“CO_2-balancing methods and increasing systems for renewable energies – a comparison of specially selected European countries”

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List of Abbreviations

BEI	Baseline Emission Inventory
CH_4	methane
CHP	Combined heat and power
CO_2	Carbon dioxide
COM	Covenant of Mayors
DENA	German Energy Agency
DH	District heating
DIW Berlin	German Institute for Economic Research
EEG	Renewable Energy Sources Act
ESS	Energy Agency for Southeast Sweden
EU	European Union
FKW or PFC	perfluorocarbons
GDP	Gross Domestic Product
GRP	Gross Regional Product
H-FKW or HFC	hydro fluorocarbons
IE Leipzig	Institute for Energy Leipzig
IPCC	Intergovernmental Panel on Climate Change
ITS	Industry, trade and service
LCA	Life Cycle Assessment
LPG	Liquefied petroleum gas
MEI	Monitoring Emission Inventory
N2O	Nitrous oxide
PV	Photovoltaic
RE	Renewable energies
RUS	Regional development and cooperation in environmental field
SAENA	Saxon Energy Agency
SCB	Statistics Sweden
SEAP	Sustainable Energy Action Plan
SF_6	Sulphur hexafluoride
SMWA	Saxon State Ministry for Economic Affairs, Labour and Transport

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1. Introduction

The climate is always in modification since the dawn of time of the earth and therefore nothing new. However, the process and impact of climate change is to be connected with population activities. In recent years the world has been warming up too fast and caused huge problems like increasing of global average temperature and sea level as well as weather disasters. The nature is not able to adapt quickly to such new situations. The main reason for global warming is the increased combustion of fossil fuels and caused increasing of greenhouse gas emissions. The urban energy consumption takes approximately 80% of total energy consumption and CO_2 emissions.[1]

Already in the early 1990 Germany and Sweden started to rethink towards climate protection within the United Nations Framework Convention on Climate Change. In the year 1997 both bound within passage of Kyoto protocol to reduce their greenhouse gases. In pass, Germans CO_2 output per capita is by 10,8t and Sweden ones by 5,2t.

In the society, recourse saving handling with energy has already taken a high priority. There, municipalities play an important role. Besides the provisions for existence, energy efficient measures for saving municipal energy costs and strengthening of climate protection become increasingly significance. Germany and Sweden are leading countries in this process.[2]

One of the first steps within this process is to create a CO_2-balance. Mainly this phase caused many difficulties for many municipalities. In this context, also renewable energies provide an important contribution within the regional and municipal energy strategy. This is the motivation of the present diploma thesis and displays CO_2 methods from chosen examples and incentive systems to expand renewable energies in the countries.

Limitations of Research

Against this background, the topic that motivates the paper is: “CO_2-balancing methods and increasing systems for renewable energies – a comparison of specially selected European countries.” The report especially focuses on country specific information, incentive systems and evaluation of different CO_2 balancing methods.

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[1] C.f Greenpeace : Klimawandel (n. Y.) ;URL: http://www.greenpeace.de/themen/klima/klimawandel/, 2011-09-20

[2] C.f DENA: Energieeffizienz mit System: Klimaschutz und kommunales Energiemanagement (n.y.), http://www.energieeffiziente-kommune.de/startseite/energieeffizienz-mit-system/, 2011-05-30

In view of the fact, the thesis evaluates methods and systems of the countries Germany and Sweden. In addition with the topic of “CO_2 balances”, the methods from the Saxon energy agency, the energy agency of southeast Sweden and from the Swedish municipality Växjö will be also evaluated in detail in present thesis.

The three methods from mentioned municipalities and the incentive systems from same Countries provides the best opportunity to evaluate the research in order to answer the questions in scale of viewed questions in the next part. Additionally, Germany and Sweden are leading countries in the field of energy industry and technology when it comes to international conclusion.

The limitation carried out according to following aspects: The research describes only the special methods regarding purposes mentioned below. Therefore, the aim is not to evaluate special data and trends from last years. In chapter of information about countries, the main pressure will be in the field of energy.

Purpose and organization of Research

The purpose of this thesis is to answer the questions in the following:

- How to assess the incentive systems of specific countries?
- Is it possible for the countries to reach expansion plans with their systems?
- Among which circumstances, CO_2-balancing methods are possible to compare with each other?

For answering the questions, it is necessary to give a short insight in topic at first. Therefore, in chapter 2, there will be lead to the final researching topic. This chapter starts with the country specific description, follow with presentation the step for developing energy efficient measures in municipalities and lay the base for chapter 3 with the general introduction to CO_2-balancing topic at the end.

The chapter 3 shows the methods and includes fallowing details which helps to answering the research questions mentioned above: The chapter analyse the data basis and quality, the way of data evaluation as well as purpose and objects from special municipality regarding CO_2 balances.

To receive an answer about the incentive systems for the researching countries, it is necessary to evaluate the systems in detail, which will be done in chapter 4. The thesis ends with an analysis and conclusion of mentioned issues in chapter 5 and 6.

2. Basics and definitions

2.1. Information about considered states

Analyse of CO_2 balancing methods and incentive systems from renewable energies concerning from Germany and Sweden. Information for balancing methods is described from the Swedish municipality Växjö and for each municipalities from county Kalmar. In Germany the method for the Federal State of Saxony will be described also in this Thesis. In this chapter, general and economical information about the countries will be provided shortly. Also, information about energy situation will be describing, but more detailed.

2.1.1. The Federal Republic of Germany

General information

Germany is part of the European Union (EU) and one of founding member. It extended from North Sea and Baltic Sea in the north to the Alps in the south as well as nine neighbour countries. With an area of 356 854 km² and approximately 82 million inhabitants Germany is the most populated country within the EU. Thus, the country has a population density of 230 inhabitants per km². The number of inhabitants is continuously decreasing and in 2011 by -0,03%. The statistical agency justified the decreasing by dying from more old people than babies are born.

Economic information

Germany is one of the most successful countries in economic field. According the forecast from the German Institute for Economic Research in Berlin (DIW Berlin), the economic growth was reduced in the last years since to the year 2012.[3] From 3,7% in 2010 over 2,2% for 2011 and 1,3 for 2012.[4] The gross domestic product in 2010 was 30.600 € per inhabitant.[5]

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3 C.f. ipicture: Deutschland, 2011, URL: http://www.ipicture.de/daten/demographie_deutschland.html. & deutschland.de Das Deutschland-Portal, (n.y.), URL: http://www.deutschland.de/, 2011-05-04

4 C.f. Pressemitteilung-online.de: DIW prognostiziert Wirtschaftswachstum Deutschland 2011 / 2012, (n.y.). URL: http://www.pressemitteilungen-online.de/index.php/diw-prognostiziert-wirtschaftswachstum-deutschland-2011-2012/; 2011-10-08

5 C.f. Gesellschaft für Wachstumsstudien e.V.: EU-Mitgliedstaaten (mit Schweiz und Norwegen): 2010, 2011, URL: http://www.economic-growth.eu/Seiten/AktuelleDaten/Daten2010.html, 2011-10-09

German brands in automobile industry have established in the whole world as well as commercial vehicles, electronically, engineering and chemical industry rate among to the most produced products in the country. Germany is also the pioneer in development of innovative solar technologies in the world.[6]

Energy situation and the way to energy supply only on base of renewable energies

With joining the Kyoto protocol was the base for energy efficient measures and with this expansion of renewable energies in Germany. In the year 1998 the "law on energy management" was amended and so, the way towards a liberalized energy market started.

Even today, the current energy consumption is dominated by fuels, electricity and gas views, that the sectors Industry and Transport change the position of highest consumer closely fallow by household sector. The sector trade and commercial has the smallest proportion of final energy consumption of Germany. The main energy source in industry and transport sector is gas and coal and was delivered at most to industries. In trade and commercial sector, petroleum products were consumed at most in the 90' and change the position with electricity at 2000 whereby the consumption of electricity in that sector tends to increase a bit. Petroleum products account the largest amount compared to all sectors as well as in the transport sector. In the household sector the consumption of gas clearly increase over the years as well as the consumption of coal, electricity and others in households has not changed so much since 1995.

The Germans currently consume 605 billion kWh of electricity. The power supply consists at most of lignite (23%), nuclear energy (22%) and coal (19%). The share of renewable energies of gross consumption of electricity mix is 16,8%. Thereby, PV-plants produce 2%, hydro power plants 3,3%, biomass plants 5,5% and wind power plants 6,0%.

The RE potential is still proceeding and based on high share of offshore and onshore wind energy plants and repowering of wind energy as well as solar plants, PV plants, geothermal plants and biomass.

In accordance with FOCUS online, despite closing of eight nuclear power plants, Germanys Export of electricity was reduced but it amounts still to 27,9 TWh. It is higher than 17% compared with

6 C.f. ipicture: Deutschland, 2011, URL: http://www.ipicture.de/daten/demographie_deutschland.html. & deutschland.de Das Deutschland-Portal, (n.y.), URL: http://www.deutschland.de/, 2011-05-04

imported electricity. One of the most imported countries are France and Czech Republic. Most of the electricity produced in Germany was exported to Austria and Switzerland.[7]

Figure 1: Development of Germans final energy consumption divided into consumer groups and energy sources; 1990-2009 [PJ][8]

7 C.f. FOCUS Online: Energiekonverenz in Deutschland: Mehr Strom exportiert als importiert (2011), URL: http://www.focus.de/immobilien/energiesparen/energiekonzerne-in-deutschland-mehr-strom-exportiert-als-importiert_aid_667158.html, 2011-10-12

8 Evaluation based on data from Bundesministerium für Wirtschaft und Technologie (2010), p. 23

According to Germany's government's energy concept, the country wants to ensure a safe, affordable and environmental friendly for their inhabitants. With this concept, Germany has the object to lay the future energy supply base on renewable energies (RE) and energy efficiency. Drastic chances of passed energy supply and high level on security of supply plays decisive roles.

Follow goals were determined:

Table 1: Energy objects written in energy concept from Federal Republic of Germany

	2020	2030	2040	2050
Reduction of green house gas emissions compared with 1990	40%	55%	70%	80%
Proportion RE at gross energy consumption compared with 1990	18%	30%	45%	60%
Proportion of electricity generation by RE of gross energy consumption compared with 1990	35%	50%	65%	80%
Primary energy consumption compared with 2008	20%			50%
Reduction electricity consumption compared with 2008	10%			25%
Reduction energy consumption in transport field compared with 2005	10%			40%

Germans nuclear power plants will be deconstructed at least to the year 2022 step-by-step. The plants have a bridging function up to the time when renewable energy will function reliable and necessary energy infrastructures will exists.

For expansion of RE and reach the ambitious objects, the Federal Republic adapted the Renewable Energy Source Act (EEG) with special amendments and ensure security for planning as well as investigation and remuneration were adjusted accord objects. More information will explain in chapter 4.1.

In addition, with supply based on use of wind power and solar energy plants, the grid has to be expanded, fluctuations has to be compensated by energy storage like with biomass production, innovation of market and system integration and enlarge the deportation of sustainable areas for wind power plants.

Germanies energy concept includes also rehabilitation program for buildings and keeping ready financial resources from 1,5 billion € by 2012 to 2014. In a script there are information for house owners for reorganization measures to reach low-energy standard by 2050. In addition, the Federal Republic aims on expansion and improvement of energy efficient products, technologies, services and energy labelling on technologies. Strategies regarding climate friendly mobility are also continuing.

2.1.2. Constitutional monarchy of Sweden

General information

Sweden has an area of 449 964 km² with an population density of 20,91 inhabitants per km² whereby the most of the people live in south Sweden and is the most density country from Scandinavian countries after Denmark. Sweden joined the European Union in 1995, but retained the own currency. The number of inhabitance is growing constantly and is currently by 9,25 million inhabitants.[9]

Economic information

Sweden has a stable economic policy beyond the monetary union. The economic growth is around 4,7% and thus over the EU-average. The gross domestic product is around 41.500 € per inhabitants and thus higher than the German ones.

Sweden is an agriculture country since the 19th century. The most of agriculture areas are in the middle and south Sweden. The forestry is also important for Swedish economic and with a logging of 60 million cubic meters per year Sweden is the second important producing country in that field. To Swedish export productions consists automobiles, steel, engineering products, electronic equipments, stationery and communication equipments.

In Sweden, the car owners pay more taxes for new cars than for older ones and the reason why Sweden has 57% of cars are older than 10 years. The Swedish government wants to stop this bad tax system and looking forward to a more environment friendly system like in Germany.[10]

Energy situation- Investigation in further renewable energy and energy efficiency projects

In the early 1970 during the oil crisis, Sweden already invested in researching alternative energies. The aim was to quit from oil business. In 1970, the energy consumption consisted of 75% oil and in 2009 it regressed to a rate of 32%.

Also the long-term research and development in the field of alternative fuels (ethanol) as well as more energy efficient vehicle engines running on motor fuels from renewable sources started in the 1980er and has continued to the present day. Since that time, Sweden became pioneer in that field, whereby ethanol is produced on base of cellulose from second generation. In contrast to

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9 C.f. EUROPA: Schweden, (n.y.), URL: http://europa.eu/about-eu/countries/member-countries/sweden/index_de.htm, 2011-10-18

10 C.f. TransWorld: Politik (n.y.), URL: http://www.schwedisch-translator.de/schweden/politik.html, 2011-10-18

ethanol produced from other countries, this product is more energy efficient than ethanol from grain. To integrate and expand the development from alternative fuels more in the country as well as to reduce the emissions, the government decided in 2006 that petrol stations have to offer a renewable fuel when the diesel and petrol consumption exceed more than 3000 m^3 per year. With this law, the share of renewable fuel in 2009 was already more than one half from the target, which should reach in 2020 by EU members. In 1980 the Government decided to phase out nuclear energy, but in June 2010 this decision was withdraw.

Sweden's current energy politic is dated back to the year 1997, where it was developed. In this it is stated the object: "The Government wants to reach an effective and sustainable use of energy and cost efficient energy supply."[11] It should also be facilitated the transition to ecological, sustainable society.

Today, more than in other EU countries, the Swedish energy consumption - electricity, district heating and fuels - consists of approximately 45% energy from renewable energy sources. The current electricity consumption amounts approximately 16.000kWh per head and year. Despite of this huge amount, the Swedish CO_2 emissions are very low (5,3 t per head and year) compared with international level (8,1 t per head and year). The reason is that more than 88% of electricity is produced by nuclear and hydro (48%) power plants, which emit no emissions. The rest is produced by fossil fuels (approximately 10%) and a small scale from wind power (approximately 1,5%).[12] In fallow Figure is shown Swedish energy supply and use for 2009.

[11] Trans. Schwedische Institut: Energie: Volle Kraft voraus für nachhaltige Lösungen, 2011, URL: http://www.sweden.se/de/Startseite/Arbeiten-leben/Fakten/Energie/, 2011-10-18

12 C.f. ibid

Figure 2: Swedish energy supply and use, 2009, TWh[13]

The Swedish climate and energy reducing targets are shown in follow table.

[13] Swedish Energy Agency, Energy in Sweden 2010, 2010, p. 50

Table 2: Swedish Government's climate and energy targets by 2020, 2030 and 2050

	2020	2030	2050
Reduction of green house gas emissions, compared with 1990	40%		0 net emissions
Proportion of energy supplied by RE of total energy use	At least 50%		
RE in Transport sector	At least 10%	Independent of fossil fuels	
Efficient energy use between 2008 and 2020	20%		

The green house gases should be reducing in following sectors: waste disposal, transport, housing, aquaculture, agriculture, forestry and some parts of industry. In addition to above mentioned reducing targets, the Government want to reduce energy consumption in houses from 20% by 2020 and 50% by 2050 compared to 1995 with a more energy efficient construction. With 290 energy advisers, the Swedish government provided possibilities for inhabitants to inform about energy saving options, energy efficient buildings and technologies.

One fifth of emission targets set by 2020 have already been achieved and the rest will made by 2020. The Government wants to reach the target by 2020 with reaching a fossil fuel free transport sector, expand renewable energies and increase energy efficiency as well as an energy supply with no net greenhouse gas emissions by 2050.

With the Electricity Certificate System, introduced in 2003, Sweden wants to increase the share of renewable energies from wind, water, solar, geothermal and bio energy as well as small scale hydro power sources. More information about this topic will be shown in chapter 4.2. In addition, it is planning a national framework for increase wind power production to 30TWh (20TWh onshore and 10TWh offshore). The conditions for produced electricity from renewable energies connecting to the grid and vehicles based on biogas are more action planes to reach the 2020 targets.

The increased investment is in the field of energy efficiency with 300 million SEK (around 27.3 million €) per year in time between 2001 and 2014. The Swedish Energy Agency is obligated for implementing the program and their monitoring afterwards. The public sector – municipalities and county councils - should act as role model in energy efficient improvements. Also companies will get a special support, when their energy consumption is over a significant amount. The support is like an “energy audit cheque” between 2010 and 2014. In addition there will be some initiatives on regional and local level to implement energy efficiency. New buildings and refurbishments have to install individual hot water and electricity meters as well as offer Energy efficient products for consumer are further action plans to reach the target in that field.

In Swedish climate and energy policy is also include actions to reach fossil-fuel-free vehicle fleet. “The basis of efforts to reduce the transport sector’s impact on the climate will be tools that put a price on greenhouse gas emissions. The Government’s action plan covers both tax proposals and investments in renewable fuels and in the development of alternative technologies.”[14] New cars, which were registered since 1 July 2009 and are environmental friendly, will be abating vehicle taxes for five years. In addition, the companies Volvo and Vattenfall have plans for 2012 to produce plug-in- hybrid cars in large numbers. In general, the aim is to increase the amount of environmental friendly cars. Also stations for filling renewable fuel, special sustainability criteria for biofuel products and some more are further action plans to reach the targets in that field.

Among mentioned things, also taxation has to deferred, for example for increase CO2 factor in vehicle tax, increased energy tax on diesel and higher carbon tax.[15]

2.2. Energy efficient measures in municipalities – The way to be energy efficient

In Kyoto protocol, many states sign the contract in an energy efficient world. Although, every state defined their own achievable and realistic national climate change objects, but they pursue a joint and transnational object: reduction of green house gas emissions. Therefore, a transnational cooperation is necessary and more efficient than work alone. In combination with reduction objects, it has to be considered the ratio of used energy and provided energy. This ratio is defined as: energy efficiency. So, reduction of energy and increasing of renewable energies in the countries are also important. But how can states reach their objects? The answer lies in every single municipality in each state. They should keep energy efficient thinking in their mind and take it into action with energy efficient projects. So, the national targets are able to reach with all municipalities together.

One approach for such projects is the municipal energy management. With this, not only energy could safe but also a lot of money. The energy management is the base to optimize the energy situation step-by-step. The German Energy Agency (*DENA*), for instance, receive information how

[14] Ministry of the Environment and Ministry of Enterprise, Energy and Communications, 2009, p. 2
[15] C.f. ibid, p. 1ff

municipalities can implement their energy efficient policy into action. In fallow, a short excerpt will be giving an overview about necessary steps.

