ENERGY BALANCE OF NORTHERN SAVONIA 2008

Thesis

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Master's Degree Programme in Industrial Management

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Abstract

The aim of this thesis was to prepare the energy balance of Northern Savonia comprising the year 2008. The purpose of energy balance was to clarify the present state of energy management in the region of Northern Savonia in order to support local planning and decision making, and to produce information for Bioenergy Programme of Eastern Finland. Bioenergy Programme of Eastern Finland is determined to develop the use of renewable primary energy sources in the regions of Northern and Southern Savonia, Northern and Southern Karelia and Kainuu.

Energy balance consists of the elements of primary energy, energy production and energy consumption. Primary energy is used to produce energy in terms of heat and electricity. The produced energy is consumed by housing and agriculture, industry, services and buildings, and transportation. If there is not enough energy production inside the region, energy will be imported.

Energy management aims to increase the amount of the solvency ratio of heat and electricity production by adding the amount of renewable primary energy sources and by improving the energy efficiency in all operations.

Characteristics for the energy management of Northern Savonia is decentralised heat production, dependence on imported electricity, and the high usage of renewable energy sources, especially peat, black liquor and solid wood fuels. Wood processing industry is not only the biggest consumer of energy but also the remarkable producer of energy.

In the future, it will be challenge for Northern Savonia to turn the negative population development into positive. This can be done only by remaining the existing work places and creating new ones within the next ten years. Northern Savonia is rich in renewable primary energy sources and potential new work places can be found in energy business.

Regional Council of Northern Savonia is working on to advance the use of local primary energy resources such as forest chips, biogas and field biomass, to develop harvesting methods and technology, and to create the production capacity of bio fuels.

Keywords
Energy balance, energy production, energy consumption, primary energy

Confidentiality
Public

PREFACE

The final thesis was carried out in Varkaus, for Savonia University of Applied Sciences within the time period of September 2009 – May 2010.

Regional Council of Northern Savonia has done several researches on the present status of Northern Savonia in terms of energy, but a comprehensive energy balance had not been done before. The need to prepare energy balance for Northern Savonia was developed by Bioenergy Programme of Eastern Finland, which is working on to increase the use of renewable primary energy sources in the regions of Northern and Southern Savonia, Northern and Southern Karelia and Kainuu.

I would like to thank the supervisor of the study, Jukka Hautamaa for a flexible and kind assistance along the process. I also would like to thank the experts of energy participating in the "ESET Meeting" in Mikkeli in September 2009. The meeting was an excellent kick-off for the final thesis. Thank you for that, Timo Karjalainen from Kajaani University Consortium, Antti Karhunen from Lappeenranta University of Technology, Urpo Hassinen from the Forestry Centre of Northern Karelia and Mika Muinonen from the Energy Agency of Southern Savonia.

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1 INTRODUCTION

Today, Northern Savonia is the domicile of 248 000 people and 30 000 summer cottages. In Northern Savonia, 8 % of work force works for agriculture while the domestic average is 4 %, and forests cover 79 % of the land area. Industry is concentrated in the biggest towns of the region. Typical for the energy management is that the heat production is decentralised and the main of consumed electricity is imported.

Bioenergy Programme of Eastern Finland is determined to develop the use of renewable energy sources in the regions of Northern and Southern Savonia, Northern and Southern Karelia and Kainuu. Energy balance is prepared for each region to support local planning and decision making, and to provide information for Bioenergy Programme of Eastern Finland. The development of the usage of energy sources is followed up regionally, in order to respond to the goal of European Union to increase the use of renewable energy until year 2020.

The final thesis was prepared to provide information for the update of Bioenergy Programme of Eastern Finland 2015. Energy balance of Northern Savonia has not been researched in this scale before.

Energy Balance of Northern Finland 2008 is prepared on the basis of energy information given by local energy producers, and the statistics of Tilastokeskus, VTT and Finnish Energy Industries. In addition to the energy balance outcome, the results of the study contain the contact list of the local energy producers to enable the update of the energy balance in becoming years. The update procedure has been considered in the end of the study.

2 BACKGROUND OF THE STUDY

The region of Northern Savonia belongs in the Regional State Administration (former province) of Eastern Finland together with the regions of Southern Savonia and Northern Karelia. As part of the update of the Bioenergy Programme of Eastern Finland 2015, the regions of Northern and Southern Savonia, Northern and Southern Karelia and Kainuu were issued to prepare or update their energy balances for year 2008.

Savonia University of Applied Sciences was issued to prepare the Energy Balance of Northern Savonia 2008, and the task was considered to suite well as the subject of Master's final thesis.

There was a meeting in September 2009 concerning the update of Bioenergy Programme of Eastern Finland 2015, in which the representatives of regions were present. The meeting provided a lot of good contacts and practical information about data sources available and problems to expect when gathering information from energy providers. The meeting was an excellent kick-off for the final thesis. The meeting also provided a couple of interesting research problems concerning the handling of energy information, which will be pondered in the study.

Energy Balance of Northern Savonia 2008 is a complex subject for a study. Not only because the needed information is spread all over the region but also the lack of operating instruction for the handling and analysing of information. The challenge of the study was to enable the comparability of the energy balance with the energy balances of other regions. To enable this, it was found reasonable to utilise the final thesis of Antti Karhunen concerning Energy Balance of Southern Savonia 2006. The energy information of Southern Savonia had been handled by using an Excel sheet, prepared for the need, and the exact Excel sheet was taken in the use of Energy Balance of Northern Savonia 2008 as well. The Excel sheet was found a useful tool for handling energy information, and the tool will be represented in more detail later in the study.

2.1 Goals and Scope of the Study

The goal of the study was to gather energy information for the energy balance, analyse the gathered information, prepare the energy balance sheets and write the report. The gathered energy information was also sent for initial data to Timo Karjalainen, who works in Bioenergy Programme of Eastern Finland and was issued to combine the energy balances of the regions of the programme. For the first time, the energy information of Northern Savonia was regarded comprehensively in the above mentioned programme.

In addition to presenting the results of Energy Balance of Northern Savonia 2008, the study will concentrate on finding solutions for a couple of research problems which were occurred within the organisation of Bioenergy Programme of Eastern Finland. The problems to be considered concern the comparison of the energy balances of different regions, dealing of imported electricity in energy balance, and the conflict of the classification of peat. The updating of the Energy Balance of Northern Savonia 2008 will also be planned later in the study.

2.2 Research Methods of the Study

It was suggested by the supervisor of the final thesis, that energy information to be gathered for energy balance would be done as a project work by the students of the Energy Technology and Economy course. The suggestion was taken into action, because the schedule for gathering energy information was challenging.

The project work was started on the 29th of September 2009. The students of the course were divided into seven teams and the municipalities of Northern Savonia were assigned to the teams. The random division of municipalities was not very successful, because the amount of work was not divided equally. It was also found inconvenient that energy companies such as Savon Voima and Fortum Heat and Power, operate in several municipalities and several students asked for same things from one company.

Project work was carried out within six lectures. The assignment was to look for energy producers in the assigned municipality, and find out which fuels do they use and how much energy do they produce. In addition, students were assigned to calculate the amount of energy used for transportation and heating of buildings excluded from district and electrical heating. The training material given to students is found attached (Appendix a).

Teams gathered the energy information of energy producers into the Excel sheet, originally prepared by Antti Karhunen. The Excel sheet is found attached (Appendix b).

Along the project work some students complained about the amount of work required to issue the assignment, and some students suffered the lack of motivation to carry out the project work at all. Despite the resistance of a few students all teams returned their results, with the references, and nearly all of them on time. More missing and faulty information was expected, but the results were surprisingly good. Therefore, it is an option that the update of Energy Balance of Northern Savonia 2008 would be done as a project work in the future if there is no professional organisation to take care of the update.

After receiving the results of project work the energy information was checked detail by detail and collected into an Excel sheet. Due to the confidential energy information given by energy producers, the Excel sheet with detailed energy information will not be included into the final thesis.

The final thesis will describe the energy management of Northern Savonia on the basis of gathered energy information. Internet was proved to be a good source of up-to-date energy information. In writing the final thesis, Internet sources such as the emission permits of Finnish Energy Market Authority and the environmental permits of Finnish Environmental Administration, the articles and statistics of Finnish Energy Industries, and the websites of Motiva, Regional Council of Northern Savonia, Centre for Economic Development, Transport and Environment of Northern Savonia (ELY Centre) and various companies, regional energy agencies and interest groups were utilised.

3 BASICS AND THEORY OF ENERGY BALANCE CALCULATION

Energy balance presents the transformation of primary energy into heat and electricity consumption and transportation. The usage of primary energy, energy production, losses and forfeiting and energy consumption are all taken into the consideration in energy balance.

Anything which consumes energy can be turned into energy balance. The goal of the final thesis was to determine the energy balance of Northern Savonia, but the reviewed object could be e.g. a single fuel, a farm or factory or even the world.

Figure 1 shows the object whose energy balance is reviewed. Inputs on the left are primary energies and outputs on the right are energy consumption in terms of heat, electricity, transportation fuels and losses.

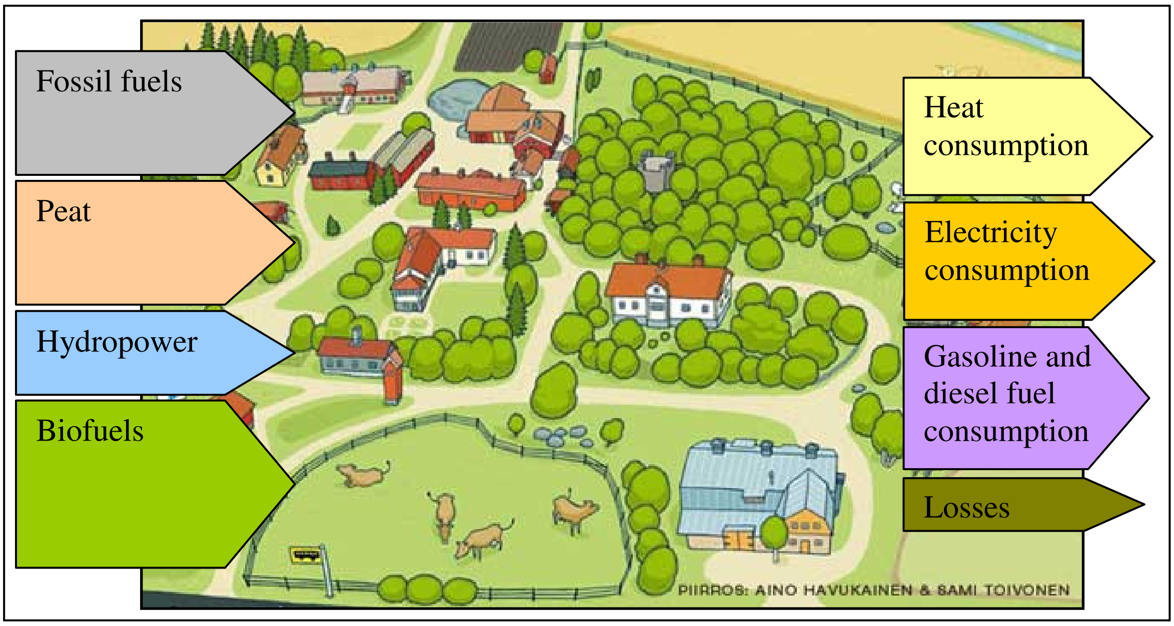

Figure 1. Principle of energy balance

Energy information was mainly gathered directly by contacting energy producers and asking for the detailed energy information. Figure 2 shows the heat and power plants of Northern Savonia in year 2005. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomi – Uusiutuvan energian mallialue)

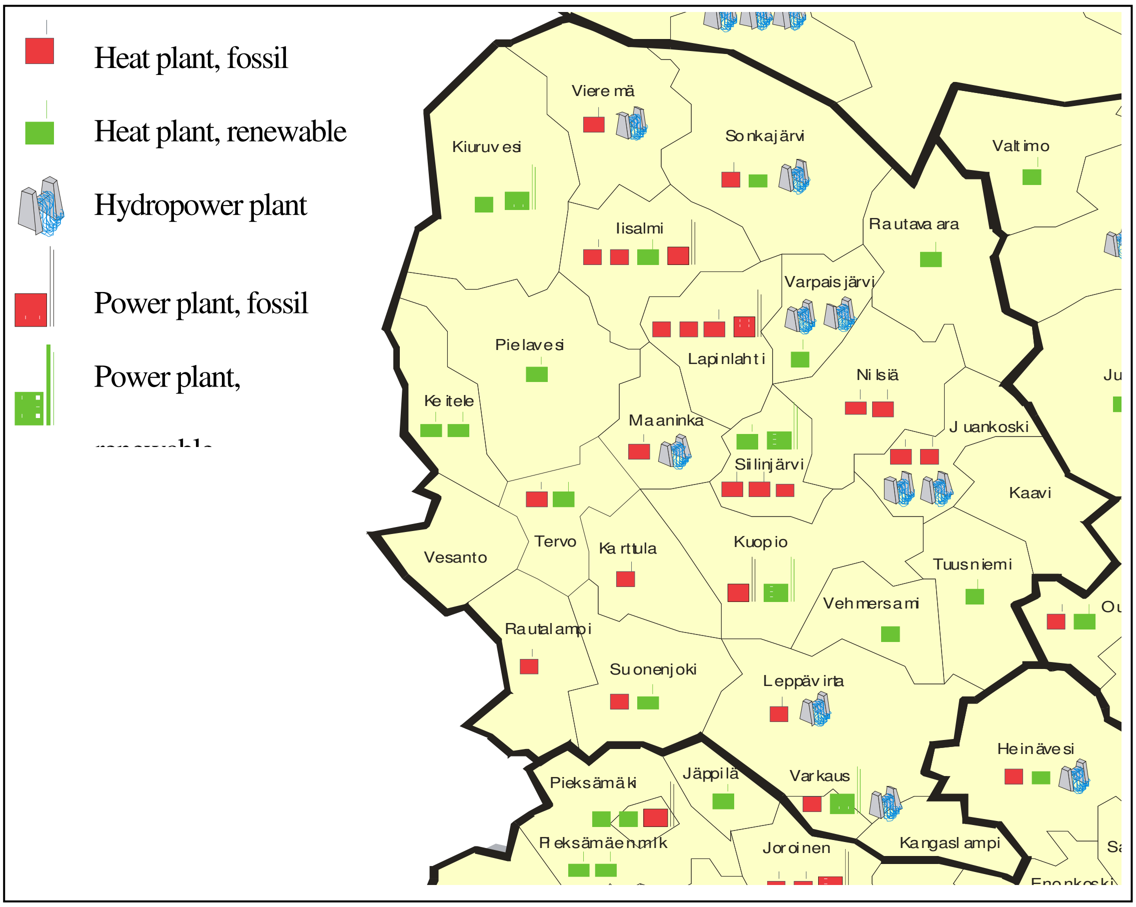

Figure 2. Heat and power plants of Northern Savonia in 2005

The inquiries were made by e-mail to receive a reference as a return and this way, to enable reliability of the results. Small energy producers were not easy to be found, and it was also found problematic that small energy producers did not give e-mail address in company registers. Therefore, several small energy producers could not be contacted. In addition to direct contact, energy information was also looked for in Internet, using sources such as EMAS-reports of companies and Register of Finnish Biogas Association.

The gathered energy information was entered into the Excel sheet, originally prepared by Antti Karhunen (Appendix b).

The Excel table includes three sheets:

1. Sheet 1 is a frame for gathered energy information.
2. Sheet 2 summarises the energy information of municipalities.
3. Sheet 3 presents the energy balance of Northern Savonia and each municipality.

Figure 3 shows a part of Sheet 1 which is a frame for gathered energy information.

PROJEKTITYÖ: ENERGIATASEEN LAATIMINEN
POHJOIS-SAVON ENERGIATASE 2008

	PRIMÄÄRIENERGIALÄHTEET						
	ÖLJY [MWh]			KAASU [MWh]			KIVIHIILI [MWh]
	Raskas	Kevyt	Liikenne	Maakaasu	Nestekaasu	Biokaasu	
KUNTA 1							
Voimalaitokset							
Lämpökeskukset							
Teollisuuden prosessivoimalaitokset							
Erillislämmitys							
Liikenne							
Muut							
KUNTA 2							
Voimalaitokset							
Lämpökeskukset							

Figure 3. Sheet 1 is a frame for gathered energy information. (Finnish)

Energy production plants were added under each municipality. The following columns to the right contain primary energies (inputs), and then produced heat and electricity (outputs).

Figure 4 shows a part of Sheet 2 which summarises the energy information of municipalities.

	PRIMÄÄRIENERGIALÄHTEET						
	ÖLJY [MWh]			KAASU [MWh]			KIVIHI [MWh
	Raskas	Kevyt	Liikenne	Maakaasu	Nestekaasu	Biokaasu	
KUNTA 1	0	0	0	0	0	0	0
KUNTA 2	0	0	0	0	0	0	0
KUNTA 3	0	0	0	0	0	0	0
KUNTA 4	0	0	0	0	0	0	0
YHTEENSÄ	0	0	0	0	0	0	0

Figure 4. Sheet 2 summarises the energy information of municipalities. (Finnish)

Figure 5 shows a part of Sheet 3 which presents the energy balance of Northern Savonia.

Yhteensä

Vasen		MWh	GWh	Oikea		MWh	GWh	
Puuperäiset		0	0	Lämmönkulutus		0	0	
	mustalipeä	#JAKO/0!			teollisuuslämpö	0	0	
Maakaasu		0	0		kaukolämpö	0	0	
Tuontisähkö		0	0		erillislämmitys	0	0	
Vesivoima		0	0		sähkölämmitys	0	0	
Turve		0	0	Sähkönkulutus		0	0	
Polttoöljyt		0	0		yksityiset	lisätään	#ARVO!	
Kierrätyspolttoaineet		0	0		maatalous	lisätään	#ARVO!	
Kivihiili		0	0		jalostus	lisätään	#ARVO!	
Muu		0	0		julkinen ja palvelu	lisätään	#ARVO!	
				Häviöt		0	0	+ sähkönsiirto häviöt
Maakunnan sähköntuotanto		0	0	Maakunnan sähkönvienti		0	0	
YHTEENSÄ		0	0	YHTEENSÄ		0	0	

Tase	0 GWh
Virhe	#JAKO/0!

Figure 5. Sheet 3 presents the energy balance of Northern Savonia. (Finnish)

Due to that the Excel sheet includes a lot of formulas good Excel skills were required to handle energy information and turn the results into the format of energy balance. On the other hand, the formulas are the definite strength of the tool, because the entered energy information is instantly summarised and turned into conclusions.

Megawatt hour (MWh) was used as the unit of energy information in the Excel table, and watt hour (Wh) was also used in the final thesis. Energy producers announced their energy information in various ways and calculations were often required before entering the value into the Excel sheet.

Conversion of energy in mega joules (MJ) into energy in megawatt hours (MWh):

$$([\text{Energy in mega joules}] / 3.6 \text{ MJ}) / 1000 = [\text{Energy in megawatt hours}]$$

Conduction of energy (MWh) when volume/weight of fuel is known:

$$[\text{Energy}] = [\text{Amount of fuel}] * [\text{Heating value}]$$

Table 1 shows heating values used in the calculations. (Finbio ry 2005, Energiayksikköja ja muuntokertoimia)

Table 1. Heating values

Fuel	**Measuring unit**	**Heating Value (MWh)**
Biogas	m^3	6.0
By-products of wood proc. industry	i-m^3	0.6
Coal	Ton	7.0
Gasoline and diesel fuel	Ton	11.5
Firewood	p-m^3	1.3
Forest chips	i-m^3	0.8
Light fuel oil	Ton	11.9
Milled peat	i-m^3	0.9
Pellets	Ton	4.7
Residual fuel oil	Ton	11.4
Sod peat	i-m^3	1.4

i-m^3 = Loose cubic meter (2.5 i-m^3 = 1 m^3 of wood)
p-m^3 = Stacked cubic meter (1 m^3 frame filled with wood, real measure)

In those cases when energy producer announced only the used fuels, the produced energy was calculated by using thermal efficiency. Table 2 shows some thermal efficiency values used in the study.

[Produced energy] = [Primary energy] * [Thermal efficiency]

Table 2. Thermal efficiencies

Fuel	**Thermal efficiency**
Biogas	0.90 (Motiva 2009, Biokaasun hyödyntäminen)
Fuel oils	0.80
Wood fuels	0.80

The thermal efficiency of fuel oils and wood fuels can differentiate depending on the boiler in use. Thermal efficiency of 0.8 is considered as an average. The thermal efficiency is the efficiency of combustion. Other losses such as transfer losses are not included in the thermal efficiency.

3.1 Heat Production and Consumption

Industrial processes require lot of heat. Especially paper and metal industry are large scale consumers of heat. In the most cases, industry produces the heat needed for their processes. In some cases, such as pulp manufacturing the factory has the excess of heat which it can sell forward to serve the community.

Heat is also needed for heating of buildings such as one-family and row houses, apartment and office buildings, business premises, hospitals and care centres, schools, industrial premises, storages etc. Heating of buildings can be private when each house of building has its heating system such as a heat boiler using e.g. fuel oil, firewood, pellets or e.g. solar system or heat pump. Heating of building can also be implemented centrally by an energy company in the means of electricity or district heating system.

The equipment and production method of energy depend on the usage target. Power plants produce huge amounts of heat and electricity to be distributed to customers through district heating or electricity network. This kind of combined heat and power (CHP) production method is popular and cost efficient way to produce energy. CHP plant can be also smaller in size and serve smaller amount of households. Heat can also be produced in small or middle scale heat plants. The energy management of Northern Savonia is decentralised as earlier shown in Figure 2.

In the point of view of energy balance calculation, buildings which apply district or electrical heating are included in the received energy information of energy producers. Building outside district or electrical heating services will be considered separately as shown next.

In the final thesis, the building statistics of Tilastokeskus was utilised to include the buildings outside district or electrical heating services into the energy balance. The building statistics of Tilastokeskus (Finnish) is a database, which is free of charge and is updated yearly.

Figure 6 shows the use of Tilastokeskus database. Municipalities were selected in the first menu. In the second menu, all types of buildings were selected, and in the third menu all other heating methods except district and electrical heating were selected. In the last menu, the square meters of heated area was selected instead of the number of heated buildings.

