be suitable for bio energy.

6.8 *Nature of societal and environmental effects*

This is one of the most difficult learning aspects due to the fact that not everybody has the same opinion about the benefits of the technology, quite often debates about the advantages and disadvantages of the technology are the result.
When the bio energy replaces oil shale the environmental effects are clear, less carbon dioxide and other green house gas emissions. But when looking towards the direction when renewable energy source should become the dominant one, the influence by the government is lacking. Due to the project based structure of research and development in Estonia, it has not been possible to consolidate and purposefully develop the field of renewable energy. The existing information is of inconsistent quality and leaves many gaps.
Eesti Energia has focused a lot on wind energy because wind cannot be stolen and biomass can, while the outsiders concentrate on biomass due to their ownership in the district heating networks. A big field inside the renewable energy market (and also bio energy market) is left unexplored and the potential for bio energy is not fully explored.

6.9 Conclusions

In this chapter the third subquestion has been answered:

“Which learning experiences have occurred so far in the bio energy projects already carried out?”

At this moment Estonia is far from ready to become a big user of bio energy for electricity generation. The usage of biomass and biogas is limited and a lot of research and assessment still has to be done to get a clear view of the real possibilities in Estonia. The government is not a regulator or stimulator for the use of bio energy, the development of bio energy is left to the market.

The outsiders “rule” the market at this moment and this is mostly because they own the district heating networks near or in the bigger cities. Estonia does not have that many “big” cities with bigger district heating networks so the possibilities for CHP plants that are of size bigger than 10 MW_e are limited because of the size of the town and district heating networks.

For biogas the potential at this moment is really low. The number of projects can be counted on one hand and the government does not have a special or additional subsidy to stimulate usage of at least reach of biogas. This part of the bio energy market is left open with a lot of research still to be done.

This is the case for the whole bio energy sector, assessments of land use, assessment of biomass resources (physical and economical availability of various types of biomass), surveys of energy crops, technology studies and possibility for use and analysis of the market regulation in the bio energy field still have to take place, before bio energy can really take off. With the following suggestions gained from the conclusions it should be able to reach the bio energies full potential.

Getting the government actively involved is priority number one, due to the fact that they can set out more clearly the path towards a more sustainable and environmentally friendly electricity market. The second priority should be more applied research to land use, biomass resources, energy crops etc. This way the risk for energy companies is less due to the fact that they already know what is possible and what should be done. And the implementation of results into projects is the third step that has to be taken in order to increase bio energy use in Estonia.

7. Conclusions

In this chapter the conclusions from previous chapters are summarized in terms of the multi-level perspective. With the overview of these conclusions of the subquestions the two main questions can be answered also. The main questions were:

What is the current situation and what are the possibilities and constraints for bio energy in Estonia?

What are the possibilities for Eesti Energia for the development of bio energy in Estonia and the Baltic States?

Subquestion 1
The first subquestion has been answered after literature study of current and previous events in Estonia.

What are the major relevant trends and events in the "socio-technical landscape"?

In the landscape level no serious pressure can be seen on the current electricity regime. No pressure from the Kyoto targets, because these have been met already from the beginning and tend to drop even further. From the European Union regulations, that have been ratified. also low until no pressure can be seen due to the fact that Estonia has been given a temporary status for oil shale, which means that Estonia can step by step meet the European standards. So landscape level does not put pressure on the regime level.

Subquestion 2
The second subquestion that has been answered in order to answer the first main question is:

What are the most important barriers and opportunities for bio energy in the current Estonian electricity regime?

The electricity regime in Estonia is a stable regime with almost no internal problems. In the electricity regime there is almost no competition, Eesti Energia has 97% of the production capacity in Estonia and an 88% retail market share. Furthermore the electricity market is still not fully liberalized, which is another reason why there is almost no competition. Another factor that makes the electricity regime so stable is the fact that Estonia generates all electricity itself and the price is really low. Changes to other methods of generating electricity would mean an increase in price of electricity.

Subquestion 3
The third and last subquestion to answer the main research question is:

Which learning experiences have occurred so far in the bio energy projects already carried out?

The third level, the bio energy niche level, is developing slowly. Some biomass CHP plants have been built and are operational (or will be soon fully operational), but there are not a lot more possibilities to build more (medium sized) CHP plants . The main reason for this is that

Estonia does not have a lot of big industries or big towns with district heating networks that can be used to transport the generated heat.
Furthermore almost no biogas projects are implemented in Estonia and most plans end on paper (feasibility studies). So the bio energy niche is developing but by far not powerful enough to put serious pressure on the electricity regime.

Main question
The main question can be answered with these 3 subquestions:

What is the current situation and what are the possibilities and constraints for bio energy in Estonia?

The landscape level (subquestion 1) is putting no pressure on the stable electricity regime (subquestion 2) and the bio energy niche (subquestion 3) is not powerful enough to put serious pressure on the electricity regime. So at this moment the possibilities are limited due to the solid, stable electricity regime and the limited development of the niche. The biggest possibility is the wide availability of bio energy sources, but incentive to use it is mostly stopped by factors from the other levels as can be seen from the conclusions drawn in the subquestions. (Kyoto targets have been met, cheap (oil shale generated) electricity etc.)