2.2.1. The steps

Field of operations

The most important field of operations within municipal energy and climate protection management are municipal buildings and street lightning, because they are the largest consumer of energy. But also important fields of operations are transport sector, electricity use from industries, energy supply systems and especially the information as well motivation of all citizens and companies.

First step: Analyse of current situation

The process starts with analysis of the current situation. The municipal energy and climate relevant data from above mentioned fields of operations will be evaluated. The energy and CO_2-balance is thereby the supporting instrument, which summarize all necessary data and provide a good overview about the current situation. Afterwards, analysis of potentials is also helpful to create, because it shows saving potentials in fields of operations by long time.

Second step: Set long-time targets and create an energy and climate change policy

On base of CO_2 balance and analyse of potentials, concrete energy and climate political overall targets have to be set. It has to be considered, that all municipalities vary in their geographical area, economic power, local specificities and other characteristics. Therefore, the targets should be realistic and established on municipal conditions. The next step is to create individual targets for each field of operation, for example to reduce energy in municipal buildings and expand renewable energy systems. After, concrete measures have to be developing and, on base of financial background and other things, the measures with the highest priority will be laid down in municipal energy and climate change policy. It is the strategic mission statement and defines the framework as well provides a long-time orientation. A good concept includes measureable long-time targets for reducing CO_2-emissions and increasing energy efficiency in municipalities as well as their verification options for all mentioned fields of operations.

Third step: Finance and planning

Essential for implementation of measures is financial resources and support. With submission of the energy and climate change policy, all states and also European Union provide therefore extensive financial programs for municipalities. A lot of financing support programs provides communication networks with other municipalities. That is a big advantage, because they can share experiences for instance. One good example is the "Covenant of Mayors (COM)". When municipalities decide to sign in COM, they have to fallow given targets, timetable and specified guidelines. In chapter 2.3 one will find more information about COM.

Furth step: implement measures

When the financial background is save, the implementation of measures can be started. An energy coordinator organises all projects and is essential for a smooth process. In this phase it is important to keep the timetable, to be in financial budget and the pass situation has to be compared with planning specifications regularly. When some mistakes are happen, it can be corrected immediately.

2.2.2. Together reach the goal – join network programs and exchange ideas

The states decided together to reduce their emission objectives with signing the protocol; so, every state and therefore every municipality are in the same decision. In that case, it is easier to work together and exchange ideas to achieving goal together.

For this, some European wide network programs, cooperation or organisations were established and work in different projects with the aim to increase the energy efficiency. For instance the European networks COM and Climate Alliance as well as the European Energy Award®. All network communities work more or less on the same field. On base of the example of COM the implement detailed steps and structures will be described in fallow.

Covenant of Mayors:

In the year 2008, COM was established after the EU energy and climate package. "The Covenant of Mayors is the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European

Union 20% CO_2 reduction objective by 2020."[16] With signing the COM, all municipalities are also support to implement their energy policy. In May 2010, 1680 cities signed in COM.

In support of an online-tool and appropriate methodological guidelines for developing "Baseline Emission Inventory" (BEI) and "Sustainable Energy Action Plan" (SEAP), the municipalities are able to go through the Covenant process step-by-step very easily (Figure 3). With signing in the COM the platform receive one other advantage for municipalities, they can exchange their ambitious objectives and ideas as well as get in touch with other ones. For this, COM developed a database for "best practice" examples in addition a catalogue for SEAPs. On the homepage is also written, that a lot of small municipalities want to sign in COM, but it is not easy for them to maintain the COM's commitments because of low financial recourses. For that case, the COM office supports the signatory with strategic, financial and technical questions.

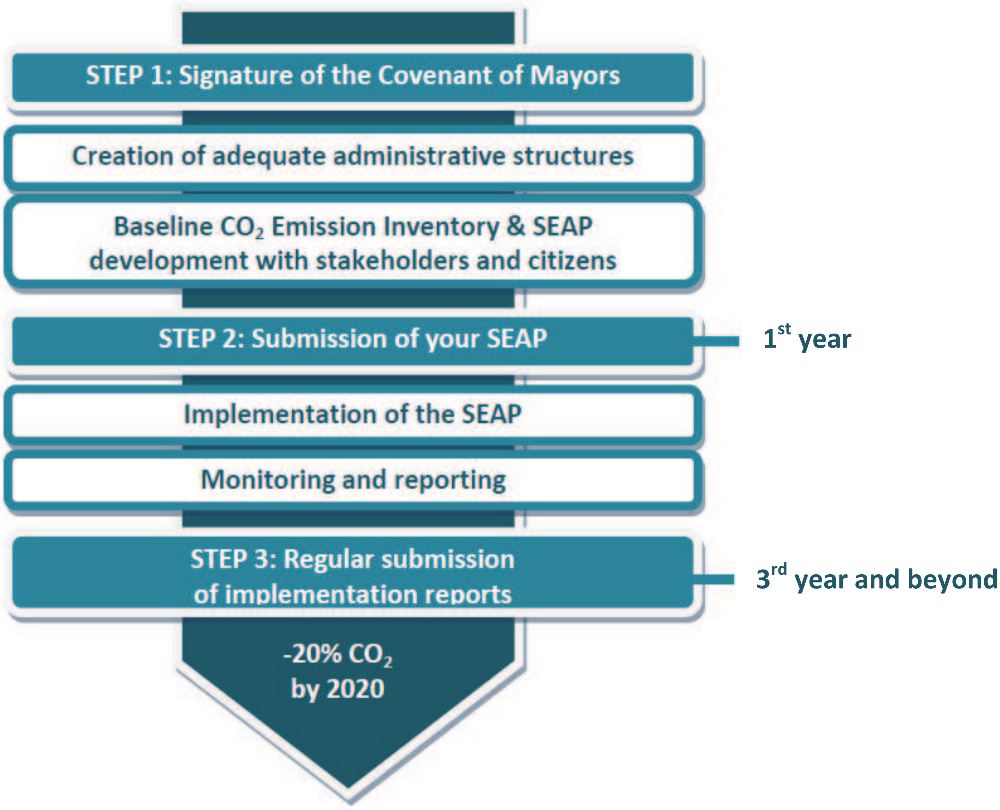

Figure 3: COM's process[17]

[16] Covenant of Mayors: The Covenant at-a-glance, (n.y.), URL: http://www.covenantofmayors.eu/about/covenant-of-mayors_en.html, 2011-10-07

[17] Source: simplified: COM, Baseline Emission Inventory & Sustainable Energy Action Plan, Converting Your Strategy into Action, (n.Y.), p. 5

As mentioned before, the Signatory from COM have to fulfil special procedure by first and three year, which Figure 3 shows. One of necessary steps in the first phase is to adapt the municipal administrative structure. Political and legal misunderstandings should be detected and change to set the course for the future implementation.

The BEI "quantifies the amount of CO_2 (or CO_2 equivalent) emissions due to energy consumption within the geographical area (territory) of the Covenant signatory".[18] More information about BEI can be seen in chapter 2.3.1.

Based on BEI, the signatory are able to identify the fields of actions and measures can be derived which helps to reach the emission reduction target by 2020. These clear strategic operation conditions which can be influenced are written down in SEAP. This document defines mentioned reduction measures "together with time frames and assigned responsibilities which translate the long-term strategy into action"[19]. It is not a rigid document and can be adapted if necessary on present circumstances. The actions should concern in field of public and private field. The main fields are: buildings, equipment and municipal transport as well as actions in the field of local electricity production and heating/ cooling generation. The industry sector consists not to the key target, therefore, the municipalities can choose if they want to include actions in this field in their SEAP. Afterwards, the strategies are implemented in the municipal live. Furthermore, after submission of each municipal SEAP, they have to hand in report in regular interval of two years, which integrate the present state of development their implemented actions and results. [20]

2.3. Methods for CO_2-balancing

The naturally greenhouse gas concentration in the atmosphere absorbed the heat reflection from earth's surface to the universe and ensure an average temperature from 15 decrees in the air. With human activities, additionally synthetic gases are emit, which have different properties and therefore various heavy potentials to increase the climate temperature. They and are the reasons for the increasing of temperatures as well as climate change. The Kyoto protocol provides emission reduction for following important greenhouse gases: carbon dioxide (CO_2) methane (CH_4), nitrous oxide (N2O), hydro fluorocarbons (H-FKW or HFC), perfluorocarbons (FKW or PFC) and

[18] C.f. Covenant of Mayors: Baseline Emission Inventory & Sustainable Energy Action Plan, Converting Your Strategy into Action!, 2010., p. 8

[19] Covenant of Mayors: How to develop a Sustainable Energy action Plan, 2010, p.5

[20] C.f. ibid, p. 5 ff & Covenant of Mayors: Baseline Emission Inventory & Sustainable Energy Action Plan, Converting Your Strategy into Action!, 2010, p. 1ff

sulphur hexafluoride (SF_6). As ones can see the emissions vary in their units, but for CO_2 balances it is necessary to summarize the amount for all greenhouse gases together with similar units. For this reason, the Global Warming Potential from mentioned greenhouse gases has been analyzed. It is the intensity of effect from special gas over the time from 100 years and explains the similar impact to CO_2.[21] Therefore, the emissions are converted in CO_2-equivalent. For instance one kilogram CH_4 has the same effect than 21 kilogram of CO_2 and so the value of CH_4 is 21, which is needed to calculate the emissions occur in the municipality base of different fuels.

As can be seen from chapter 2.2, a CO_2-balancing is an important instrument and the foundation of further steps. The first balance is called „basic inventory“ or „basis balance“. With data survey should be shown strengths and weaknesses in all fields of operations on base of this strategies and targets can be develop. In addition, it is important to emphasise that the starting situation from all municipalities is different. Not all have the possibility to receive real data for preparing the balance also the financial situation varied, the geographical area and political situation is different. Therefore, they have to find the best solution for their municipal situation. Based on first balance the balancing shall be continuing periodically and maybe refined. Only in this way, long-term-process as well strategies can be controlled and optimized.

There are many opportunities to create CO_2 balances, for instance with spreadsheet programs or with help from special tool, which are programming and the customer have only to fill in all data. With the second variant, on the one hand customers have not to deal with questions like: Which data should be included and how to evaluate? But in the other hand, they cannot prepare the balances in another way if they want to.

According extensive researches it has to be stated, there is no regulation about how to create a CO_2 balance and which data have to include.

2.3.1. Description of Baseline Emission Inventory as an example of CO_2-balancing

The BEI is part of Covenant of Mayor process, which was mentioned before. With the help of BEI, the Signatory are able to quantify the amount of emit CO_2 as a result of energy consumption within the boundary and in the base year. It allows locating the amount of different green house gas emissions in different sectors and on base of this, reduction measures can be derive and pri-

21 BMU: Glossar, (n.Y.), URL: http://www.bmu.de/klimaschutz/internationale_klimapolitik/glossar/doc/2902.php#treibhausgase, 2011-10-13

oritizes. It is not only an instrument for laying the first strategies or measures; it is also an instrument for monitoring of activities regularly. Therefore, the BEI have to be continued on the same principle in a “Monitoring Emission Inventory (MEI)”. The COM developed a step-by-step guideline for creating a BEI or MEI. The follow description based on mentioned guidelines is an extract and will show the data to be collected and necessary information, which should keep in mind in context with the evaluation. More information is shown in the guideline.

The first observations

The municipalities have to find the baseline year, which compare the further reduction targets and measures with it. The EU compares targets with 1990 and also in Kyoto protocol need this year as the basis. To compare the COM with EU targets, it is necessary to take a common base year. Therefore, in BEI shall be need 1990 as the base year. However, if the municipalities are not able to create a BEI on base of data from 1990, they shall choose the closest year to 1990 with the most comprehensive and reliable data.

The administrative boundary from municipality shall also be defined. It is not only the geographical border of municipality. It should also think about the including evaluation data from sectors, which can be reduced and can be falsify the result. For instance, the nuclear power plant, situated in the municipality should exclude from the CO_2 balance.

Emission factors

For calculating the BEI, there can be choose between two different approaches: with using Standard emission factors (IPCC) or Life Cycle Assessment (LCA) factors. “The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change ...”[22] created Standard emission factors. This model summarizes all emissions which occur and emit directly in the boundary or indirectly base on electricity or heat/cold using within the municipality. The standard emission factors are based on Global Warming Potential of different fuels, which are listed like in Kyoto protocol. The LCA process is standardized in ISO 14040 and therefore an international accepted method. It evaluates the effect of products, processes, activities, fuels or other sources on the environment during their life cycle. The uses of different resources are measured quantitatively and emit emissions within the life cycle. There are two different ways, which can be seen in Figure 4.

22 IPCC: Organization, (n.Y.), URL: http://www.ipcc.ch/organization/organization.shtml, 2011-10-13

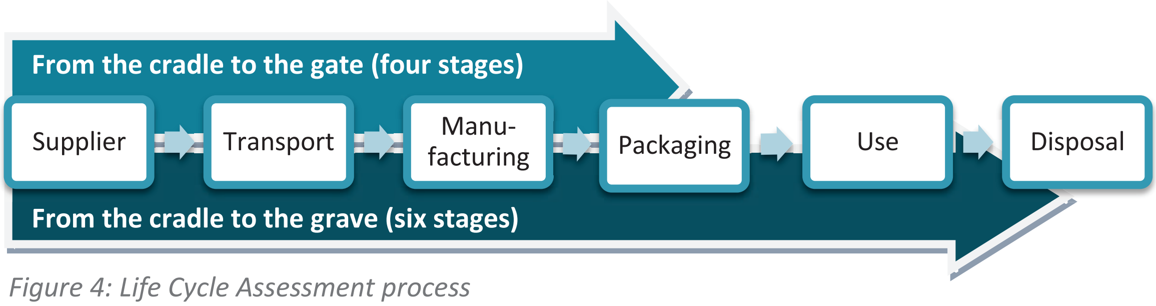

Figure 4: Life Cycle Assessment process

In follow table there is shown a comparison between standard emission factors (IPCC, 2006) and LCA emission factors from most common fuels.

Table 3: Comparison between standard emission factors and LCA factors from some fuel types[23]

Type	*Standard emission factors [t CO_2/MWh]*	*LCA emission factors [t CO_2-eq/MWh]*
Motor gasoline	0.249	0.299
Gas oil, diesel	0.267	0.305
Residual Fuel oil	0.279	0.310
Anthracite	0.354	0.393
Other Bituminous Coal	0.341	0.380
Sub-Bituminous Coal	0.346	0.385
Lignite	0.346	0.375
Natural Gas	0.202	0.237
Municipal Wastes (non-biomass fraction)	0.330	0.330
wood	0-0.403	0.002-0.405
Plant oil	0	0.182
Biodiesel	0	0.156
Bioethanol	0	0.206

Content of BEI and MEI

The COM provides evaluation sheets to create BEI, which can be seen in Appendix 1 It is an evaluation for follow issues:

1) ***Table A and B, Appendix 1: final energy consumption from different energy forms, which occur in sectors and emit emissions***

The sectors "municipal buildings, equipment/facilities", "residential buildings" and "municipal lighting" are examples which are included in this table. In that part, all buildings and facilities owned by municipality, their energy delivered points and for this the departments, which receive energy data and invoices have to be identified.

[23] Source: Covenant of Mayors, How to develop a Sustainable Energy Action Plan, 2010, p. 62

Energy consuming entities, which are not buildings, are equipments/facilities. Other buildings are, for instance, non-municipal buildings.

In all matters, the share of energy productions has to be included in the rights part. For instance, in the case of local waste incineration plant, which not produce electricity and heat, the energy production have to be divided and include in "municipal buildings, equipment/facilities", the renewable share in "other biomass" and non-renewable fraction in "other fossil fuels". As well as peat is consumed in some power plants. In that case, this share should be account in column "other fossil fuels".

The 'transport' sector includes road transportations, which is the consumption of fuels within the boundary. This amount is based on mileage driven, vehicle fleet (busses, taxis, passenger cars for instance) and the consumption (average) of each transportation type within the territory. In addition public transport and private commercial transport is also including in the evaluation.

2) Table C, Appendix 1: Electricity, which is produced locally with their emit emissions

In that table, amounts of local electricity production from wind power plants, photovoltaic plants or combined heat and power plants are registered.

The municipality can choose if they want to include plants from local electricity production in their BEI. When they decided to do so, the biomass and fossil fuel plants have to be an input below or equal to 20MW thermal energy and other renewable energy plants have to be a nominal output from below or equal 20 MW. It is assumed, that larger plants produce electricity for the larger grid and so for regions outside the territory. That's the reason why there is no provision for large plants.

In general, above mentioned electricity generation facilities, which are owned by private companies, owned by municipality or owned by private persons are able to include in the balance, but they have to be listed separately and located within the boundary.

3) Table D, Appendix 1: Heat/cold, which is produced locally with their emit emissions

In the list are included all heat/ cold production plants, which produce energy for end users of municipality. Combined heat and power plants and district heating plants are examples. The same applies to its CO_2 emission calculating. If amounts of heat/cold production plants are exported outside from boundary, this share of CO_2 emissions should be deducted and if energy is coming from outside located plants, this share of emissions should be account for.

Reporting and documentation

At the end, the signatory have to present the survey in a report. It includes information about the municipal boundary, which emission factors are chosen and their units (CO_2 or CO_2-eq), how the data collected, references to all mentioned information, any information about the situation and more.

The municipality shall also resolve if the emission reduction targets set absolute reductions or per inhabitant reduction. They should also choose if they want to calculate the emissions with temperature corrections. Because in times of colder days, people are heating more and therefore they need more energy.[24]

2.3.2. Balancing according to polluter pays or territorial principle

The municipal geographical, economic and politic situation is very different. Some municipalities consist of lot of industries as well export and import a huge amount of products. Another one is able to build a lot of renewable energy power stations or nuclear power plants use a lot of energy. Before municipalities start to create a CO_2 balance they should lay the boundaries and think about to implement rational and comprehensible data.

At first the words final energy and primary energy have o be define. Primary energy is that energy, which is in natural energy sources, like coal, wind and gas. After some transformation (preparation, transportation) which is afflicted with losses, for the consumer arise usable amount of energy which is referred to final energy. When municipalities create CO_2 balances, they should think about these forms of energy.

The polluter pays principle (Appendix 2, Figure 14) means in general that the regions, which produce or need the energy also have to calculate the CO_2 emissions. Therefore, in the balance is calculating the energy and CO_2 emissions, which is produced, used and emit only within the boundary and imported energy and there released emissions which is used in it. The produced and exported energy within the boundary are excluded. In this context, the CO_2 emissions which are necessary to prepare and transport the primary energy sources to the power station can be calculated also in the balance. Therefore, the LCA-factors mentioned in chapter 2.3.1 can be use.