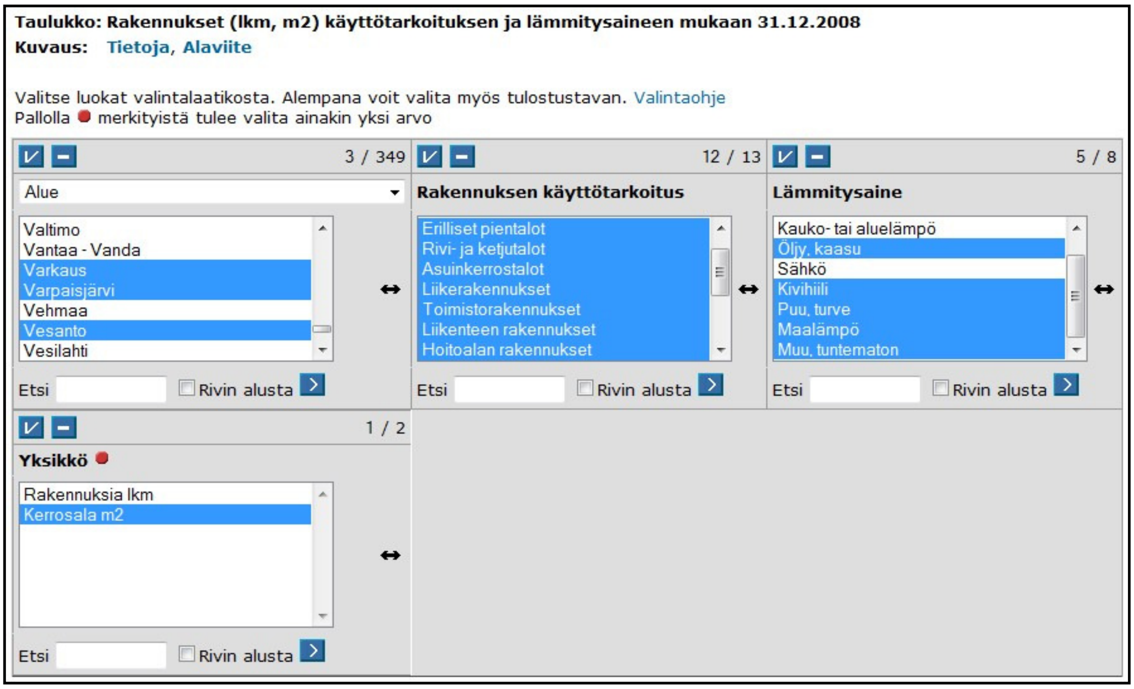

Figure 6. Tilastokeskus database of heating of buildings (Finnish)

The database created a list detailing heated area by fuel used, by the type of building. For example, Table 3 shows a part of the report of Varpaisjärvi.

Table 3. Statistical information of Varpaisjärvi from Tilastokeskus database (Finnish)

		Kerrosala m²
Erilliset pientalot	Öljy, kaasu	16816
	Kivihiili	0
	Puu, turve	61911
	Maalämpö	1165
	Muu, tuntematon	2259
Rivi- ja ketjutalot	Öljy, kaasu	3350
	Kivihiili	0
	Puu, turve	470
	Maalämpö	0
	Muu, tuntematon	450
Liikerakennukset	Öljy, kaasu	2794
	Kivihiili	0
	Puu, turve	2119
	Maalämpö	0
	Muu, tuntematon	756

Generated heated area was turned into heated volume by multiplying heated area by an average room height. Table 4 shows the used room heights.

[Heated volume] = [Heated area] * [Room height]

Table 4. Used room heights (Karhunen 2008, 10)

Type of building	**Room Height (m)**
Private houses	2.7
Agricultural houses	3.0
Public and office buildings	3.2
Storages and halls	5.0

The amount of primary energy needed to heat the calculated volume, was defined by using the heat consumption of 40 kWh/m^3/year and the thermal efficiency of heating equipment 0.80. (Karhunen 2008, 10)

[Needed produced energy] = [Heated volume] * [Yearly heat consumption]

[Needed primary energy] = [Needed produced energy] * [Thermal efficiency of boiler]

3.2 Electricity Production and Consumption

The information of electricity production and the used fuels was received directly from the owners of energy production plants. The biggest electricity producers of Northern Savonia are energy companies of Savon Voima, Fortum Heat and Power and Kuopion Energia, and industrial companies of Stora Enso, Powerflute and Yara Finland.

In Finland, the electricity price is split in two separate fees: Electricity transfer fee and used electricity fee. Electricity transmission network is divided into main grid (400/220/110 kV) which is owned by Fingrid, area grid (110 kV) and distribution grid (< 110 kV). There are about 13 area grid operators and 89 distribution grid operators in Finland. Grid operators are responsible for the reliability of their transmission network and the quality of the transferred electricity. Grid operators are supervised by Finnish Energy Market Authority. (Energiamarkkinavirasto 2010, Sähköverkkotoiminta)

Finnish electricity market is open for competition, and electricity suppliers are not required for a licence. Customers have freedom to choose any electricity supplier in the market. (Energiamarkkinavirasto 2010, Sähkön myyjät)

Due to that an electricity supplier of any size, located in any part of Finland is able to sell electricity in Northern Savonia it would had been a huge task to get the sales information from all electricity suppliers. Instead the statistics of Organisation of Finnish Energy Industry concerning the electricity consumption per municipality (Table 5) was utilised in the study. As shown in Table 5 big and industrial towns are the biggest electricity consumers of the region. (Energiateollisuus 2010, Kunnat sähkön käytön suuruuden mukaan)

Table 5. Electricity consumption per municipality in year 2008

	Housing and agriculture (GWh)	Industry (GWh)	Service and building (GWh)	Total (GWh)	Rank of all munic. of Finland
Varkaus	87	1282	59	1429	17
Kuopio	275	172	329	776	31
Siilinjärvi	97	366	58	520	37
Iisalmi	93	67	70	231	70
Juankoski	30	81	9	120	110
Lapinlahti	40	44	20	104	118
Leppävirta	56	21	23	100	125
Nilsiä	60	6	24	89	137
Suonenjoki	35	21	25	80	152
Kiuruvesi	50	6	15	71	169
Keitele	13	31	4	48	207
Vieremä	26	9	7	42	220
Pielavesi	27	1	10	37	251
Sonkajärvi	25	2	10	37	253
Kaavi	18	9	6	34	268
Maaninka	24	0	5	30	283
Rautalampi	20	1	8	29	285
Varpaisjärvi	17	7	5	29	286
Karttula	21	1	5	27	299
Tuusniemi	18	2	5	25	305
Vesanto	14	2	4	20	336
Tervo	16	0	3	19	343
Rautavaara	10	0	5	15	360
Northern Savonia	1072	2131	709	3912	

The statistics above was utilised to determine imported electricity of energy balance.

Imported electricity equals to electricity consumption reduced by produced electricity.

[Imported electricity] = [Electricity consumption] – [Produced electricity]

Where:
[Electricity consumption] was shown in Table 5.
[Produced electricity] was received from energy producers.

3.3 Gasoline and Diesel Fuel, and Transportation Losses

Finnish Oil and Gas Federation keeps the record of sold transportation fuels on each station. This information is based on reality but unfortunately it could not be utilised in the final thesis because the statistics if chargeable.

VTT Technical Research Centre of Finland has developed a database called LIISA which estimates the consumption of transportation fuels and the generation of emissions per municipality. Unfortunately LIISA database does not separate gasoline and diesel fuel, but it provided adequately reliable estimate of transportation fuels to be regarded in the energy balance of Northern Savonia. LIISA database is available in Internet free of charge.

The transportation of fuels was received in terms of tons per year. The amount of fuel was calculated into primary energy using the heating value of 11.5 MWh/kg. Consumed energy was calculated using the thermal efficiency of 40 %.

[Primary energy] = [Weight of used fuel] * [Heating value]

Where: [Weight of used fuel] was gained from LIISA database
[Heating value] = 11.5 MWh/kg

[Produced energy] = [Primary energy] * [Thermal efficiency]

Where: [Thermal efficiency] = 0.40

4 MUNICIPALITIES, AND POPULATION OF NORTHERN SAVONIA

Northern Savonia is one of three regions of the Regional State Administration (former province) of Eastern Finland. Other two regions are Southern Savonia and Northern Karelia. Figure 7 shows the 23 municipalities and the five sub-regions of Northern Savonia. (Regional Council of Northern Savonia 2010, Pohjois-Savon kunnat)

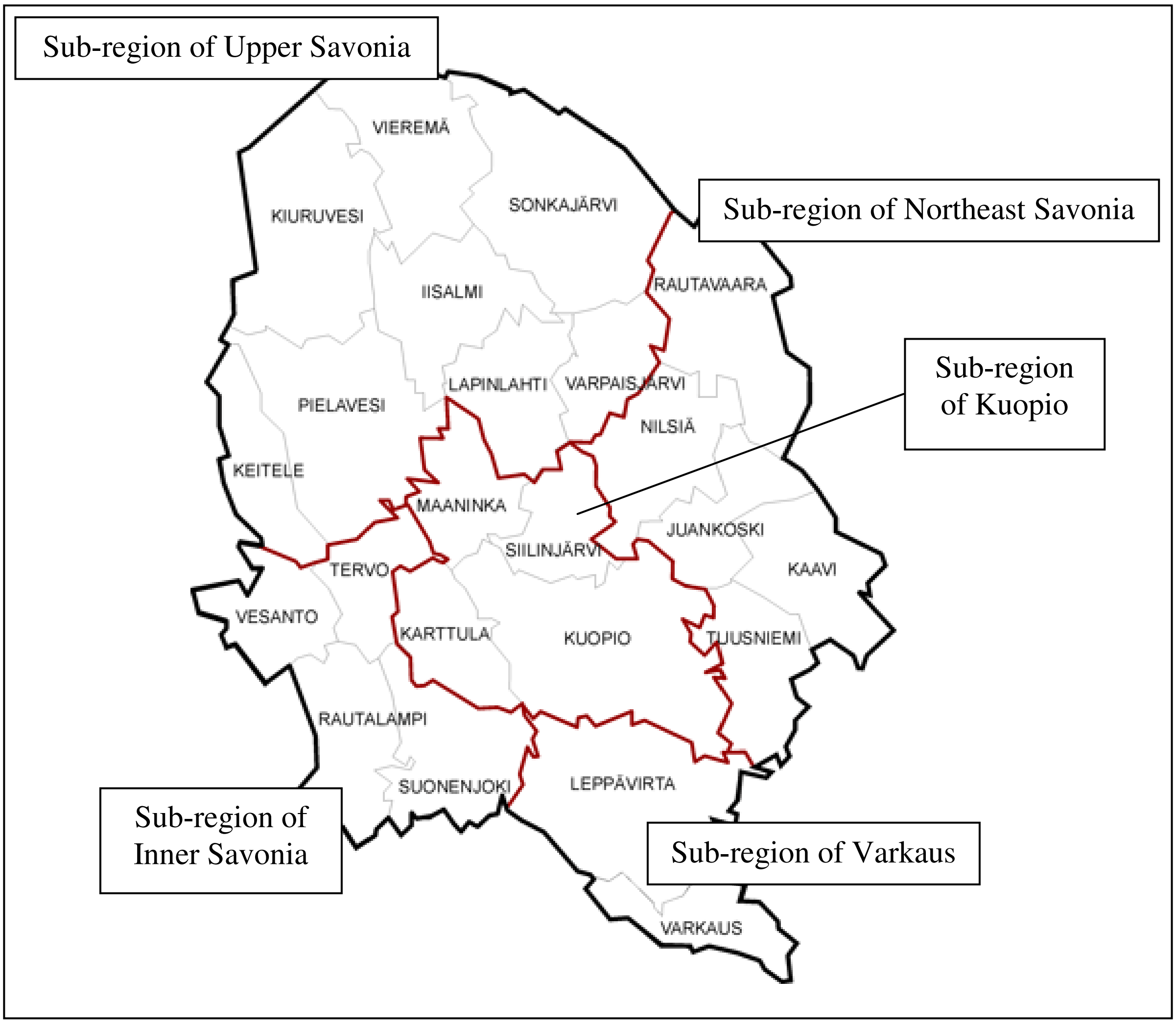

Figure 7. Municipalities and sub-regions of Northern Savonia

Table 6 shows the key figures of the municipalities of Northern Savo. Seven of the municipalities (bolded) are towns. (Regional Council of Northern Savonia 2010, Pohjois-Savon kunnat)

Table 6. Key figures of the municipalities of Northern Savo

	Population	Area	% of Lakes	People/km^2	Median age
Kuopio	92 626	1728,5	0,35	82,4	40,3
Varkaus	22 935	524,6	0,26	59,4	44,4
Iisalmi	22 169	872,1	0,13	29,1	43,2
Siilinjärvi	20 964	507,9	0,21	52,3	38,9
Leppävirta	10 633	1519,8	0,25	9,4	45,3
Kiuruvesi	9 318	1422,9	0,07	7,0	44,9
Suonenjoki	7 611	862,4	0,17	10,7	46,4
Lapinlahti	7 525	712,0	0,14	12,3	42,8
Nilsiä	6 521	847,8	0,16	9,2	46,0
Juankoski	5 273	586,4	0,21	11,3	46,5
Pielavesi	5 147	1406,6	0,18	4,5	48,0
Sonkajärvi	4 694	1576,8	0,07	3,2	46,6
Vieremä	3 985	973,4	0,05	4,3	44,4
Maaninka	3 870	575,2	0,19	8,3	43,8
Rautalampi	3 520	762,0	0,29	6,5	47,8
Karttula	3 509	588,8	0,20	7,4	41,6
Kaavi	3 429	789,7	0,15	5,1	47,4
Varpaisjärvi	2 952	533,2	0,09	6,1	46,6
Tuusniemi	2 864	699,5	0,22	5,3	48,5
Keitele	2 563	578,4	0,17	5,3	48,3
Vesanto	2 412	569,8	0,26	5,7	50,2
Rautavaara	1 918	1235,1	0,07	1,7	50,5
Tervo	1 744	494,2	0,30	5,0	49,7
Northern Savonia	248182	20366,7	0,18	14,8	42,9
Finland	5 326 314 303	390919,9	0,09	17,5	41,3

(Väestökeskus 2010, Väestötilastot)

Some characteristics and industrial companies of each municipality are listed in Appendix c.

Kuopio is the 9th biggest city of Finland and the centre of Northern Savonia. Lot of people are employed by University Hospital and University of Eastern Finland in health and social services, and education. Lot of industry is focussed in Kuopio, among others Haapaniemi power plant and Savon Sellu fluting cardboard mill.

Varkaus is originally created around metal and paper industry. Stora Enso paper mill has still three operating paper machines, saw mill and sulphate pulp production plant. Two paper machines will be closed down by the end of September 2010. There are also a lot of metal industry and two heat and power plant suppliers located in Varkaus. NSE Biofuels pilot plant of biofuel gasifier of Stora Enso and Neste Oil joint venture is located in Varkaus.

Iisalmi and Lapinlahti are also highly industrialised municipalities. Both of them also have power plants, Savon Voima power plant in Iisalmi and the power plant of Fortum Heat and Power in the Valio dairy factory of Lapinlahti.

Municipalities of Siilinjärvi, Karttula and Maaninka benefit the neighbourhood of Kuopio in terms of population growth and low age structure. The biggest employer of Siilinjärvi is Yara fertilizer and phosphoric acid factory. Karttula and Maaninka are less industrialised, agricultural municipalities.

Leppävirta is located close to both Varkaus and Kuopio. There are even three factories manufacturing equipment for heating systems: Gebwell, HögforsGST and Danfoss LPM. But Danfoss LPM will close down the factory by the end of March 2011. Leppävirta is strongly agricultural municipality.

Kiuruvesi is the location of several administrational units of Northern Savonia and Eastern Finland. The biggest employer of Kiuruvesi is MW Biopower which is a supplier of small and medium scale power and heat plants.

In Northern Savonia, 8 % of work force works for agriculture while the domestic average is 4 %. (Regional Council of Northern Savonia 2008, Pohjois-Savon työpaikat toimialan mukaan 31.12.2007)

Agriculture is very important for the most municipalities of Northern Savonia, such as Suonenjoki, Nilsiä, Juankoski, Pielavesi, Sonkajärvi, Vieremä, Rautalampi, Kaavi, Varpaisjärvi, Tuusniemi, Keitele, Vesanto, Rautavaara and Tervo.

In addition to agriculture the following municipalities have remarkable operations:

- Suonenjoki is famous of its numerous large strawberry fields and its yearly Strawberry Carnival.
- Nilsiä benefits for Tahko downhill skiing and holiday resort which employs lot of local people and brings tourists in the area.
- Stromsdal cardboard factory of Juankoski was closed down in 2008 and is looking for new owner.
- There are two mines in Northern Savonia: Talvivaara mine producing base metals, especially nickel and zinc in Sonkajärvi and Luikonlahti mine producing talc powder in Kaavi.
- The biggest employer of Vieremä is Ponsse which manufactures cut-to-length forest machines.
- Keitele-Forest sawmill is remarkable employer of forest industry in Keitele and its neighbour municipalities.
- Tervo is known for its facilities for salmon fishing in terms of Lohimaa fishing resort. Fisheries Research and Aquaculture institute is located in Tervo.

It can not be disregarded that there are 30 000 summer cottages in Northern Savonia which is the domicile of 248 000 people. (Regional Council of Northern Savonia 2008, Kesämökit Pohjois-Savossa v. 1970-2008)

Remarkable amount of summer and leisure cottages compared to constant houses are found in Rautalampi, Leppävirta and Tervo. Due to big amount of summer cottages, the amount of residents is increased in summer time. Also tourism and seasonal workers of agriculture bring lot of people in Northern Savonia especially in summer.

Economical circumstances are very difficult in Northern Savonia at the moment, and the differences of deployment rates within sub-regions are big. Since many years of growth in exports, the decrease of exports has been even faster in Northern Savonia than in Finland as a whole. The rapid decrease of exports has caused serious problems in paper and metal industries in Varkaus and Northeast Savonia sub-regions which has resulted in remarkable amount of lay-offs and denouncements. Due to the big amount of lost work places, Varkaus and Northeast Savonia sub-regions are announced as so called areas of rapid structural change. (Regional Council of Northern Savonia 2010, Pohjois-Savon aluetalouskatsaus syksy 2009, 3-5)

4.1 Development of Population of Northern Savonia

The population change of Northern Savonia is negative, which means that more people die than are born in the region. Due to the high age structure of the region, the negative population change will strengthen in the future. (Regional Council of Northern Savonia 2007, Pohjois-Savon maakuntakaava, 3)

In 2006, the population of Northern Savonia was 249 498 and according to the forecast of Tilastokeskus, the population will be decreased into 240 553 until year 2030.

Figure 8 shows the population of Northern Savonia in 2006 and the population forecast within 2010-2040. (Regional Council of Northern Savonia 2007, Pohjois-Savon maakuntakaava, 25)

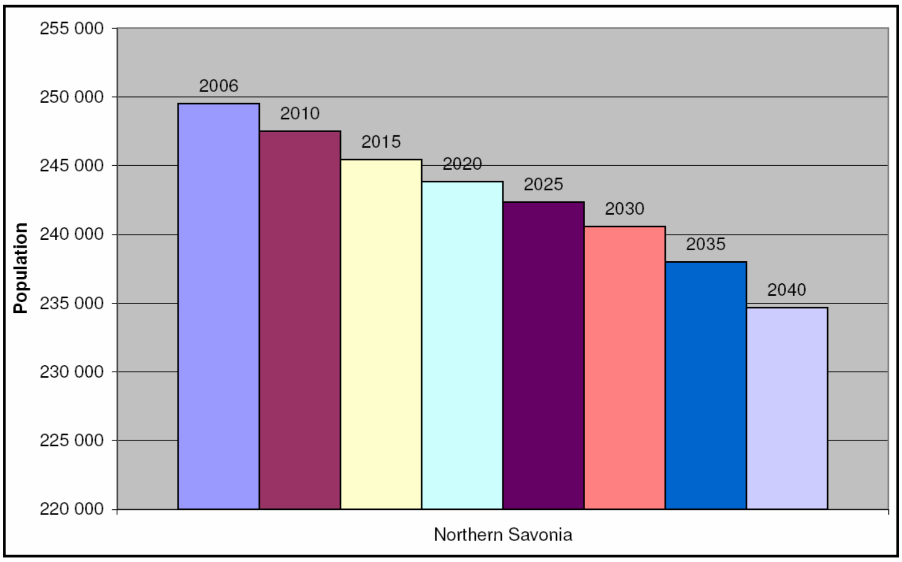

Figure 8. Population development of Northern Savonia

Figures 9-12 show the population of the municipalities of Northern Savonia in 2006 and the population forecast within 2010-2040. (Regional Council of Northern Savonia 2007, Pohjois-Savon maakuntakaava, 25)

Due to enable the readability the population development is shown as a few separated diagrams.