The second main question will be answered in the next chapter.

8. Recommendations

This chapter will answer my second research question:

What are the possibilities for Eesti Energia for the development of bio energy in Estonia and the Baltic States?

After the conclusions that at this moment the possibilities for bio energy in Estonia are limited due to the solid, stable electricity regime and the limited development of the niche, the question rises: Is it smart for Eesti Energia to participate in bio energy projects?
At this moment the answer is: no, it is not smart to participate. Eesti Energia does not participate in any biogas projects that are put into practise and the number of biomass projects in which they are participating is also limited. So the answer is in accordance with the current state of projects.

In chapter 2, five different possible transition pathways have been discussed in which developments in the landscape and niche level might reinforce or disrupt the relationship with the regime. One could ask which pathway fits the best for using bio energy in the future to its full potential. The five possible pathways are: reproduction process, transformation path, de-alignment and re-alignment path, technological substitution and reconfigurations pathway.

At the moment, but also towards the near future the reproduction process will be most likely the path to be followed in Estonia. The reason for this is that there is no external landscape pressure so the regime stays stable and can reproduce itself. Because of this dynamically stable regime radical niche innovations have little chance to break through. I recommend Eesti Energia to explore possibilities for bio energy, gain knowledge but not fully participate in expensive and time consuming (pilot) projects because of the limited possibilities to exploit bio energy in the near future.

A bit further in the future towards the year 2016 some changes and pressure from the landscape level on the regime can be seen. From this year on forward all pulverized combustion boilers have to be closed in order to meet European regulations. This landscape change might have influence on the pathway to be followed in Estonia. A change from the reproduction process towards the transformation path is possible. In this path the landscape puts moderate pressure on the regime at the moment that the niche developments have not yet been sufficiently developed. In the transformation path outsiders play an important role and that is also the case at this moment in the bio energy niche. In order to further develop and stabilize the niche the following criteria are reasonable indicators:
(a) learning processes have to be stabilized in a dominant design, (b) powerful actors have to join the support network, (c) price/performance improvements have to be improved and there are strong expectations of further improvement (e.g. learning curves) and (d) the innovation is used in market niches, which cumulatively amount to more than 5% market share[141]

I recommend Eesti Energia to proceed with a multi-level scenario analysis, maybe with other stakeholders, to systematically investigate the future for bio energy in Estonia.
When this gives a more positive view on using bio energy the following recommendations can be important to develop bio energy to its full potential.

A distinction is made between direct recommendations, recommendations that Eesti Energia can fulfil itself and indirect recommendations, recommendations of which Eesti Energia has to make other parties aware of, to make the necessary changes.

8.1 Indirect measures

Indirect recommendations or measures are recommendations that Eesti Energia cannot change or influence directly, like governmental decisions or regulations.
The problem concerning biomass usage in CHP plants is as explained in previous chapters the size of the towns, because the generated heat is used in the district heating networks of these towns. Small cities/towns have small district heating networks with less potential and the district heating networks are often in a very bad state.[142]
Furthermore can be seen in the Electricity Market Act that there is a limit on the size of the biomass CHP plants of which the maximum capacity may not exceed 100 MW otherwise no subsidy is given.[143] For Eesti Energia this is bad because two units in the Narva Elektrijaamad can be used for cogeneration but because these units exceed 100 MW they are used just for oil shale burning.

The government has been standing on the side long enough it is about time that the government become a more active actor in the development of bio energy in Estonia and the first recommendation is related to this point.

The first indirect recommendation for Eesti Energia is to stimulate the government to adjust or completely erase this limitation of 100 MW and use the possibility for cogeneration in these two units of the Narva power plant. The government is promoting the use of renewables but has limitations in the size of biomass CHP's so that is rather contradictory.

The second recommendation is about the subsidy scheme. The subdidy scheme's are equal for all renewable energy sources. It might be better to split the renewable energy sources and make schemes for them seperately. (This is also discussed in the Electricity market act and the EU directive towards promotion of renewable energy but the earliest 2010 the discussions will be opened.)
An example of the usage of a subsidy scheme with split energy sources is the SDE (stimulation of sustainable energy production) subsidy in the Netherlands.[144] In this subsidy scheme energy producers can apply for subsidies when they generate sustainable electricity or/and sustainable gas. These two categories have different sub categories and in each sub category a different amount of subsidies the government can be handed out. This way when too many applications apply in one sub category, projects will be rejected and companies can look into other subcategories to get subsidy and generate renewable electricity or gas. An overview of the subsidy prices can be found in appendix 7.[145]

When this last recommendation, the sub categorisation of the renewable energy subsidy scheme, would be applied a bigger market would be available for renewable energy sources, not only bio energy but also solar and tidal energy can be explored.

So the two indirect recommendations for Eesti Energia I see are:

- changing the maximum limit of 100 MW in electricity generation by renewable energy sources (push from the energy company to show that the government is limiting the possibilities for renewable electricity production);
- sub categorization in the subsidy scheme to stimulate other renewable energy sources.

8.2 Direct measures

The direct recommendations are those that Eesti Energia can perform itself.
At this moment Eesti Energia does not participate in a lot of projects related to bio energy and especially biogas, so it would be good for knowledge and experience in the field of biogas if Eesti Energia would participate in pilot projects.