In territorial principle (Appendix 2, Figure 15), the total amount of produced final energy within the boundary or territory is collected and the basis for balancing. The CO_2 emission can be derived

[24] C.f. ibid

from this energy evaluation. The consumption of primary energy as well as the consumption of primary energy which is imported is not calculated within the balance for the municipality. As consequence, the emissions of imported energy are emission-free and also not calculated within the municipal balance. The energy which is produced and exported within the boundary attributed to the municipality by 100%. Energy from power plants required for producing energy for consumers is not calculated only the supplied energy.[25]

2.4. Definitions of terms

For further analyse of this topic it is necessary to define fallow terms:

The countries have different administrative districts (Provinces, Federal States, counties and so on) and the geographical sizes are also different. In general, a municipality is the smallest independent territorial unit. Therefore a city is also to be considered to municipality. As mentioned before, when it comes to CO2 balancing it is necessarily to lay the boundaries within the municipality. Due to this, the term "municipality" means the examining object within the boundary in combination with this thesis.

Other greenhouse gases than CO_2 are measured in CO_2-equivalent. Due to simplify the process, all green house gases which have to be reduces are summarized within the term "CO_2 emissions.

In general, "renewable energies" are originated from sustainable sources, which are "renewable" or inexhaustible. They are also called alternative or regenerative energies. Within this definition there are associated follow energy sources: Solar, Photovoltaic (PV), wind power, hydro power, geothermal, bio energy (biomass, bio diesel, bio gas) and tidal power. Nowadays, also heating pumps are assigned to alternative technologies, because the machines work on base of regenerative sources. As well bio fuels, which are produced on base of biodegradable of waste (e.g. bio ethanol) and natural materials, which could be cultivated again (e.g. wood) can be also considered as a kind of renewable. For instance in Sweden, there are also such kinds of renewable sources mentioned as renewable fuel or electricity which will be classified as "renewable energies" in connection with CO_2 balances. For this reason, in this thesis all mentioned issues are summarized under the heading "renewable energies".

[25] C.f. BSU: Einführung in und Umgang mit der CO2-Bilanzierungssoftware ECORegion smart, 2011, p. 12ff

3. Analysis of CO_2 Balancing Methods

There are different possibilities to prepare a CO_2-balance. Even every municipality combines various objects with this balance as well as several conditions and circumstances. For this reason, every municipality has to find the best solution for their individual situations.

In this chapter the topic includes a discussion about the different CO_2-balancing methods from Germany and Sweden. Also selected good practices from other countries are prepared. This chapter also gives answers about where the information is coming from, the data quality and how they are prepared.

The focus of the thesis is lying on the evaluation of the method. An evaluation of the data quality is not provided because of the lack of information potential. Provided data quality analysis is only given for a proper answer to the researching question

3.1. German Methods: The Federal State of Saxony

The estimation from German CO_2-balancing methods at municipal level is based on methods from the Federal State of Saxony. The information about the Saxony's situation is based on an interview with Antje Fritzsche from the Saxon Energy Agency (*SAENA*) and responsibilities cover the field of energy efficiency.

In Germany normally all municipalities have to create a CO_2 balance to get a review and to control the nationwide objects. The same applies to Sweden. Such a process is time consuming and cost intensive, but the biggest problem is to receive energy information on municipal level. The Statistical State Office of Saxony, for instance, provides information only on area level.

When municipalities decide to create an energy efficient concept everyone has to start at the same base: How to create an energy balance? Which information is necessary and where can all information be received from?

At the end of this year or with the beginning of 2012, the state of Saxony will be remedying the situation as follows: The Saxony energy agency cooperates with the Swiss company ECOSpeed and buys licenses from their software tool ECORegion for Saxony's municipalities. Therefore, every municipality in Saxony is able to receive this tool.[26]

This decision is a loom large for Saxony's development in this field. In this chapter in follow there is specified further information about ECORegion (see chapter 3.1.1).

3.1.1. ECORegion - an software solution for creating CO_2 balances

General information

In cooperation with the headquarter of European Energy Award® and Climate Alliance, the Swiss company ECOSpeed developed a method in 2008 and created a web-based software named ECO-Region.[27] On base of this solution, the energy and CO_2 balances can be created coherently by federal states, administrative districts, municipalities and cities (in following called municipalities). With this development it is accelerated the proceedings on the way to energy efficient live.

The company cooperates also with the COM program and enables a way to create SEAP templates more easily. It is also possible to create balances retroactive to 1990. The software is already well established in Switzerland, Germany, France and Italy.

ECORegion is a web-based tool and it is possible to choose one of three versions: Smart, Pro and Premium. The costumers have to pay an annually license and so they are able to work with this tool at any place with a web connection.

Evaluation sheets

The first important step is to put in number of inhabitants and workforce divided into economic sectors (Appendix 3, Figure 16 and Figure 17). In Pro Version also data about size of area is necessary. In the same category information about transportation situation has also to enter. Either put in numbers of registered vehicles (Appendix 3, Figure 18) or numbers about miles travelled from personal transportation, long-distance passenger transport, transport of goods by road and other goods traffic (Appendix 3, Figure 19 to Figure 22). The numbers of travelled miles are calculated on base of inhabitants and workforce in economic sector.

Air traffic is calculating by polluter pays principle, because it is not easy to get information about numbers of municipal travellers by plain or emit green house gases within the municipal bound-

[26] Cf. Fritzsche, A.; Interview, 2011-06-07

27 Cf. European Energy Award®: Die Energie- und CO_2-Bilanzierung mit ECORegion, 2011, URL: http://www.european-energy-award.de/ecoregion-instrumente, 2011-09-08

ary. Therefore, the program assumes that every inhabitant receives a share in air traffic and national data are broken down on municipal level base on number of inhabitants.

In addition, the following energy data have to put in and evaluated:

1) Energy consumption of buildings/ infrastructure:

- Overall energy consumption from energy sources (Appendix 3, Figure 23)
- electricity, heating oil, natural gas, district heating, wood, environmental heat, solar collectors, biogas, waste, liquid gas, lignite and coal.
- Absolute energy consumption in households divided into same energy sources (Appendix 3, Figure 24)
- Energy consumption of mentioned energy sources in business sector sub-divided into primary, secondary and tertiary sector whereby affiliation of single business sectors cannot be determined at this place (Appendix 3, Figure 25). It is calculated on base of workforce in business sectors and overall energy consumption.

2) Energy consumption of municipal administration

- Energy consumption of municipal buildings/ infrastructure (Appendix 3, Figure 26)
- Fuels consumption in municipal fleet (Appendix 3, Figure 27)
- Energy consumed in municipal fleet (Appendix 3, Figure 28)

In the table in first point, every mentioned energy sources above are divided additionally into public street lightning, municipal buildings, public infrastructure and others, if possible.

Numbers of fuel and energy consumed in municipality are divided into petrol, diesel, kerosene, natural gas, biogas, liquid gas, vegetable oil and biodiesel. Whereby number of electricity consumed in municipal fleet is also necessary to enter in table of energy consumption.

3) Energy supply:

Electricity with different evaluations in fallow fields (Appendix 3, Figure 29 and Figure 32)

District heating with different evaluations in fallow fields (Appendix 3, Figure 33 and Figure 36)

Both can be evaluate in tables for overall import-mix, regional product volume, percentage regionally sold and regional consumer-mix (calculated). Numbers of mentioned evaluation sheets in category of electricity are divided into the electricity products water, nuclear power, natural gas, sun, biogas, waste, wind, wood, oil, lignite, coal and geothermal. Numbers for district heating evaluation sheets are divided into already mentioned energy sources above.

- Other energy carrier with evaluation of energy autarky (Appendix 3, Figure 37)

If it is possible, the percentage rate of this evaluation is divided into heating oil, petrol, diesel, kerosene, natural gas, wood, coal, environmental heat, solar collectors, biogas, waste, liquid gas, vegetable oil, biodiesel and lignite.

In every evaluation sheet it is possible to see information about data source. There is also a possibility to receive information for handling with data sources. Diagrams can be creating by each mask from total evaluation or single evaluation source and displayed in eight different diagram types. The toll is keeping ready also other different display settings and filter.

4) Result of energy data and CO_2-emissions:

After input of necessary and possible energy data the result of this as well of calculated green house gases in same sections can be compiled in this category. At this place it is also possible to chance some filters, display settings or measurement types again. For the report, the customer can choose between export only graph, table or both.

At this place it is also possible to get an overview about data sources. In detail it means to see own evaluated data, measured data and data from starting balance (normally from statistical sources).

It is also possible to export data for COM reporting sheet SEAP and for Benchmark of local climate protection in special provided masks/ tables as well as receive in the form of ECORegions Fact-Sheet. It works only by pushing a button and the data extract and include in the right form.

How does ECORegion work?

The web based tool ECORegion has clearly and user friendly architectures, which was described above. The energy data only have to be added there and the tool adopts the measurements in the background immediately.

Some municipalities are not able to get all information about the necessary fields. Mostly at the beginning it is hard to get information as soon as the first or basic balance is needed. In that case the tool provides the balance quickly only to enter municipal indicators mentioned above (first step). In ECORegion, this balance is called “starting balance”.

ECORegion provides also the possibility for customers to integrate original acquired data and gaps will be completed with country-specific data. Therefore, balances can be refined over the years and it is not essential to have all detail information at the beginning.

Normally, ECORegion's CO_2-balances is calculated on base of final energy consumption, but the costumer are also able to calculate with LCA factors, which can be choose in each evaluation sheet by pushing a button. In other words it means that the evaluation will be measured normally on base of territorial principle and calculation on base of polluter pays principle can be done by choosing LCA. It is not possible to provide more detailed information about measurements in the background.

Information about data sources

Most of the data are coming from national statistics. Data for calculation in parts of transport issues, the data are receive from German Institute for Economic Research, Institute for Energy and Environmental Research and Federal Statistical Office. CO_2 balances are calculating in the one hand with emission factors based on report of Federal Environmental Agency Berlin. Within this calculation, renewable energies have to be considered as emission free, so in final energy balancing it is assessed with Zero (emissions). To calculate CO_2-balances on base of LCA factors, necessary numbers for emission factors from all energy sources receiving from the GEMIS 4.2 database and ecoinvent database 2.0. From Institute for Global Environmental Strategies, surveys and calculations from ECOSpeed and other sources, which are not mentioned in ECORegion tool (2011). Some data include more than one source and some are mixed with statistical sources and calculations by the company, which is not possible to see how it is calculated[28]

The national statistics works with the "button-up-principle". According to Gabler Wirtschaftslexikon, individual partial solutions will be summarised from 'bottom' to 'top' until the overall problem is solved.[29] In that case all necessary energy data from all sectors at municipal level will be collected and results in national energy data. On base of this, the national statistics are able to broken down on municipal level with special indicators again.

New knowledge's

In collaboration with IE Leipzig, *SAENA* ascertained that a CO_2 balance based on national average values are insignificant for Saxons' decision. Because, during the German reunification also the

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[28] Survey by Steffi Hänig base on ECORegion Test license (2011) & Vögel, S.; Interview, 2011-09-22

29 C.f. Gabler Verlag, Buttom-up-Prinzip (n.Y.), URL: http://wirtschaftslexikon.gabler.de/Definition/bottom-up-prinzip.html, 2011-08-22p

industrial structure and the energy industry has been changed in Saxony. For this reason, the Federal State counteracts this situation and wants to enable to develop more significant CO_2 balances for the municipalities in Saxony. This innovation will be described in next Part of this thesis.

Saxony's development of a unified balancing method with ECORegion

SAENA would like to offer the best conditions to their municipalities and engage with Institute for Energy in Leipzig (IE Leipzig) with developing an energy and CO_2 balance based on Saxony's circumstances. In future this data will be implemented in ECORegion and serves as data basis instead of the country-specific data. *SAENA* is going to keep available licenses for Saxon municipalities with this specific ECORegion tool. According to *SAENA*s statement, the provision shall be established and take place at the end of this year or with beginning of 2012. At this time all municipalities are able to buy this tool.

The tool is working in the same way and the municipalities are able to calculate their balances as mentioned before. But now, the gaps are filled with data, which is broken down from data from federal state. Just now, a handbook is also created with information of data collection they are necessary for ECORegions balance. *SAENA* have not yet been published this handbook and the report from IE Leipzig, but the Saxony Energy Agency grant the option to inform about it. The chapter 3.2.1. is prepared based on selected extracts from mentioned documents.

3.1.2. Data basis of Saxons special ECORegion tool

The institute of energy Leipzig researched the energy situation of Saxony, as mentioned before. It is the database for Saxony's special ECORegion tool and decisive for energy strategies of their municipalities. For this reason, it is necessary to describe. Some numbers are delineating clearly by the web-tool, which will be describe also in the following, but before the figure gives a generally overview about the structure and which statistical sources enter in which part.

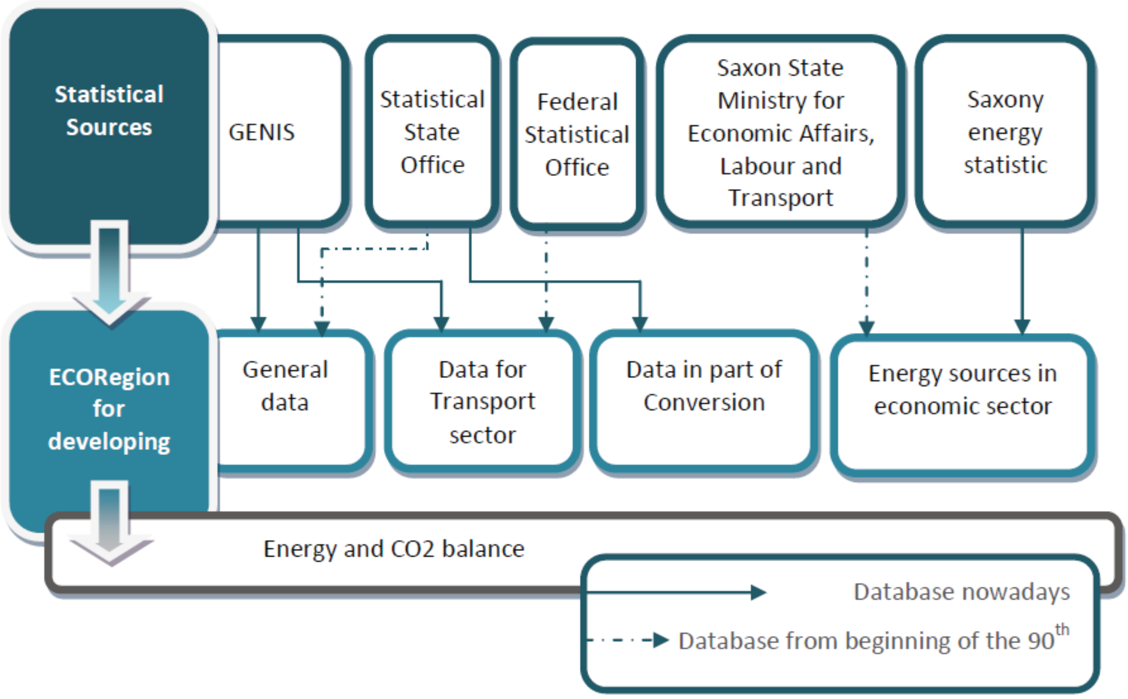

Figure 5: Overview about database of Saxony's structure

1) General data

General information within ECORegion is

- Number of inhabitants,
- Private households and
- Working population.

Inhabitants with their principle residence are available at database GENIS just in time. The number of 1990 was registered by statistical state office of Saxony. The definition of private households regarding ECORegion is people who live together and are an economic unit as well as persons who live alone. Relatives and non-family members could consist to the household. Working population are employees, self-employed worker and family workers. Both last numbers are also available at GENIS with a time lad from one year and the number of 1990 was received by statistical state office of Saxony.

2) Structure of energy source

Within this part following energy sources separated in parts are reported: heating oil, natural gas, coal, lignite, wood, liquid gas, bio gas, waste, heat from environment and solar cells (excluding photovoltaic).

It is noted within the report, that the calorific values and emission factors from mentioned energy sources are different. Therefore, on the basis of a detailed energy balance created by the institute, the energy source structure of Saxony was referred to *ECOSpeed* and included in the tool. From this, uniform numbers of emission factors and calorific values can be derived and included in the tool. The energy sources of electricity and district heating consists also to Saxony's energy structure and is included. In general, the energy balances are available with a delay of two years.

Necessary parts are:

- Private households
- Industry, trade and service (ITS)
- Manufacturing industry
- Proportion from economic sector of energy consumption by energy sources

Data from energy sources in private households, ITS and manufacturing industry shared deeper in inclusive, excluding mining and only in mining are receive from Saxony's energy balances. The data in these fields from 1990 to 1992 was recorded by Saxony's State Ministry for Economic Affairs, Labour and Transport (SMWA). Diagrams shows energy consumption from all energy sources as well, based on this, percentage distributions separated in mentioned three parts.

In ECORegion it is also required to detect the energy consumption from energy sources in all necessary economic sectors, mentioned in the following:

- Agriculture, forestry and fishing
- Energy and water supply
- Construction industry
- Trade, maintenance and repair from automobile, petrol stations
- Hotel and restaurant industry
- Communication and information transmission
- Credit business and insurance industry

- Property and housing
- Public administration, national defence, social security
- Public and private service
- Private households and
- Exterritorial organisations and statutory corporations

The energy balances from Saxony do not provide data in mentioned detailed energy sectors. Instead, the data is estimated on base of ITS accrue in energy sources and numbers of working population shared in energy sectors. In the report is also mentioned, that any weaknesses could exist in this measurement and, therefore, plausible results would not be achieved.

3) Conversion

The usage of the energy sources geothermal power plants, Coal, Lignite, Oil, Wood, Wind power, waste, bio gas, sun power, natural gas, nuclear power and hydro power from following sections are also examined:

- Electricity generation
- District heating generation

The statistical state office of Saxony provides information from both fields. Data from district heating generation were not collected in years 1990 to 1995. Therefore, an estimation base on mentioned energy sources for district heating generation in thermal power stations and district heating power stations was made. The data for that period was obtained from Saxony's energy balances.

4) Activities in field of transport

The parts in the following are examined:

- Local public transport
- Long-distance passenger transport
- Traffic of goods
- Fleet of vehicles and classification numbers of motorized individual traffic

In the part of local public transport, the numbers of light rail vehicles, tram/metro, urban bus, cars and motorbikes have to be included. Since 2004 all data, without cars and motorbikes, is received from the data base GENIS. The shares from years before were examined based on the German value from passenger kilometres in 2004 and passenger kilometres from Saxony in 2004. Specific data from cars and motorbikes for Saxony are not available, but instead they were measured also with help from German values. Originating from number of inhabitants in Saxony and Germany, the data from passenger kilometres were measured.

In the part long distance passenger transport, data for air traffic, rail passage traffic and passenger shipping are necessary to collect for ECORegion. Even, there are no statistical sources available on Saxony's level. There are also no German statistical data available for passenger shipping. For this reason, the data cannot be included in the survey. To provide information for passenger kilometres for air traffic, a measurement bases on German passenger kilometres and share of Saxony's air passenger from total air passenger from Germany, who are dispatched at the airports. The numbers of Saxony's passenger kilometres from rail passenger traffic were derived based on German passenger kilometres and share of inhabitants.