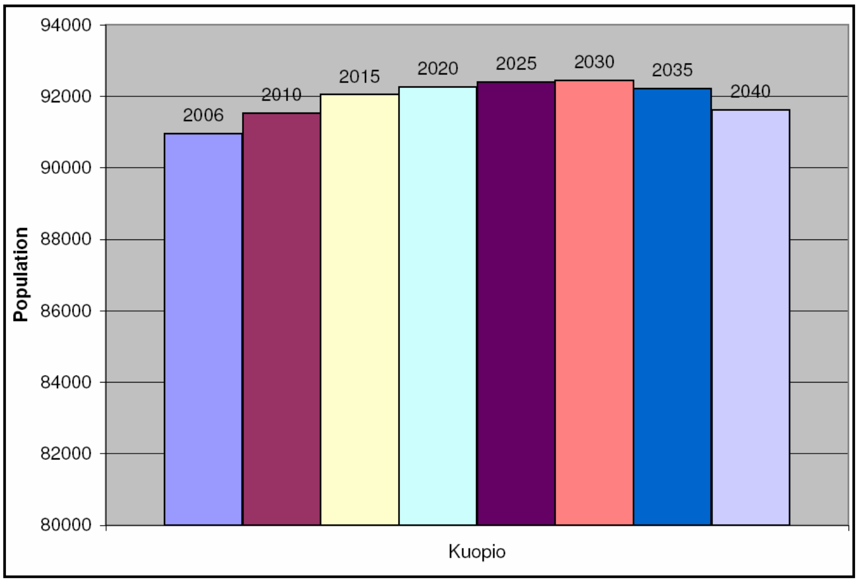

Figure 9. Population development of Kuopio

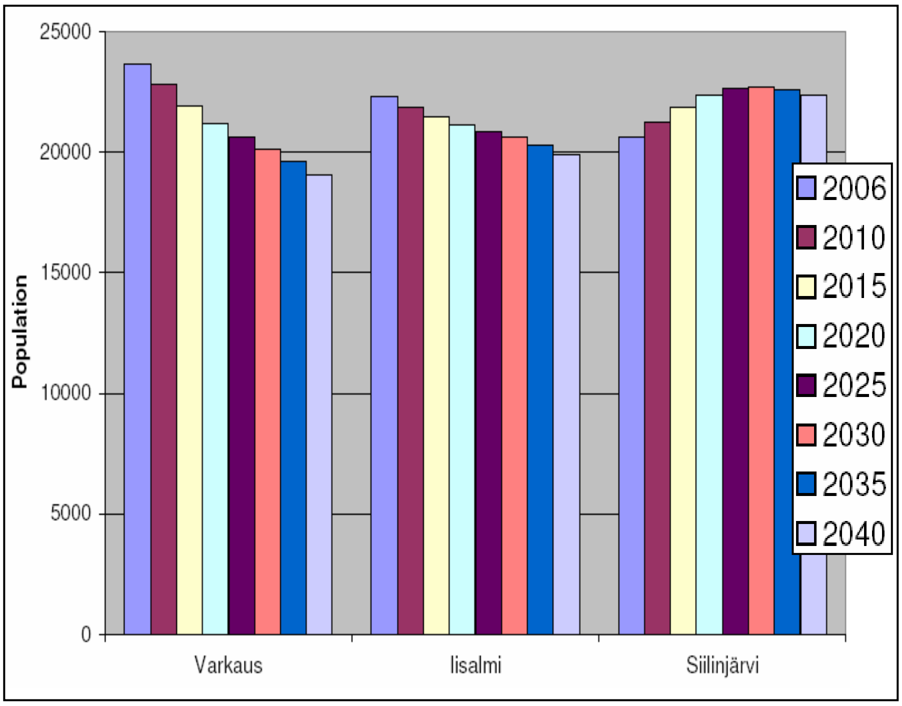

Figure 10. Population development of Varkaus, Iisalmi and Siilinjärvi

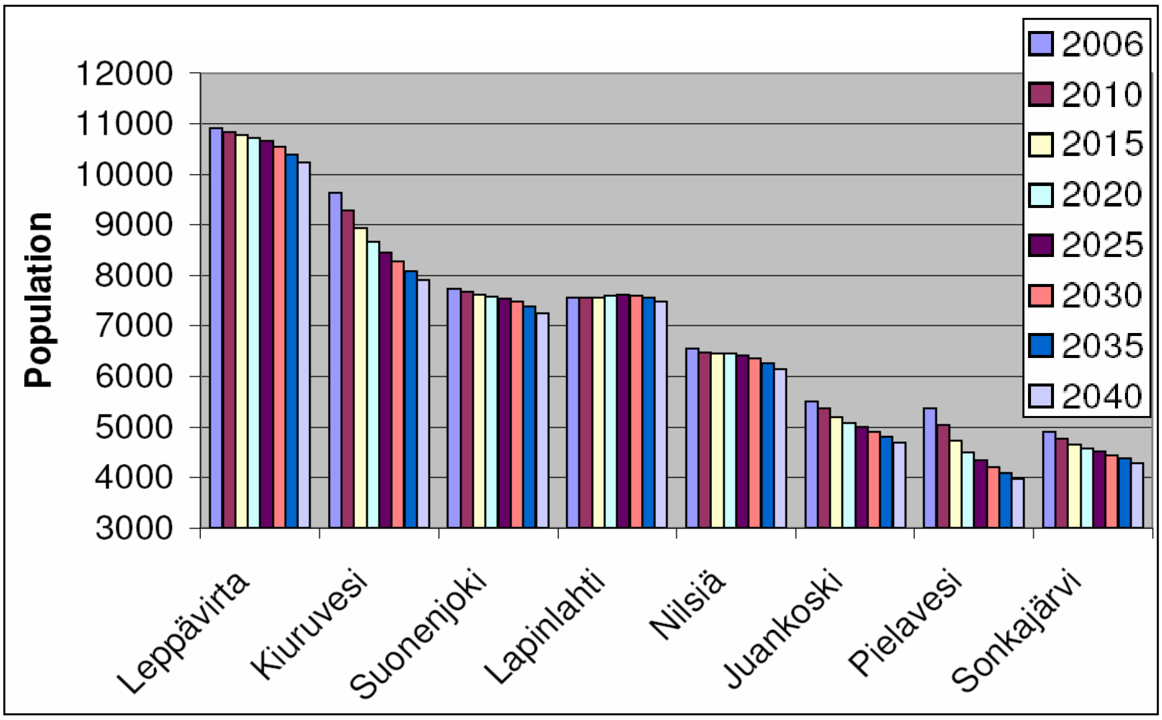

Figure 11. Population development of the middle scale municipalities of Northern Savonia

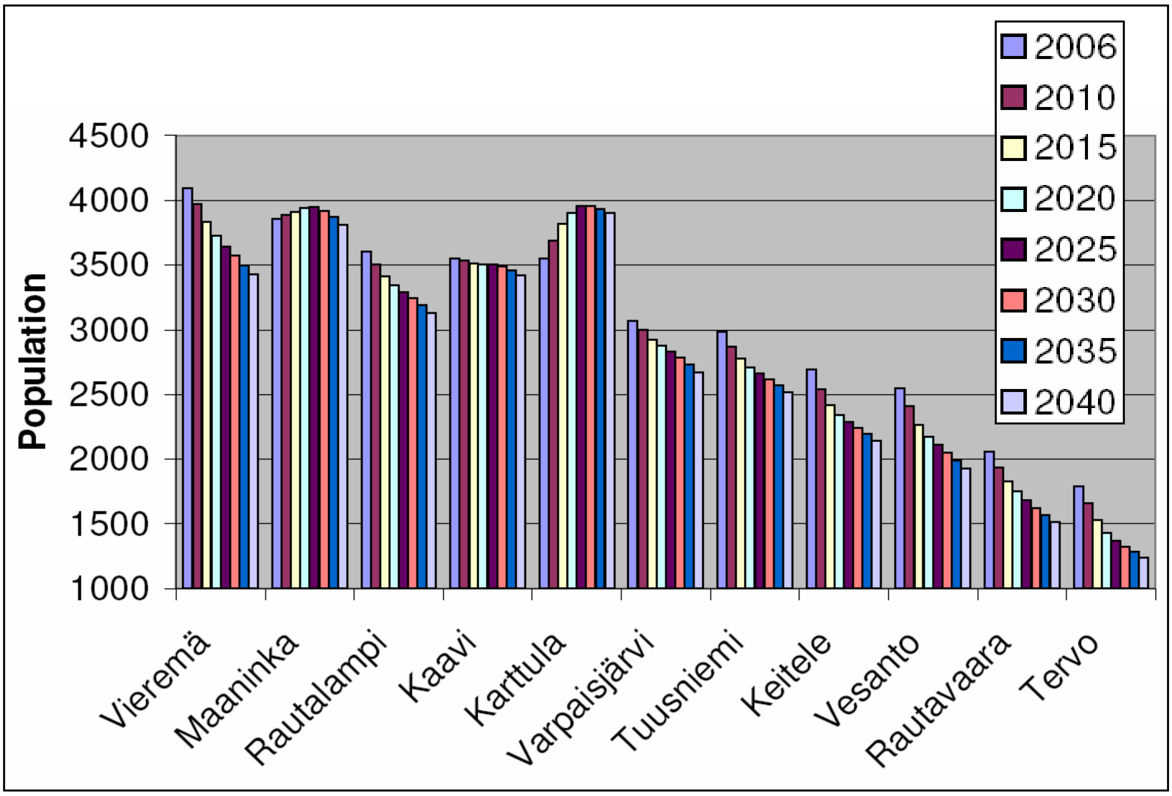

Figure 12. Population development of the small scale municipalities of Northern Savonia

Table 7 shows clearly the population development of Northern Savonia. In the top of the list with highly negative population change, there are municipalities with high age structure and low level of industry. Industrial towns of Varkaus and Juankoski are also forecasted to loose population due to reduced level of industrial work places. On the other hand, especially the neighbours of Kuopio are being expected to gain remarkable migration surplus.

Table 7. Statistical development of Northern Savonia

	2006	2030	Population Change
Tervo	1790	1322	-26,15 %
Pielavesi	5367	4213	-21,50 %
Rautavaara	2061	1623	-21,25 %
Vesanto	2548	2052	-19,47 %
Keitele	2692	2243	-16,68 %
Varkaus	23643	20111	-14,94 %
Kiuruvesi	9639	8273	-14,17 %
Vieremä	4095	3572	-12,77 %
Tuusniemi	2983	2617	-12,27 %
Juankoski	5508	4912	-10,82 %
Rautalampi	3603	3244	-9,96 %
Sonkajärvi	4900	4447	-9,24 %
Varpaisjärvi	3066	2788	-9,07 %
Iisalmi	22319	20612	-7,65 %
Suonenjoki	7741	7475	-3,44 %
Leppävirta	10921	10548	-3,42 %
Nilsiä	6547	6358	-2,89 %
Kaavi	3552	3492	-1,69 %
Lapinlahti	7552	7604	0,69 %
Maaninka	3853	3916	1,64 %
Kuopio	90960	92455	1,64 %
Siilinjärvi	20609	22719	10,24 %
Karttula	3549	3957	11,50 %
Northern Savonia	249498	240553	-3,59 %
Finland	5276955	5683182	7,70 %

Figures 13-14 show the forecasted development of work force of Northern Savonia. (Regional Council of Northern Savonia 2010, Pohjois-Savon maakuntasuunnitelma 2030, Maakuntastrategia, 33)

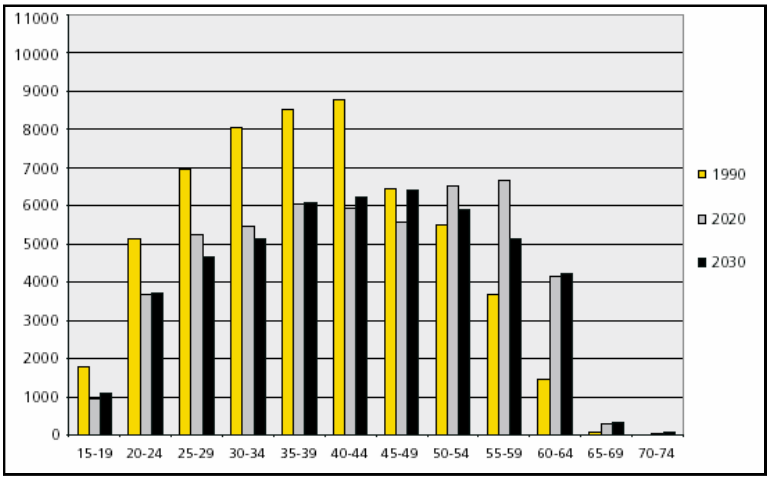

Figure 13. Development of female work force in Northern Savonia by age group

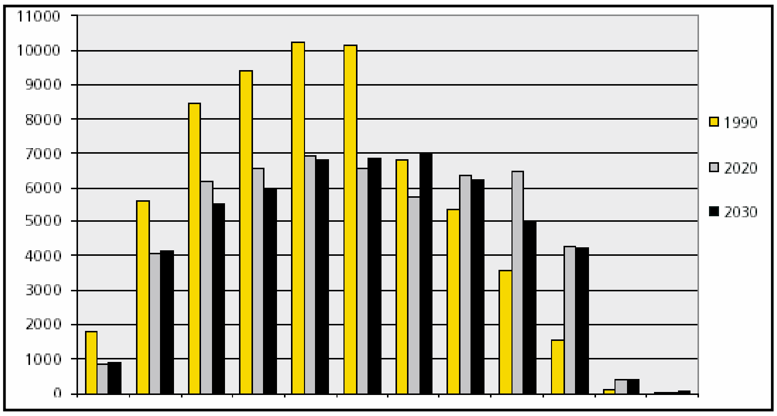

Figure 14. Development of male work force in Northern Savonia by age group

Regional Council of Northern Savonia is statutory joint municipal authority which operates for the regional development and planning and is in charge of looking after regional interests. Regional Council of Northern Savonia states in its Region Pattern that one of the most important goals is to remain the population level of today until year 2030. (Regional Council of Northern Savonia 2007, Pohjois-Savon maakuntakaava, 3)

Table 8 shows the goal of Regional Council of Northern Savonia for the population development of Northern Savonia. (Regional Council of Northern Savonia 2007, Pohjois-Savon maakuntakaava, 3)

Table 8. The goal of population development by Regional Council of Northern Savonia

	2005	2010	2015	2020	2025	2030
Population	250 492	249 479	249 408	250 000	250 370	251 000
Migration	-262	48	277	439	506	756
Born/died	-170	-250	-291	-320	-433	-630
Population change	-432	-202	-14	119	73	126

According to Regional Council of Northern Savonia, the attainment of the goal will secure the issues to enable the development of the region: Availability of labour and balanced age structure. The structural differences of industry and age are big within the municipalities at the moment as described earlier in the study. (Regional Council of Northern Savonia 2007, Pohjois-Savon maakuntakaava, 3)

The attainment of the goal will require the turning of the population change into positive by making more people move into the region within the next years on. The goal of population will require the migration surplus of 10 000 until year 2030, which will require active emigration politics and 8000 new work places. (2007, Pohjois-Savon maakuntakaava, 3-4)

Big investments are required to change the direction of the population change of Northern Savonia and to keep the region as vital and attractive domicile. The strategy of Regional Council of Northern Savonia states the actions to reach their goal, and one of the actions is to strengthen especially the position of Kuopio, but also to support the efforts of Varkaus and Iisalmi to remain and redirect their industry. (Regional Council of Northern Savonia 2010, Pohjois-Savon maakuntasuunnitelma 2030, Maakuntastrategia, 16)

4.2 Forests and Agriculture

Forests and lakes are typical characteristics for Northern Savonia. Forests cover 79 % of the land area of the region, and typical forest is flourishing dry peaty forest. The most common trees are pine and spruce. In the upper and northeast parts of the region, forests are plain pine swamps. The utilisation level of forests is about 70 % of yearly growth. (Metsäkeskus 2010, Metsävarat)

Due to the history of land use and active forestry, there are not much untouched forests. There are 1.3 million hectare of forest land of which 22 000 hectare is conserved. The most of the forests is owned by private people, companies and government own 28 % of forests. There are 25 000-32 000 forest owners on Northern Savonia, which means that forest ownership concerns remarkable part of households in the region. (Metsäkeskus 2010, Pohjois-Savon metsät and Metsänomistus)

Forests can be considered as the most important raw material of Northern Savonia because the utilisation of forests returns remarkable cash flow, about 145 million euros yearly. The companies of forest industry located in the region acquire main part of their raw material inside the region while their final products are exported. Forest industry employs about 6000 people in Northern Savonia, of which 23 % work in forestry. In the future, the employment of forest industry is expected to remain the same or to increase, especially in mechanical wood processing is expected to increase. (Pohjois-Savon työvoima- ja elinkeinokeskus 2005, Pohjois-Savon maaseutuohjelma 2007-2013, 8)

The land of Northern Savonia is mainly countryside, forests and fields. Over half of the municipalities is sparsely populated area or so called core countryside. The agriculture of the region is competitive to other parts of Finland. The size of farms has grown rapidly. (Pohjois-Savon työvoima- ja elinkeinokeskus 2005, Pohjois-Savon maaseutuohjelma 2007-2013, 6-7)

Tables 9-12 show some statistics about the agriculture of Northern Savonia. (Pohjois-Savon työvoima- ja elinkeinokeskus 2005, Tilastokatsaus 2005, 10-11)

Table 9. Use of agricultural land

	Area (ha)	**% of area**
Grassland	77 300	53 %
Fodder corn	46 600	32 %
Lie waste	12 800	9 %
Bread corn	2 600	2 %
Other plants	3 700	3 %
Garden plants	1 800	1 %
Total	144 800	100 %

Table 10. Farms

	Amount	% of all
Dairy cattle farms	2 100	44 %
Other cattle farms	450	9 %
Piggeries	110	2 %
Poultries	20	4 %
Horse & lamb farms	170	0,04 %
Grain growing	880	18 %
Garden plant growing	310	6 %
Other growing (potato, onion..)	65	1 %
Other plant growing (grass)	710	15 %
Total	4 815	100 %

Table 11. Production

	Amount	% of all domestic production
Milk production	302 million litre	13.2 %
Beef	11.5 million kg	12.2 %
Pork	6.5 million kg	3.4 %
Eggs	0.6 million kg	1.1 %
Berries	4.6 million kg	31.0 %

Table 12. Average farm size

	Amount
Field land	30 ha
Forest land	59 ha
Number of cattle	19
Milk production	143 800 l

5 PRIMARY ENERGY SOURCES OF NORTHERN SAVONIA

In this chapter, the fuels which are used in Northern Savonia are introduced. Figure 15 shows the consumption of primary energy sources in Northern Savonia. The fuel oils of transportation are presented as light blue column. Heating of buildings is included into the graph.

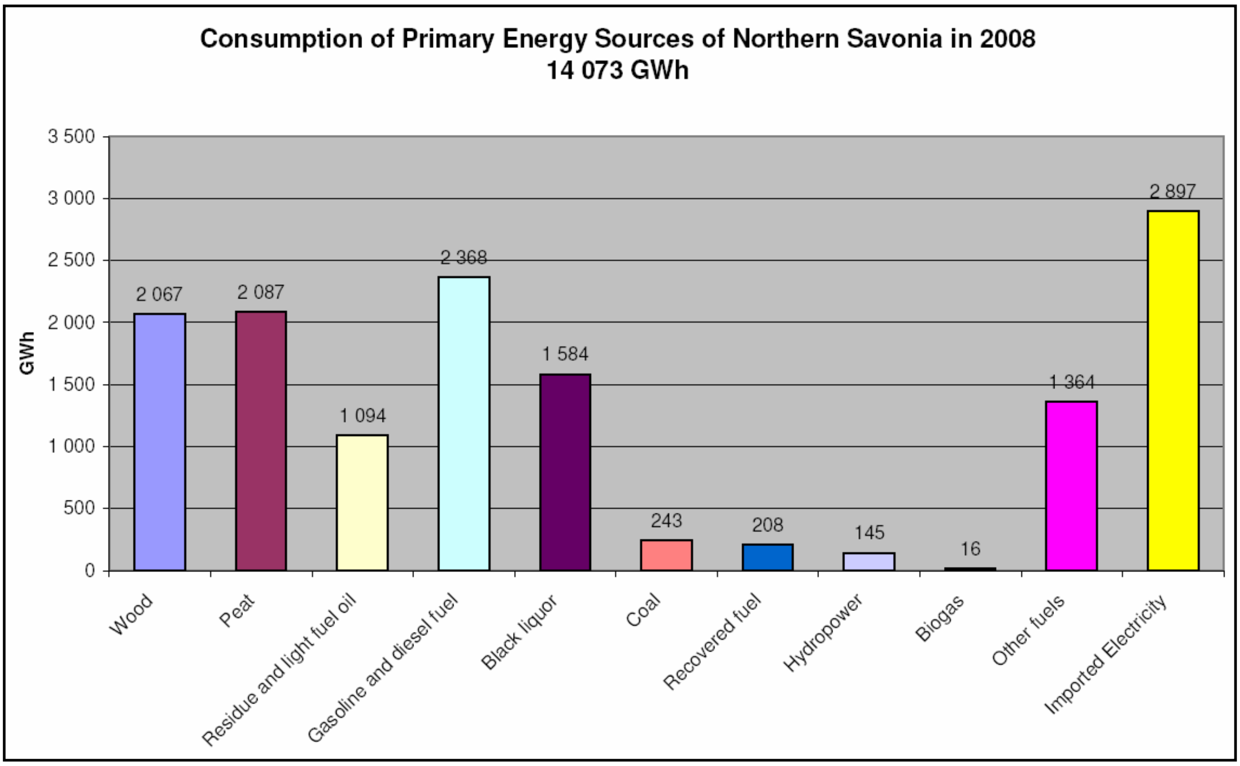

Figure 15. Consumption of primary energy sources in Northern Savonia

5.1 Price and Taxation of Energy Sources

In energy production, wood is usually used together with peat. Wood is used alone or as main fuel only within wood processing industry and in small heat plants. Typically, wood is used as far as it is available for a certain price, there after wood is replaced by peat. The competitors of wood are peat in large scale heating and power plants and oil in small scale heat plants. (Pöyry Energy 2007, 3)

In addition to the fuel price, the competence of each fuel is affected by the taxation of fuel, supporting politics, emission trading and the features of the fuel. Emissions trading which started in 2005 and the price increase of emission allowances have improved the competence of wood fuels. (Pöyry Energy 2007, 4-5)

Table 13 shows the consumer prices of fuels in heat production, excise tax included, VAT not included. (Tilastokeskus 2010, Taulukko 06. Kivihiilen, maakaasun ja kotimaisten polttoaineiden käyttäjähinnat lämmöntuotannossa)

Table 13. Consumer prices of fuels in heat production in December 2009

Energy source	**Price**
Coal	14.64 €/MWh
Milled peat	10.16 €/MWh
Forest chips	17.96 €/MWh*
Pellet	5.32 c/kWh**

* Price is not valid for the whole Finland, because there are regional differences in the price.
** Consumer price, VAT included

The taxation of energy is an important way to control energy and environmental development. It is used to control the society to decrease the growth of energy consumption and use energy sources which cause less emission. (Ministry of Employment and Economy 2008, Energiaverot)

Fossil fuels excluding peat and electricity are under excise taxes in Finland. The excise tax of peat was withdrawn in July 2005 to enable peat to remain its competence towards coal in the combined heat and power (CHP) plants. (Pöyry Energy 2007, 4)

The taxation of gasoline and diesel fuel is remarkable high. About 75 % of the yearly accumulation of energy tax is coming from the taxation of transportation fuels, and depending on the price of crude oil even half of the price of gasoline litre can be tax. (Ministry of Employment and Economy 2008, Energiaverot)

Table 14 shows the taxes of energy sources in Finland. (Ministry of Employment and Economy 2008, Verotaulukko 1.1.2008)

Table 14. Taxes of energy sources in Finland in January 2008

Energy source	**Excise tax**
Gasoline	
- Reformulated sulphur free	62.70 c/l
- Other	64.35 c/l
Diesel fuel	
- Sulphur free	36.50 c/l
- Other	39.05 c/l
Light fuel oil	8.70 c/l
Residual fuel oil	6.70 c/kg
Coal	50.50 €/t
Natural Gas	2.10 €/MWh
Pine oil	6.70 c/kg
Electricity	
- Tax class I (industry)	0.883 c/kWh
- Tax class II (others)	0.263 c/kWh