Pilot projects are mostly small scale learning projects about feasibility and transformation of best practices and innovating in new areas. In Estonia there are some pilot projects that are in the starting phase. One of these projects is the competence centre project “Bio energy and Biofuels”. The competence centres programme is intended to facilitate cooperation between companies and research institutions with the focus on applied research. At this moment 13 companies and universities are involved in this project (overview in appendix 8) which will run until the 31st of August 2015. EAS, financed by the ministry of economy, subsidies this project with 25 million EEK (1 EUR = 15,65 EEK) and the other costs approximately 10,7 million EEK will be split by the different participants[139].

In this competence centre three projects will be implemented:

- Conversion of biomass to biogas;
- Process monitoring and control of anaerobic digestion;
- Bio waste co-digestion and reuse.

A fourth project, namely research towards the advanced feedstock supply systems, will be added if the other projects are done on time, before 31st of August 2015 .

Within this project Eesti Energia can gain two important things:

1. cooperation with other companies and split research cost;
2. gaining knowledge and results concerning the implementation of biogas.

Pilot projects give also the chance to try out the biogas technology in the Nordic climate, so concerns like energy company Fortum has about corrosion can be researched. Also concerns like what will happen when the temperature drops to -20 ˚C for some time and possible options in this situation, for instance shutting down the plant and doing some maintenance work instead of using more heat, can be tested.

Eesti Energia has the possibility (money wise) to do pilot projects on its own. These pilot projects can be used as backup for electricity supply in remote areas of Estonia. These areas can be cut off from the electricity grid when for instance trees fall down on the power lines because of a heavy storm. This is possible because the electricity is mostly generated from one centralized place, namely Narva. A good example is the snowstorm in November 2008 which caused trees to fall on power lines and thousands of people were cut off the electricity grid.[146] These pilot projects could in the beginning be a backup, but later on small units can take over when proven the technology is feasible and reliable.

Another possibility is when Eesti Energia would work with universities like Eesti Maaülikool (Estonian University of Life Sciences) or Tallinna Tehnikaülikool (Tallinn Technical University), the universities gain a lot of knowledge by the research and Eesti Energia can use the results or outcomes. This way Eesti Energia gains knowledge and saves money and time when biogas projects will become feasible to implement them by, for instance, changes in the subsidy schemes.

To go on about cooperation, Estonia as a country by itself has a too small electricity market to become a major player in the development of renewable energy, but Eesti Energia is one of the three major electricity suppliers in the Baltic States (see also chapter 6). The Baltic energy market consists of the Baltic States and the north western part of Russia and the total electricity generation is above 9000 MW with a total annual consumption of 24 TWh.[147] The Baltic states are, as explained in chapter 5, interconnected by the former north western Russian electricity grid and have only one connection with an EU member, namely Finland through Estlink. The Baltic States have a bigger energy market than Estonia on its own, more inhabitants and more large cities. With cooperation the Baltic States can secure the electricity supply in the three countries and work together in the development of renewable energy. When there will be more connections to the European electricity grid, the Baltic States can even become the distributer of cheap electricity to Europe, also cheap electricity from Russia can be transported. But a step towards cooperation in energy security in the Baltic States and joined bio energy development would be a good start.[148]

To end this chapter I will give an overview of the most important direct measures I see for Eesti Energia:

- cooperation with universities or other companies to gain knowledge and split costs;
- participating in pilot projects or start them to gain knowledge;
- cooperate with other Baltic States in order to gain a bigger electricity market and potential to develop renewable energy sources.

Appendix 1

Table 1: Ethnic composition of the population in Estonia, 1934-2006

Ethnicity	**1934**		**1989**		**2000**		**2006**		**2008**	
	Total	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
Estonians	993.000	88	963.000	61	930.000	68	921.900	69	920.885	69
Russians	93.000	8	475.000	30	351.000	26	345.200	26	343.568	26
Germans	16.000	2	3.000	0,2	2.000	0,1	1.900	0,1	1.910	0,1
Swedes	8.000	0,7	300	0,02	..	..	..	..		
Jews	4.000	0,4	500	0,3	2.000	0,1	1.900	0,1	1.870	0,1
Finns	..	..	17.000	1	12.000	1	11.200	1	10.890	1
Ukrainians	..	..	48.000	3	29.000	2	28.300	2	28.003	2
Belarusian	..	..	28.000	2	17.000	1	16.300	1	15.925	1
Others	13.000	1	30.000	2	27.000	2	18.000	1	17.884	0,9
Total	**1.127.000**	**100**	**1.564.800**	**100**	**1.370.000**	**100**	**1.344.700**	**100**	**1.340.935**	**100**

Source: http://www.culturalpolicies.net/web/estonia.php?aid=421
And 2008 numbers www.stat.ee