The numbers of Saxon good traffic are dividing into good traffic per shipping and railway. Information about good traffic per railway is calculated by GENIS at the year 2005. The data before were estimated with the ratio from 2005. Even the numbers of good traffic per shipping are not available for the years 1990 to 2006 and measured on base of data from handling of goods from inland navigation and the distance of the river Elbe. The data in 2007 is provided by Federal Statistical Office.

To the fleet of vehicles consist trucks within tractors, semi-trailer truck, cars and motorbikes and enfolds numbers of reported and licensed vehicles. The numbers were reported from Federal Statistic Office and Statistical State Office. Starting with the year 2008, notices for departure were not reported anymore. This change is considered in ECORegion. Therefore, the official statistic can be used. For number of trucks within tractors, the data for agriculture tractors has to be calculated in truck-equivalent. The share of kilometres travelled by tractors and trucks are evaluated. It is also necessary to get information about percentage from all mentioned sources. Due to unavailable statistical sources on Saxony's level, the average of German values deposited in ECORegion is used.[30]

[30] Ebert, M.: Bereitstellung energetisch relevanter Daten ab 1990 für die Erstellung regionaler Energiekonzepte in Sachsen (2011: not published), p. 5ff & Fritzsche, A.: Leitfaden für die Datenbeschaffung zur CO2-Bilanzierung mit ECORegion (not published), 2011, p. 3ff

Data quality

According statements of the Statistical State Office, the starting point of Saxony's energy balance is the energy balance from SMWA. Based on this, the CO2 balance will be measured with the help from CO2-equivalent factors.

In general, the measurement to create the energy balance is complicated. Data from different sources will be collected (for instance the official statistics of Federal States, information by associations and other sources). Some data will be measured by bottom-up-principle and other one, which is not available at the Federal State level, will be measured by top-down-principle. The gabs will be closed with estimations on Federal State level.[31] It is not possible to provide more detailed information about the statistical sources from the method of Saxony.

3.2. Swedish Methods

The Energy Agency of Southeast Sweden (*ESS*) is one of three energy agencies in Sweden and was established in 1999. The company has the aim to support municipalities in energy efficient issues. The field of activities includes projects in sector building, learning and lifestyle as well as transport. Not only projects on local and regional level will be implement, but also on national level in European (EU) projects, where they work together with other countries and share their knowledge's.

Every municipality is allowed to choose if they create their own CO_2-Balance or ask for support from *ESS*. The first CO_2 balance was created due to an EU project which finalised the work and a wish of county council Kalmar County who founded the remaining part.

The municipality of Växjö for instance decided to create a balance by their own. This chapter shows a CO_2-Balance created by *ESS* for municipalities in counties from southeast Sweden and one balance from a municipality created by itself.

3.2.1. Method of energy Agency of Southeast Sweden

Structure and general information

The *ESS* calls the balance "Energy-Balance", which consists of an Energy-Report and CO_2-Emission-Report. The balances extend back to the year 1990. So, it is to be considered as the base year.

[31] Oettel, Dr.; Email: data base of Statistical State Office (2011)

Starting with the first balance, the data is provided on a statistical base on national level. The adjacent nuclear power plant, which consists to municipal territory, is excluded from the balance since the consumption of fuel as well as production of electricity is consider to be on a national level.

ESS has no instructions how to create energy balances for southeast Sweden. For this reason, the institution has developed a guide, in which all relevant information is written, for example condense, which tables are to be use and in which way the data can be processed. But the interval is not prescribed, since there is no standard regarding this. So, it would create more options and the balances would provide in irregular intervals.

In the beginning it was created in form of an Excel-Sheet, where the data was added and prepared since the beginning. Every preparation period is extended by this year. The regional and municipal CO_2-balances are prepared on the same way.

ESS uses statistical sources, which data is trustful, significant and processed continuously. The most important source is the "Statistics Sweden"(*SCB*). It is an authority who provides data of a range of topics of national, regional and local level from Sweden. *SCB* broke down data from national level due to provide data on regional and local level. For security reasons, some data are hidden on local level in order to prevent disclosure of the sources (more information: s. Part "background of statistical data" of this Chapter). Therefore, they cannot include in municipal balance. Also some further information is also necessary to create the report optimally. Therefore, *ESS* uses five other free statistical sources: municipal environmental management (for heating pumps), administration of province Kalmar county (for solar and photovoltaic plants), Swedish energy agency (for Wind power plants), regional facts (gross regional product) and regional development and cooperation in environmental field (RUS: for CO_2 emissions).[32]

As mentioned before, *ESS*'s energy-balances are based on public data. On the webpage of *SCB*, users have to pick their region and municipality. After, the user can choose between seven tables. The main table shows all categories and their accrued energy sources and volume by one year. All other tables vary in their data compilation, but the data behind is the same as in the main table. It is only another form of preparation of data. On that score, *ESS* picks up only all data from *SCB*'s main table and inserts it in their Excel table next to the previous analyse years.

32 Links in mentioned order: no source, http://www.lansstyrelsen.se/kalmar/sv/Pages/default.aspx, http://webbshop.cm.se/System/Info.aspx?p=Energimyndigheten&pg=default, http://www.regionfakta.com/, http://www.rus.lst.se/airviro.html

Furthermore, to install geothermal energy pumps in households it requires permissions of municipality by citizen. Therefore, the number of these heating pumps is available and can be used for the energy-report. However, the number of exhaust air heat pump is calculate on base of numbers of sold exhaust heating pumps from statistical source compared with numbers of other heating pumps from statistical source. Information about all other statistical sources is not available.

Next by general information about the region and municipality, information about the present energy and CO_2 situation is described in the report. Figure 6 shows which statistical sources enter in several parts of *ESS*'s balance.

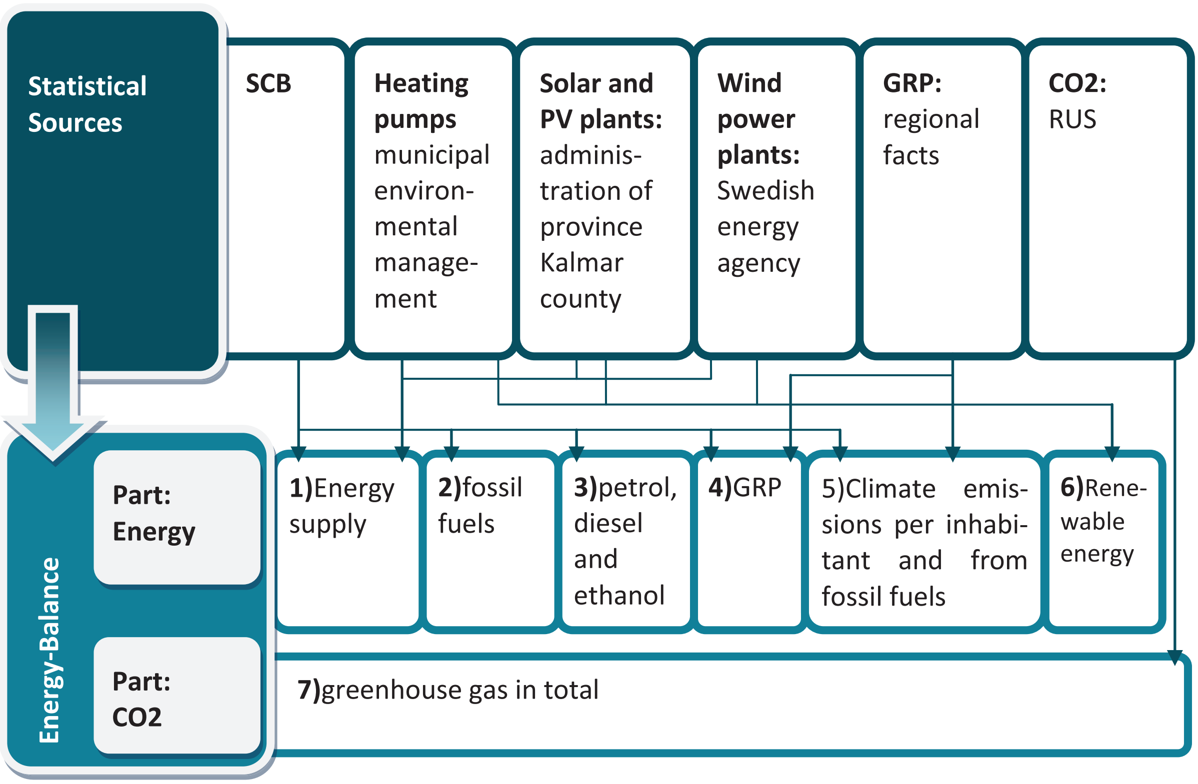

Figure 6: Overview about the method from ESS

Balance: energy-part and CO_2-part

1) Energy supply

The energy part shows at first an overview about the energy consumption over the years. This table (overview s. Table 4) and also the figure show the energy supply from fossil fuels, also renewable fossil fuels, electricity and a total energy supply.

Table 4: Overview about table "energy consumption" mentioned in the report[33]

Gross supply	1990	1995	2000	2005	2008
∑ fossil fuels [GWh]					
coal [MWh]					
coke [MWh]					
petrol [MWh]					
diesel [MWh]					
heating oil 1 [MWh]					
heating oil >1 [MWh]					
Liquefied Petroleum Gas (LPG) [MWh]					
∑ fuels based of RE [GWh]					
ethanol					
wood fuels [MWh]					
Others [MWh] (bio oil etc.)					
sun (MWh)					
energy from heating pumps [MWh]					
∑ Total fuel [GWh]					
electricity [MWh]					
Imported electricity [MWh]					
hydro power [MWh]					
wind power [MWh]					
CHP[34] [MWh]					
∑ Total energy [GWh]					

All numbers, excluding followings, are taken from the *SCB*'s main table. Following numbers has to be calculated in another way:

In the year 2004, petrol was mixed with five percent Ethanol in Sweden. For this analyse, the real value of petrol and Ethanol has to be shown. But in the national statistics the data regarding ethanol is not included and has to be estimated. So, the five percent have to be subtracted from the statistical petrol number (95% petrol) and in the line "Ethanol" one will find again this five percent.

In that case, the point "other" includes data, their amount is too low to mention in the categories (e.g. landfill gas, sewage gas and thermal heat). It means the energy consumption from district heating without energy consumption from the municipal nuclear power plant.[35]

Heating pumps summarize sun energy in the air, earth, rocks and groundwater. When heating pumps are producing, electricity will be stored. An efficient heating pump uses one share for energy and delivers two shares thermal energy. Also important to know is that one family house

[33] Source, simplified, trans.: Eckerberg, L.: Energibalans 2008 Oskarshamn kommun, 2011, p. 18

[34] combined heat and power

[35] C.f. Eckerberg, L.: Energibalans Oskarshamn (2011), Excel-Sheet

needs 16.000kWh renewable energy to heat their house. A heating pump will extract energy from the environment on an average of 70% of the required heat. A private houseowner, who wants to have a heating pump, need permission from municipality for installing the technique by "municipal environmental management". Therefore, they registered every heating pump and *ESS* receives the numbers from this institute. *ESS* has no information about the different pump types, so they have to apply an average-measure.[36] Therefore, the following formula is to be used to measure the total energy by heating pumps:

$$total\ heating\ pumps\ [MWh] = \left(\sum instatt\ hp * 16\right) + \left(\sum instatt\ hp * 16 * 0{,}7\right)$$

The electrical energy consists of the transmission losses[37] and the total energy of all flats, apartment buildings, normal houses, services, industries, agriculture, forestry, fisheries and more.

Import electricity is used within the boundary but not produced in it. So it is measured based on the number of electricity one column above subtracted the amount of wind power, hydro power and combined heat and power (CHP).

The number of CHP includes all CHP plants and power plants. It is the energy from thermal power plants and all other power plants, which deliver energy from CHP.

In the next step, all evaluations possible on base of *SCB* and all other statistical Sources show another view about the current energy situation, which is described in the following.

2) Fossil fuels separated in areas

In the next step, tables are prepared to show all fossil fuels (is standing in parenthesis), which are accrued in following fields:

- Agriculture, forestry and inland fishery (diesel, heating oil1, electricity)
- Industry and construction (coal, LPG, diesel, heating oil 1, wood fuel, electricity, district heating)
- Public sector (diesel, heating oil, electricity, total)
- Transportation (petrol, diesel, electricity, total)
- Other services (diesel, heating oil 1 and >1, electricity, district heating)
- Household (diesel, heating oil 1 and 2-5, wood fuel, electricity, district heating)

[36] C.f. trans. Eckerberg, L.: Energibalans Oskarshamn kommun 2008, 2011, p. 29

[37] Reason: On the way from producer to the house hold, a part of energy will be loss and so it will not be used.

All information is pasted from the statistical sheet in the excel sheet without any measures.

In addition, the above mentioned results of all tables are represented visually in form of a graph. The graph can thus be used to see the trend in all field regarding energy consumption and especially the areas where further action is needed.

3) Petrol, diesel and ethanol

After, a diagram gives a short overview about the trend from 1990 to 2008 including the sources petrol, diesel and ethanol. The numbers are also from *SCB*'s main table. As described before, the number of petrol consists of five percent Ethanol from 2005 on. Therefore, the number of petrol and Ethanol has to be considered separately at this place. [38]

4) Gross regional product (GRP)

Also the GRP compared to the energy have to be evaluated (Table 5):

Table 5: Overview about table "GRP compared to energy" mentioned in the report[39]

Per inhabitant	1990	1995	2000	2005	2008
GRP [SEK/ inhab.]					
kWh/SEK					
CO_2 [t/ inhab.]					
Supply [MWh/inhab.]					
Fossil fuels [MWh/ inhab.]					
Renewable energy [MWh/ inhab.]					
Electricity [MWh/ inhab.]					
Total final energy per inhab.					
CO_2 [t]					
GRP [kkr]					
CO_2/GRP [kg/ SEK]					
kWh/ GRP [kkr]					

Now a further statistical source has to be used: the number of GRP and included in SEK per inhabitant and specified in thousand SEK. All other numbers has to measured based on given values.

The number "kWh/SEK" is calculated by total energy (Table 4) per inhabitant and divided by the GRP per inhabitant.

[38] C.f. ibid p. 21ff

[39] Source, simplified, trans.: ibid. , p. 24

At first, the emitted green house gasses from fossil fuels (Table 4) have to be calculated based on CO_2-index (Table 6). For this estimation it is necessary to bring all data in one comparable unit. The sum of this calculation is divided by the population. (s. next formula).

$$CO2\ [t/head] = \frac{\sum consumption_i\ [MWh] * CO_2\text{-}\ index_i \left[\frac{kg}{MWh}\right]}{total\ population * 1000}$$

Table 6: CO_2-index for necessary fossil fuels[40]

Fossil fuels	***CO_2- index [kg/MW]***
petrol	264,6
diesel	266,2
heating oil 1	271,1
heating oil 2-5	274,3
natural gas	203,4
LPG	234,0
coal	344,2
peat	386,3
Renewable energy	***CO_2- index [kg/MW]***
chips	-
bark	-
firewood	-
waste	117,7

The total energy supply of fossil fuels, renewable energies and the supply electricity is also to be calculated per inhabitants.

The sum from all three numbers are summarised in total energy per inhabitant.

Furthermore, the total amount of all accruing CO_2-Emissions and the total GRP are also evaluated. It is nearly the same measure as mentioned before in this table, but now it is related to all inhabitants.

At the end of this table, one can see the trend over the years in form of the comparison CO_2 with GRP and kWh with GRP.

[40] Source: , simplified, trans.: ibid., p. 27

5) Climate emissions per inhabitant and from fossil fuels

At first a figure shows the development from CO_2-emission in ton per inhabitant based on the number “CO_2 [t/inhabitant]” from Table 5. After, the consumption of fossil fuels over the years is shown a second time (Table 4) and a measure from total fossil fuels per inhabitant. On base of this table and the indexed from Table 6, a figure about the trend from CO_2-emissions from all fossil fuels is also evaluated.

6) Renewable Energies

For the Energy-Balance is also important to know about the kind of renewable energy sources used and the number of current installations.

In the last part of the Energy part, all necessary information about the current situation of renewable energies is written: In that case, it is mentioned everything about bio fuels, hydropower, wind power, biogas, solar power, heating pumps and about the usage of peat and waste.

7) greenhouse gases in total

In this part, all CO_2-emissions shared in several fields are listed. The mentioned CO_2 calculated by *ESS*, based on data from fossil fuel numbers (*SCB*) and CO_2-index, provides another overview about their usage. With this data, it is impossible to create an overview shared in several fields. Therefore, another source was necessary. Due to this, the numbers are coming from the institution RUS, which means: regional development and cooperation in environmental field. This institute prepares CO_2-data in their origin and emission share for all regions/ municipalities over the time. For this, *ESS* can pick it out and include it to 100%. So, any other measures are not necessary. The figures are collected in another way than *SCB* is doing it, which is not announced from RUS.

In following table an overview about mentioned things is shown, which you can find also in *ESS*’s energy-balance.[41]

[41] C.f. trans.: ibid., p. 25ff & Eckeberg, L.: Energibalans Oskarshamn, 2011, Excel-sheet

Table 7: Overview of emissions after their geographical distribution and emission share[42]

Main sector	Under sector	1990	2000	2005	2008
CO_2		**[t/year]**			
Energy	Thermoelectric plants Boiler houses Self heating				
Industrial processor	Mineral industry Metal industry Use of fluorinated gases				
Transportation	Cars Light trucks Heavy trucks and buses Mopeds and motorcycles Home civilian shipping Domestic flights Others				
Machinery	Machinery Household machinery				
Solvent use	Colour usage Solvents from products				
Agriculture	Intestinal gases from ruminants Manure Pig manure Horse manure Chicken manure Sheep manure etc. Others				
Waste and sewage management	Landfill Treatment of sewage				
Methane (CH4)		**[t/year] CO_2 equivalent**			
All	all				
Energy	All Thermoelectric plants Boiler houses Self heating				
Transport	Cars Light trucks Heavy trucks and buses Mopeds and motorcycles Home civilian shipping Domestic flights Others				
Machinery	All Machinery Household machinery				
Agriculture	All Intestinal gases from ruminants Manure Pig manure Horse manure Chicken manure				

[42] Source, specified, trans.: Eckeberg, L.: Energibalans 2008 Oskarshamn kommun, 2011, p. 33ff

Main sector	Under sector	1990	2000	2005	2008
	Sheep manure etc.				
Waste and sewage management	all Landfill				
Halogenated fluorocarbons (HFC)		***[t/year] CO_2 equivalent***			
Industrial processor	Use of fluorinated gases				
Nitrous oxide (N2O)		***[t/year] CO_2 equivalent***			
Energy	Thermoelectric plants Boiler houses Self heating				
Transportation	Cars Light trucks Heavy trucks and buses Mopeds and motorcycles Home civilian shipping Domestic flights Others				
Machinery	Machinery Household machinery				
Solvent use	Colour usage Solvents from products				
Agriculture	Manure Pig manure Horse manure Chicken manure Sheep manure etc. Others				
Waste and sewage management	Treatment of sewage				
sulphur hexafluoride (SF6)		***[t/year] CO_2 equivalent***			
Industrial processor	Metal industry Use of fluorinated gases				
perfluorocarbons		***[t/year] CO_2 equivalent***			
Industrial processor	Use of fluorinated gases				

Background of statistical data

After a detailed explanation about the method, the central question is: What is behind the statistical data from *SCB*? Furthermore, the way of processing, data quality, sources of errors and other comments will be clarified in the following. The statistical data background from *SCB* is the most important source in this method. Therefore, only this source will be analysed in the following.