According to Tilastokeskus there were about 24 % of the price of household electricity and 18 % of the price of district heating tax in the year 2005. (Tilastokeskus 2004, Energiatilasto)

The taxation of energy sources is regulated by the Finnish law. European Union aims to unify the taxation systems of the member countries. (Ministry of Employment and Economy 2008, Energiaverot)

Table 15 shows the consumer heat prices of different primary energy sources used for housing or agriculture. (Motiva 2010, Käytetyt energian hinnat)

Table 15. Wood prices for housing and agriculture in May 2009

Heat source	Price (c/kWh)
Pellet	4.78
Firewood	4.92

Table 16 shows the electricity prices of different consumer groups. (Energiamarkkinavirasto 2010, Sähkön hinnan kehitys 1.5.2010)

Table 16. Electricity prices for housing and agriculture in May 2010

Consumer	Price (c/kWh)
K1	15.19
K2	13.00
L1	10.62
L2	9.87
M1	12.28
M2	10.48

K1 Apartment, no sauna, line fuse 1x25 A, usage 2 000 kWh/year

K2 One-family house with sauna, no electrical heating, line fuse 3x25 A, usage 5 000 kWh/year

L1 One-family house, room applied electrical heating, line fuse 3x25 A, usage 18 000 kWh/year

L2 One-family house, partly reserving electrical heating, line fuse 3x25 A, usage 20 000 kWh/year

M1 Farm, no electrical heating, line fuse 3x35 A, usage 10 000 kWh/year

M2 Farm with cattle, room applied electrical heating, line fuse 3x35 A, usage 35 000 kWh/year

Table 17 shows the prices of transport fuels. (Tilastokeskus 2010, Energiaennakko 2009 – Taulukot)

Table 17. Energy prices of fuel oils in December 2009

Fuel	Price (c/l)
Gasoline - Unleaded 95 oct. - Unleaded 98 oct.	 132 136
Diesel fuel	102
Light fuel oil	64 (64 €/MWh)
Residual fuel oil	51 (45 €/MWh)

According to Tilastokeskus the price development of all fuels reflected to the price development of crude oil in year 2009. The price of crude oil was constantly increased in 2009, but in the end of year 2009 the price was decreased rapidly. The consumer price of gasoline became 16 % more expensive and light fuel oil 16 % in a year. The price of diesel fuel got up only 2 % as consequence of the decrease of transports. (Tilastokeskus 2010, Energian kokonaiskulutus väheni 6 prosenttia vuonna 2009)

Table 18 shows the district heating price of different consumer groups. (Tilastokeskus 2010, Energiaennakko 2009 – Taulukot)

Table 18. Energy prices of district heating in January 2010

Type of consumer	Price (€/MWh)
One-family house	71.6
Row house	65.7
Small apartment building	65.0
Apartment building	62.9
Big apartment building	60.3

One-family house	Volume 500 m^3	Energy consumption 20 MWh/year
Row house	Volume 2000 m^3	Energy consumption 100 MWh/year
Small apartment building	Volume 5000 m^3	Energy consumption 225 MWh/year
Apartment building	Volume 10000 m^3	Energy consumption 450 MWh/year
Big apartment building	Volume 25000 m^3	Energy consumption 1125 MWh/year

5.2 Solid Wood Fuels

Finland is the leader of the world in utilising solid wood fuels, as well as a pioneer country in timber harvesting and the development of boiler technology. Finnish forest industry is the biggest user of wood energy in the market. (Energiateollisuus 2010, Puuenergia)

Heat and power plants apply about 15 million cubic meters of solid wood fuels yearly, which mean the energy of 27 TWh and is about 7 % of all Finnish fuels. The use of Finnish solid wood fuels lowers dependence on imported fuels and improves employment in sparsely populated areas. Wood is also ecologically safe and renewable fuel. Wood energy is the most competent when used for producing in combined heat and electricity (CHP) process. In power plants, wood is often used together with peat. (Energiateollisuus 2010, Puuenergia)

Figure 16 shows the flow of wood and the production of wood fuels, as well as the recycling of used wood.

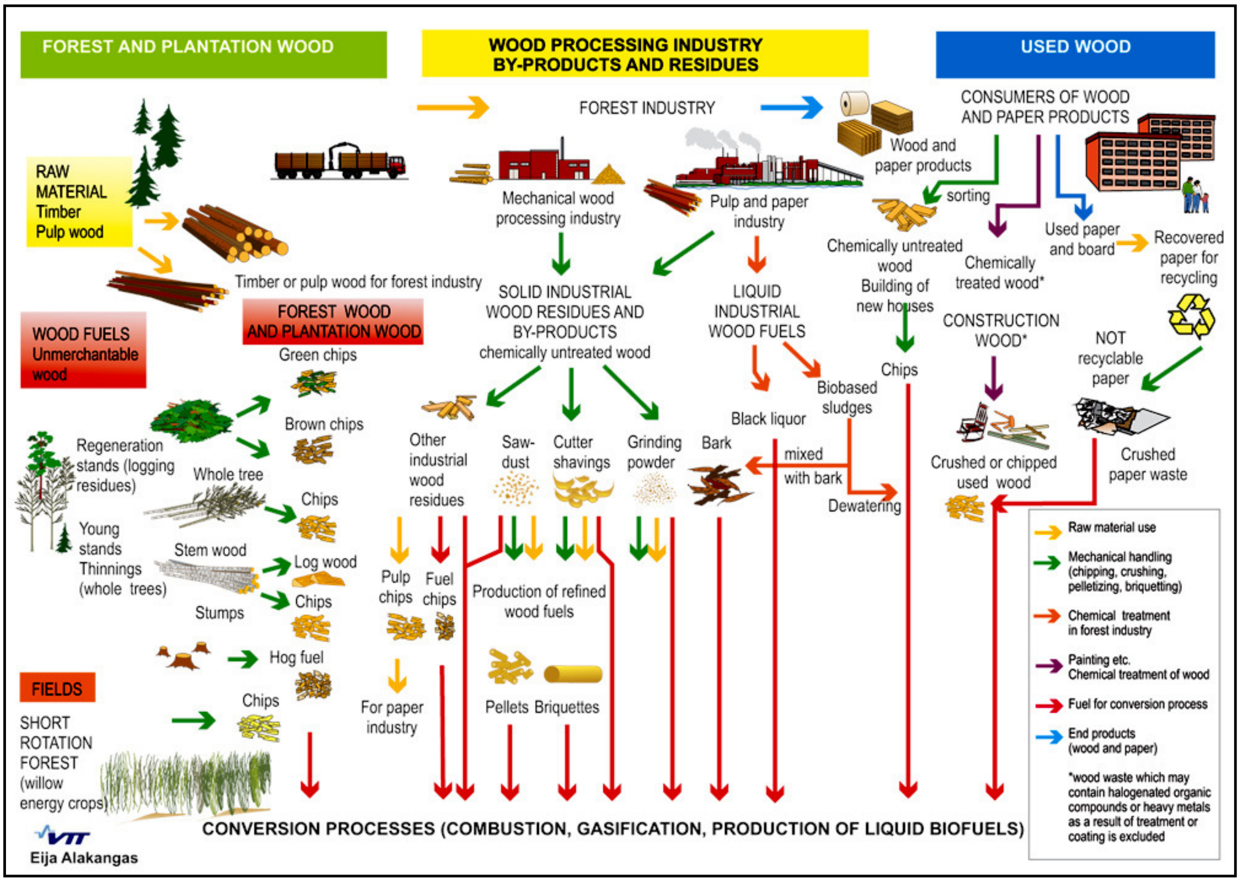

Figure 16. Production of wood fuels (Finbio ry 2005, Woody biomass)

Figure 17 shows the use of wood in Finnish forest industry, and it is easy to see how thoroughly wood is utilised in the process. . (Alakangas et al. 2009, 8)

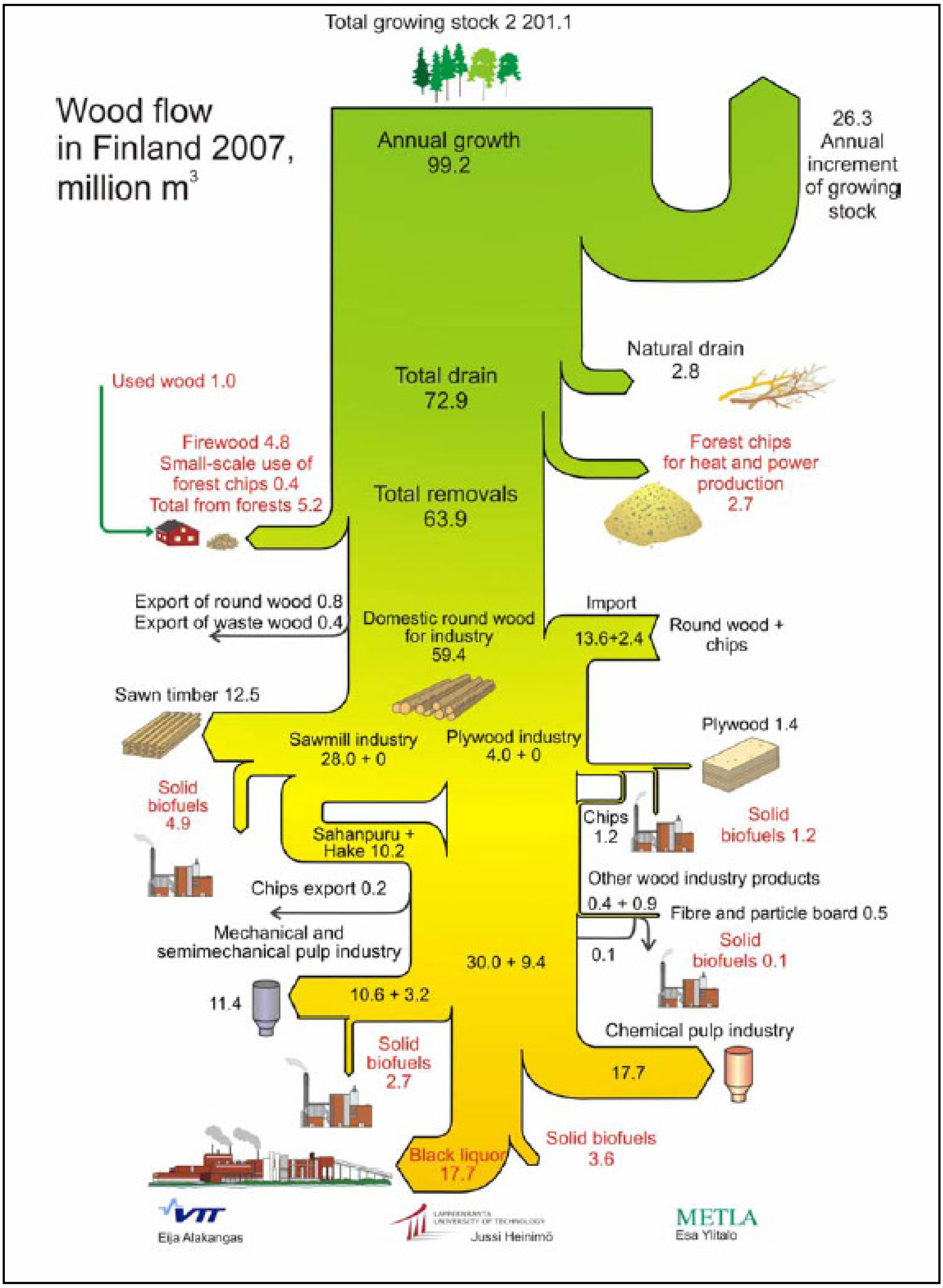

Figure 17. Wood flow in Finland 2007, million solid m^3 (energy market by red colour)

The availability, demand and price of wood fuels depend on the area. Wood is a local fuel because the transportation of wood fuels is not cost effective. Wood fuels can be used to replace e.g. peat in the case wood fuel is available for competitive price. (Energiateollisuus 2010, Puuenergia)

5.2.1 By-Products of Wood Processing Industry

Saw dust, saw chips, grinding dust, and cutter chips are pure wood waste which is created in the processes of mechanical forest industry and wood processing industry. The pure, non-processed biomass can be used in energy production as such, sieved or compressed e.g. into wood pellets, and is important and cost effective fuel for local heat plants and power plants. (Finbio ry 2005, Puupolttoaineet)

Bark is created in the industrial debarking of log. Moist bark is dried by compressing and crushed into chips. Bark is used on power and big heat plants and it is an important, domestic fuel for forest industry. (Finbio ry 2005, Puupolttoaineet)

5.2.2 Forest Chips

Forest chips are mechanically chipped fuel, made of non-thinned or thinned trees, felling residue or other wood material. Non-thinned tree covers all above ground parts of tree such as log, branches and needles, while thinned tree includes only the log without green leaf. Felling residue include crowns, branches and clearance wood. Stump chips are produced by crushing while they are often too hard to chip. (Alakangas 2000, 48)

Wood waste is usually dried in storage areas close to a road, and it is chipped either on storage area or in the destination. Wood chips are used in modern automated heat boilers, local heat plants and industrial heat and power plants. Moisture is the most important quality feature of forest chips, and different kind of boilers have own quality requirements for the wood chip. Small boilers require 1-3 cm long, homogenous and dry wood chip. Heat and power plants are able to utilise chipped felling residue, sawing chip, non-thinned tree chip and their combinations together with other solid fuels. (Finbio ry 2005, Puupolttoaineet)

Another important feature is the density of chip load. The density depends on the species of tree and chipping machinery. Quality Instruction of Wood Fuels of Finbio ry defines practice to appraise the quality of energy. Quality Instruction of Wood Fuels is applied as supplement to delivery agreements in fuel business. Also boiler and boiler plant suppliers and fuel producers utilise the above mentioned instructions. (Alakangas 2000, 49)

As shown in the Figure 18 Northern Savonia has good potential in forest chips. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomi – Uusiutuvan energian mallialue)

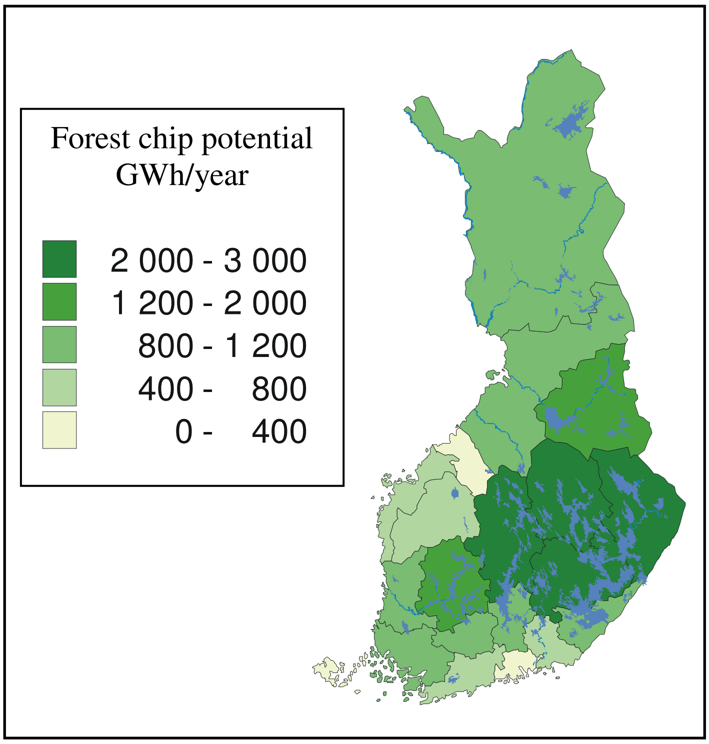

Figure 18. Potential of forest chips in Finland

By-products of wood processing industry are utilised thoroughly as raw material or in energy production. The usage of solid wood fuels can be increased effectively only by producing more forest chips. (Vapo Oy 2010, Metsähaketta luotettavasti and Finbio ry 2005, Puupolttoaineet)

5.2.3 Firewood

Firewood is about 1 m long, split or round block, usually from birch or the combination of several tree species. Chopped firewood is 0.25/0.33/0.50 m long, split block used mainly by households. (Alakangas 2000, 70-71)

Amount of firewood is measured either in stacked or loose cubic meters. Good quality of firewood is ensured by the drying time of at least a year before usage. Wood is used alone or as a main fuel only within wood processing industry, in small heat plants and households. (Finbio ry 2005, Puupolttoaineet, and Pöyry Energy 2007, 3)

5.2.4 Wood Pellets and Briquettes

Wood pellets are compressed cylindrical or quadric grains, made of the wood residues of industry, bark and forest chips. The diameter of pellet is 8-12 mm and the length 10-30 mm. Pellets are used as heating fuel of households, farm houses and other premises, which have been equipped with a special boiler for combust pellets. (Alakangas 2000, 76)

Wood briquettes are compressed pieces, made of dry saw dust, grinding dust and cutter chip. Additional chemical adhesives are not needed, due to the own substances such as lignin work as adhesives. The cross-section of briquette is round of square shaped, with the size of 50-80 mm. Compared to other fuels, briquettes are heavy and dry. (Alakangas 2000, 74)

The benefits of wood pellets and briquettes are easy storage and transportation, usability in automated heating systems and homogenous fuel. Within the last years, the price increase of wood pellets and briquettes has weakened their competence towards residual fuel oil. On the other hand, it seems that estimating the price development of wood fuels is nowadays more reliable compared to fuel oils. (Elektrowatt Ekono Oy 2001, 45)

5.3 Peat

Peat is organic soil type, which is developed in swamps, in conditions free from oxygen where vegetable matter does not decompose properly. The decomposition level of peat is varying, and the soil which is defined as peat, should include 75% of organic matter. In peat production process, all vegetation is cut down, and the swamp is ditched and flattened suitable for drying. Peat is dried utilising sunny weather, and therefore the drying process is dependent on dry summer. When the peat has dried out, it can be pealed from the surface of the peat field. (Wikipedia 2010, Turve)

In Finland, about 30% of land area is swamp, and about 1% of the swamps (120 000 hectare) have been reserved for peat production. At the moment, there are at least 63 000 hectare of swamps able to be used in peat production, which would enable energy production of 7 300 TWh. One hectare of swamp produces the energy of 11 700 MWh. (Alakangas 2000, 84-85)
The production potential of peat is estimated about 44-144 TWh if 20 % of all peat production capable swamp will be mobilised within the next 60 years. (Alakangas 2000, 84-85)

Finland’s peat reserves alone are double the oil reserves in the North Sea and 2/3 of Norway’s known oil reserves. Annual peat growth outstrips consumption, and only a fraction of peat lands are exploited for industrial harvesting. (Vapo 2010, The Leading Supplier of Peat)

Figure 19 shows the potential peat swamps of Northern Savonia.

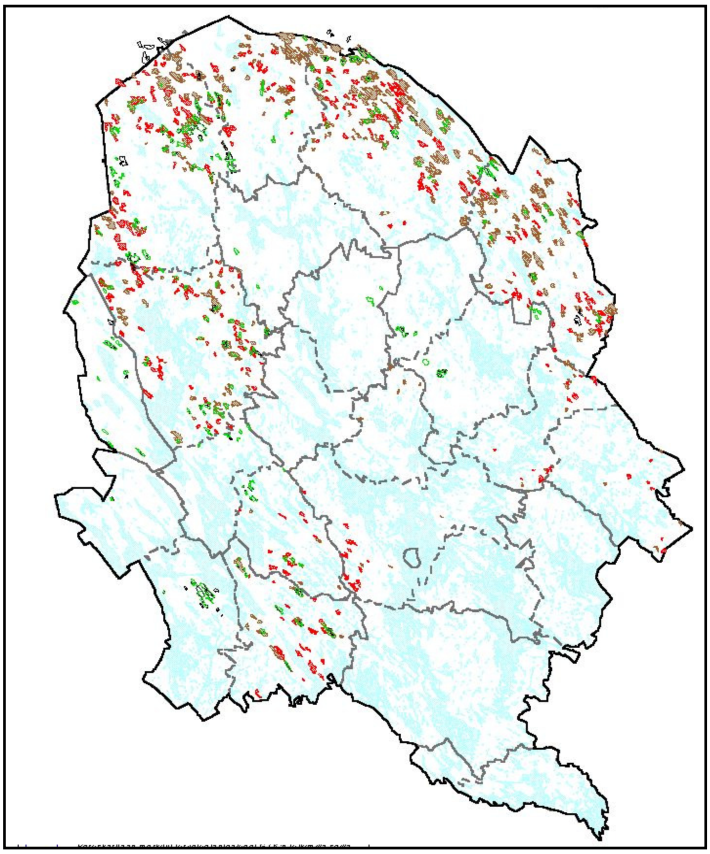

Figure 19. Potential peat swamps of Northern Savonia

Peat is used as a fuel in power plants and also in the heating of private buildings. Depending on the used production method, peat is classified as milled peat or sod peat. Milled peat is produced by milling peat from the peat land surface and drying it on site. It varies in its particle size, consisting mainly of powder-like peat and peat particles of differing sizes. Sod peat is produced by lifting peat from the peat land at a depth of 30-60 cm. It is macerated mechanically into sods and dried on the production field. (Vapo 2010, Milled Peat, and Vapo 2010, Sod Peat)

In Finland, 6-7 % of energy production is done by peat, mainly by Vapo Oy and Turveruukki Oy. Finland is one of the biggest peat producers in the world, and all peat production is utilised locally. There are about 60 peat power plants around Finland, to produce heat and electricity. Big power plants usually apply milled peat, while sod peat is applied in single buildings and small heat plants. (Wikipedia 2010, Turve Suomen energiantuotannossa)

5.4 Fuel Oils

Oil products such as fuel oils, gasoline and diesel fuel are processed by distilling from crude oil in oil refinery. In distillation process, oil is heated until it becomes gas and then it is condensed into liquid form. Oil refineries aim to produce the maximum amount of worthy, highly needed oil products such as kerosene and diesel fuel, and for example fuel oils are processed from less favourable parts of crude oil. (Huhtinen et al. 2000, 34)

Fuel oil is classified into six classes, numbered 1 through 6, according to its boiling point, composition and purpose. The boiling point (from 175 °C to 600 °C), carbon chain length and viscosity are increased with classification number. Price usually decreases as the fuel number increases. (Wikipedia 2010, Fuel Oil)

Fuel oils classified in categories 1-3 are variously referred to as distillate fuel oils, diesel fuel oils, light fuel oils, gas oil or just distillate. For example, “No. 2 fuel oil”, “No. 2 distillate” and “No. 2 diesel fuel oil” are almost the same thing in practise. (Wikipedia 2010, Fuel Oil)

Categories of fuel oils:

- Number 1 is similar to kerosene and is the fraction that boils off right after gasoline.
- Number 2 is diesel fuel used in trucks and some cars, and heating oil fuel.
- Number 3 is distillate fuel oil and is rarely used.
- Number 4 may be classified as diesel, distillate or residual fuel oil. It is usually a blend of distillate and residual fuel oils, or just a heavy distillate.
- Number 5-6 are residual fuel oils (RFO), also called as heavy fuel oils.