Appendix 2

POPULATION*, 31 March 2000 by Place of residence, Religious affiliation and Sex	
Religious affiliation total	1.121.582
Follower of a particular faith	327.832
..Lutheran	152.237
..Orthodox	143.554
..Baptist	6.009
..Roman-Catholic	5.745
..Jehovah Witness	3.823
..Pentecostal	2.648
..Old Believer	2.515
..Adventist	1.561
..Methodist	1.455
..Muslim	1.387
..other religion	5.008
..faith unknown	1.890
Has no religious affiliation	381.911
Atheist	68.547
Cannot define the affiliation	163.304
Refused to answer	89.691
Religious affiliation unknown	90.297

Footnote: * Population - persons aged 15 and older and persons whose age is unknown.
Source: http://pub.stat.ee/px-web.2001/I_Databas/Population_census/16Religious_affiliation/16Religious_affiliation.asp

Appendix 3

AVERAGE MONTHLY GROSS AND NET WAGES (SALARIES) by Year, Economic activity and Indicator

	Average monthly gross wages (salaries), kroons
2000	
Average of economic activities	4.907
2001	
Average of economic activities	5.510
2002	
Average of economic activities	6.144
2003	
Average of economic activities	6.723
2004	
Average of economic activities	7.287
2005	
Average of economic activities	8.073
2006	
Average of economic activities	9.407
2007	
Average of economic activities	11.336

Footnote:
Employees with an employment contract, a service contract and working under the Public Service Act are included.

Source: www.stat.ee

Appendix 4

CO2 emissions per inhabitant in the EU and in developing countries in Tonnes

time geo	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
European Union (27 countries)	8,9	8,7	8,6	8,5	8,5	8,6	8,6	8,7	8,7	8,6	8,6	8,4
European Union (25 countries)	9,1	8,9	8,9	8,7	8,7	8,9	8,8	8,9	8,9	8,8	8,8	8,6
European Union (15 countries)	9,0	8,8	8,9	8,8	8,9	9,0	8,9	9,1	9,0	8,9	8,8	8,6
Belgium	12,6	12,0	12,6	12,0	12,1	12,1	11,9	12,2	12,2	11,8	11,3	10,8
Bulgaria	7,8	7,6	6,7	6,2	6,2	6,5	6,3	6,9	6,8	7,0	7,2	7,7
Czech Republic	13,4	12,8	12,1	11,7	12,4	12,6	12,2	12,4	12,4	12,3	12,5	12,6
Denmark	14,1	12,2	11,4	10,8	9,9	10,2	10,1	11,0	10,0	9,3	10,7	9,7
Germany (including ex-GDR from 1991)	11,5	11,1	11,1	10,7	10,7	10,9	10,7	10,8	10,7	10,3	10,5	10,2
Estonia	13,5	13,3	12,2	11,5	11,4	11,6	11,4	12,7	12,9	12,5	12,2	14,2
Ireland	10,2	10,5	10,9	11,2	11,8	12,2	11,6	11,3	11,3	11,5	11,1	10,9
Greece	8,3	8,7	9,1	9,0	9,5	9,6	9,6	9,9	9,9	10,0	9,8	10,1
Spain	6,2	6,6	6,8	7,4	7,6	7,6	8,0	8,0	8,2	8,5	8,1	8,2
France	6,8	6,7	7,0	6,8	6,7	6,7	6,6	6,6	6,6	6,6	6,4	6,2
Italy	7,7	7,8	8,0	8,1	8,1	8,2	8,2	8,4	8,4	8,4	8,2	8,0
Cyprus	8,6	8,8	9,7	10,7	11,1	10,8	10,5	10,4	10,4	10,5	10,6	10,6
Latvia	3,7	3,6	3,4	3,2	3,0	3,2	3,2	3,3	3,3	3,4	3,6	3,8
Lithuania	4,4	4,3	4,5	3,9	3,4	3,7	3,7	3,8	4,0	4,2	4,3	4,7
Luxembourg (Grand-Duché)	22,8	21,0	18,8	19,4	20,4	20,9	23,1	23,8	26,6	26,5	25,9	24,7
Hungary	6,1	5,9	5,9	5,9	5,7	5,9	5,8	6,1	5,9	6,1	5,9	5,7
Malta	6,3	6,2	6,2	6,4	6,0	6,2	6,2	6,6	6,4	6,6	6,5	6,6
Netherlands	11,4	11,0	11,0	10,6	10,7	10,9	10,9	11,1	11,1	10,8	10,6	10,5
Austria	8,5	8,4	8,4	8,2	8,2	8,7	8,9	9,6	9,5	9,6	9,4	8,9
Poland	9,7	9,6	8,8	8,5	8,3	8,3	8,0	8,3	8,3	8,3	8,6	8,6
Portugal	5,0	5,3	5,8	6,4	6,2	6,3	6,7	6,2	6,4	6,6	6,2	5,9
Romania	6,0	5,4	4,8	4,1	4,2	4,5	4,9	5,1	5,2	4,9	5,1	5,1