SCB created an extensive handbook about all necessary information regarding prepared statistical data. This handbook will be the base to examine the questions in the following.

The database consists of further statistical sources:

- AREL: annual electricity, gas and district heating statistics (e.g. district heating, electricity)

- ICE: industry's annual energy use (e.g. wood fuel) and
- KOMOLJ: oil delivers, presented by municipality (e.g. numbers for petrol and diesel)
- A model based on surveys in single-family houses. A trend for households is to be determining due to previous calculated data. Therefore, in 2003 nearly 100.000 single-family-houses were interviewed about their energy situation. It is assumed that a special percentage rate about the usage of bio fuels will be the same about the years.

AREL and ICE collect data on national level and KOMOLJ only on municipal level.

SCB works on the bottom-up-principle. Also in that case national data is broken down on regional and municipal level with the help of special indicators. The reason for this will be mentioned in the following.

It is mentioned in the statistic handbook about the possibility, that some data from several sectors not available. For example, the data from LPG, natural gas, peat, waste, black liquor and other are only prepared from industry sector. Also important is that some data is excluded from special sectors. For instance, data from refineries, gas plants and coking plants are excluded from point 3 in main table and, in addition, aviation fuel is excluded.

It is important to know, that the petrol stations provide information about the supply of petrol and diesel and not about the final consumption. It is assumed that all delivered fuel will be used in the period.

When it comes to electricity, one has to know that network operator specify the transfer into municipalities. It assumes that the supply is equal with the usage.

Altogether, further studies or statistical sources for *SCB*'s statistic sheets have good baseline conditions. Not all data will be taken into the sheet, only at a certain responsible and significant number. They hid the number, if they have less than three sources, if one source causes more than 50% or more of the number, and if two sources cause 75% of the number. The reason is, the numbers have not to show detailed information about large important industries or energy suppliers.

Broadly, it must be ensured that the national data is not complete. The reason is the security and privacy of company data. Mostly, the companies do not like to disclose their data for calculation on municipal level. The extension on national level is not as considerable as on municipal level. Incomplete or excluded data from any company may result on municipal level in a high restriction of data or they are totally missing. Therefore, the data quality on municipal level is deeply influenced. In the Energy report at several places there is no data and signet with "…" or anything else. The reason is above mentioned problem.

Measurement errors ought to be studied more closely as well. The main problem from KOMOLJ is to allocate the energy supply to the municipality. Up to a certain extent AREL has nearly the same problem in the field of heating supply. Also device errors and false reports are hard to define, when data from previous year is absence. At the end, on municipal level every uncertain source can be represent the data in a slightly other way.[43]

New insights provide new information about further developments of *SCB*'s statistic measures. Some sources will be collected in one, because in that way, more data can be collected and published.

According to statements on RUS homepage, they mentioned to have most correct data which are also comparable on national and international level. Unfortunately, there is no further detailed information available regarding the data quality of RUS. Furthermore information about the other sources is not available and cannot comment.

3.2.2. Method from municipality of Växjö

Structure and general information

The city Växjö started their environmental strategy in 1993 and in that way, the first Energy- and CO_2-balance has been prepared. This balance, which is equivalent with the base energy inventory, the city Växjö started their strategy to become a "fossil fuel free city". Based on that CO_2-Balance, precise goals were set and which can be controlled over the time. Also methods of improvement can be derived since that time.

In the early 1990 statistical data was not available. Therefore, Henrik Johansson, responsible for that issue within municipality Växjö among other things, started to collect Energy data in an Excel-Sheet. He began to summarise data from approximately ten main energy parts and refined it year by year.[44]

Just at the beginning it has been focused on getting data in a very good quality and data which is able to present the nearly real energy and CO_2 situation from Växjö. Therefore, all information for the energy balance is coming from sources which deliver almost real energy data, for example

[43] C.f. Statistika centralbyrån: kommunal och regional energistatistik 2007 EN 0203, 2009, p.2ff

[44] Johansson, H., description about energy balance from City of Växjö kommun (n.Y.), p. 1f & Johansson H., Interview, 2011-07-04

from energy companies and environmental reports and a low amount from *SCB*. It is also important to specify the boundaries of the system, which was done also with the first balance. The preparation method of Växjö is described in the following.

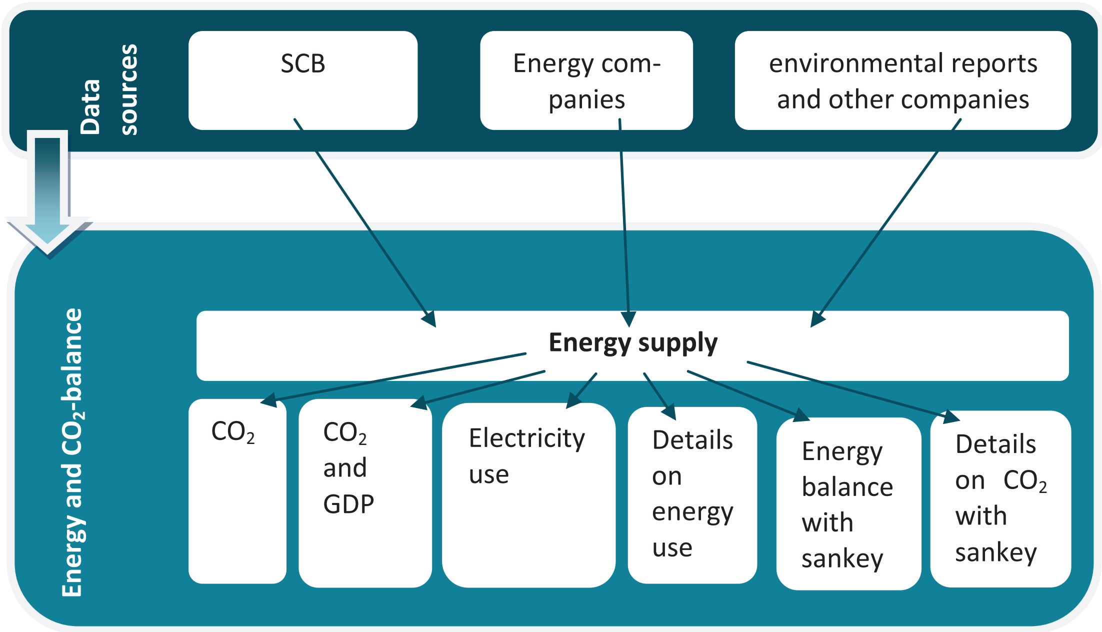

Figure 7: Overview about the method from municipality Växjö

The Method: energy supply - origin of data

The table "energy supply" is the main table to be used as base for all other tables and figures to be created. In Table 8 all relevant energy data from municipality of Växjö is pictured. Thus it appears in which fields the fuels will be used in detail.

Table 8: Overview about main table "energy supply" of Växjö's Energy and CO_2-balance[45]

	1990	*...*	*2009*
Gasoline (m3)			
of which fuelled as gasoline			
of which part of E85			
Diesel (m3)			
Aviation fuel (m3)			
Oil, Eo1 (m3)			
of which Sandvik CHP plant			
of which Rottne DH[46] plant			
of which Ingelstad DH plant			

[45] Source, simplified: Johansson, H.:Energy and CO2 1993-2009, 2011, Excel-sheet

[46] District heating

	1990	…	2009
of which Braås DH plant			
of which Lammhult DH plant			
of which dwellings			
of which others (service, industry)			
Oil, Eo5 (m3)			
of which Sandvik CHP plant			
of which others (service, industry)			
Peat (GWh)			
Woodfuels (GWh)			
of which Sandvik CHP plant			
of which flue gas condensation			
of which Rottne DH plant			
of which Ingelstad DH plant			
of which Braås DH plant			
of which Lammhult DH plant			
of which Räppe DH plant			
of which other larger boilers			
of which the Airport			
of which household boilers			
Imported electricity (GWh)			
of which renewable			
of which non-renewable			
Local wind power (GWh)			
Local hydropower (GWh)			
of which municipally owned			
of which others			
Biogas (GWh)			
of which electricity production			
of which heat production			
of which vehicle fuel production			
Solar energy (GWh)			
of which at Värendshus			
of which Ingelstad DH plant			
of which PV systems			
of which swimming hall			
of which households and others			
Ethanol (m3)			
of which used by public transport			
of which part of E85			
of which blended into gasoline			
FAME (m3)			
of which used by public transport			
of which blended into diesel			
of which technical department			
Heat pumps (GWh)			
geo-heat pumps (numbers)			
air heat pumps (GWh)			

	1990	…	2009
Straw (GWh)			
LPG (GWh)			
Ecopar (m3)			

The data from the company is received as total amount. But for development of further estimations it is important to share the energy data with different fields of origin. The *SCB* evaluates data in different fields. The municipality Växjö calculates only the percentage rates and transfers it to the original data. Therefore, energy data received from companies could be calculated in deeper structures.

The municipality of Växjö is not able to receive energy information about diesel, gasoline and ethanol by companies or other original sources. Therefore, the data from *SCB* has to be taken. The amount gives information about the delivered fuel to different places (gas stations, power plants, etc., s. also Table 8). With oil it is the same procedure. The information for oil is retrieved from power plants and also from *SCB*. Both data is compared. If there are differences between the data, the most realistic information is taken for the energy balance. The Swedish Petroleum and Biofuel Institute provides information that 5% of ethanol is being blended into gasoline (but 15% of gasoline is blended with ethanol to the fuel E86) and 5% of Fame[47] blended into diesel.

The aviation is also important, because an airport is located in municipality Växjö. Therefore, information about frequency of occurrence air traffic has to be included in the balance. Every year, the airport company has to prepare an environmental report. On base of this report, the only possibility is to calculate with petrol consumption.

The municipal energy supplier "*VEAB*" provides households with district heating on base of biomass. A special amount of peat has to be mixed in, to make the process more efficient. The yearly consumption of both fuels is passed by *VEAB* to the municipality. In addition, the company has to produce more heat only in winter, while the consumption is higher than in summer. The amount of bio fuels is not sufficient enough in that time and so, oil has also to use for energy supply of Växjö's inhabitants.

Furthermore, biomass is to be used in few households to heat up their houses. The amount of this number is not able to receive about *SCB*, but an inventory provided from chimney-sweeps gives answers about the increased usage every year and possible revisions from current systems. Växjö

[47] Special oil

has six solar plants installed on the roofs of schools and city administration. The number of solar energy is estimated in a similar way.

Sweden's inhabitants are allowed to choose between many electricity suppliers. In this context, it could be hard to get information about the total consumption, which is used within the geographical boundary. In the energy balance of Växjö is shown "imported electricity" and electricity produced within the municipality, for example, on base of biomass, small scale hydro power and wind power plants. To separate both parts as far as possible, one more source has to be use. The municipal grid operator can retrieve the amount in total, which has been transferred over the grid. Based on mentioned sources, the municipality can deduce now how much electricity is produced within the boundary. The difference both numbers provides information of used electricity, produced inside and outside the boundary. However, also in that case, grid operators sometimes cannot provide complete information about using electricity because of security reasons.

Information about geo-heat pumps installed in households, amount of biogas which has been produced at sewage treatment plant, local wind power and hydro power plants is retrieved from different municipal departments.[48]

"Sometimes, the information about energy sources reaches the city 'by accident or luck'. There was an article in the local newspaper about one farm in the municipality using about 0,4GWh straw to heat up its own localities. This information was therefore included in the energy balance.

The information of 'liquefied petroleum gas (LPG)' is based on statistics from *SCB*. Ecopar (which is fossil synthetic diesel) is used by the municipality, so municipal departments are providing me with this information"[49] said Henrik Johansson. All data in Table 4 are given in different units and it has to be adjusted accordingly.

The Method: Data Evaluation in different ways based on table energy supply

The energy balance from Växjö starts with an overview from energy supply from all listed fuels and also the separation in renewable and non-renewable electricity. The main table (Table 8) is the starting point for all following tables and the data was evaluated in different ways, which is described now. Most of the measures are not complicated and visible with description of numbers and units. All other measures will be described in detail.

[48] C.f. Johansson, H.: description about energy balance from the City of Växjö kommun (n.Y.), p. 1f. & Johansson H.: Interview, 2011-07-04

[49] Ibid.

1) CO_2 (Appendix 4, A)

In some evaluations, the temperature changes have an impact on different fields. At the end it is crucial for the CO_2 balance. For instance, in times when it is colder outside, people heat their houses more than in warmer times. The reason is more consumption of heating fuels. Therefore, it has to be estimated a decision who showing the real situation without temperature change, because of the comparison of CO_2 emissions in Växjö from year to year. For this only the number of temperature days is necessary. They are different between countries. In Sweden, the temperature days are measures every day if the average temperature is below +15°C. For instance, if the average temperature is 0°C it would account 15 temperature days and if it is -15°C is would count with 30 temperature days. This numbers are including in the tables. On base of this, has to be calculated the change over the years compared with the number of 1993. The temperature day in 1993 have the number 1 (starting point) and the following year shows in a short way, if the temperature was higher (over 1) or lower (under 1) than in 1993. It has to be also considered in the measurement to take account of only a half of the temperature variation.

$$calculation\ factor = 1 + 0{,}5 * \frac{\left(temp.day_{year\ of\ evaluation} - temp.day_{1993}\right)}{temp.day_{1993}}$$

Also in this folder the CO_2 emissions are measured with CO_2-equivalent factors (Table 9) and the numbers of main parts, sign in light grey in Table 8. The sources for CO_2-equivalent factors are coming from the Swedish Environmental protection Agency.

Afterwards, a diagram shows the trend of CO_2 emissions in transport, heating and electricity sectors per capita from 1993 until now. It shows also how far away the numbers to the emission target in 2015 will be. But it has to be different measurements before:

- The amount of heating and electricity has to be identified separately from the number of local CHP plant Sandvik. That means, with the help of numbers of wood fuel supply, peat supply and produced electricity from Table 8 the share of electricity from peat and their CO_2 target can be calculated.
- Calculation of CO_2 emissions from electricity used for heating: the sum from imported electricity and CO_2 from peat, which are measure before, multiplied with the given percentage on heating divided with 100.
- Calculation of CO_2 emissions from electricity used in transport sector: in the same way than electricity, but with the percentage rate of transport.

- The number of CO_2 emission for transport field is the result of the sum of CO_2 emissions from Gasoline, Diesel, Aviation fuels, Ecopar and electric transport. The number of CO_2 from heating sector is to be calculated from the sum of CO_2 emissions from oil, peat, and electric heating minus peat for electricity. Afterwards it is to be divided with the temperature day calculation factor. This factor means the increase or decrease of temperature compared to 1993. The number of electricity is calculated with the sum of CO_2 emissions from imported electricity, LPG, peat for electricity and minus CO_2 from electric heating as well CO_2 from electric transport.

Table 9: CO_2 index for necessary fossil fuels in from Växjö[50]

CO_2 emissions	CO_2-index	
Gasoline	2,28	ton/m3
Diesel	2,68	ton/m3
Aviation fuel	2,36	ton/m3
Oil, Eo1	2,68	ton/m3
Oil, Eo5	2,97	ton/m3
Peat	386	ton/GWh
Wood fuels	0	ton
LPG	234,37	ton/GWh
Ecopar	1,99	ton/m3

2) CO_2 and economical growth

At another folder once can see the trend of CO_2 emissions and economic growth. In this context the numbers from Växjö and Sweden per inhabitant are compared (in SEK, kg and %). For developing this, only the number of inhabitants, the GDP and number of total CO_2 emissions from the previous folder is taken. From another diagram in this folder the trend regarding CO_2 emissions, energy and GDP (all numbers per inhabitants) can be seen, which shows a good view about the development over the last years. The number of inhabitants and total GDP is received from *SCB*.

3) Electricity use (Appendix 4, B)

In the part “electricity use”, the consumption of all electricity sources will be recorded and a figure illustrates the trend from electricity consumption per capita over the years from: imported electricity from renewable and non-renewable electricity, local wind power, local hydropower, PV plants, biogas and electricity based on a CHP plant.

[50] Source: Johansson, H.:Energy and CO2 1993-2009, 2011, Excel-sheet

4) Details on energy use (Appendix 4, C)

Afterwards, the folder shows a detailed survey of energy supply divided into main emission parts: Transport, Heating and electricity. At first, the share of renewable energy in these parts is out-sourced and observes a trend of recent years. Another figure shows the consumption of every energy component, which accrues in transport, heating and electricity part. The detailed analyse is also graphically represented in all parts.

5) Energy balance with sankey

In the last folder named "energy balance" is at first divided in the parts conversion, distribution and usage and afterwards split into further issues. The Table 10 is an extract of this folder and shows mentioned issues.

Table 10: Extract from folder "energy balance" of Växjös Energy- and CO_2 Balance[51]

Conversion	*1993*	*...*	*2009*
Combined heat and power plant (CHP)			
From oil			
From peat			
From wood fuels			
District heat plant (DH)			
From oil			
From wood fuels			
From solar energy			
Distribution	***1993***	***...***	***2009***
District heating			
From CHP plants			
From DH plants			
Electricity			
From CHP plants			
From renewable electricity			
From non-renewable electricity			
From local hydro power			
From biogas			
From PVs			
From local wind power			
Use	***1993***	***...***	***2009***
Transport and machinery			
From gasoline			
From diesel			
From ethanol			
From FAME			

[51] Source, simplified: ibid.

From biogas			
From aviation fuel			
From electricity			
From ecopar			
Dwellings			
From district heating			
From oil			
From pellets/ wood			
From solar energy			
From heat pumps			
From electric heating			
From household electricity			
Service, industry etc.			
From district heating			
From oil			
From pellets/ wood			
From solar energy			
From electricity			
From biogas			
From straw			
From LPG			
Losses			
From district heating			
From electricity			

The part "use" is the most interesting feel. Therefore, to clarify the energy consumption in this part a Sankey diagram is plotted. In this Sankey it is shown the energy flow and how much and which energy source enter in view parts. For this reason, it is it shows the present state and controlled the objectives. As well as saving potentials can be conducted.