(Wikipedia 2010, Fuel Oil)

5.4.1 Light and Residual Fuel Oils

Fuel oils are divided into light and residual (also known as heavy) fuel oils according to their usage characteristics. Light fuel oil is fluid and flammable distillate, which does not require heating while stored or pumped. Residual fuel oil is stiff in room temperature, and therefore it requires heating and the use of circulation system. (Huhtinen et al. 2000, 35)

Light fuel oil is mainly processed from the distillate of crude oil (No. 2), but heavier distillates or remain distillate (No. 4) can be blended into the light fuel oil. (Wikipedia 2010, Polttoöljy)

Residual fuel oils are what remain of the crude oil after gasoline and the distillate fuel oils are extracted through distillation. Residual fuel oil is processed from the heavy distillates and remain distillate of crude oil which have been able to decompose by cracking. (Wikipedia 2010, Polttoöljy, and Wikipedia 2010, Fuel Oil)

There are several kinds of light and residual fuel oils available in the market. The most remarkable difference for light fuel oils is cold resistance and for residual fuel oils viscosity and sulphur content. Sulphur can not be extracted from residual fuel oil due to the heavy metals which reject desulphurisation catalyser. Therefore, the production of low-sulphur residual fuel oil (sulphur content less than 1 %) is based on the use of low-sulphur crude oil which is available e.g. in the North Sea. The sulphur content of residual fuel oil can be even 4 %. In Finland, the use of high-sulphur residual fuel oil (sulphur content from 1 % to 2.3 %) is allowed only if the boiler plant includes desulphurisation system. (Huhtinen et al. 2000, 34-35, and Wikipedia 2010, Polttoöljy)

5.4.2 Transportation Fuels

Gasoline is primarily used as a fuel in internal combustion engines. Gasoline is obtained by the fractional distillate of crude oil, enhanced with iso-octane or the aromatic hydrocarbons toluene and benzene to increase its octane rating. Small quantities of various additives are common, for purposes such as tuning engine performance or reducing harmful exhaust emissions. Some mixtures also contain significant quantities of ethanol as a partial alternative fuel. (Wikipedia 2010, Gasoline)

In general, diesel fuel can mean any liquid fuel used in diesel engines. The most common is a specific distillate of crude oil, but there are alternatives which are not derived from crude oil, such as biodiesel, biomass to liquid (BTL) diesel or gas to liquid (GTL) diesel. (Wikipedia 2010, Diesel Fuel)

In this study, by diesel fuel is meant only the distillate of crude oil which is used in the diesel engines of trucks and cars.

Diesel fuel is light fuel oil which has been processed further in terms of cutting down sulphur and particle emissions. Sulphur and particle emissions are not remarkable when combusted in heat boiler with low combust pressure and high temperature, but for diesel engine the fuel must be processed. (Wikipedia 2010, Dieselöljy)

Diesel-powered cars generally have a better fuel economy than equivalent gasoline engines and produce less greenhouse gas emission. Their greater economy is due to the higher energy per litre content of diesel fuel and the efficiency of diesel engine. A disadvantage of diesel as a vehicle fuel is that in some climates its viscosity increases quickly as the temperature of fuel decreases, turning into a non-flowing gel at temperatures as high as -19 °C or -15 °C. (Wikipedia 2010, Diesel Fuel)

5.5 Black Liquor

Black liquor is the mixture of chemicals including lot of lignin, which is generated in chemical pulp boiling process and captured when the pulp is cleaned. Captured black liquor is concentrated in an evaporation plant and combusted in a recovery boiler to regenerate chemicals and to produce energy. Black liquor is one of the most important biofuels in Finland. (Finbio ry 2005, Puupolttoaineet)

The chemical composition and features of black liquor vary remarkably depending on the amount of solid substances, quality of used forest chips, boiling process and the recycling of process water. Difference of black liquor compared to any other fuel is the amount of water and inorganic substance. (Alakangas 2000, 79-81)

5.6 Coal

Coal is a generic name for solid fuels consisting a lot of carbon. Coal can be defined into metallurgic coal or steam coal on the basis of its purpose of use. Metallurgic coal is used for processing coke for industry, and steam coal, also called as hard coal, is combusted in power plants and other industrial boilers to create steam. (Alakangas 2000, 128)

The features of coal vary a lot on the basis of its origin, age, excavation and treatment methods, and storage time and conditions. The feature defining the classification of coal is the degree of carbonising which is a sum of moisture, volatiles, heat value, carbon and oxygen contents and the reflection rate of light. (Alakangas 2000, 129)

Coal is often pulverized before combustion. Coal types which include more volatiles (more than 33 %) apply better for dust combustion. Coal types which are mainly used in Finnish power plants include volatiles about 30-38 %. Coal types including volatiles less than 14 % are more advantageous to combust in circulating fluidised bed (CFB) boiler. (Huhtinen et al. 2000, 33)

Carbon content is increased according to the age of coal: Carbon content is about 73 % in lignite (also known as brown coal), about 84 % in bituminous coal and about 94 % in anthracite. (Alakangas 2000, 129)

Coal is fossil fuel, which is estimated to last over two hundred years ahead, while oil and natural gas are estimated to become dry within next 40-60 years. Coal is widely used around the world; even 40 % of electricity is produced using coal. In addition to producing energy in the form of heat and electricity, coal is used in the production of iron, steel and concrete, as well as in other industrial processes. Coal is easy to transport, storage and combust, and coal is often stored for the state of emergency. (Hiilitieto ry 2010, Hiilen edut)

In energy production, coal has various disadvantages which assign special requirements for combusting technology. The biggest problem in combusting coal is the release of carbon dioxide (CO_2). The release of carbon dioxide contributes towards greenhouse effect, and it can be decreased only by improving the combustion of coal. Technologies to recover carbon dioxide are developed, but their implementation is still too expensive to utilise them in practise. (Hiilitieto ry 2010, Hiilen haitat)

Coal includes heavy metals, which are mainly separated and not released into the atmosphere. Mercury is an exceptional compound in this case because it can not be totally separated due to its gaseous form. In addition to carbon dioxide, the combustion of coal generates other flue gases such as nitrogen (NO_X) and sulphur (SO_X) fragments, and also fly ash, which are controlled by using so called Low NOx fuel technologies, desulphurisation plants and catalytic separators. (Hiilitieto ry 2010, Hiilen haitat)

5.7 Recovered Fuels

Energy waste or energy fraction is assorted, dry and combust-capable waste produced by industry, companies, and communities. Energy waste can be combusted in heat or power plant as such together with other solid fuels, or it can be processed as recovered fuel (also known as REF fuel) before combusting. Energy waste is crushed into equal sized grains when processed into recovered fuel. (Alakangas 2000, 109 and Wikipedia 2010, Kierrätyspolttoaine)

According to the estimation of Finnish Ministry of the Environment, 6.5 million tons of recovered fuels are used yearly, of which more than 6 million tons is solid wood waste and waste silts. Other recovered fuels are packaging, paper, plastic and construction waste, which have been left out from material recycling. (Alakangas 2000, 110)

In this study, wood waste and waste silts are handled separately because they have so remarkable role in Finnish energy production.

Due to the raw materials of recovered fuel originate to different sources the quality of recovered fuel varies. The essential features of quality criteria for recovered fuel are piece size, moisture, ash content and impurities such as metal and glass, and chemical composition. (Alakangas 2000, 112)

The following materials can not be utilised as recovered fuels: PVC plastic, metal, glass, plaster board, fibre glass, insulation wool, earths and rocks, stumps, biowaste, juice cartons covered with aluminium, aluminium yoghurt tops, aluminium wrappings, coffee packages, rubber, leather, hygiene products, vacuum cleaner bags, impregnated wood and textiles. (Wikipedia 2010, Kierrätyspolttoaine)

Cardboard packages, corrugated cardboard, paper bags, and kraft paper are made of fibrous packaging materials and different kind of combination materials. Paper and cardboard packages are widely recycled in reuse, but they are also utilised in energy production. (Alakangas 2000, 114)

Plastic is made of oil, and it can be recycled into new plastic products or utilised in energy production. The heat value of plastic is high, even 5.5-11.1 kWh/kg. The most common plastic used in packaging industry is polyethylene (PE). Other plastics are polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), polyamide (PA) and polyvinyl chloride (PVC). PVC plastic which is used e.g. in the bottles and packages of hygiene and food products, pipes, cables, rain coats and hand bags, contains chloride. Due to chloride, PVC waste is problematic to dispose. It can not be combusted in normal household boilers, or in heat and power plants because hazardous chloride compounds generated when combusting. PVC plastic can be combusted only in special waste heat boilers. (Alakangas 2000, 118, and Wikipedia 2010, Polyvinyyliklorodi)

The identification of plastics is not simple, and it usually requires burning examination. Combusted plastic can be identified on the basis of smoke colour and odour. Nowadays, plastic packages usually include identification stamping to enable fast identification. (Alakangas 2000, 118)

5.8 Hydropower

Hydropower is a form of renewable energy, which is turned into electricity in hydropower plant, through the use of the gravitational force of falling or flowing water. Together with fire, hydropower is the oldest way of producing energy. (Wikipedia 2010, Hydroelectricity, and Wikipedia 2010, Vesivoima)

The major advantage of hydropower is the elimination of fuel cost. The cost of operating a hydropower plant is nearly immune to increases in the cost of fossil fuels and no imports are needed. Hydropower plants also tend to have longer economic lives than fuel-fired generation. Operating labour cost is also usually low, as plants are automated and have few personnel on site during normal operation. (Wikipedia 2010, Hydroelectricity)

Once a hydropower plant is constructed, the power plant does not produce any direct waste, and the level of produced greenhouse gases are considerably low compared to fossil fuel powered energy plants. (Wikipedia 2010, Hydroelectricity)

Hydropower plant does not require a dam. A run-of-river hydropower plant uses part of the stream flow and is a characteristic of small hydropower plants. Small scale hydro power systems can be installed in small rivers or streams with little or no discernible environmental effect on things such as fish migration. A small hydropower plant can be connected to a distribution grid, or it can provide power only to an isolated community. (Wikipedia 2010, Hydroelectricity, Wikipedia 2010, Hydropower)

The major advantage of hydroelectric dams is their ability to handle seasonal or even daily peak loads. When the electricity demand drop the dam simply stores more water, which provides more flow when it releases. Some electricity generators use water dams to store excess energy by using the electricity to pump water up into a basin. (Wikipedia 2010, Hydropower)

In Finland, differences in levels are small, typically a few tens of meters. Finnish hydropower plants are small and quite often they are located along streams where water wheel driven mills once stood. (Wikipedia 2010, Vesivoima)

5.9 Biogas

Biogas is generated when various micro-organisms decompose organic matter in conditions free of oxygen. Biogas a gas mixture, containing 40-70 % of methane (CH_4), 30-60 % of carbon dioxide (CO_2) and very little amounts of sulphur compounds. Biogas compares to natural gas, and its heat value is considered as good, 6.4 kWh/m^3 in average. (Kuittinen, V. and Huttunen, M.J. 2009, 7)

The recovery and utilisation of biogas decreases the emission of greenhouse gases. When released in the atmosphere, methane is more than twenty times stronger greenhouse gas compared to carbon dioxide. (Kuittinen, V. & Huttunen, M.J. 2009, 7 and Wikipedia 2010, Biokaasu)

Biogas is generated in nature all the time, in wet lands, in the base layers of water systems, and in animal intestines. There are several technical alternatives to produce biogas into energy consumption, for example a biogas reactor or a pumping station. (Kuittinen, V. & Huttunen, M.J. 2009, 7)

Biogas reactors operating in Finland are located in the sewage treatment plants of municipalities and industry, farms and biowaste treatment plants. The most common production method is to combust biogas in heat boiler or combined heat and power plant. (Kuittinen, V. & Huttunen, M.J. 2009, 12)

Biogas pumping stations are located on waste disposal sites. About two million tons of community and industrial waste is dumped on Finnish waste disposal sites. Within several decades the waste decomposes into biogas. Disposal site of an average Finnish municipality releases about 200-400 m^3 methane gas per hour. It is estimated that over 200 million cubic meters of biogas is generated on Finnish waste disposal sites yearly, and only a small part of the biogas is utilised. (Kuittinen, V. & Huttunen, M.J. 2009, 43, and Alakangas 2000, 145)

On large waste disposal sites, biogas is recovered with pumping stations and utilised in energy production. On small waste disposal sites, methane emission can be decreased by using filtering layers on the top of the waste. (Kuittinen, V. & Huttunen, M.J. 2009, 44)

Biogas pumping stations have a problem with the poor utility function, due to the excess of biogas fuel. Because biogas can not reasonably be stored, the surplus is often combusted on site. An option for utilising the surplus would be transforming it e.g. into electricity or biodiesel. (Kuittinen, V. & Huttunen, M.J. 2009, 7)

5.10 Imported Electricity

The most municipalities of Northern Savonia do not have enough electricity production to cover the need. Therefore electricity needs to be imported from other parts of Finland and abroad. Due to the free electricity market it is almost impossible to determine which primary energy sources are used to produce the imported electricity. This kind of research would require contacting almost hundred electricity suppliers operating in Finnish market.

In the final thesis, it is assumed that imported electricity follows the electricity structure of Finland as shown in Figure 20. (Energiateollisuus 2010, Sähköntuotanto)

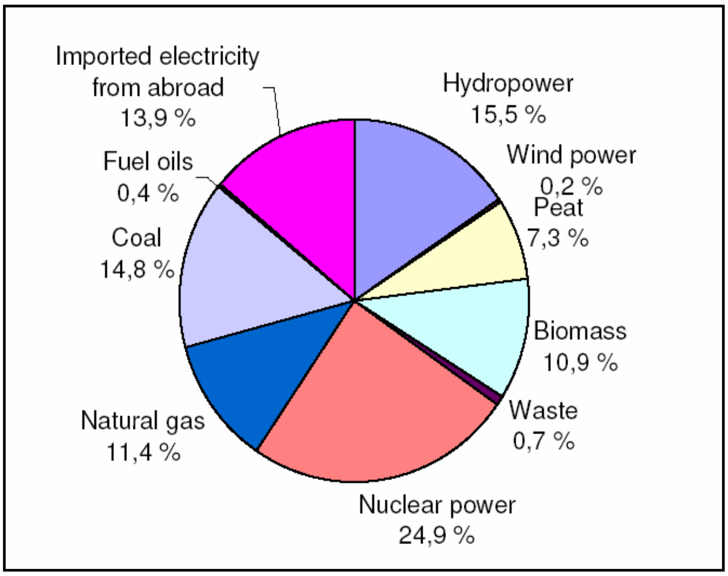

Figure 20. Primary energy sources of Finnish energy in 2007

The electricity which is imported in Northern Savonia is mostly renewable electricity, of which half is produced in nuclear power plant. The division for renewable, non-renewable and other is as follows:

- 52.2 % Renewable electricity
- 26.6 % Fossil electricity
- 7.3 % Peat electricity
- 13.9 % Imported electricity

Finnish production of wind power is small at the moment, but the trend is about to increase. (Energiateollisuus 2010, Sähköntuotanto)

Finland is a member of Nordic electricity market, and big part of used electricity is imported from abroad. The imported electricity is mostly hydropower electricity from Norway and Sweden. In the case of rainless summer in Norway or Sweden Finland is affected to produce electricity by using more expensive coal power plants. (Energiateollisuus 2010, Sähköntuotanto and Wikipedia 2010, Vesivoima)

6 The Use of Energy Sources in Northern Savonia

Next there will be presented the usage of primary energy in Northern Savonia in year 2008. As described earlier, the energy information has been gathered from the following sources:

- Energy producers: Energy production information
- Statistics of Tilastokeskus: Heating of buildings
- LIISA database of VTT: Transportation fuels
- Statistics of Finnish Energy Industries organisation: Electricity consumption per municipality to enable the calculation of imported electricity

Figure 21 shows the usage of primary energy sources in Northern Savonia in 2008. The statistical energy information of the heating of buildings is included into the results to be described. Transportation fuels are handled separately from heat and electricity production.

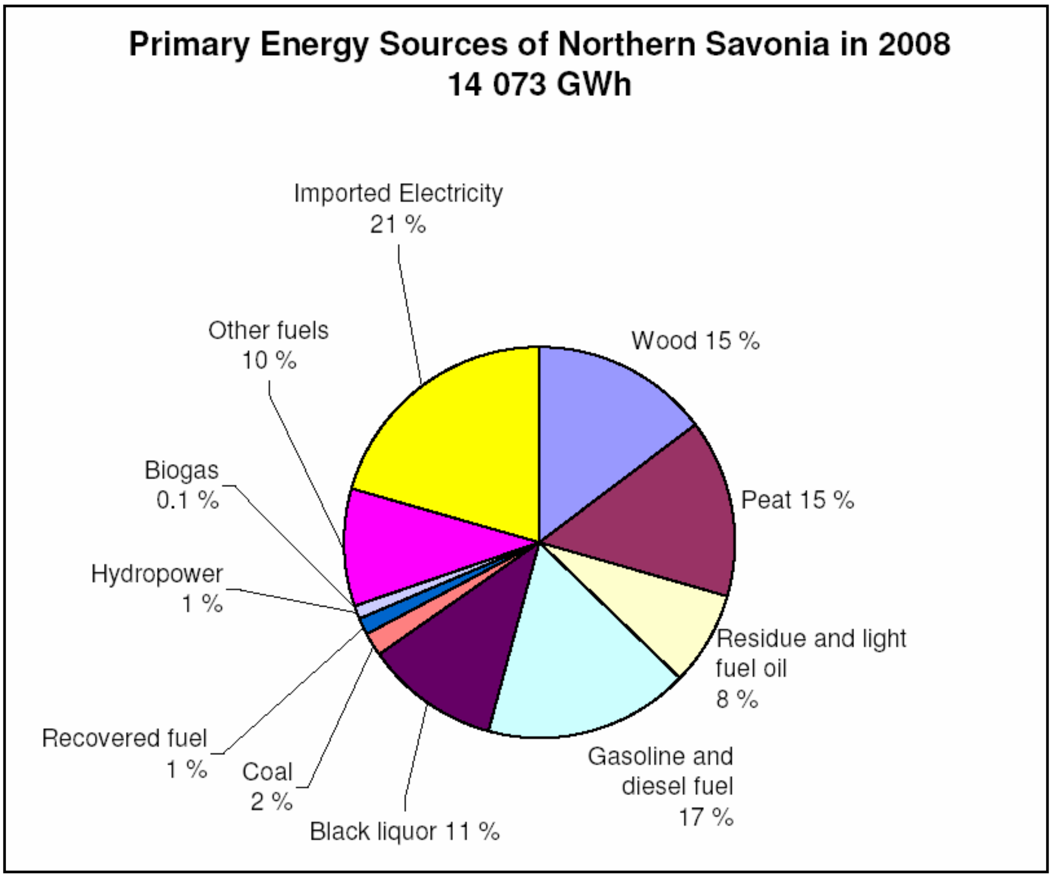

Figure 21. Circle diagram of primary energy usage in Northern Savonia in 2008

Lot of electricity is imported from other regions and abroad to Northern Savonia. In 2008, the own production of electricity of Northern Savonia was 1 015 GWh and electricity was imported for 2 897 GWh.

The mostly used primary energy sources in Northern Savonia are wood in all its forms and black liquor, peat and fuel oils. Others -sector includes big amount of so called industrial heat which means the reaction and process heat, steam and hot water.

Figure 22 shows the division of primary energy sources excluding transportation. If transportation fuels were included, the sector of fossil fuels would grow into 26 %.

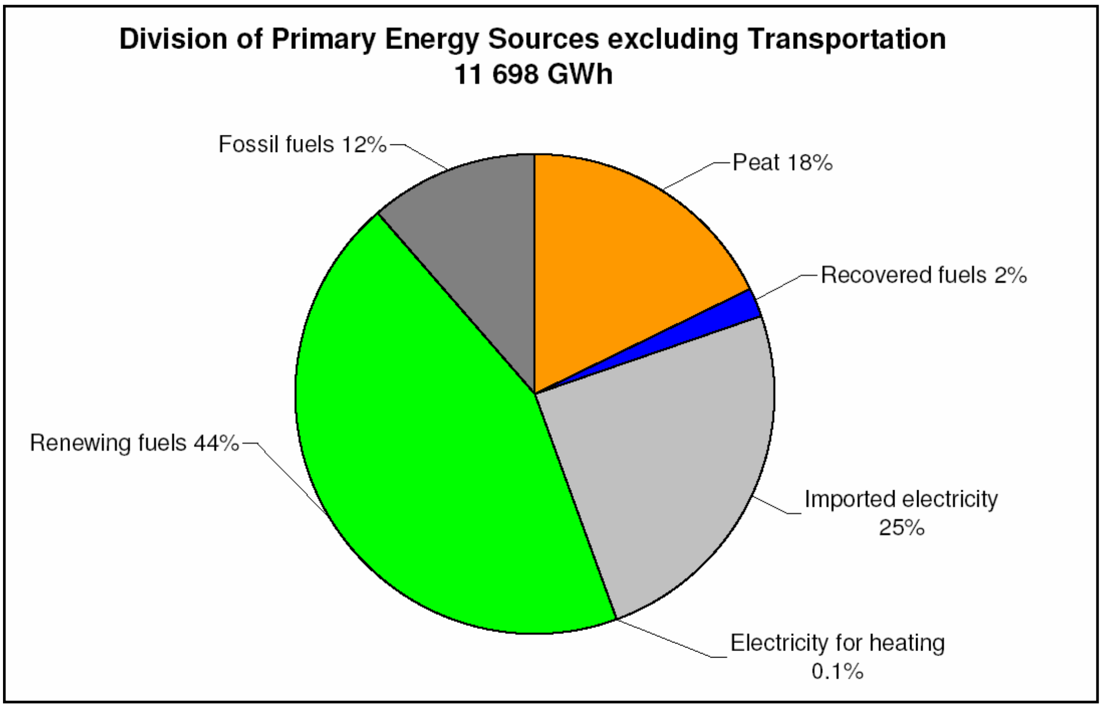

Figure 22. Division of primary energy sources excluding transportation

6.1 Use of Wood Fuels

In 2008, energy production plants and private wood consumers used 3651 GWh of wood as primary energy which is 26 % of all primary energies in the region. The share of wood fuels is over the average wood fuel usage of whole Finland.