Slovenia	7,9	8,1	7,9	7,6	7,6	8,1	8,2	8,0	8,2	8,3	8,4	8,4
Slovakia	7,9	7,7	7,8	7,7	7,5	7,8	7,4	7,7	7,6	7,6	7,4	7,1
Finland	12,5	12,1	11,5	11,4	11,0	11,9	12,4	13,8	13,0	10,7	12,9	12,5
Sweden	7,0	6,4	6,5	6,2	6,0	6,1	6,2	6,2	6,2	5,9	5,8	5,6
United Kingdom	9,8	9,4	9,4	9,2	9,3	9,5	9,2	9,3	9,3	9,2	9,1	8,9
Croatia	3,9	4,1	4,3	4,5	4,5	4,7	4,9	5,3	5,2	5,3	5,3	5,6
Former Yugoslav Republic of Macedonia, the	:	:	:	:	:	:	:	:	:	:	:	:
Turkey	3,0	3,2	3,1	3,0	3,3	3,0	3,1	3,3	3,4	3,6	3,8	4,3
Iceland	8,9	9,2	9,1	9,8	9,8	9,7	9,9	9,8	10,0	9,7	:	:
Liechtenstein	6,8	7,2	7,4	7,3	7,0	6,8	6,8	7,0	7,0	6,9	6,9	6,0
Norway	9,3	9,3	9,3	9,4	9,3	9,5	9,3	9,5	9,6	9,3	9,3	9,5
Switzerland	6,2	6,1	6,3	6,3	6,1	6,2	6,0	6,1	6,1	6,2	6,1	5,8
Countries of the Development assistance committee (DAC)	1,8	1,8	1,8	1,8	1,8	1,8	1,9	2,0	2,2	2,3	2,4	:

:=Not available

Source of Data: Eurostat

Last Update: 01.07.2009

Date of extraction: 6 Aug 2009 12:58:12 GMT

Hyperlink to the table: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=0&language=en&pcode=tsdgp410 http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=0&language=en&pcode=tsdgp410

General Disclaimer of the EC: http://europa.eu/geninfo/legal_notices_en.htm http://europa.eu/geninfo/legal_notices_en.htm

Short Description: The indicator compares the level of CO_2 emissions from fuel combustion in the EU with the emissions in the developing countries. Developing countries are here identified with the 'developing countries and territories' on Part I of the OECD Development Assistance Committee List of Aid Recipients ('DAC part I countries').

Appendix 5

Electricity price list for business users, since August 1st 2009

Name	Unit	Rate (net of VAT)
EN1 - Basic rate electrical energy		
- basic rate	cents/kWh	51,43
EN2 - Time rate electrical energy		
- day rate	cents/kWh	61,81
- night rate	cents/kWh	35,85
EN3 * - Time rate electrical energy and ampere-based power fees		
- day rate	cents/kWh	44,42
- night rate	cents/kWh	16,23
- ampere-based power fee	kroons/A per month	9,95
EN4 - Base rate electrical energy and ampere-based power fees		
- basic rate	cents/kWh	38,65
- ampere-based power fee	kroons/A per month	9,95
EN5 - Time rate electrical energy and ampere-based power fees		
- day rate	cents/kWh	44,42
- night rate	cents/kWh	29,42
- ampere-based power fee	kroons/A per month	9,95
EN6 - Base rate electrical energy and kilowatt-based power fee		
- basic rate	cents/kWh	38,65
- kilowatt-based power fee	kroons/kW per month	39,40
EN7 - Time rate electrical energy and kilowatt-based power fee		
- day rate	cents/kWh	44,42
- night rate	cents/kWh	29,42
- kilowatt-based power fee	kroons/kW per month	39,40
EN8 - Electrical energy consumption package without a measurement system		
3-phase electrical energy consumption fee without a measurement system	kroons/A per month	182,73
EN9 ** - Electrical energy with seasonal time rates and kilowatt-based capacity fee		
- day rate in winter	cents/kWh	55,76
- day rate in summer	cents/kWh	42,25
- night rate in winter	cents/kWh	39,13
- night rate in summer	cents/kWh	37,17
- kilowatt-based power fee	kroons/kW per month	9,80
ENV - Electrical energy price package replacement fee ***		
- price package replacement fee at a low-voltage network connection up to 63A, if less than 365 days have passed since the previous replacement	kroons/replacement	125,00

* EN3 can be selected by clients, whose place of consumption includes a main circuit breaker of 3x16A to 3x 63A at 0.38 kV voltage. The minimum divided main circuit breaker in an apartment is 3x16A.
** EN9, with seasonal time rates and kilowatt-based capacity fee, may be chosen by business consumers at a consumption location with a voltage over 1 kV and at a consumption location with a voltage of 0.38 kV, the total of the protection relay(s) of the grid connection(s) of which is at least 800 A and by network operators. The price package must be used for at least 12 consecutive months.
*** Electrical energy price package replacement fee is also valid in case of divided sale of network services (e.g. in an apartment).

Name	**Unit**	**Rate**
EN20 – Time rate electrical energy as a delivery specified for line possessor for purchase of loss energy		
- day rate in the winter	cents/kWh	54,02
- general rate	cents/kWh	46,07

Day rate in the winter is valid from 1 November to 31 March, from Monday to Friday from 07:00 to 23:00 according to local time.
General rate shall be valid during the rest of the time outside the validity of the “day rate in the winter”.