6) *details on CO_2 with sankey*

The folder "details on CO_2" examined the energy consumption in the same way than in folder about energy details. But here only the extended emissions of field "use" are mapped. So, the including numbers are the same as in Table 10 mentioned under "use".

For Växjö it is not possible to calculate the emissions, which emit from special transport types. Only the total amount of transport sector is available. The statistical source called RUS estimates CO_2 emissions from cars, light trucks, heavy trucks/busses, other transports and machinery. There, the amounts are distributed from national to municipality level. However, they only provide CO_2 data not associated energy data and data of current year can only be provided with delay of 1 year. Researchers discovered also, that the CO_2 amount of transport sector by calculating from Växjö disagrees with the calculated amount of RUS. These problems are reasons why the amounts cannot be include 100% in the figure of Växjö. For this reason the municipality measure the percentage of every transport type and this ratio can be applied on Växjö's calculated transportation amount. With the help of this calculation, the distribution of emissions occur in Växjö's municipality can be done more detailed. Even in this part, a sankey- diagram pictured the data, too.[52]

Data Quality

The most of the data is coming from energy companies. Small proportions are requested by environmental reports, other companies and *SCB*. The companies reported all data, which are available. Henrik Johansson mentioned, that some data can be secured and therefore not 100% reality. It is different every year. Therefore, the data quality is totally good, but with including of statistical data it will never be exact. When companies or institutes, from which *SCB* receive data from, makes mistakes or do not provides all data, it will have impact also on Växjö's figures. Chapter 3.2.1. has already been informed about the data quality by *SCB*.

It can be assumed that the environmental reports from aviation are correct. Unfortunately, there is no description about the data quality in this field available.

[52] C.f. ibid. & Johansson, H.: description about energy balance from the City of Växjö kommun (n.Y.), p. 1f.

4. Incentive Systems to expand Renewable Energies in the countries

People only invest in Renewable Energy Projects, when it is attractive to build. Therefore, it has to exist a responsible financial basic. Renewable Energies investments are long-term investigations where people need a safe system. Furthermore, it has to expand Renewable Energies very quickly and establish on the renewable goals from the country.

Germany's way to expand the Renewable Energies in the country and to reach their climate goals build on the base of different laws. Beside "The Renewable Energy Sources Act" (EEG), "The new Renewable Energies Heat Act" promoted also the expansion of renewable energies. The most important is the EEG, which will only be described in this chapter.

4.1. Germany's incentive with "Renewable Energies Sources Act"

The EEG was passed for the goal to develop away from fossil fuels like coal, oil, natural gas and nuclear power, forward to increase the renewable Energies in Germany. So it is one of the most important climate protection instruments for Germany. It supports the increase and minimization of energy supply costs, which are accrue about a long term, and also the distance to fossil fuels. Furthermore, all technologies should be promoted, which produce alternative electricity.

The first EEG was decided in 2000 and thereby, the law for energy supply became replaced. Every fourth year the law will be revised. The newest version of 2009 comprised the object to increase renewable energies to 30% in 2020 and after this time, it will increase continuously. The electricity production from follow systems: photovoltaic, wind power, hybrid power, biomass, geothermal and landfill gas.

4.1.1. Function of the EEG-procedure in general

Operators of power generation plants on the base of renewable energies receive a definite rate of remuneration per kilowatt hour. It will be financed about a contract period over 20 years. The network operator is bound to receive the electricity produced by renewable energies at predetermined conditions. The ratio of remuneration is also determined in the EEG. But there are other remunerations for each technology, depending of their size and location.[53]

It includes also a degression, where the remuneration will be reduced by fixed percent. It means that the operator of a plant gets less money, when he/she will commission it at a later time than others. But it does not mean that, operators get less money from year to year over a period from 20 years (more see follow). More information about this will be described in detail in follow.

Due to the fact, that alternative electricity is more expensive than conventional electricity and because of purchase obligation, the costs are allocated to user by network operator n order to a price difference (more information see next description).

EEG levy

The costs for electricity user in households is approximately 24,1 ct/kWh in 2010. Among other things, the EEG-levy is including in this invoice. Therefore, the consumers will be involved to the expansion of renewable energies directly. The Table 11 shows that the levy between 2008 and 2011 has almost been tripled.[54]

Table 11: EEG levy development over the years

EEG-levy and its development	***Height of levy***
EEG levy 2011	3,5 ct/kWh
EEG levy 2010	2,0 ct/kWh
EEG levy 2009	1,30 ct/kWh
EEG levy 2008	1,10 ct/kWh

4.1.2. Other important information

Fact is that the system engineering, for example, is very expensive. Therefore, among other aspects the degression system should settle incentives to reduce these costs and established renewable energies on the market.

The law also allows priority supplying of electricity produced by alternative technologies, and also an immediately and priority connection to the electricity grid. In order to guarantee a secure purchase of clean electricity, network providers have to expand their grid.[55]

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[53] Cf. EEG-2011.de: Home, 2011, URL: http://www.eeg-2011.de/, 2011-07-10.

[54] Cf. Ibid.

[55] Cf. Bundesverband Windenergie e.V.: Das Erneuerbare-Energien-Gesetz (EEG), 2011, URL: http://www.eeg-aktuell.de/das-eeg/, 2011-07-10.

4.1.3. Remunerations of renewable energies which were support by EEG – the youngest developments

In the following there is shown necessary information about renewable energies provided by EEG 2009 and subsequent modifications. Renewable Energies according to the law are hydroelectric power plants, landfill gas, gas from purification plants, mine gas, biomass, geothermal plants, wind energy plants and radiant energy plants.

1) Hydroelectric power plants

The remuneration for electricity from hydroelectric power plants are divided into new plants and modernized plants to a performance installation from 5MW as well as new and renovated plants over an installation from 5MW. Fallow tables shows remunerations for different systems and also other necessary information. The remuneration measure is based on equivalent performance and shares of performance a period. One example is showing in Appendix 5.

Table 12: Summarized information from new and modernized plants to performance installation from 5MW[56]

<table>
<tr><th colspan="4">New plants to 5MW: no degression, remuneration over 20 years</th></tr>
<tr><th>Commissioning year</th><th>To 500 kW [ct/kWh]</th><th>500kW-2MW [ct/kWh]</th><th>2MW-5MW [ct/kWh]</th></tr>
<tr><td>From 2009 to +20</td><td>12,67</td><td>8,65</td><td>7,65</td></tr>
<tr><th colspan="4">Modernised plants to 5MW, commissioning before Jan. 01st 2009 and modernised after Dec. 31st 2008 : do degression, remuneration over 20 years</th></tr>
<tr><th>Commissioning year</th><th>To 500 kW [ct/kWh]</th><th colspan="2">500kW-5MW [ct/kWh]</th></tr>
<tr><td>From 2009 to +20</td><td>11,67</td><td colspan="2">8,65</td></tr>
</table>

Operators of modernised plants will get the remuneration, when plants demonstrable are in good environmental conditions.[57]

[56] Source specified, tans.: BMU: Vergütungssätze und Degressionsbeispiele nach dem neuen Erneuerbare-Energien-Gesetz (EEG), (n.y.), p. 2.

[57] Cf. Juristisches Informationssystem für die Bundesrepublik Deutschland: Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz - EEG), 2008, p. 12.

Table 13: Summarized information from new and renovated plants to performance installation over 5MW[58]

New or renovated plants over 5MW with commissioning before Jan. 01st 2009 and modernised after Dec. 31st 2008: degression 1,0%, remuneration over 15 years					
Commissioning year	***to 500 kW [ct/kWh]***	***to 10 MW [ct/kWh]***	***to 20 MW [ct/kWh]***	***to 50 MW [ct/kWh]***	***From 50MW [ct/kWh]***
2009	7,29	6,32	5,80	4,34	3,50
2010	7,22	6,26	5,74	4,30	3,47
2011	7,14	6,19	5,68	4,25	3,43
2012	7,07	6,13	5,63	4,21	3,40

Renovated plants over 5MW have to prove higher performance installation than before.

2) Landfill gas

Due to material in waste and biochemical degradation processes from organic compounds, landfill gas is arises. It consists at most of methane and carbon dioxide. Because of large proportion of methane, landfill gas is flammable and can be used for heating and electricity production.[59]

According to §24 EEG 2009, the remuneration for landfill gas to a performance installation 500 KW is 9,0 cent per kWh. The remuneration for performance installation up to and including 5 MW is 6,16 cent per kWh.

Operators are able to achieve a higher remuneration, which are produced from innovative technologies in accordance with information of the law (bonus for technology, see below).

3) Gas from purification plants

Gas from purification plants is also called fermentation gas and it arise with help of anaerobic degradation of organic matter. It is used in thermal power stations and can be produced from almost all organic waste. The product of this process is also heating and electricity, which can be used for instance in the power station by itself or the electricity can be feed in the grid.[60]

58 Source: trans. BMU: Vergütungssätze und Degressionsbeispiele nach dem neuen Erneuerbare-Energien-Gesetz (EEG), (n.y.), p. 3.

59 C.f. KATALYSE Institut für angewandte Umweltforschung e. V., Deponiegas, (n.y.), URL: http://www.umweltlexikon-online.de/RUBabfall/Deponiegas.php, 2011-11-03

60 C.f. Pro2 Anlagentechnik: Klärgas, (n.y.), URL: http://www.pro2.de/t/22_67.html, 2011-11-03

The remuneration of electricity produced by gas from purification plants up to and including 500 kW is 7,11 Cent per kWh and for performance installation up to and included 5 MW is 6,16 Cent per kWh. (§ 25 EEG 2009).

Also at this point, a bonus for innovative technology is applied.

4) Mine gas

Mine gas is released from mining of coal and it consists also at most of methane. Also from closed mines the gas can be used on the surface due to large release of methane. The usage of this gas is the same than the both gases mentioned above.[61]

The remuneration of electricity produced by mine gas, for the performance installation

- Up to and included 1 MW is 7,16 Cent per kWh
- Up to and included 5 MW is 5,16 Cent per kWh
- From 5 MW is 4,16 Cent per kWh.

Mine gas is only eligible, when the gas is coming from active or close down mining's.

The rate of remuneration could also increase regarding the bonus for innovative technology.

5) Biomass

Under §27 EEG 2009, the remunerations from electricity from biomass, a performance installation

- Up to and included 150 kW is 11,67 cent per kWh,
- Up to and included 500 kW is 9,18 Cent per kWh,
- Up to and included 5 MW is 8,25 Cent per kWh and
- Up to and included 20 MW is 7,79 Cent per kWh.

Vegetable oil methyl ester is necessary for the process and so it is deemed to be biomass.

Over performance installation from 5 MW, the plants are only entitled for remuneration when they produce their electricity by CHP plants in accordance with information of the law (bonus for CHP).

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61 C.f. Interessenverband Grubengas e. V., Grubengas, 2011, URL: http://www.grubengas.de/german/grubengas_g.htm, 2011-11-03

For plants which include also other biomasses, operators are able to get only remunerations, if they keep documentation about charge materials.

The remuneration could increase, when operator produce electricity from biomass by innovative technologies, renewable raw material or liquid manure and CHP.

6) Geothermal

Up to a performance installation of 10 MW, operators from geothermal plants receive remunerations from 16,0 Cent per kWh. When the commissioning is taken place before January 1st 2016, operators could receive remuneration for their electricity from 4,0 Cent per kWh in addition. Installations with a performance from 10 MW receive 10,5 Cent per kWh.

Increased remuneration for geothermal installation is also possible, when electricity combined with energy recovery is produced (each 3,0 Cent per kWh) and combined with petro thermal technology[62] (each 4,0 Cent per kWh).

7) Wind energy plants

In EEG there are three subdivisions for remunerated electricity produced by wind energy: Onshore plants, existing, repowering able onshore plants and offshore plants.

Electricity, which is produced by onshore wind energy plants receive a starting remuneration from 9,2 cent per kWh during the first five years. Including this number is a basic remuneration of 5,02 cent per kWh, which is available after the five years and over the whole duration time for onshore wind energy plants without degression. So it is a fixed number. But operators may extend the five-year period. Behind this is a very complicated measure, which will be described in the following (remuneration list see Appendix 5, number B):

Every wind energy plant has its own reference yield depending on hub high and others, which is listed in Appendix 5 from EEG. After five years, the energy supplier measures effective output, which is an arithmetic mean after 5 years. When the effective output is higher than 150% as the reference yield, the remuneration will increase by 2 month per 0,75%.[63]

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62 „Use of low lying heat reservoirs, they have no or only very low channel flow [...].” Tr. by GtV Bundesverband Geothermie (n.d): „Petrothermale Geothermie”, URL: http://www.geothermie.de/wissenswelt/geothermie/technologien/petrothermale-systeme.html, 2011-07-12.

63 Cf. Juristisches Informationssystem für die Bundesrepublik Deutschland: Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz - EEG), 2008, p. 15.

Wind energy plants, which stared operation between December 31st 2001 and January 01st 2009, are able to receive a bonus system for service and increase their remuneration by 0,7%. For this, operators have to make a technical retrofit[64] at their past machines before December 31st 2010. For new plants with this retrofit, they will receive 0,5% more. The bonus system for service is paid for plants with a commissioning date before January 1st 2014.[65]

When operators install a plant over 50 kW, it has to present an environmental report. In this report they have to show evidence that the machine is able to work 60% of its reference yield at the planned location. Only with this report, the energy supplier shall be entitled to pay the remuneration for the energy input.

Repowered wind energy plants receive 0,5% more to starting remuneration listed above, when they fulfils following conditions:

- One or more plants have to replaced into the same or neighbouring administrative district
- Commissioning date has to date back to 10 years and
- The power has to be doubled at least and maximum quintupled.

In Appendix 5 B an overview with all mentioned information from 2009 to 2015 is presented.

For Offshore wind energy plants there is a basic remuneration from 3,5 Cent per kWh. In the first 12 years starting with commissioning, the starting remuneration is 13,0Cent per kWh. Turbines could receive a higher starting remuneration, when:

- The commissioning date is before January 1st 2016: 2,0 cent per kWh increased performance
- Minimizing land distraction from 12 see miles and a minimize installation from 20 meters deep in the water: 0,5 month more for every additional full mile and 1,7 month more for every additional full meter.

[64] The grid stability has to be upkeep. For this, wind energy plants have to install a system, which is compatible with the grid. With this technical installation, wind turbines performance are able to turn completely down to a fixed percent rate (100%, 60%, 30%, 0%), in times when energy demand is low. Without this system, turbines could only deactivated or work.

[65] Cf. BMU: Vergütungssätze und Degressionsbeispiele nach dem neuen Erneuerbare-Energien-Gesetz (EEG), (n.y.), p. 10.

8) radiant energy plants (PV and solar)

The EEG remunerated energy for electricity produced plants, which are installed to or on houses and plants for large areas. After the year 2009 and with the rates of remuneration from EEG 2009 the commissioning of radiant energy plants boomed immensely. So, a new remunerations system was needed and it was written down in the amendment 2010.

The old single-stage system was removed from the new on (see following). With the beginning of 2010, the remuneration will be separated into three parts throughout the year.[66]

Table 14: Compensation for electricity fed into the grid for Photovoltaic systems divided in different power scales[67]

Commissioning	Degression	Remuneration
Up to 30 KW power		
2010-01-01 - 2010-06-03	9,00%	39,14 Cent per kWh
2010-07-01 – 2010-09-31	13,00% special cut	34,05 Cent per kWh
2010-10-01 – 2010-12-31	3,00% special cut	33,03 Cent per kWh
2011-01.01 – 2011-07-01	13,00%	28,74 Cent per kWh
Up to 100 KW power		
2010-01-01 - 2010-06-03	9,00%	37,23 Cent per kWh
2010-07-01 – 2010-09-31	13,00% special cut	32,39 Cent per kWh
2010-10-01 – 2010-12-31	3,00% special cut	31,42 Cent per kWh
2011-01.01 – 2011-07-01	13,00%	27,33 Cent per kWh
Up to 1 MW power		
2010-01-01 - 2010-06-03	11,00%	35,23 Cent per kWh
2010-07-01 – 2010-09-31	13,00% special cut	30,65 Cent per kWh
2010-10-01 – 2010-12-31	3,00% special cut	29,73 Cent per kWh
2011-01.01 – 2011-07-01	13,00%	25,86 Cent per kWh
Larger than 1 MW power		
2010-01-01 - 2010-06-03	11,00%	29,37 Cent per kWh
2010-07-01 – 2010-09-31	13,00% special cut	25,55 Cent per kWh
2010-10-01 – 2010-12-31	3,00% special cut	24,79 Cent per kWh
2011-01.01 – 2011-07-01	13,00%	21,56 Cent per kWh

Bonus systems

As described above, operators from renewable energy plants in compliance with the EEG are able to increase their remuneration when they fulfil the bonus system regulations.

[66] Cf. Juristisches Informationssystem für die Bundesrepublik Deutschland: Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz - EEG), 2008, p. 15 ff.

[67] Source trans. EEG-2011.de: Home, 2011, URL: http://www.eeg-2011.de/, 2011-07-10.

In the bonus system for innovative technologies conditions regarding gas processing and innovative system engineering are described. If operators fulfil these conditions, they can get a higher remuneration from 1 to 2 cent per kWh depending on describing law conditions.

Bonus for electricity from renewable raw materials could be between 1 and 7 cent per kWh more than starting remuneration. In the appendix of the law a description of which material is renewable and also other conditions are presented.

The CHP-Bonus could also increase the starting remuneration, when plants fulfil conditions present in the appendix of the law. For example in the fields of housing (heating, coaling and hot water preparation), generate heat from industrial processes and heat for animal stables.

Furthermore, bonus for energy recovery is also available in accordance with regulations by law.[68]

4.2. Sweden's system to promote renewable electricity production – The Electricity Certificate System

Renewable energies already play a great role in Sweden. It is the country with the highest proportion of renewable energies in the EU.

The Swedish kingdom support the expansion of renewable energies and energy efficiency in the country with different promoting instruments, for instance funding system for research and development as well as planning of wind energy plants, regulatory mechanism of taxes, financing programs for energy efficient municipalities and financing support for installation of photovoltaic systems on houses. The most important promoting program is the "Electricity Certificate System" for electricity produced by renewable energies and peat. This chapter give necessary information about the incentive program.

4.2.1. General information and aim of certificate system

The Certificate System entered into force in January 2003. The aim was to increase renewable electricity production of 12 TWh during the period from 2007 to 2016 compared to 2002. So, in 2016 the total electricity consumption shall include 17TWh renewable electricity. In the year 2009, Sweden and Norway signed the agreement in principle and founded a joint market for "green electricity certificates", which will be started in 2012. With this joint green certificate mar-

[68] Cf. Juristisches Informationssystem für die Bundesrepublik Deutschland: Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz - EEG), 2008, p. 32 ff.

ket, Sweden increases their target of renewable electricity production additionally of 25 TWh by 2020. Afterwards, the allocation period of certificates was expended to 2030.