Figure 23 shows the usage of different wood fuels.

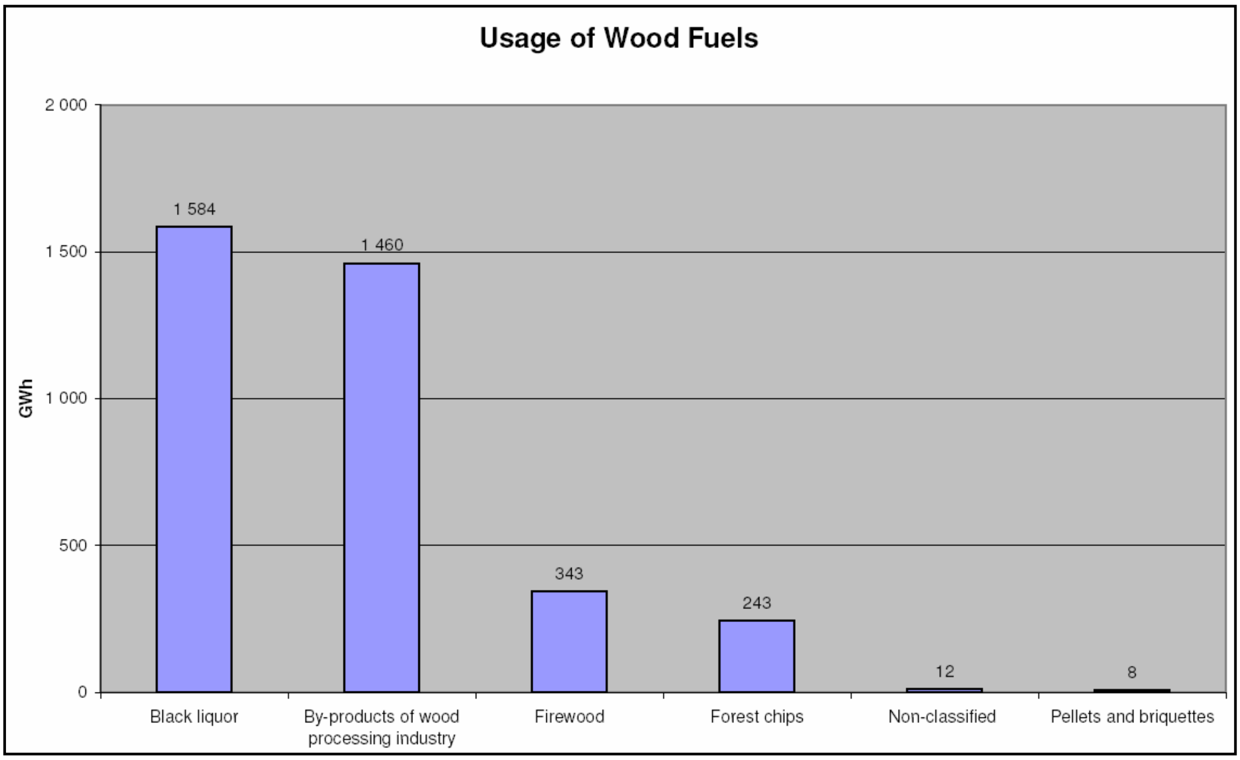

Figure 23. Usage of wood fuels of Northern Savonia in 2008

As shown in Figure 24, the 83 % share of wood fuels is black liquor and by-products of wood processing industry, which both are involved in wood processing industry. The usage of other wood fuels than these two is not remarkable.

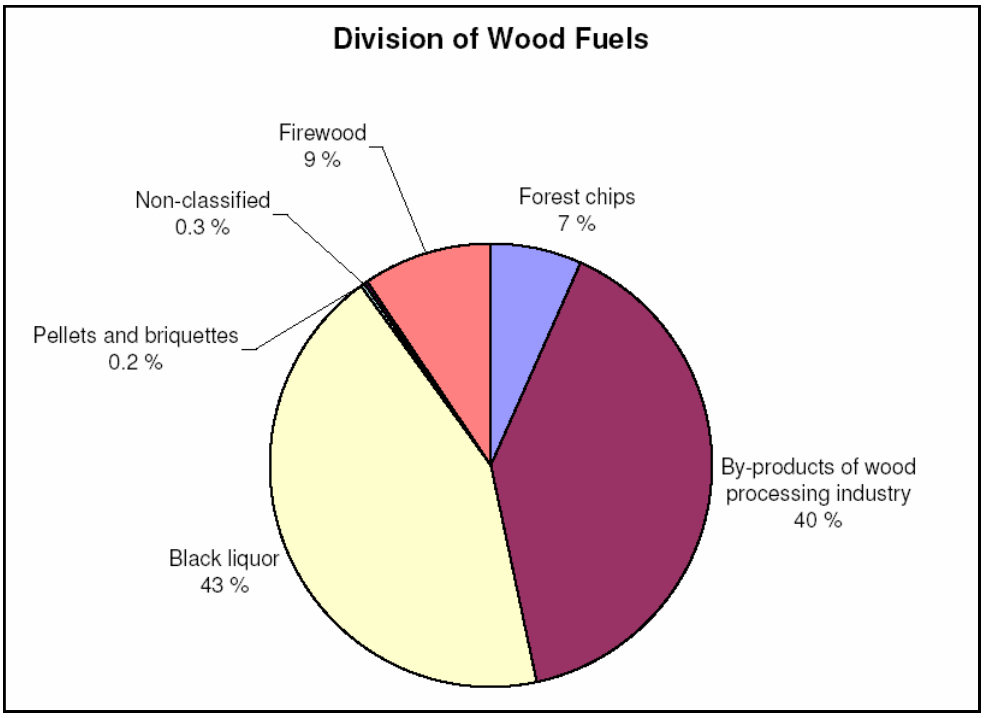

Figure 24. Division of wood fuels

6.1.1 Use of Black Liquor

There are two pulp producers in Northern Savonia, Stora Enso paper mill in Varkaus and the Savon Sellu fluting cardboard mill of Powerflute in Kuopio. Black liquor is generated as a by-product of pulp manufacturing, and the black liquor is combusted in recovery boiler to separate chemicals and produce energy. In total, the energy content of the black liquor used in 2008 was 1 584 GWh.

In summer 2009 Stora Enso informed to consider the closing down of Varkaus paper mill. The announcement triggered local district heating company to make plans for re-arranging the district heating of the town of 23 000 people. About eight months later Stora Enso announced that Varkaus paper mill will not be closed down but some operations such as two paper machines would be cut down.

There are a couple of municipalities in Northern Savonia whose energy production is based on the industry. Naturally, it is reasonable to utilise the by-products of industrial processes, but the possible closing down of Varkaus paper mill and the re-arrangement of district heating systems would had become expensive for the customers.

6.1.2 Use of By-Products of Wood Processing Industry

By-products of wood processing industry are utilised thoroughly by the industry. Good quality shaving is used as a raw material for pulp production and everything else is utilised in energy production. (Finbio ry 2005, Puupolttoaineet)

In 2008, the consumption of the by-products of wood processing industry was 1 460 GWh which is 40 % of the total amount of wood fuels used in Northern Savonia. This is even as big share as the use of black liquor, so it is remarkable fuel supply.

Forest industry uses 75 million cubic meters of wood yearly. In year 2007 20 % of the wood was imported mainly from Russia. Russian wood is mainly used as raw material of pulp. Within years 2007 and 2008 Russian government increased the customs duty of wood from 4 €/m^3 into 15 €/m^3. Until January 2010 wood imports from Russia have decreased by 23 %. (Metsäteollisuus ry 2008, Venäjän puu – Facts & figures)

Figure 25 shows the development of the wood imports of Finland within years 2006-2009. (Metsäntutkimuslaitos 2010, Metsäteollisuuden ulkomaankauppa, tammikuu 2010)

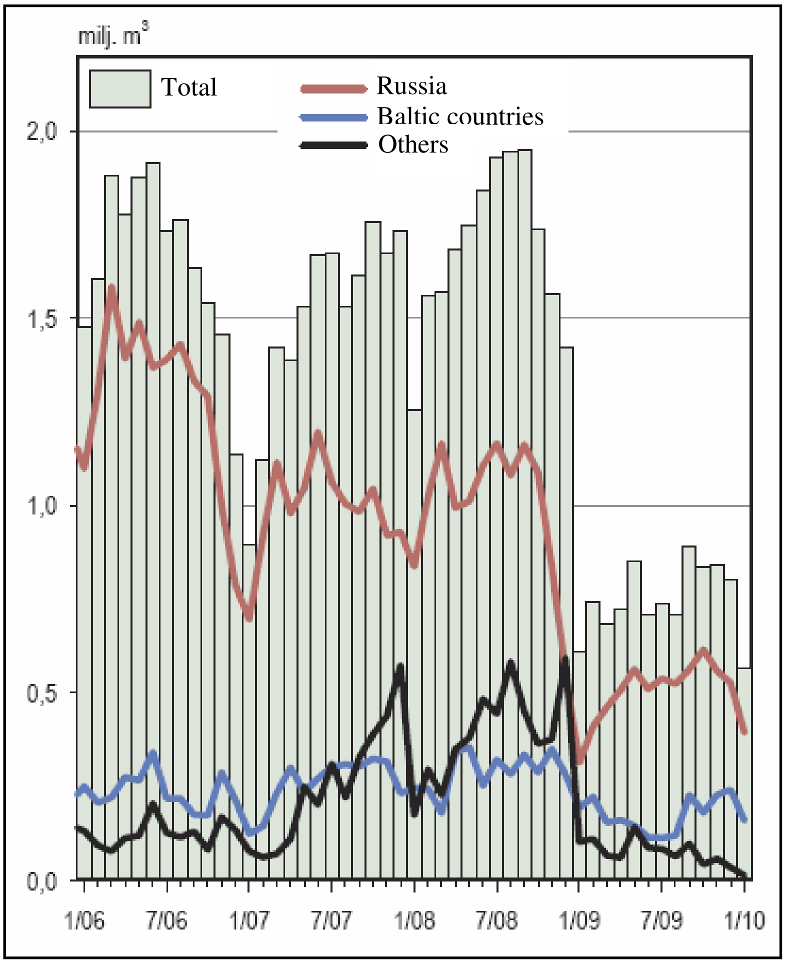

Figure 25. Wood imports of Finland within 2006-2009

The decrease of wood imports is the cause of risen customs duty and ongoing recession. Russia is still planning to increase the customs duty even up until 50 €/m^3 which would make the imports of Russian wood totally unprofitable. This could lead into wood crisis and threaten the operation of Finnish saw mills and plywood factories. In the case of decreased saw mill operation and plywood manufacturing, by-products of wood processing industry would decrease and should be replaced with something else, possibly fossil fuel. (Metsäteollisuus ry 2008, Venäjän puu – Facts & figures)

6.1.3 Use of Forest Chips

In 2008, the consumption of forest chips was 243 GWh which is 7 % of the total amount of wood fuels used in Northern Savonia. The usage of forest chips is on low level in Northern Savonia compared to surrounding regions. As shown in Figure 26 forest chips usage has still increased constantly. (Metsäkeskus Pohjois-Savo 2008, 34)

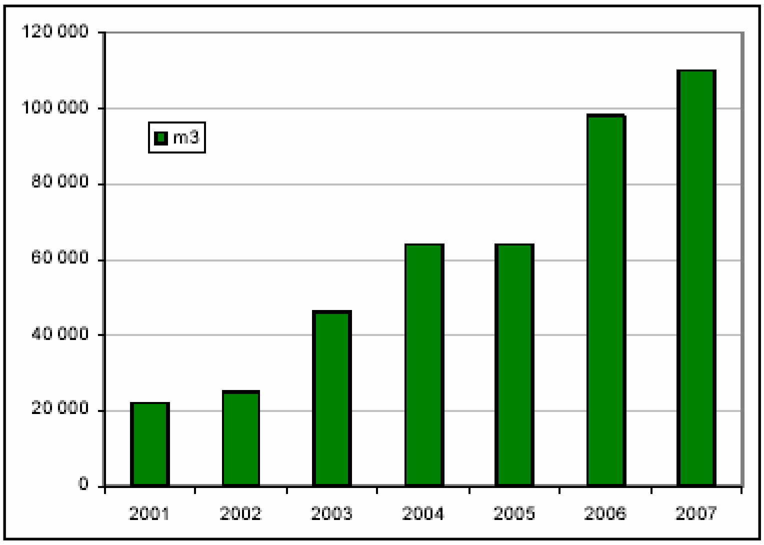

Figure 26. Growth of forest chips usage in Northern Savonia

The use of forest chips is remarkably more popular in the surrounding regions but the reason for the phenomenon is simple: The use of peat. Northern Savonia has generous supplies of peat and the use of peat has long traditions in energy production. In addition, peat is more cost effective than forest chips as long as it does not need to be transported from far. (Regional Council of Northern Savonia 2006, 24-25)

Despite of the availability of peat, the use of forest chips has increased and it will increase more in the future. For instance, Kuopion Energia is planning the establishment of new Kumpusaari power plant which will use solid wood fuels to produce energy. The new power plant will replace the power plant unit of Haapaniemi I while Haapaniemi II power plant will continue its operation.

6.1.4 Use of Firewood, Pellets and Briquettes

In 2008, the consumption of firewood was 343 GWh which is 9 % of the total amount of wood fuels used in Northern Savonia. All consumed firewood is used in the heating of private buildings. There are other, more inexpensive biofuels available for industrial heat and power plants.

The use of pellets and briquettes are used in the heating of housing and agriculture, and in industry, but the use is minor in Northern Savonia. In 2008, the yearly consumption was only 8 GWh which is 0.2 % of the total amount of used wood fuels. In private sector pellets and briquettes have not been successful due to the need of big storage for the fuel. For industrial use pellets and briquettes are often expensive compared to other biofuels.

6.2 Use of Peat

In 2008, the consumption of peat was 2 087 GWh which is 15 % of the total amount of fuels used in Northern Savonia. Biggest users of peat are power plants and large scale heat plants. Peat is usually combusted together with solid wood fuels.

As already mentioned, the popularity of peat is based on the easy and close availability of the fuel, long tradition on the usage of peat and low cost. Northern Savonia has rich sources of peat, and peat is always used locally because it is not cost-efficient to be transported for long distances.

6.3 Use of Fuel Oils

In 2008, the consumption of fuel oils was 1 094 GWh which is 8 % of the total amount of fuels used in Northern Savonia. Residual and light fuel oil are used almost the same amount as shown in Figure 27.

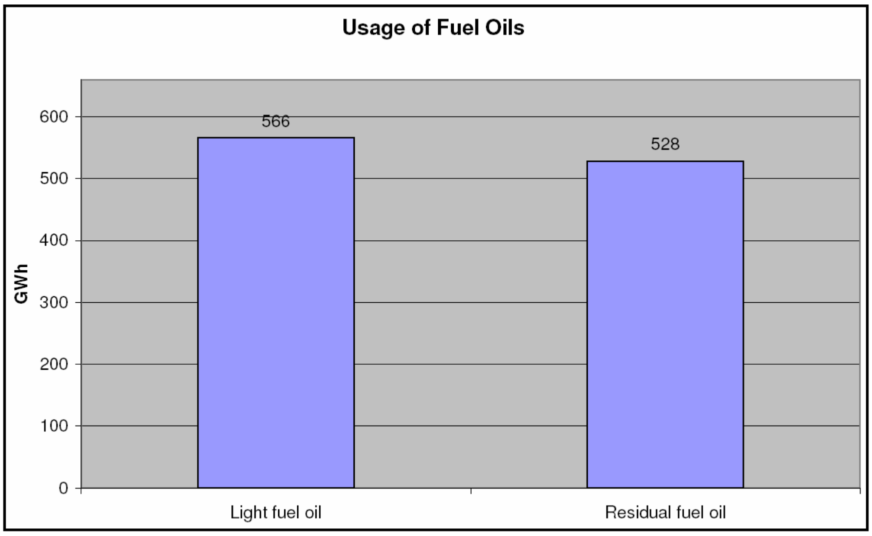

Figure 27. Usage of fuel oils of Northern Savonia in 2008

Almost every heat and power plant use fuel oils but it rarely is the main fuel. Plants which use fuel oils as a main fuel are usually so called seasonal plants, to be used only in the case of high demand such as in freezing cold weather.

Finland is a big country. The most of products are transported by trucks and each average Finnish family has a car. This is seen in the high usage level of transportation fuels. In 2008, the yearly consumption of transportation fuels was 2 368 GWh which is even 17 % of the total amount of fuels used in Northern Savonia.

The taxation of gasoline and diesel fuel is high already, and the same tax is paid everywhere in Finland. A person who lives in a city with good public transportation pays the same than a person who lives in Keitele. Oras Tynkkynen, who is a Finnish politician, Green member of Finnish Parliament and Tampere city councillor, states that the traffic fees should be focused in the cities in which the traffic of private cars causes problems and which provides decent public transportation. (Haapakoski 2007, Energian hinta taivaisiin)

6.4 Use of Reaction and Process Heat, Steam and Hot Water

Other fuels which are mainly the reaction and process heat, steam and hot water of industry, were used 1 529 GWh in 2008. The share of the industrial heat, steam and water is 11 % of the total amount of fuels used in Northern Savonia. Due to the big share of other fuels, the industrial heat, steam and water of industry should be separated in its own category for the update of the energy balance of Northern Savonia.

The reaction and process heat utilised in energy production is concentrated in Yara factory in Siilinjärvi in which there operates the sulphuric and nitric acid factories of Yara and the sulphur burning plant of Fortum Heat and Power. The steam and hot water utilised in energy production is concentrated in Stora Enso paper mill in Varkaus.

6.5 Use of Coal and Recovered Fuels

In 2008, the yearly consumption of coal was 246 GWh which is 1.7 % of the total amount of fuels used in Northern Savonia. The coal used in Northern Savonia is practically used in one plant. In addition, there are a few small consumers, including also the private use.

In 2008, the yearly consumption of recovered fuels was 208 GWh which is 1.5 % of the total amount of fuels used in Northern Savonia. The status of recovered fuels is similar to the status of coal. All the recovered fuel used in Northern Savonia is used by one power plant.

6.6 Use of Hydropower

In 2008, the yearly production of hydropower was 145 GWh which is 1 % of the total amount of fuels used in Northern Savonia. The hydropower of Northern Savonia is produced in the following ten waterfalls:

- Juankoski: Karjalankoski and Juankoski
- Leppävirta: Yläsorsa and Alasorsa
- Maaninka: Viannankoski
- Sonkajärvi: Kiltua
- Varkaus: Huruskoski
- Varpaisjärvi: Atro and Sälevä
- Vieremä: Salahmi

The waterfalls of Northern Savonia are small and they do not have much energy economical significance but they have usually been constructed for a local need and have been operating since serving the local company or community.

6.7 Use of Biogas

The yearly consumption of biogas is 16 GWh which is even 0.1 % of the total amount of fuels used in Northern Savonia. The use of biogas is minor in Northern Savonia but there is a huge potential for the technology and therefore, biogas is expected to be one of the trends to produce energy in the future.

The only biogas reactor of Northern Savonia is located in the Lehtoniemi sewage treatment plant of Kuopion Vesi. Lehtoniemi sewage treatment plant has been in operation since 1987 and nowadays it processes the sewage water of 80 000 people. Until year 2003, the energy production applied air compressor, and in 2003 it was replaced by power generator. In 2008, the biogas plant of Lehtoniemi sewage treatment plant produced 2 090 MWh electricity and 4 222 MWh heat, and only a minor amount of energy was wasted by burning. Figure 28 shows the combusted biogas of Lehtoniemi sewage treatment plant within 1994-2008. (Kuittinen, V. and Huttunen, M.J. 2009, 20)

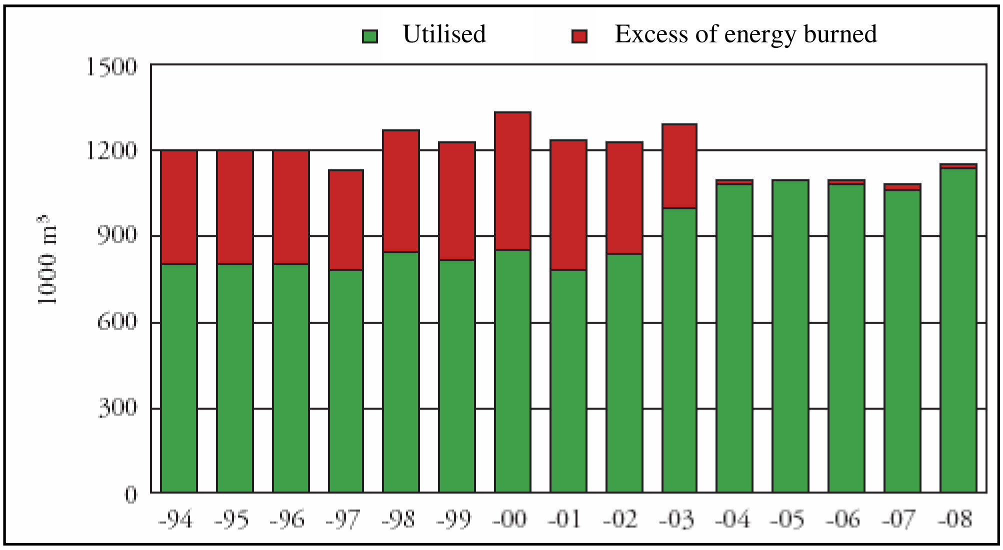

Figure 28. Combusted biogas of Lehtoniemi sewage treatment plant within 1994-2008

In addition to the biogas reactor of Lehtoniemi sewage treatment plant, there are also biogas pumping stations in two waste disposal sites in Kuopio and one in Iisalmi.