Marginal rate of the weighted average price of electrical energy cents/kWh47,54
Concordance of decision No 7.1-4/09-0025 by the Competition Board. 28.07.2009
Source: http://www.energia.ee/index.php?id=1798&L=1 Accessed September 9, 2009

Price packages up to 63A, since August 1st 2009

Price package	Name of the tariff	Price excluding VAT	Price including VAT
Home 1	Electricity (EN1) base rate	51,43 s/kWh	61,72 s/kWh
	Network service (V1) base rate	60,12 s/kWh	72,14 s/kWh
	Renewable energy charge**	6,07 s/kWh	7,28 s/kWh
	Electricity excise tax	5,00 s/kWh	6,00 s/kWh
Home 2	Electricity (EN2) day rate	61,81 s/kWh	74,17 s/kWh
	Electricity (EN2) night rate	35,85 s/kWh	43,02 s/kWh
	Network service (V2) day rate	72,24 s/kWh	86,69 s/kWh
	Network service (V2) night rate	41,90 s/kWh	50,28 s/kWh
	Renewable energy charge**	6,07 s/kWh	7,28 s/kWh
	Electricity excise tax	5,00 s/kWh	6,00 s/kWh
Home 3	Electricity (EN1) base rate	51,43 s/kWh	61,72 s/kWh
	Network service (V3) base rate	38,66 s/kWh	46,39 s/kWh
	Network service (V3) measuring system charge	20,56 EEK/month	24,67 EEK/month
	Network service (V3) ampere charge	4,49 EEK/A per month	5,39 EEK/A per month
	Renewable energy charge**	6,07 s/kWh	7,28 s/kWh
	Electricity excise tax	5,00 s/kWh	6,00 s/kWh
Home 4	Electricity (EN2) day rate	61,81 s/kWh	74,17 s/kWh
	Electricity (EN2) night rate	35,85 s/kWh	43,02 s/kWh
	Network service (V4) day rate	46,46 s/kWh	55,75 s/kWh
	Network service (V4) night rate	26,94 s/kWh	32,33 s/kWh
	Network service (V) measuring system charge	20,56 EEK/month	24,67 EEK/month

	Network service (V4) ampere charge	4,49 EEK/A per month	5,39 EEK/A per month
	Renewable energy charge**	6,07 s/kWh	7,28 s/kWh
	Electricity excise tax	5,00 s/kWh	6,00 s/kWh
Heating plan	Electricity (EN3) day rate	44,42 s/kWh	53,30 s/kWh
	Electricity (EN3) night rate	16,23 s/kWh	19,48 s/kWh
	Electricity (EN3) ampere charge*	9,95 EEK/A per month	11,94 EEK/A per month
	Network service (V4) day rate	46,46 s/kWh	55,75 s/kWh
	Network service (V4) night rate	26,94 s/kWh	32,33 s/kWh
	Network service (V4) measuring system charge	20,56 EEK/month	24,67 EEK/month
	Network service (V4) ampere charge	4,49 EEK/A per month	5,39 EEK/A per month
	Renewable energy charge**	6,07 s/kWh	7,28 s/kWh
	Electricity excise tax	5,00 s/kWh	6,00 s/kWh

* EN3 ampere charge included in the heating plan is calculated based on a flat based on 16 A, if the distributed portion of the main fuse remains below 16 A.
** The renewable energy charge given in the price packages is valid as of 1 January 2009.

Base rate applies round the clock, irrespective of the day of the week.
Day rate applies Monday to Friday: 8.00 to 24.00 during daylight saving time and 7.00 to 23.00 outside of the daylight saving period.
Night rate applies Monday to Friday: 24.00 to 08.00 during daylight saving time and 23.00 to 07.00 outside of the daylight saving period, and round the clock Saturdays and Sundays.

Terms and definitions

Abbreviation EN – electricity (kilowatt-hours consumed).

Abbreviation V – network service (kilowatt-hours consumed).

Measuring system charge – charge collected for the measuring system. Used for price plans where measuring service costs are separated from the kilowatt-hour charge for network service.

Consumption location – location where electricity is consumed.

Ampere charge – charge based on the rating (amperes) of the fuse at the network connection.

Supply point – precisely defined connection point between the electrical installation of the network connection user and the network operator's network. The supply point is the place which is the boundary between the electricity network and the electrical installation.

Electrical installation – also referred to colloquially as the electricity system, e.g. the electrical installation in a private house includes distribution boards, indoor wiring and the like.

Source: http://www.energia.ee/index.php?id=1802&L=1 Accessed September 9, 2009

The price packages at a consumption point with a main circuit breaker over 63 A since August 1st 2009

Price package	Name of the tariff	Tariff excluding VAT
Electricity (EN1) + basic tariff network service on a line (VML1)	Electricity (EN1) basic rate	51,43 s/kWh
	Network service (VML1) basic rate	4098 s/kWh
	Network service (VML1) ampere fee	3,27 EEK/A per month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
Electricity (EN2) + time tariff network service on a line (VML2)	Electricity (EN2) day rate	61,81 s/kWh
	Electricity (EN2) night rate	35,85 s/kWh
	Network service (VML2) day rate	48,53 s/kWh
	Network service (VML2) night rate	28,57 s/kWh
	Network service (VML2) ampere fee	3,27 EEK/A per month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
Electricity (EN4) + basic tariff network service on a line (VML1)	Electricity (EN4) basic rate	38,65 s/kWh
	Electricity (EN4) ampere fee	9,95 EEK/A per month
	Network service (VML1) basic rate	40,98 s/kWh
	Network service (VML1) ampere fee	3,27 EEK/A per month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
Electricity (EN5) + time tariff network service on a line (VML2)	Electricity (EN5) day rate	44,42 s/kWh
	Electricity (EN5) night rate	29,42 s/kWh
	Electricity (EN5) ampere fee	9,95 EEK/A per month
	Network service (VML2) day rate	48,53 s/kWh
	Network service (VML2) night rate	28,57 s/kWh
	Network service (VML2) ampere fee	3,27 EEK/A per month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
	Electricity (EN1) basic rate	51,43 s/kWh