Renewable power plants are entitled to “green” certificates for maximum 15 years. With this regulation, power plants with a commissioning date no later than 2016 will be promote and receive electricity certificates up to 2030. Renewable plants existing before the system was introduced are able to receive certificates until the end of 2012. Plants, which receive public financing support after 15th February 1998 are also able to receive electricity certificates until the end of 2014. The reasons of these conditions for renewable energy sources are the aim to keep down consumer costs.

The purpose of the market-based support system is also to increase power plants which produce electricity by renewable sources and new technologies.[69]

4.2.2. Supported Technologies

Within the electricity certificate system, fallowing renewable energy sources are entitled to receive support:

- Wind power plants
- Solar energy
- Wave energy
- Geothermal energy
- Biofuels
- Peat, but only when burned in CHP plants
- Hydro power

Wind, sun shining and raining days are depending on weather conditions from time to time. Therefore it is not simple to plan future electricity production.

Sweden has excellent conditions to produce biofuels. The most effective way to use technology based on biofuels are CHP plants, whereby electricity and heat can be converted. The originating heat can be used in public district heating plants or in industrial processes. The electricity produced by such technologies is more constant, the electricity can be forecast better and therefore

69 C.f. Ministry of Sustainable Development, Renewable electricity with green certificates, 2006, p. 1

it is more reliable instead of many other renewable sources. Therefore, in winter time there is needed such a reliable technology, when the weather conditions for other alternative energies are not the best. Due to this fact, the largest proportion of produced electricity in this period is coming from CHP plants. Due to the different operational areas for using of biofuels, they are CHP plants, biogas plants and industrial back pressure within the certificate systems. In this connection the fallowing biofuels were needed in the last years: products from forests, products from forest industries, other wood waste, energy crops, peat and biogas.

Peat is used as a fuel in CHP plants and normally not classified as alternative fuel. But for the reason, that it is being displaced by coal and thus more environmental friendly, it was included in the scope of the certificate system only in combination with CHP plants.

Also very important energy source are hydro power plants. No matter if there are new plants or renovated old plants in the system, it is a sustainable investment. They have to fulfil special requirements. Small scale hydro power plants with a maximum installed capacity of 1,5MW per production unit at the end of 2003, new plants, plants which had been closed and afterwards were put into operation again and existing plants with an increased production capacity are only supported for instance.

The solar energy technique is interesting for private houses. The plants have to meet special requirements to for inclusion within the certificate system. They have to measure hourly electricity production and send reports about it. For small scale plants, the cost of metering is too expensive and exceed the revenue receive from the system. Therefore, the benefit is not proportional to the effort and so it does not make sense.

4.2.3. Description of procedure in general

The electricity suppliers have to purchase electricity certificates. The number of certificates is depending on a certain percentage of electricity, which they sell. This is called as their quota obligations. Every year, at the latest than 1st March of each year, the suppliers have to submit a return to the Swedish Energy Agency with the special amount of their certificates (quota) and with amount of electricity which they invoiced to their customers during the previous year. This return is necessary to fulfil their obligations. No later than 1st April of each year, the supplier require to report the calculated number of certificates to the Government. Afterwards, the Government are able to perform the cancelation of certificates. Only then, the company can purchase new electricity certificates for the coming year. “The quantity of certificates to be purchased is adjusted from year to year in step with progressive changes of the quota proportion, thus generating an increasing demand for the certificates."[70]

This regulation applies also for electricity-incentive companies as well as for electricity users, which produce their electricity by themselves, import or buy on the Nordic power exchange. The differentiation of "electricity-incentive companies" is defined in the guideline about the green certificate system.

The electricity producer based on renewable energies and peat, receive not only revenue from their produced electricity, but also the proceeds by selling their certificates for each MWh from renewable energy sources mentioned before. The revenue from produced electricity is equal for each renewable source. The whole process is shown in Figure 8.

[70] Swedish Energy Agency, The electricity certificate system, 2009, 2009, p. 9

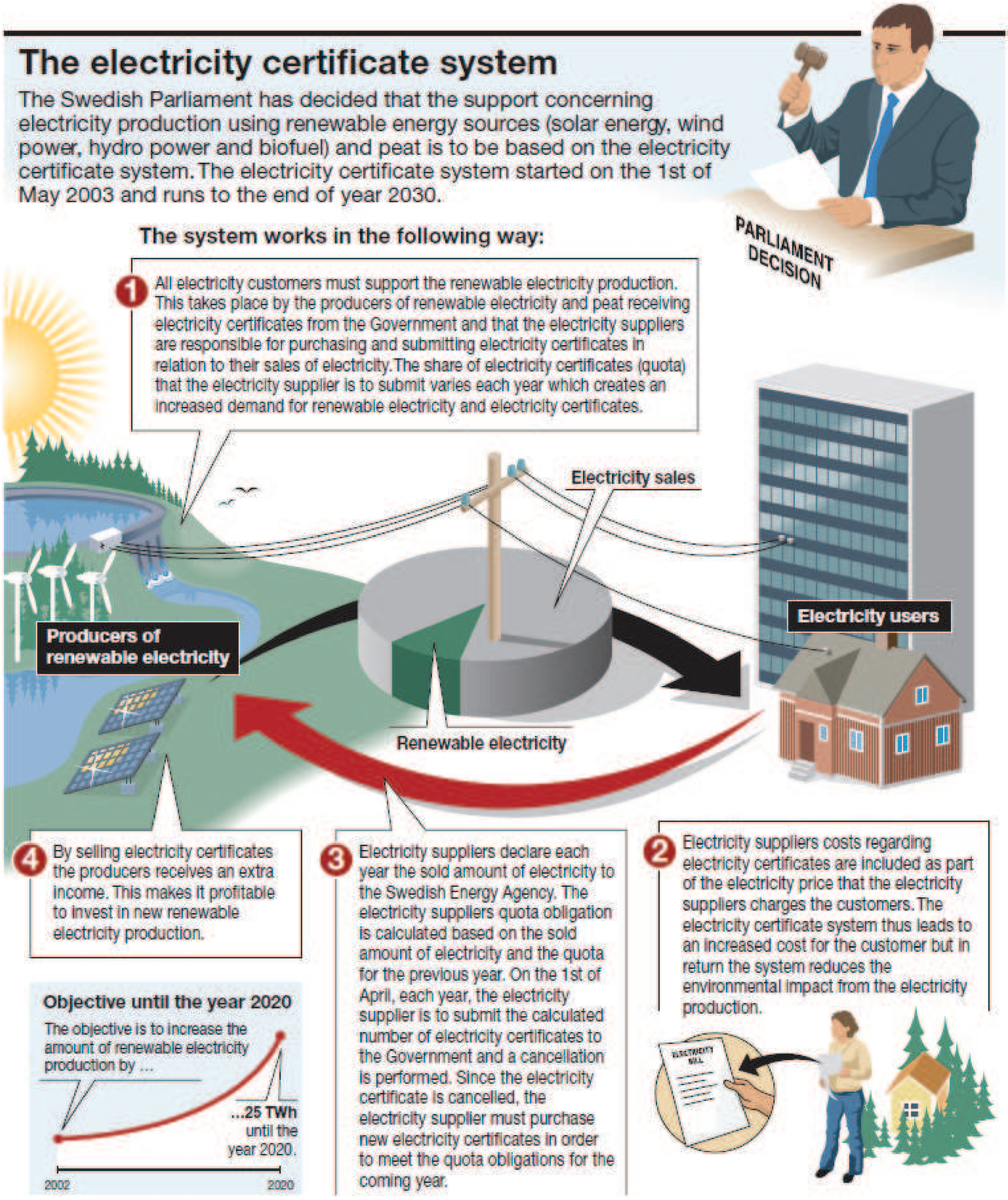

Figure 8: The functionality of electricity certificate system[71]

[71] Source: Swedish Energy Agency (2009), p. 11

4.2.4. Important information within the process of green certificates

Quota

Each year, the numbers for "Quota" are calculated on base of forecast values of future electricity production from renewable energy sources and from peat as well as of future electricity use in Sweden. To achieve the target, the quota obligation has to increase from time to time. It is absolutely not simple to reach the number expected, because it is difficult to know before, how much electricity will be supply to the customers and also when exactly planned projects will be put into operation. In addition, the production of renewable electricity is depending on several external factors, for instance temperature and precipitation. Also the amount of electricity produced from wind power and solar plants, for instance, depend on sunshine hours and wind intensity of previous year.

Certificate's Cancellations and penalty fee for quota obligations

As mentioned before, on basis of information in annual return submit to Swedish Energy Agency (at least 1st March), the Government can be calculating the company's quota obligation (at least 1st April) and account if the company have purchased too few certificates. In this case, the company have to pay a quota obligation penalty fee. It is calculates with 150% of the volume weighted average price of electricity certificates incidental during the last season from 1st April to 31th March of the following year. Every year, the penalty fee is limited with a special amount. For instance in 2008 the fee was amount to 431 SEK for each certificate unit. The limitation is necessary to protect the customers against too high certificate prices.

Trading within the system

Certificates are traded by electricity companies which have the most cases their own trading department, industries, district heating companies as well as small electricity supplier and producer. The interest and circumstances of these parties are quite different. For this reason it has prevent to use brokers who are doing the trade instead.

The certificate does not exist in paper form, but they are trading on a virtual marked in form of spot contracts. On the trade involved parties are able to trade certificates for immediate delivery with immediate payment or as forward contract. In last case, the price is settled when the trading will take place, but the delivery and payment will be at this time when the certificates are needed. With bilateral agreements from seller and purchaser the trading will be done.

In order to participate on the trade, it is necessary for sellers and purchasers to have an account electronic register "Cesar", which manage the company "*Svenska Kraftnät*". Public and current prices as well as average price for certificates in monthly, weekly and historical form are published on the website of *Svenska Kraftnät*. In addition, all transfers are secured in the account and are available at any time.

The price is determined by supply and demand which happens on the market. There are different reasons for setting the price. On the one hand it is depending of expected amount of electricity production and new production capacity and on the other hand cause of changes in the system due to political decisions. In addition, the price is depending on current production respectively cause of different weather conditions and therefore from the numbers of certificates available. In times of certificate shortages, the price will rise and if there is a surplus of certificates is, the price will fall.

4.3. Swedish support for installed photovoltaic plants on houses

This program support started in July 2009 and complete in December 2011. The aim is to support house owners with their investigations in PV technology. If the plant produces electricity and heat in combination like a hybrid system, the only one condition is to receive grand is unless 20% of total energy consumption per year is generated by electricity. In addition, the support is only for one PV plant per house. If the house consists of some residential houses, there are PV plants eligible as much as exist residential houses on the property.

The conditions to be able to receive the support are that the plant is installed and get into operation between the mentioned periods. Afterwards the customer will get back 60% of investment costs. There are included labour costs, material costs and planning costs (eligible costs). The grand per plant is limited to two million SEK, the eligible cost per installed kW from electrical high-performance may not exceed 75.000SEK (incl. VAT) and the same for hybrid systems may not exceed 90.000SEK (incl. VAT). The responsible provincial government decided about awarding of funding and the payment is managing from regional planning authority.

With PV plants, the house owners are able to use the produced electricity by themselves, feed it into the grid or use both versions. Normally, there is a possibility for Swedish house owners to feed electricity into the grid, but it is a really hard way. Last year, all meters in houses were change into computerised meters. In General, the system is able to measure the electricity which was used and feed into the grid. The system sends the consumption also to grid operator automatically. Therefore, the operator has not to visit the consumer anymore and the bill includes the original consumption. But, the customer needs a second meter for measuring the produced electricity feed into the grid. To receive this special meter, the house owner has to ably for it by grid operator and they have the obligation to approve it. The operator has only the job to provide the service for this system, not to provide money for feeding electricity. It is the second task to do for the owner: To look about an electricity supplier who allow feed electricity into the grid and providing money for it. The remuneration is 0.5 SEK per kWh and when the house owner joining the green certificate system, they will receive extra money, but as mentioned before it is not efficient for small scale plants.[72]

[72] Swedish Energy Agency, The electricity certificate system, 2009, 2009, p. 5ff

5. Evaluation of CO_2 methods and increasing systems

5.1. CO2 Methods

5.1.1. Saxons method based on ECORegion

The web-based tool ECORegion can be used at all places all over the world with only conditions to have a web connection. With ECORegion there can be create individual CO_2 balances, because the diversity of aspects and situations can be different between municipalities and this was considered by developing of this tool. As seen in Figure 5, in some categories and numbers are entering two sources which help to show the trend from 1990 to nowadays. But these are small amounts and are necessary to describe the situation in the 90^{th}.

For instance, with the possibility to decision between two transportation measurements- about registered vehicles or numbers about miles travelled from different types. With this decision, municipalities with close motorway connection are not to be disadvantaged and can measure its CO_2-balance on base of registered vehicles. Customers can also decide to calculate the CO_2 emissions with LCA factors. Nevertheless, both methods are inherent in the same problem. Nobody knows if the cars only drive in the municipality all the time.

But one disadvantage is the calculation from air traffic. Really important to know is, there is still a problem with receiving information about numbers of air travellers within the boundary because the data are secured or not estimated. Therefore, it is the best possibility to average the numbers of all municipalities with the same share. According to statement by Stefan Vögel, employee of the company ECOSpeed, it is used by mostly costumers. But all municipalities, who measure in this way, have to consider that it does not reflect the real situation of its region and consequently cannot be influenced. Because, it is not possible to identify the real effect of actions, which can be processed by a special municipality.

The statistics in Germany cannot be provided on municipal level, but only on level of federal state. This makes the process more complicated. The reason is on the one hand that a certain number of companies keep their energy data under lock. On base of this, it is not possible to produce meaningful results for municipalities. On the other hand it is an obstacle because the statistical institutes resists and do not discover the true sense to create balances on municipal level.[73] With the "background paper for climate protection in Saxony" the Federal State determined strategic measurements to promote energy efficiency in Saxony and remedy the deficit by supporting of municipalities. One aim is to enable one uniform system to create municipal CO_2 balances on base of ECORegion and statistical data which shows the real few of Saxony's energy situation. In general, all municipalities have to create their own CO_2 balances separately and therefore all municipalities also have the same starting position: They do not know how to create it, where they can receive data from and more. Saxony wants to counter against this situation and push the process more by providing an individual web-based solution for all municipalities in Saxony. The combination from ECORegion agreed with Saxon data and the handbook with information where the statistical starting data can be received from is a good base to develop the first CO_2 balance. This attractive offer supports the municipalities all round.

There have been difficulties in data collection in most of the evaluation areas to find sources, which provide data from 1990 to nowadays continuously. Some data are only available at a special year. The gabs were closed by estimation from years after, for instance number of workforce from 1990. Or it was found other sources, for instance data from 1990-1992 from private households, ITS and manufacturing industry as well as data district heating production from 1990-1995 differ from the years after. It is not the best decision to calculate the balance on base of different statistical data in one area, because the data is estimated on different ways and therefore municipalities cannot do comparisons between years. But in this case they are only few years from the beginning of this evaluation.

However, also dada from energy consumption in economic sectors are not provided from Saxony's statistical sources, but they are necessary for the report. Therefore, they are estimate on base of ITS and numbers of working population. Also data from local public transport are available only at 2004 (passenger kilometres). From years before they were estimated based on two different numbers. Saxon specific data for cars and motorbikes are not available and were measured base on national data. These weak points should be considered cautiously, because the allocation is not possible to 100% and reduction targets cannot be defined much less pursue. For the starting balance can be made base on this numbers but for the following balances real data has to be found.

[73] Based on statements from Fritzsche, A. (2011)

Data for passenger kilometres for Saxony's air traffic and rail traffic are also not available in Saxony's statistic and can be estimated based on two data. In this context it is a good replacement and municipalities can be made its balances without problems.

Summary of this method

All in all, the ECORegion with Saxony's specific data is a well hand tool for creation CO_2 balance. The IE Leipzig found sources on Saxony's level, exclude few data. The data are coming from different sources, which are measured on different ways but all gabs will be closed with special evaluations. Therefore, the municipalities can be proceeded to have complete amount of data every year. At mentioned points or areas the municipality has to consider the weak points and different needed sources. Not only on these places, but also in nearly all fields of evaluation the municipalities should adopt the aim by itself to fill in real data step by step.

5.1.2. The statistical method from the energy agency ESS for a province

The balance from *ESS* is developed based on available data. In Sweden statistical sources are provided until to municipal level. When ones work with statistical data, they have to consider that there are some difficulties.

As mentioned in Chapter 3.2.1 the data of petrol and diesel delivered from petrol stations specified the value of supplying. It should be emphasised that the total petrol and diesel, which will be fuelled up within the municipality also may not be consumed in it. So it is also to see as a weak point. For instance the petrol station in the city Oskarshamn has the only one in the surrounding area between approximately 50 km and in the near of the motorway. One can proceed from the assumption that persons take a break in Oskarshamn, fuel up and subsequently drive further on the motorway.

The evaluation of energy data and CO_2 emissions specified the amount of emissions only occurring within the boundary. The energy data (*SCB*) and CO_2 emissions occurring in areas (RUS) are not calculated or summarized on same statistical source and therefore cannot be compared with each other. Another reason why CO_2 emissions are estimated on two different ways is, because *ESS* wanted to make it transferable into COM-system, which calculates the emissions based on fossil fuel consumption like with *SCB* way. It was not able to do it on base of RUS data, because there are only CO_2 data available.

As the *SCB*'s guidelines make clear, the user has to assume that the data constellation can be different from year to year. In some years also data is missing because not enough data is available.

This in turn is to be substantiated in security of data from big companies. When companies allow disclosure of their data for the preparation statistical reports at municipal level, more data could be published and the data quality would be better. The result is, that municipalities have to consider that and to make comparison between the years is also difficult. But if the numbers are not excluded, the user can make it sure, that the data is meaningful enough to include it in the CO_2 balance.

SCB's innovation makes it more complicated because many EU programs like COM want to have a more detailed CO_2 balance than it was before, the own CO_2 targets over the years cannot be compared and it is possible, that some reduction targets have to be defined new.

Summary of this method

The task of *ESS* was in this comparison to develop an energy and CO_2 balance for the Province of Kalmar County with it including 14 municipalities. It was the first job for the time being. Due to expenditure of time this method was the best appreciated option. The balance is well though-out and shows the fields of actions. When the province need this estimation to elaborate the first reduction targets on base of statistical sources is feasible as well as to get an overview about current situation. But when they want need it as general balance method they should think it over, if it is the best decision or have to take a critical look about all evaluated numbers at any time. Better is to include more real data.

5.1.3. Växjö's energy and CO_2 balance for its own use

The numbers of petrol, diesel and ethanol consumption in the municipality are taken from *SCB* and with combination there is the same weak point (s. chapter 3.2.2).

The data from petrol consumption is fuelled up at the airport, but not every plane has to be fuelled at every airport. Therefore, it is to be considered that not the total amount of emission based on air traffic is to be included.