Pumping stations of Kuopio operate in Heinälamminrinne waste disposal site which is in operation and in closed Silmäsuo waste disposal site. Both biogas pumping stations were introduced in year 2003. The pumped biogas is combusted in the Pitkälahti heat plant of Kuopion Energia. In 2008, the biogas pumped in Heinälamminrinne was combusted into 5 560 MWh and in Silmäsuo into 2 851 MWh. The pumped biogas was fully utilised. Figure 29 shows the amount of pumped biogas in Heinälamminrinne and Silmäsuo waste disposal sites within 2004-2008. (Kuittinen, V. and Huttunen, M.J. 2009, 58)

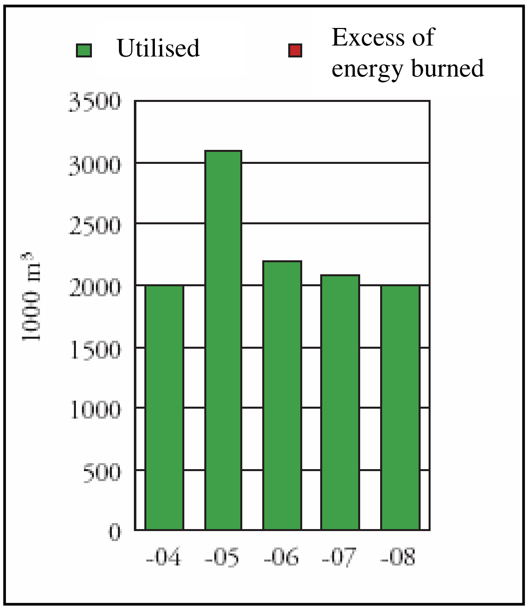

Figure 29. Amount of pumped biogas in Heinälamminrinne and Silmäsuo waste disposal sites within 2004-2008

Pumping station of Iisalmi has been in operation in Peltomäki waste disposal site since 2002. Yearly capacity of biogas is about 3 500 MWh but so far it has not been utilised. Iisalmi is planning to provide building sites for industry nearby to Peltomäki waste disposal site to enable the use of the pumped biogas in the heating of the buildings in the future. (Kuittinen, V. and Huttunen, M.J. 2009, 48)

Despite wide spread dairy-cattle agriculture in Northern Savonia, there is not a single farm utilising the energy of silts in its own biogas plant. There are not any in the whole Eastern Finland, either. However, there are several potential cattle and piggery entrepreneurs to invest in the biogas systems. (Regional Council of Northern Savonia 2006, 24-25)

7 ENERGY MANAGEMENT OF NORTHERN SAVONIA

The aim of the energy management of Northern Savonia is to increase the amount of the solvency ratio of heat and electricity production by adding the amount of renewable energy sources and by improving the energy efficiency of all operations. (Regional Council of Northern Savonia 2006, 24-25)

Northern Savonia is relatively independent in the means of the fuels of energy consumption. The share of imported fuels, practically fuel oils and minor amount of coal is 10 %. The share of transportation fuels is 17 %. The share of wood is 26 %, peat is 15 % and industrial heat is almost 11 %.

Of all buildings of Northern Savonia, 45 % is connected into district heating system and 38 % use fuel oil or electricity in heating. Private buildings and agriculture are remarkable users of firewood.

As a whole the solvency ratio of Northern Savonia in primary energy sources is only 47 %. This is mainly because 74 % of consumed electricity was imported and the solvency ratio of transportation fuels is basically 0 %.

7.1 Energy Balance of Northern Savonia 2008

Energy balance of Northern Savonia 2008 is shown in Figure 30. Energy balance figures of the municipalities of Northern Savonia are found attached (Appendix c).

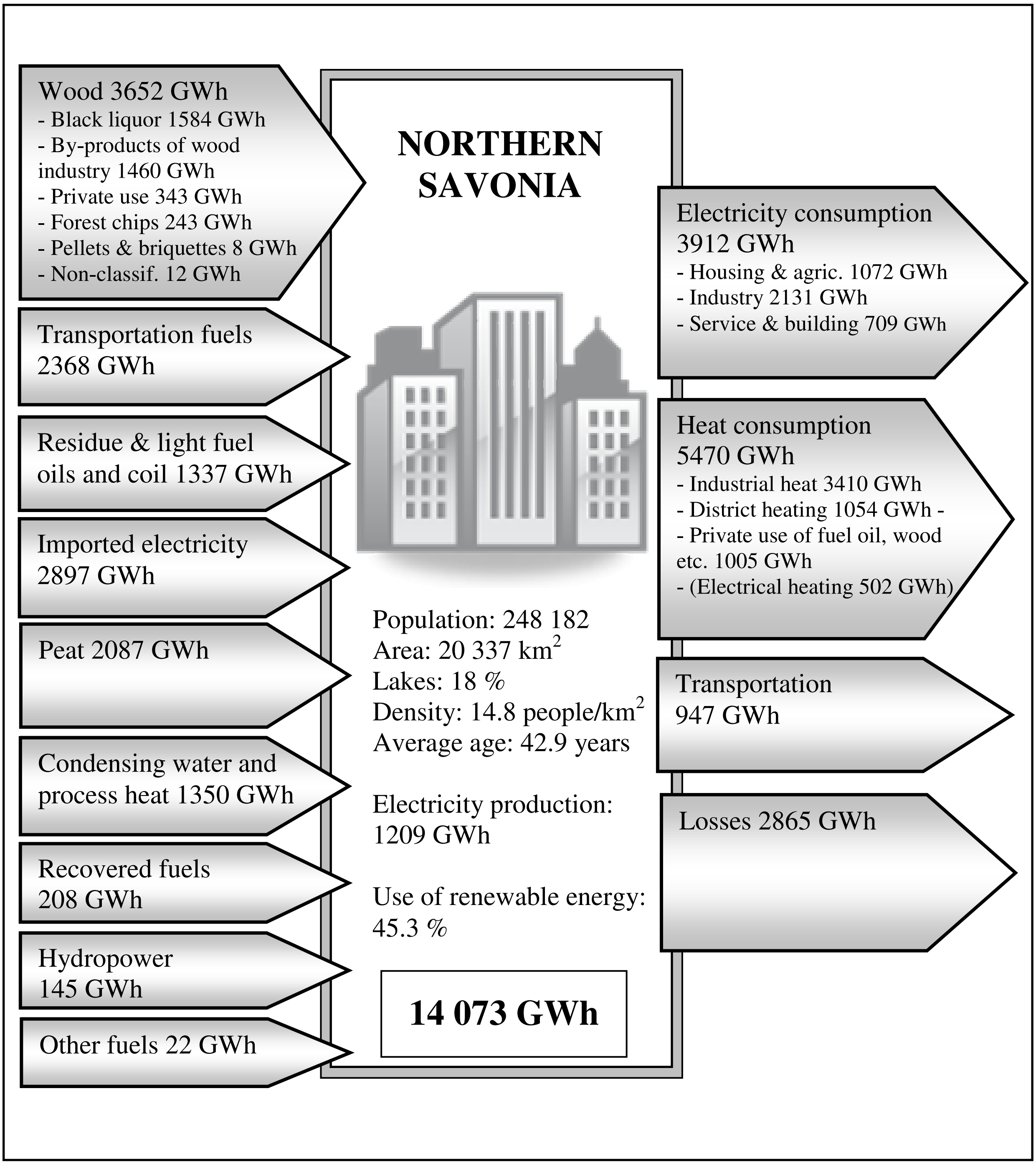

Figure 30. Energy balance of Northern Savonia 2008

Primary energy is seen on the left and energy consumption and losses on the right. Energy consumption is divided into three categories:

1. Electricity consumption
2. Heat consumption
3. Transportation

Electricity consumption comes from the statistics of Organisation of Finnish Energy Industry which has been shown earlier in Table 5. Value of imported electricity on the left side has been calculated on the basis of the statistics, too.

Heat consumption comes from several different sources:

1. Industrial heat comes from the energy information gathered from energy suppliers.
2. District heating comes from the database of Tilastokeskus introduced earlier in Chapter 2.1.1.
3. Private use of fuel oil, wood etc. comes as well from the database of Tilastokeskus as shown earlier in Chapter 2.1.1.
4. Electrical heating comes from the same database of Tilastokeskus as the two points above. Electrical heating is only shown in the heat consumption, but it is not regarded in the sum of energy consumption because the energy consumption of electrical heating is regarded in electricity consumption below heat consumption.

Detailed energy balance calculation of Northern Savonia is shown in Figure 31. Detailed energy balance calculations of the municipalities are found is Appendix d.

Northern Savonia

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		3 651 718	3 652	Heat consumption		5 469 732	5 470
	Black liquor	43 %			Industrial heat	3 410 295	3 410
Natural gas		0	0		District heat	1 054 401	1 054
Imported electricity		2 896 992	2 897		Private heating	1 005 036	1 005
Hydropower		145 217	145		Electrical heating	502 417	502
Peat		2 086 726	2 087	Electricity consumption		3 912 000	3 912
Oil fuels		1 093 765	1 094		Housing and agriculture	1 072 000	1 072
Recovered fuels		207 920	208		Industry	2 131 000	2 131
Coal		243 322	243		Service and building	709 000	709
Others		1 379 394	1 379	Transportation		946 522	947
Gasoline and diesel fuel		2 368 306	2 368	Losses		2 865 061	2 865
Electricity production		1 015 008	1 015	Imported electricity		-2 896 992	-2 897
TOTAL		14 073 360	14 073	TOTAL		13 193 315	13 193

Balance **880 GWh**

Figure 31. Detailed energy balance calculation of Northern Savonia 2008

The structure of the calculations is similar to the structure of Figure 30. Primary energy is detailed on the left and energy consumption and losses on the right. In theory, both sides should be equal and the “Balance” should equal to zero. In practice, the balance value of balance is not definitely zero and the value can have several meanings: Heat import or export to or from other regions, lacking energy information on the left side of calculation or calculation failure.

7.2 Energy Production

Heat energy production of Northern Savonia is based on industry in terms of using black liquor, industrial heat, and small or middle scale heat plants spread around the region. A couple of biggest towns such as Iisalmi, Kuopio and Lapinlahti only have power plants without direct contact to industry.

Strong influence of especially forest industry is a bit unsure at the moment due to the unsteady state of forest industry in Finland. Paper mills have been closing down through the whole country within the last year when the paper production has been transferred into the countries where forests grow faster and work force is cheaper. Therefore, also Stromsdal cardboard factory in Juankoski and several saw mills have been closed down in Northern Savonia within the last couple of years.

On the other hand, wide-spread, small and middle scale heat plants are strength of the energy production of Northern Savonia. Decentralised energy supply provides reliability of energy supply and support local employment.

7.3 Energy Consumption

The consumption of electricity has increased for years in Northern Savonia as well as in everywhere in Finland but the electricity production of Northern Savonia has not increased. Therefore, the amount of imported electricity has increased up to 74 %. There are even thirteen municipalities in Northern Savonia which do not have any electricity production what so ever.

Figure 32 shows the energy consumption of Northern Savonia in 2008. 44 % of the produced energy is used in heating, and 27 % is used in lighting, electrical appliances and machines. 7 % of energy is consumed by transportation, but the amount of lost energy due to the poor efficiency of combustion engine is remarkable 11 %. Transportation causes the same amount of losses than industry, households, agriculture, services and buildings in total.

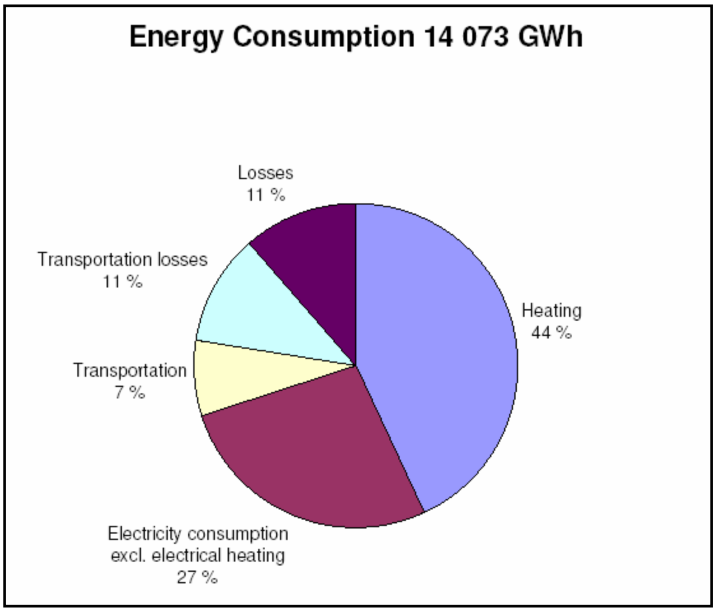

Figure 32. Energy consumption of Northern Savonia in 2008

As shown in Figure 33 industry is clearly the biggest electricity consumer in Northern Savonia. Forest and metal industries especially require huge amounts of energy in their manufacturing processes.

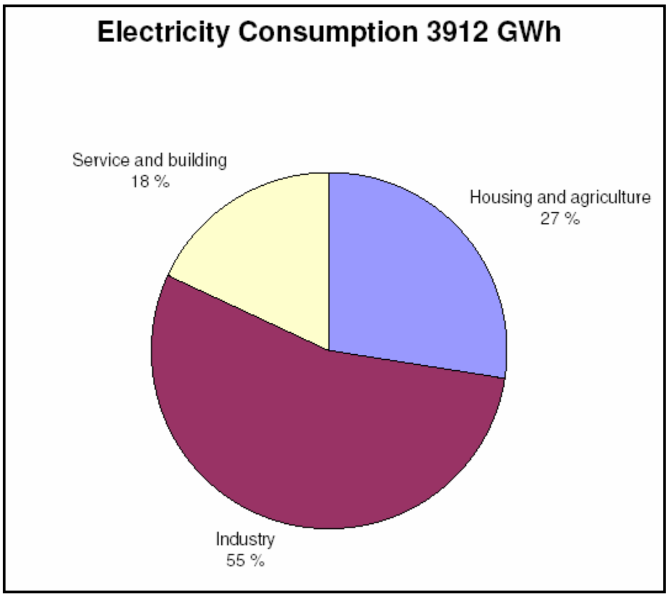

Figure 33. Electricity consumption of Northern Savonia in 2008

The electricity consumption of housing and agriculture includes 48 % of the electrical heating of houses, buildings and greenhouses. 52 % of the electricity of housing and agriculture is consumed in:

- Housing: Lighting, household appliances, electronics, electrical machines, the heating of car motors, air conditioning etc.
- Agriculture: Grain drying plants, cattle-breeding machinery, milking machines, additional heaters of cowsheds etc.

As energy consumer, service and building sector is an incoherent group. The group consists of community services, street lighting, public buildings and service buildings such as hotels, grocery stores and medical centres. (Kara et al. 2004, 62)

Heat consumption is categorised differently than electricity consumption which was categorised on the basis of consumer group. As shown in Figure 34 heat consumption is categorised according to the heating method.

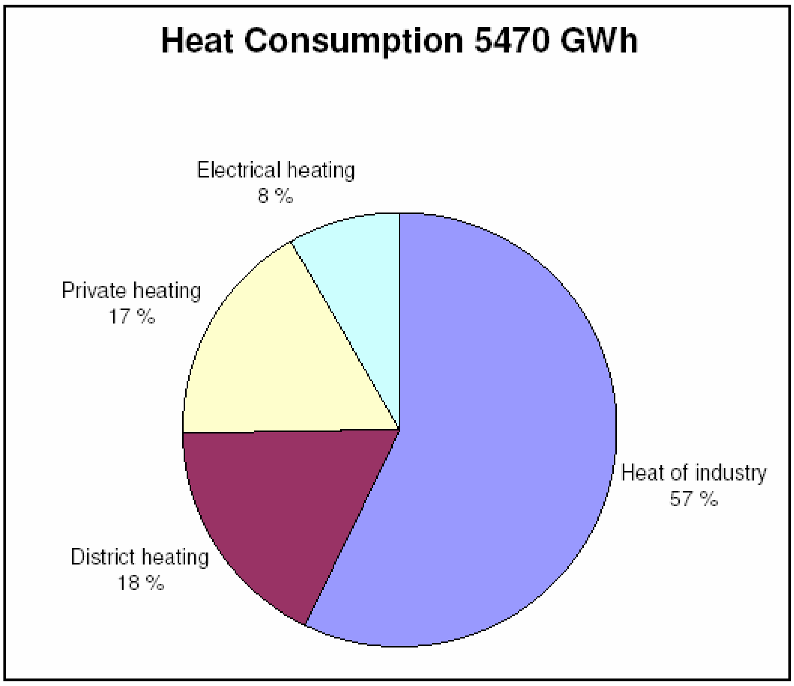

Figure 34. Heat consumption of Northern Savonia in 2008

57 % of produced heat is consumed by industry, and the rest 43 % is used to heat buildings. There are 73 900 buildings in Northern Savonia of which the main part, 63 600 buildings are used for housing. Table 16 shows the heating methods of buildings. (Regional Council of Northern Savonia 2010, Asuminen ja kaavoitus Pohjois-Savossa, 2)

Heating of buildings is divided into three sectors: Private heating, district heating and electrical heating. Private heating sector includes own heat production by firewood, oil fuels, earth heat, pellets and briquettes etc. while district heat and electricity for heating are supplied by energy companies.

Table 16. Heating methods of private houses in Northern Savonia

Heating method	**Amount of buildings**
Private heating	
- Wood	19 200
- Oil fuels	9 100
- Earth heat	650
District heating	8 000
Electricity	24 400

Energy consumed in the heating of buildings is divided into following way:

- Private heating 40 %
- District heating 42 %
- Electrical heating 18 %

Jyri Seppälä, the Professor of Finland's Environmental Administration, states that the energy consumption per capita of Finland is one of the highest in the world which can not be accepted despite the cold climate, long distances and heavy export industry. (Haapakoski, K. 2007)

The reduction of energy consumption has been discussed for years but Finland has not been able to achieve the goals agreed in the Kyoto Protocol. Sweden, instead, has decreased the energy consumption tens of percents more than expected. This was done by committed environmental politics and by, for example, traffic fees. Mr. Seppälä also states that the increase of energy prices can not be avoided, and that seems to be the way to make the Finns cut down their energy consumption. (Haapakoski, K. 2007)

7.4 Future of Energy Management of Northern Savonia

Forest chips, field biomass, agricultural and community silts and solid waste are the raw materials of renewable energy which could be utilised to develop the energy production of Northern Savonia. By adding the use of biofuels, the region could also affect remarkably to reject climate change and decrease harmful effects. (Regional Council of Northern Savonia 2006, 24-25)

The energy use of peat has a remarkable effect on employment in Northern Savonia. The increase of peat usage is highly supported locally by the Regional Council of Northern Savonia. (Regional Council of Northern Savonia 2006, 24-25)

The new power plant venture of Kuopion Energia is answering for the need for a power plant utilising local biomass and to supply local electricity to decrease the demand of imported electricity.

The fact is that the used transportation fuels are practically all fossil fuels. There are big amount of ventures ongoing to develop the future fuels for transportation. The trend is global and the new technology will be taken into action everywhere within near future, also in Northern Savonia. It will be possible to produce new biofuels locally in Northern Savonia, so this development should not be dismissed.

Regional Council of Northern Savonia has been working on to develop the energy production of Northern Savonia in order to strengthen the use of biomass and renewable energy and to develop the value chain of energy management. (Regional Council of Northern Savonia 2006, 24-25)

The key points to strengthen the use of biomass and renewable energy are:

- Remarkable increase of wood in energy production
- Creation of the production capacity of liquid biofuels
- Starting and development of the use of biogas technology
- Increase of the use of field biomass
- Increase of the use of community waste
- Promotion of the use of hydropower and heat pump and earth heat technologies

The key points to develop the value chain of energy management, to develop logistics and manufacturing process are:

- Developing of new solutions, technologies services and entrepreneurships to utilise by-masses
- Creation of business based on fuel production and exports
- Development and productisation of the operations model of heat entrepreneurship
- Development of harvesting methods and technologies
- Development of fuel quality and increase of processing degree e.g. pellets and briquettes

According to Jorma Telkkä, the Office Manager of the Regional Energy Agency of Eastern Finland, Eastern Finland should become self-sufficient in heat and electricity production and partly also in the production of transportation fuels. For electricity production the goal is rather ambitious for Northern Savonia, because achieving the goal it would require the tripling of the electricity production of the region. The vision of the Regional Energy Agency of Eastern Finland rely on decentralised energy production and on the use of the renewable primary energy sources available in Eastern Finland, especially by-products of wood processing industry and forest chips. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomi – Uusiutuvan energian mallialue)

To work towards the vision, there should be built district heating systems in all population centres and unutilised heat should be taken in use in electricity production. On countryside electrical and fuel oil heating systems should be replaced by earth heat, forest chips and pellet heating systems. Maybe the most important thing to increase the self-sufficiency of local energy production is to decrease energy consumption. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomi – Uusiutuvan energian mallialue)

To support the development of energy production, research activities should be strengthened to develop the harvesting, processing, transportation, storage and combustion of primary energies. In addition, local entrepreneurship will be supported to start up the production of transportation fuels from forest chips and grain. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomi – Uusiutuvan energian mallialue)

Regional Energy Agency of Eastern Finland has calculated that the addition of 5 000 MWh/year of forest chips used employs one person. The availability of forest chips is very good in Eastern Finland and there would be a potential for the increase of 1 700-3 300 new work places within the forest chips business. The work places would be created into countryside suffering unemployment at the moment. Also it should be started to grow fast growing grains for energy use, which would offer a new way to utilise field land when traditional cultivation is diminished. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomi – Uusiutuvan energian mallialue)

7.5 Potential New Fuel of Field Biomass

Cultivation of energy plants and beginning of so called non-food –production is an alternative to utilise the land released from traditional food production and peat land released from peat production. Biomasses can be used in energy production or they can be processed into pellets or briquettes or into biofuels.