Electricity (EN1) + basic tariff network service in substation (VMA1)	Network service (VMA1) basic rate	35,33 s/kWh
	Network service (VMA1) fee for using network	16,99 EEK/month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
Electricity (EN2) + time tariff network service in substation (VMA2)	Electricity (EN2) day rate	61,81 s/kWh
	Electricity (EN2) night rate	35,85 s/kWh
	Network service (VMA2) day rate	42,45 s/kWh
	Network service (VMA2) night rate	24,62 s/kWh
	Network service (VMA2) fee for using network	16,99 EEK/month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
Electricity (EN6) + basic tariff network service in substation (VMA1)	Electricity (EN6) basic rate	38,65 s/kWh
	Electricity (EN6) capacity fee	39,40 EEK/month
	Network service (VMA1) basic rate	35,33 s/kWh
	Network service (VMA1) fee for using network	16,99 EEK/month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh
Electricity (EN7) + time tariff network service in substation (VMA2)	Electricity (EN7) day rate	44,42 s/kWh
	Electricity (EN7) night rate	29,42 s/kWh
	Electricity (EN7) capacity fee	39,40 EEK/month
	Network service (VMA2) day rate	42,45 s/kWh
	Network service (VMA2) night rate	24,62 s/kWh
	Network service (VMA2) fee for using network	16,99 EEK/month
	Renewable energy charge*	6,07 s/kWh
	Electricity excise tax	5,00 s/kWh

* The renewable energy charge given in the price packages is valid as of 1 January 2009

Basic rate applies round the clock, irrespective of the day of the week.
Day rate applies Monday to Friday: 8.00 to 24.00 during daylight saving time and 7.00 to 23.00 outside of the daylight saving period.
Night rate applies Monday to Friday: 24.00 to 08.00 during daylight saving time and 23.00 to 07.00 outside of the daylight saving period, and round the clock Saturdays

and Sundays.

Terms and definitions

Abbreviation EN – electricity (kilowatt-hours consumed).

Abbreviation V – network service (kilowatt-hours consumed).

Measuring system charge – charge collected for the measuring system. Used for price plans where measuring service costs are separated from the kilowatt-hour charge for network service.

Consumption location – location where electricity is consumed.

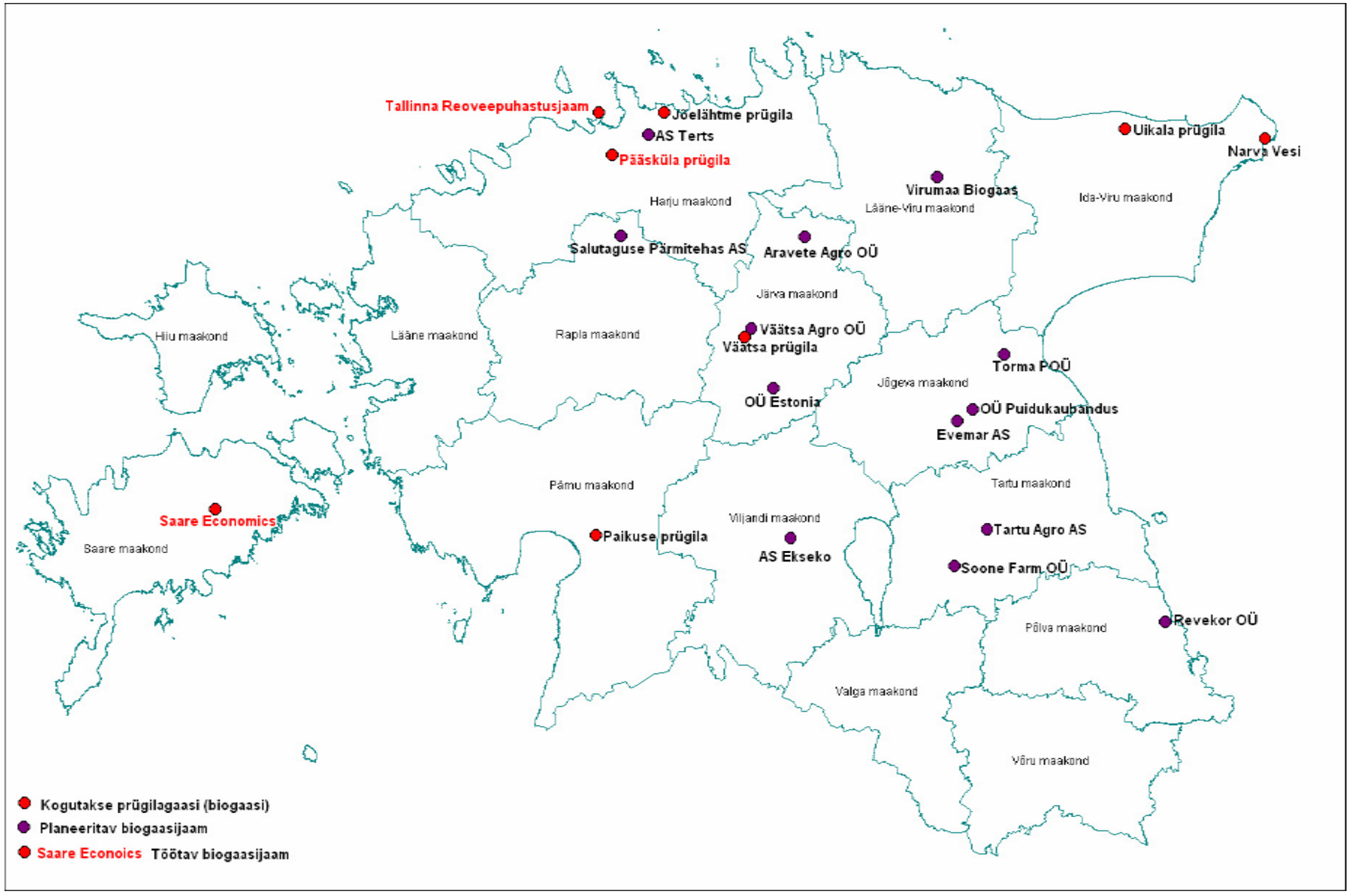
Ampere charge – charge based on the rating (amperes) of the fuse at the network connection.