The CO_2 emissions are calculated on energy supply data based on CO_2-equivalent factors. The amount reflects only the emit emissions occurring in the boundary without emissions emit in the surrounding area. To estimate the trend over the years, the weather conditions are also considered in the measurement by calculating with temperature days.

Summary of this method

All in all it is a well done method, which was developed over the years. Most of the data are real data, which means they reflect the real situation from the municipality. The responsible person tried to use as much as possible real numbers and revert to statistical data when there is no other possibility. But a small scale is received from *SCB* and environmental reports. As mentioned in chapter 3.2.2 it have to be consider that at this points will never be exact, but with the small amount of including numbers it is justifiable. The same shall be valid as well with respect to statistical data, which are only used for doing percentage distributions of some fields. For instance, in order to calculate the percentage of every transport type.

5.1.4. Comparison of three methods at glance

It is not easy to compare the three methods, because the methods have been developed in different ways. The Swedish methods can be compared more with each other, because the processions of data in some field are nearly the same. The German method is developed in a completely different way, but shows in the end nearly the same consideration. It was determined three points with similarities and differences in the view of data, which is described in the fallowing. It is not possible to compare the measurements in the fields, because in the one hand there is no information available for the Saxony's variant and on the other hand the data collection of the Swedish methods are also different.

Example one: Energy consumption shared in fields

ESS shows energy sources which occur in parts like agriculture, industry, households, public sector, others and transport sector. Saxony shows nearly the same parts with occurring energy sources, but they are able to separate it in more energy sources. The energy consumption of municipal buildings is shared in sectors, energy sources and energy consumption in other buildings. Växjö is able to demonstrate energy sources shared in their parts which is another subdivision. The municipality is also able to show electricity and heating consumption in household and electricity and heating in service and industry sector as a total amount.

Example two: Evaluation in Transport sector

Saxony is able to measure energy consumption on base of numbers of registered vehicles, personal transportation, long-distance passenger transport, transport of goods by road, other goods traffic and fuel consumption in municipal fleet. The detailed way of doing this is unknown. In the method of Växjö it is also able to see how much emissions are emitted from some car types, but it is not able to demonstrate the energy consumption. But the total amount of emissions and the total amount from public sector as well as the share of renewable within transport sector can be determined. However, in the method of *ESS* it can be only demonstrated the total amount of some fuels and separated in transport sector.

Example three: Renewable Energies

The renewable energies can be seen in three methods nearly on the same way. At the end it shows the total consumption of renewable energies, but in different sectors. In Saxony the numbers can be found, for instance, in sectors households, buildings and district heating evaluations. Whereby in the *ESS*' method is includes only an overview about renewable and non-renewable consumption. In the method from Växjö, the part is shown separately with all possible notes and is also included in some other parts.

Summary

All in all the Saxon method is more detailed and *ESS* is only able to show the energy data in describing way while the degree of detail is not so deep. Due to the possibility to receive a lot of original data, Växjö is able to evaluate the numbers in another and also detailed way.

In summary, quality of the evaluation of energy and CO_2 balances is always depending on the database. Not all municipalities are able to get real data and also the statistical database differs between countries. Therefore, it is not possible to transfer the method from one municipality to another one.

5.2. Increasing Systems

5.2.1. The German way to expand the renewable energies in the country - The EEG

With the EEG, the share of renewable energies at gross consumption increased from 6,4% to 16,8% in 2010 and with this the Government saved over 74 million tons. The goal to reach 12,5% in 2010 was reached already in 2007.

In the last years, there is a remarkable development in the electricity production from onshore wind power plants and usage of biomass strongly expanded. Also, PV suggests a large development since 2004 (Figure 9). In this Figure is also to see the importance of the novellas. The adjustment to innovations regarding development of technologies, prices and demand is necessary and shows that this system works well.

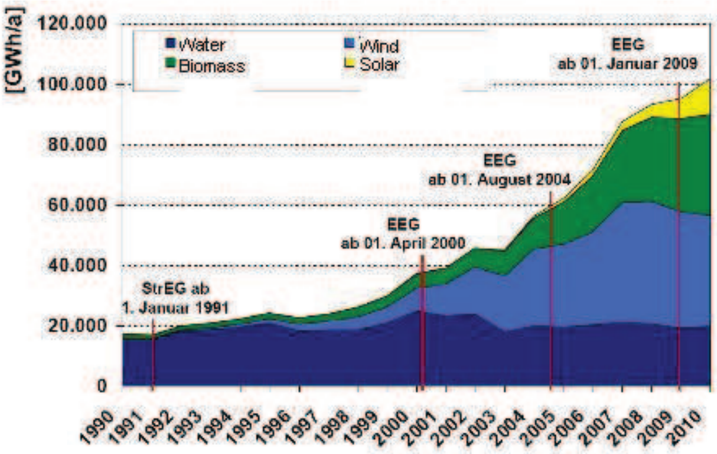

Figure 9: Trend of electricity production from renewable energies in Germany; 1990-2010[74]

As one can see, the Act has been reinforced very successfully. There are three reasons to list: The EEG ensures to its investors a high potential of safety because of priority to feed-in, fixed remunerations as well as obligations for grid connection and grid expansion.

Electricity price and remuneration rates

The share of EEG levy from renewable electricity production was 3.53ct/kWh by 2011. As it was shown in Chapter 4.1.1 Table 11, the levy went slightly up over the years at least from 2009 to 2010 only around 0,7%. But there was a massive increase from previous years until now. One reason for the rapid increase of EEG levy is supported by photovoltaic development in 2009 and 2010. The module prices were unexpectedly reduced and with result of over-supply, there was a high demand by PV users because of the lucrative business. After this development, the PV remuneration rate was revised downwards (described in chapter 4.1.3). Now, the newest degression depends on installations from the prevent year.

Normally, the remuneration rates have been reduced every years by a fixed the EEG-degression. But with the last novella(s) the remuneration was increased a little bit to push the expansion of renewable energies more. In Figure 10 appears that the remuneration will be a reduction by 2012 to 2014. After there will be a little push again, but it will never be increase at a second time to the same level than in 2011.

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[74] Source: BMU (2011); Entwurf EEG Erfahrungsbericht 2011; p. 5

Prospects

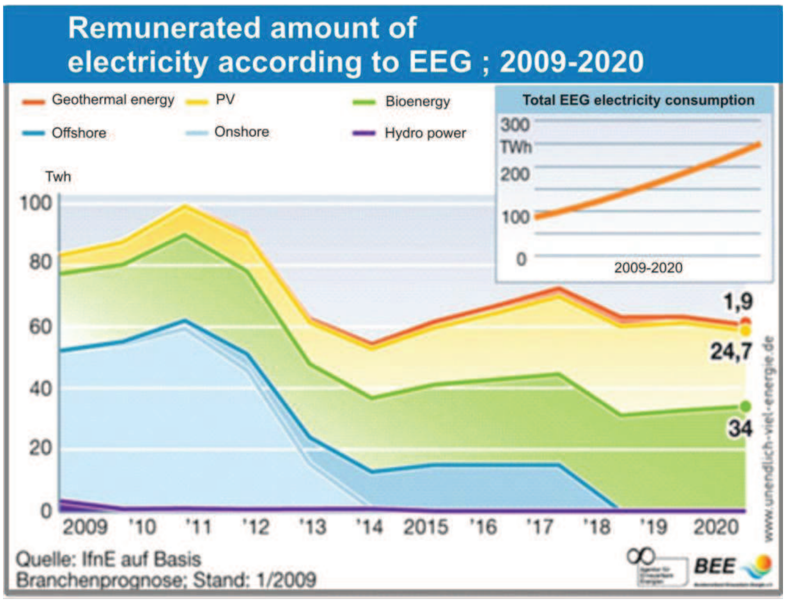

Figure 10: Future trend of remunerated electricity amount; 2009-2020[75]

On the base of expansion plants of Federal Government, the grid has to absorb the electricity produced by renewable energies. Currently, the grid is not yet designed for this high amount and therefore there are a lot to expand on this level. With this further object, the Government has also objects to the grid and market integration of renewable energies as well as flexibility system-wide. The last mentioned point is also called load management and means that the renewable energies have to be in a position to feed-in electricity only with a special amount- depending upon demand.

With the last mentioned aspect there is another approach for expand the grid and therewith also the renewable energies: If a wind power plant, for instance, has regulated its performance, a financial loss occurs which the grid operator have to pay as well. This argument in combination with the priority to feed-in the operator have to pay more and therefore forced to expand the grid soon as possible to avoid this payment.

The EEG is indispensable and adheres at the fundamental principles with the next novellas. Otherwise the expansion plans are not realisable. But remuneration ratios have to adjust to changing market conditions and make sure not to increase the load more that now.

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75 Source: http://www.eeg-2011.de/inf/eeg-bilanz.html, 2011-07-10

5.2.2. The Swedish Electrical Certificate System with financing support by the Government for house owners

The electricity production from renewable energies which qualifies for green certificate system is dominated by biofuels, hydropower and wind power. There is also a small scale of solar. Peat is not defined as renewable source, but it plays a decisive role for the efficiency of the production. With the change to accept the combustion of peat in combination with CHP plants, the electricity production from such plants rose up to 254GWh more than in the year before. Therefore, it is listed separately. In Figure 11 the trend is demonstrated the trend from the green certificate system since the beginning in 2003 and only from sources which are entitled for the system: The expansion from renewable energies still growth. The electricity production was tripled from 5,6 TWh by 2003 to15,5 TWh by 2009 (without peat it is 14,7TWh). It is an indication for the well development of the certificate system.

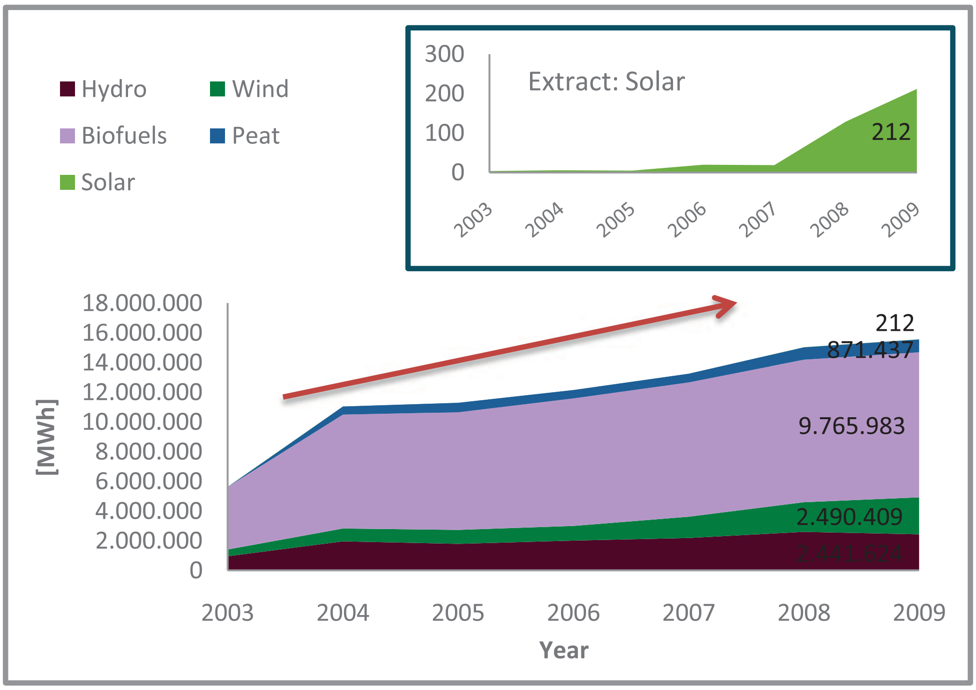

Figure 11: Electricity production from renewable energies and peat qualifies for the green certificate system [MWh], 2003-2009[76]

Price for electricity certificates in combination with quota obligation

Generally, the supply and demand determined the price at the market. In the electricity certificate system, the demand is regulated with the quota obligation. That means, all parties who participate to the system have to buy certificates for their electricity use or sale corresponding to a cer-

[76] Source: Database: Energimyndigheten (2010), Energy in Sweden 2010, p. 33 (Appendix 6, Table 15)

tain proportion. The quota will rise up every year. A consequence, the amount of certificates will increase and with this also the numbers of new renewable plants.

The Figure 12 shows the trend of the spot price from the beginning of the system until now. In 2006, the price rose and after 2 years, in 2008, it was at the currently highest point. It is an indicator for a relatively good revenue level of the system.

The investors in new alternative plants have the safety to receive certificates for 15 years, but it is clouded with uncertainty regarding the price. The price is achieved in the market place between the interactions of supply and demand. Therefore, the investors cannot calculate with a fixed price every year. However, as long as the quota obligation exists, a guarantee for continuous demand of electricity and certificates is to be recorded. More information to the quota effect, see in follow.

In addition, with the increase of quota obligation over the long-term arise another effect. The parties who have to buy certificates can choose if they want to buy more certificates every year or safe energy and therewith money.

The grid operator transfers the costs to end user and he pay the expansion with the electricity invoice. Regarding to statements from *ESS*, the amount will be rise up every year but only to a certain amount, which is reflect in places after comma.

Figure 12: Average spot trade price for electricity certificates, 2003-2009[77]

Every renewable energy source can be promoted by certificates with the same amount. On the one hand, the investor is free in choosing their renewable source. On the other hand, no special source can be pushed.

[77] Source: Energimyndigheten (2010), Energy in Sweden 2010, p. 34

Prospects

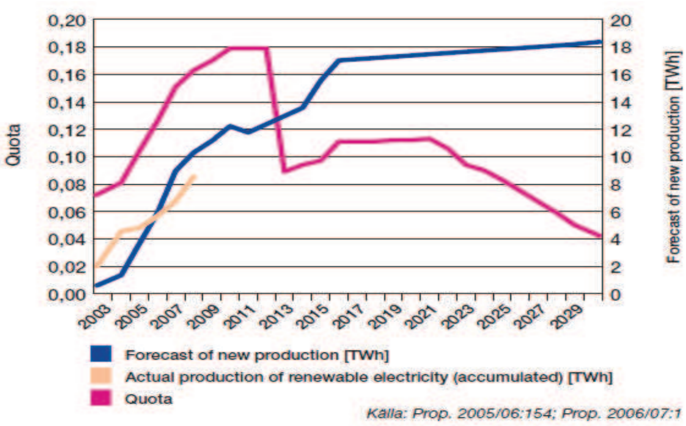

Figure 13: Forecast new renewable electricity, Quota and actual values; 2003-2030[78]

As one can see in the Figure 13, the Quota will be reduced at the beginning of 2013. The reason is the phasing out of certificate system from some plants at the end of 2012. The electricity production will be reduced by renewable energy plants and peat. With this effect also the certificates available will be reduced. Also at the end of 2014, a smaller amount will be phased out with the result of an increase in the quota will be slightly flattened out. However, it does not mean the end of the certificate system. Also in the Figure provided, the electricity production will be increase constantly. The plants, which leave the system, will be replaced from new plants which are in the planning phase and therefore the certificates can be received from the new one.

With the expansion of allocation period, the consumer costs can be keep down in the long term and increase the expansion in new renewable electricity production.

The potential of wind energy plants is immensely high. Not only because of their climate conditions, but also regarding their topological structure it is an interesting area. Thus, has been made available not yet. However, in the near future it is expected a true boom in installation of wind power plants. For instance, regarding information in the certificates' report from 2009, in 2008 was disbursed a second grand by the state fund (Pilot Fund) to support offshore projects. The grand is leaving out at the end of 2012.

In 2012 some new projects will be connected to the grid. For instance, the electricity production from Sweden will be 1TWh more, produced by CHP plants. The electricity production from hydro power will be 0,42 higher in 2012 and 7 TWh will be produced from new wind power projects by 2012.

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[78] Source: Swedish Energy Agency (2009), The electricity certificate system, 2009; p. 16 (Appendix 5, Table)

Less support for house owners with PV installations

The Government support also new PV plants after the installation with an investment grant. But the program will leave out by the end of 2011. Currently, there is no extension in sight.

The Swedish inhabitants have also the possibility to feed their produced electricity by PV cells in the grid. But the way is really hard and could be take long time. Small scale plants are too small that the effort is too high and makes no benefits.

With both arguments concludes that the support for the most of the Swedish PV plants are too lousy to expand PV plants in the country more.

5.2.3. Summary about incentive systems from Germany and Sweden

The German system offers an incentive to invest in renewable energies with the remuneration to feed in, which is specially designed for each alternative source and adjusted to new market situations. The incentive in the Swedish system is provided with the quota obligation on the one hand by a forced to purchase a special amount of electricity to users and on the other hand there is the possibility to install more renewable plants with the results of more certificates which are needed.

The fixed remuneration over the lifespan of the plants provides more investment security to their stakeholders than in the electrical certificate system.

As it is demonstrated in Figure 2, Sweden's currently electricity consumption is based on approximately 50% from renewable sources. The German value is only approximately 20%. It shows clearly that Germany has to do more to reach its reduction targets and for this, the EEG is the best decision. It seems the Swedish Government has been chosen deliberately to increase the renewable energies in the country. As it was described, the certificate system does not debit the electricity invoice of their customers so much than with the German method. In view of the fact, that Sweden is closer to their reduction targets, the electricity certificate system is the best decision for the Government and their inhabitants.

6. Conclusion

The thesis described three different CO_2-balancing methods from municipalities in Germany and Sweden. The Saxony energy agency found a reason for their municipalities based on the software-tool “ECORegion” and with Saxon specific statistical database to create energy and CO_2 balances in future. The energy agency for southeast Sweden developed an energy balance on base of municipal statistical sources for all municipalities in Kalmar County and the municipal of Växjö has the possibility to create an energy and CO_2 balance based on mostly real data for itself. Additionally, there are described also two inventive systems to expand the renewable in the countries. Germany focuses on the EEG and Sweden on the electrical certificate system. Before, the thesis gives a brief from past to future energy situation from Germany and Sweden as well as general and economic information. Both countries purchase remarkable reduction targets and expansion plans for renewable energies.

The evaluation regarding incentive systems of renewable energies from Germany and Sweden proves that both methods are good functioning instrument to expand the alternative sources in their country. A critical perspective, the Swedish certificate system is considered with high risks more than with the German EEG system. In addition, there are lousy incentives to invest PV plants in private houses, because there is currently no supporting program to expect.

Based on the systems, the future renewable projects will be growing in both countries. Nobody knows if the countries will reach their expansion targets for real, but the evaluation shows that both countries are in the right way to reach it with their specific methods.

This evaluation shows in additionally, that the CO_2 balances depend between municipalities because of different evaluation method, databases and amounts of data. For this reason, it is difficult to compare the balancing methods with each other and they are also not transferable another one. In addition, the CO_2 emission values can only be seen as own tendency not as 100% significant value of their produced emissions.

On base of available data and regarding municipal objects, the municipalities have to find the best possible way to evaluate the data in anyway. The CO_2 balance should only be used to control the own targets and in order to compare not with other one. It is not a game. It should be considered as a way together. Because, the municipalities can only be reach national reduction targets through a shared effort.