Supply point – precisely defined connection point between the electrical installation of the network connection user and the network operator's network. The supply point is the place which is the boundary between the electricity network and the electrical installation.

Electrical installation – also referred to colloquially as the electricity system, e.g. the electrical installation in a private house includes distribution boards, indoor wiring and the like.

Source: http://www.energia.ee/index.php?id=1801&L=1 Accessed September 9, 2009

Appendix 6



For better understanding of map I will translate the legend:
Kogutakse prügilagaasi (biogaasi) - There is the landfill gas (biogas) gathering
Planeeritav biogaasijaam - Biogas station in planning
Töötav biogaasijaam - Biogas station in work.

Appendix 7

Financiële Steun

Subsidiebedragen 2009

Het basisbedrag en de basiselektriciteitsprijs van de verschillende productiecategorieën worden jaarlijks vastgesteld door de minister van Economische Zaken, op basis van berekeningen van het Energieonderzoek Centrum Nederland (ECN). Deze bedragen gelden vervolgens voor de gehele looptijd van de SDE-subsidie. De werkelijke subsidie waarop u recht hebt, is het verschil tussen de volgende twee bedragen (euro/kWh of euro/m^3):

- Het basisbedrag
- Het correctiebedrag. Dit is de elektriciteitsprijs of de gasprijs, gecorrigeerd met andere factoren die op deze prijs van invloed zijn. Het correctiebedrag van de verschillende productiecategorieën wordt voorafgaand aan elk jaar geraamd en na afloop van het jaar vastgesteld door de minister van Economische Zaken, op basis van berekeningen van ECN.

Daarnaast wordt er in 2009 een warmtestaffel ingevoerd. Naarmate een installatie meer restwarmte nuttig aflevert, wordt het subsidiebedrag hoger.

Voor 2009 zijn de basisbedragen:

Elektriciteit uit biomassa		
	Basisbedrag SDE 2009	
	Geen warmtebenutting	**Maximale warmtebenutting**
Verbranding (10-50 MWe)	11,5 €ct per kWh	15,6 €ct per kWh
GFT vergisting	12,9 €ct per kWh	14,9 €ct per kWh
Co-vergisting en kleinschalige verbranding	15,2 €ct per kWh	17,7 €ct per kWh
Overige vergisting	15,8 €ct per kWh	15,8 €ct per kWh
RWZI, AWZI en Stortgas	5,9 €ct per kWh	5,9 €ct per kWh
AVI's	11,7 €ct per kWh	14,0 €ct per kWh
Biogas uit biomassa	**Basisbedrag SDE 2009**	
Biogas uit GFT-vergisting	46,5 €ct per Nm^3	
Overige Vergisting (co-vergisting + VGI)	58,3 €ct per Nm^3	
RWZI, AWZI en Stortgas	21,8 €ct per Nm^3	

Source: http://www.senternovem.nl/sde/biomassa/subsidiebedragen_2009.asp

Appendix 8

Consortium:

1. Eesti Maaülikool
2. Tallinna Tehnikaülikool
3. Tartu Ülikool
4. Baltic Biogas OÜ
5. Biomass OÜ
6. Aravete Biogaas OÜ
7. Tartu Biogaas OÜ
8. OÜ Biogaas
9. Aqua Consult
10. Tallinna Vesi AS
11. Tartu Veevärk AS
12. Märja Monte OÜ
13. Estonian Environmental Research Centre

Source: Personal communications Argo Normak Maaülikool

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