Plant oil bases fuels made of sun flower, rape, turnip rape, hemp and soybean are used for replacing diesel fuel. Sugar producing plants or amylum producing grains such as sugar cane, sugar beet, potato, corn and straw grain, are used to replace alcohol based fuels, as such or together with gasoline. Straw, kernel, energy grass and briquette waste of sugar cane can be utilised in solid form in energy production. (Alakangas 2000, 97)

In Finland, the straws of cultivated grains, reed canary grass, and plant oil based plants and grains are considered as field biomasses to produce ethanol and biofuels. In addition, energy willow is considered suitable for energy production. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomen peltoenergiaohjelma vuoteen 2010, 13)

Reed canary grass is perennial and easily spreading grass which grows wild on the water-fronts of sea and lakes, ditch banks and road sides. Reed canary grass is suitable for energy production, but it is also used in paper production, for the filtering and evaporation of surface runoff areas, and as fodder. Heat value of reed canary grass is 4.7 kWh/kg and moisture is 10-15 %. Therefore, the heat value in arrival conditions can be even better compared to peat or wood. Reed canary grass can be harvested either on spring or on autumn. The fuel features of reed canary grass are generally better when harvested in spring time. (Alakangas 2000, 103-105)

Common reed is the biggest grass in Finland. It can grow until three meters long and the leaves can be even 2 cm wide, and it has long, thick, wide-spread and perennial root. Common reed grows in lakes rich in nutrients, and in swamps and accretion land. Heat value of common reed is 4.9 kWh/kg and moisture is less than 20 %. Common reed is harvested in winter. (Alakangas 2000, 103-105)

Northern Savonia has good conditions for growing field biomasses. The region belongs into production zones of III and IV, and the theoretical production of biomasses is shown in the Table 17. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomen peltoenergiaohjelma vuoteen 2010, 15)

Table 17. Theoretical production of biomasses

Field biomass	**Zone II**	**Zone III**	**Zone IV**	**Zone V**
Reed canary grass	7.6	8.4	6.8	5.6
Willow	8.2	9.0	7.3	6.0
Spring turnip rape	1.9	2.0	-	-
Straw	2.0	2.0	2.0	-

The production potential of Northern Savonia has been estimated for reed canary grass 1268 GWh/year, for willow 809 GWh/year and for straw 281 GWh/year. The cost efficiency of growing biomass is improved by the financial support to be paid per each grown hectare by European Union. (Regional Energy Agency of Eastern Finland 2004, Itä-Suomen peltoenergiaohjelma vuoteen 2010, 33)

At the moment the energy use of reed canary grass and straws is the mostly researched biomasses but the interest especially towards energy willow is increasing. The growing of field biomass is still experimental in Northern Savonia, but there is a strong interest among the Regional Council of Northern Savonia, as well as the Regional Energy Agency of Eastern Finland to create local biomass production to support own energy production and to enable biofuels production.

8 RESEARCH ISSUES OF ENERGY BALANCE

The process of the final thesis has taken eight months to complete. The gathering of energy information from energy producers was straightforward, but to apply the gathered information into practice on the energy balance sheet required checking of calculations and references over and over again. Along the process some research problems have occurred and ideas for the future updates have developed, and those remarks will be introduced next.

8.1 Reliability of the Study

The energy information needed to calculate the energy balance has been gathered from the following sources:

- Energy producers: Energy production information
- Statistics of Tilastokeskus: Heating of buildings
- LIISA database of VTT: Transportation fuels
- Statistics of Finnish Energy Industries organisation: Electricity consumption per municipality to enable the calculation of imported electricity

Energy information gathered from energy producers can be considered as relatively reliable information. The energy information was gathered by the students of Energy Technology and Economy course, and all the details have been checked for mistakes and fidelity on the basis of e-mail copies. Two e-mails are only missing and the energy information related to them could not be checked.

The Excel sheet of energy balance calculation is complicated with hundreds of formulas, which has required good knowledge of Excel and ability to solve the problems. The possibility of formula failures exist but they are not likely.

Statistics of Tilastokeskus which was used to calculate the private heating of buildings, and the LIISA database of VTT, which was used to calculate the transportation fuels, can also be considered as reliable sources. On the other hand, neither is based on reality but both are computationally generated statistics. Therefore, one could say that the results of private heating of buildings and transportation fuels are estimates about the issues in concern.

While knowing the remarkable number of summer cottages, in the future updates the private heating consumption of buildings could be supplemented by including the heating of summer cottages into the calculation. There are the statistics of Tilastokeskus available concerning heating of summer cottages as well.

The statistics of Finnish Energy Industries organisation can be considered as reliable sources as well. The statistics was used to determine imported electricity.

8.2 Comparing Energy Balances of Different Regions

It has been found problematic that there are no guidelines established for the calculation and representation of energy balance. The principal of the result, which is a figure or a table with primary energies on the left and energy consumption on the right, was known but the path to get there to be found.

Energy balance calculation is surprisingly complicated assembly of information. There are primary energies, produced energy, energy consumption, transportation, private heat energy, district heating, electrical heating and imported electricity. Many of those things are slightly overlapping with each other which should be taken into consideration. There are numerous ways to present the issues which make the comparing of energy balances rather difficult.

The result for the problem would be to assign guidelines how to handle the initial data and to turn it into energy balance. The guidelines attached with the Excel sheet of energy balance calculation would make the creation of the next new energy balance straightforward and enable the comparison of new energy balance.

Despite the guidelines, the comparison problem of inconsistent energy balances made earlier would still remain, unless the other regions would also ratify the newly written guidelines and modify their energy balances into the commonly agreed format.

8.3 Imported Electricity

One of the research topics was to study how to implement imported electricity into the energy balance.

When gathering energy information from energy producers, they usually gave the amount of imported energy among the energy information of their own production. This information was however inadequate, because the most of imported energy was imported by electricity companies instead of energy producers. Therefore, the information concerning imported energy given by energy producers was totally disregarded in the study. Since all needed information concerning the electricity production was received from energy producers, there was a need to find only the energy consumption to solve the amount of imported electricity.

As earlier described, Finnish electricity market is open for competition, and a consumer has a freedom to choose any electricity supplier in the market. Therefore, gathering electricity consumption information of Northern Savonia would have required contacting tens of electricity companies around Finland. Instead, statistics of Finnish Energy Industries was used in the study.

After all, in the Energy Balance of Northern Savonia 2008 imported electricity is calculated as the difference of electricity production and electricity consumption:

[Imported energy] = [Electricity consumption of Northern Savonia] – [Electricity production of Northern Savonia]

Where:
[Electricity production of Northern Savonia] was received from local energy producers.
[Electricity consumption of Northern Savonia] was received from the statistics of Finnish Energy Industries.

8.4 Classification of Peat

Peat land holds carbon ten times more than any other ecosystem. Cleaning and drying of peat land, as well as fires release over 3000 million tons of carbon dioxide every year, which is 10 % of all emissions of fossil fuels on earth. (Wikipedia 2010)

Kyoto Protocol, which is an international agreement to United Nations Framework Convention on Climate Change aimed at fighting global warming, does not take notice of the released carbon dioxide and methane of peat lands. (Wikipedia 2010)

Finnish Ministry of Trade and Industry (nowadays Ministry of Employment and Economy) defines peat as a slowly renewable biomass fuel, but European Union and Intergovernmental Panel on Climate Change of United Nations instead classify peat as a fossil fuel. (Alakangas and Kaivola 2010, 4)

Environmental organisations are worried about the carbon dioxide emissions but also about dried swamps. The economical value of peat is remarkable for Finland and Finnish politics do their best to remain and support the strong status of peat in domestic energy production. The confusion in classification of peat reflects also into energy balance calculation.

Locally it is advantageous to support and keep the strong status of peat. On the other hand, environmental debate should be continued. Therefore, in the Energy Balance of Northern Savonia 2008, peat was classified into renewable fuels but not intentionally hidden into renewable fuels. Instead, when possible, for example in figures peat was represented separate from fossil and renewable fuels.

8.5 Updating of Energy Balance of Northern Savonia 2008

There are nine local and regional energy agencies operating in Finland. The main task of the energy agencies is to promote energy efficiency and the use of renewable energy sources. Energy agencies provide their services to companies and communities and take part in co-operative projects. (Motiva 2010, Energiatoimistot)

Energy balances are often updated by the local energy agency, if there is one in the region. Northern Savonia does not have an energy agency of its own. The easiest way to implement the updating of the energy balance would be to assign an energy agency such as Energy Agency of Southern Savonia or Energy Agency of Eastern Finland to update it for a fee.

If this is not possible, an option to implement the updating of the energy balance would take place in an educational institute such as Savonia University of Applied Sciences. Once the energy balance has been created, the update is not that big task that it could not be carried out as project work by students. The implementation of the project work requires some effort from the lecturer, due to that he is the one to be responsible for the results and handle the information on the Excel sheet of energy balance calculation. If the project work is run successfully it can be the most educating exercise on energy management.

The most important thing is to prepare the project work well. The project work should be carried out in groups of two or three persons and the division of responsibilities could be the following:

- Iisalmi, Contacting to Savon Voima
- Juankoski, Contacting to Fortum Heat and Power
- Kuopio, Sonkajärvi, Kaavi
- Lapinlahti, Suonenjoki, Rautalampi
- Varkaus, Calculation of heating of houses and summer cottages
- Siilinjärvi, Rautavaara, Calculation of transportation fuels
- Karttula, Vieremä, Calculation of electricity consumption and imported electricity
- Keitele, Leppävirta, Excel Master (responsibility of the operation of formulas in the Excel sheet)
- Maaninka, Nilsiä, Vesanto, Tuusniemi
- Pielavesi, Kiuruvesi, Varpaisjärvi, Tervo

All tasks needed to update the energy balance are considered in the division of responsibilities above. The Excel sheet of energy balance could be saved in Moodle, and each group could fill in the information they are responsible for. There should also be a file for each group in Moodle, in which they could save the copies of the e-mails received from energy producers.

Table 18 shows possible time consumption for the project work. Four three-hour lectures are required to carry out the project work, while part of the tasks such as adding energy information into the Excel sheet of Moodle could be done as home work.

Table 18. Time consumption of project work

Time used	**Room**	**Task**
3 hours	Computer class	Introduction of project work Students get familiarised with their responsibilities.
3 hours	Computer class	Sending inquiries and looking for possible new energy producers
3 hour	Computer class	Supplementing inquiries and filling energy information in the Excel sheet
-	-	Deadline of project work
-	-	Lecturer checks and corrects the project work results.
3 hours	Classroom	Students represent their responsibility areas, and lecturer gives feedback of their work.
-	-	Finishing the course

The updating of energy balance should be continuous. The time between updates should not be more than two years, but yearly updating is not required because big amount of changes within one year is not expected.

9 CONCLUSIONS

The energy management of Northern Savonia relies greatly on the basis of industry. In year 2008, more than 30 % of used primary energy was utilised in industrial power plants in terms of primary energy sources such as by-products of wood processing industry, black liquor and reaction and process heat, steam and hot water. On the basis of energy balance, industry applied about 30 % of the produced heat, but in towns such as Varkaus, the most buildings were heated by the excess heat of the paper mill. Knowing the condition of Finnish forest industry, the dependency of the industry is not very farsighted. The operations of the paper mill of Varkaus have already been diminished strongly, and there is also a threat that the whole factory would be closed down in the future. If this would happen, the energy balance of Northern Savonia would change dramatically. Varkaus is a large scale example of the dependency of industrial heat production, but the dependency is found among several smaller municipalities or separate heat plants. In these cases, heat was produced by using by-products of wood processing industry such as a saw mill. Saw mills compete with each other not only for customers but also for raw materials. The increase of the customs duty of Russian wood would probably increase the price of Finnish wood and make saw mills to compete for raw materials also with paper industry. The kind of development would end up with closing down of saw mills, which would force into the increased use of peat and fossil fuels in heat production.

Peat is a renewable energy source which is a remarkable natural source of Finland, and especially in Northern Savonia. Finnish government has put a lot of effort in remaining the strong status of peat in local energy production, but the success of peat is not absolute. The environmental resistance against the use of peat is strong.

Northern Savonia has good resources for the production of forest chips, but so far it has not been very popular in use. Good availability and price of peat have not encouraged new entrepreneurs to explore the possibilities of a new primary energy source. The potential of forest chips have lately been noticed in Northern Savonia, and the use of forest chips is expected to increase within the next years. Actually, there is no other way than to increase the production of new primary energy sources in order to ensure the supply of biofuels for the biopower plants to be constructed in the future. A biopower plant in Varkaus has just been finished, and another will be constructed in Kuopio shortly.

The most fossil fuels used in Northern Savonia were transportation fuels. Even 17 % of all used primary energy was gasoline and diesel fuel. Residue and light fuel oils were used for 8 % and coil for 2 %. Despite the amount of used transportation fuels, the amount of used fossil fuels is justified. Most of the municipalities of Northern Savonia are small, agricultural towns. The heat plants to serve public buildings such as a municipal hall, a medical treatment centre, a school and a nursing home are often operated by fuel oils, solid wood fuels and peat. Fuel oils are used as supplementary fuel in power plants as well. So called back-up heat plants which are used in the case of failure of a power plant or in very cold winter days when more heat is needed, are mainly operated by fuel oils. The usage of transportation fuels is difficult or even impossible to influence on the level of region. In practice, only the government has an effect on the usage of transportation fuels through taxation at the moment, but the circumstances will change in the future when more vehicles are enabled to apply biofuels instead or beside fossil fuels. And when biofuel production will become profitable business, local entrepreneurs of the field are expected to show up in Northern Savonia as well.

Almost 75 % of consumed electricity was imported electricity. 55 % of electricity is used by industry. Northern Savonia should put effort to increase own production of electricity in order to fulfil the demand of electricity to take place if electrically operated cars begin to become more popular. On the other hand, there will be the shutting downs of two paper machines and separate factories in the near future, which will decrease the demand of electricity too. Over 90 % of locally produced electricity was combined heat and power (CHP) production. About 10 % of own electricity was produced by hydropower plants. The increase of own electricity production could be implemented by supporting small, private investments such as farms to construct their own biogas plants or small CHP plants.

Most of the houses and buildings in Northern Savonia are connected into district heating. In 2008, 41 % of premises were heated by district heating, 39 % had a private heating system usually using light fuel oil of wood and 20 % used electricity for heating. Regional Council of Northern Savonia has set one of its goals to improve the availability of district heating in every town centre. This would enable the decrease of fuel oil usage in urban areas. Due to the age of construction base in Northern Savonia, big part of private heating systems needs to be renewed shortly. This will also tend to decrease of the use of light fuel oil and to increase the use of new heating alternatives such as air and earth heat pumps, and pellet boilers.

In overall, the energy balance of Northern Savonia is domestic and versatile. This means that in Northern Savonia, local primary energies are strongly used and the energy management does not rely on only two or three primary energy sources. The weakness of the energy balance of Northern Savonia is the dependency on the energy and primary energy produced by industry. Northern Savonia should also improve the solvency ratio of own electricity production.

The natural resources of primary energy in terms of forest chips are very good in Northern Savonia. The increase of forest chips usage would create new work places locally and decrease the dependency of criticised peat. It is possible though, that the strong influence of peat will lengthen the breakthrough of forest chips.

In addition to forest chips there are also a few other, less utilised primary energy sources with favourable developmental potential. The utilisation of the biogas of sewage treatment plants and waste disposal sites, as well as the silts of farms, would be generally beneficial. The growing of field biomass is still minor in Northern Savonia. In the years to come when traditional agriculture becomes unprofitable and more peat land is harvested into field land, it is likely that the growing of energy plants will be increased.

Northern Savonia has a challenge to control negative population change and the decrease of traditional industry. Kuopio is the centre of Northern Savonia and its significance will also be remarkably increased, but the development of Kuopio will not solve the problems of Northern Savonia. Instead, small and middle size municipalities should urgently receive more attention in order to prevent the countryside of Northern Savonia from dying.

As a thesis theme, Energy Balance of Northern Savonia 2008 has been an interesting and the study has taught me more than I ever could have imagined. Many issues have been familiar to me from my studies, but the final thesis process has made me to realise the relations and the scale of the energy business. The implementation of energy information gathering by students required some extra effort but it was worthwhile learning process for me as project manager of the project work. As a wholeness the final thesis has been a beneficial experience to support me in my further working life.

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APPENDIX A: TRAINING MATERIAL FOR PROJECT WORK

Ohjeita projektityön tekemiseen

- Etsi netistä, mitä energiaa tuottavia yrityksiä paikkakunnallasi sijaitsee.
- Tutki, millaisia nuo tuotantolaitokset ovat:
  - Mitä polttoaineita tuotantolaitos käyttää ja mikä on vuosittainen kunkin polttoaineen kulutus?
  - Kuinka paljon energiaa tuotantolaitos tuottaa?
- Energiatiedot löydät internetistä, tiedustelemalla yrityksestä ja/tai laskennallisesti.
- Täytä tiedot Excel – taulukkoon (energiatase laskentapohja.xls).
  - Jokaiseen taulukkoon täytettyyn arvoon on liitettävä lähde, mistä tieto on saatu! Lähde merkitään kommenttina soluun tai mahdollisesti Lähteet –sarakkeeseen.
  - Kaikki energiatiedot täytetään megawattitunteina (MWh).
  - Tarkastelujakso 2008

Hyödyllisiä linkkejä energiataseen laadintaan 1(3)

- Pohjois-Savon energiatilastoja: http://www.pohjois-savo.fi/fi/pohjois-savo/index.php
- Tilastokeskus → Energia: http://www.stat.fi/til/ene.html
- Kuntien nettisivut
- Yrityshaut kuten www.inoa.fi tai www.020300200.com
- Yritysten vuosikertomukset
- Pohjois-Savon Ympäristökeskus
  - Ympäristöluvat: http://www.ymparisto.fi/default.asp?node=217&lan=fi
  - Ympäristö- ja paikkatietopalvelu: www.ymparisto.fi/oiva
- Energiamarkkinavirasto → Päästöluvat: http://www.energiamarkkinavirasto.fi/select.asp?gid=218
- Kaukolämpötilasto: http://www.energia.fi/fi/tilastot/kaukolampotilastot
- Sähkötilasto: http://www.energia.fi/fi/tilastot/sahkotilasto

Hyödyllisiä linkkejä energiataseen laadintaan 2(3)

- Öljy: www.oil-gas.fi
- Liikenne: http://lipasto.vtt.fi/liisa/liisa07.htm
- Kaasu: www.oil-gas.fi
- Biokaasu:
  - http://www.biokaasuyhdistys.net
  - http://joypub.joensuu.fi/publications/other_publications/kuittinen_biokaasulaitosrekisteri12/kuittinen.pdf
- Puu:
  - http://www.metla.fi
  - www.metsateho.fi
  - www.pellettienergia.fi
- Bioenergia:
  - www.finbioenergy.fi
  - www.finbio.fi

Hyödyllisiä linkkejä energiataseen laadintaan 3(3)

- Stora Enson ympäristöselonteko tehtaittain: http://www.storaenso.com/sustainability/publications/emas%20reports/Pages/EMAS%20reports.aspx
- Pienet kaukolämpölaitokset: http://kunnat.net/k_peruslistasivu.asp?path=1;29;356;1033;38099;38139
- Lämpöpumput: www.sulpu.fi

Hyvä vastaanottaja

Savonia ammattikorkeakoulun Varkauden yksikkö laatii parhaillaan Pohjois-Savon energiatasetta, jonka tulokset vaikuttavat vuosittain päivitettävän Itä-Suomen bioenergiaohjelma 2015:n sisältöön. Pohjois-Savon energiataseen laatiminen toteutetaan opinnäytetyönä, jonka osana energiatiedon keruuseen osallistuvat "Energiatekniikka ja -talous" -kurssin opiskelijat. Kurssin opettajana toimii energiatekniikan yliopettaja Jukka Hautamaa (044 785 6767, jukka.hautamaa@savonia.fi).

Energiataseessa huomioidaan kaikki maakunnan lämpöä ja sähköä tuottavat laitokset, niin kattavasti kuin se on mahdollista. Energiatietoa etsitään internetistä yritysten vuosikertomuksista, ympäristö- ja päästöluvista jne. Yrityksenne … osalta emme ole löytäneet seuraavia tietoja:

-
-
-

Voisitteko ystävällisesti edesauttaa maakunnan energiataseen laatimista, ja lähettää tarvitsemamme tiedot mahdollisimman pian, kuitenkin viimeistään maanantaina 19.10.2009?

Tarkastelujakso on vuosi 2008. Yksittäisen yrityksen energiatietoja käsitellään luottamuksellisesti eikä niitä julkaista.

Kiittäen avustanne etukäteen,

Yhteistyöterveisin,
…..
Savonia ammattikorkeakoulu
Puhelin: …
Sähköposti: …

Linkki Itä-Suomen bioenergiaohjelma 2015:en:
http://www.kainuu.fi/UserFiles/kylateemaohjelma/File/Ita-Suomen%20bioenergiaohjelma_252952496.pdf

Erillislämmitys

- Tilastokeskus, rakennukset (m^2) käyttötarkoituksen ja polttoaineen mukaan
  http://pxweb2.stat.fi/database/StatFin/asu/rakke/rakke_fi.asp
- Ajetaan kunnista tilastotiedot, joiden pohjalta lasketaan kokonaislämmöntarve sekä primäärienergia polttoaineittain.
  - Poista Kaukolämpö ja Sähkö –rivit, niitä ei huomioida taseessa.
  - Tyhjennä tilaston Yhteensä –solut.
  - Laske **Lämmitysala (m^3)**, siten että tilan korkeus on:
    - Asuinrakennukset 2,7m
    - Julkiset tilat ja toimistot 3,2m
    - Teollisuustilat, varastot ja hallit 5,0m
    - Muut tilat 3,6m
  - Laske **Lämmöntarve (MWh)**
    - Ominaislämmönkulutus 40kWh/m^3
    - Merkitse arvo Energiatase-taulukkoon Energian myynti –kohtaan (”oikea puoli”).
  - Laske **Primäärienergian tarve (MWh)** polttoaineittain
    - Hyötysuhde 80% (Primäärienergia = Lämmöntarve / 80%)
    - Merkitse arvot Energiatase-taulukkoon polttoaineittain (”vasen puoli”).

Esimerkki erillislämmityksen laskemisesta

	A	B	C	D	E	F	G	I
5				Rakennuksia lkm	Kerrosala m2	Lämmitysala m3	Lämmöntarve MWh	Primäärienergi MWh
6	Kuopio	Kaikki rakennukset	Yhteensä			3506662,9	140267	175333
7			Öljy, kaasu	1765	602720	1991319,6	79653	99566
8			Kivihiili	3	3234	14946,8	598	747
9			Puu, turve	1864	276270	824328,7	32973	41216
10			Maalämpö	138	28410	76843,5	3074	3842
11			Muu, tuntematon	906	147670	599224,3	23969	29961
12								
13		Erilliset pientalot	Yhteensä	9890	1581062	4268867,4	170755	213443
14			Öljy, kaasu	1381	237812	642092,4	25684	32105
15			Kivihiili	1	200	540	22	27
16			Puu, turve	1791	221626	598390,2	23936	29920
17			Maalämpö	136	[illegible]	[illegible]	3089	[illegible]
18			Muu, tuntematon	117	[illegible]	[illegible]	916	[illegible]
19		Rivi- ja ketjutalot	Yhteensä	1192	[illegible]	[illegible]	60732	[illegible]
20			Öljy, kaasu	98	[illegible]	[illegible]	5242	[illegible]
21			Kivihiili	0	0	[illegible]	[illegible]	[illegible]
22			Puu, turve	7	236	[illegible]	[illegible]	[illegible]
23			Maalämpö	0	0	[illegible]	[illegible]	[illegible]
24			Muu, tuntematon	0	0	[illegible]	[illegible]	[illegible]
25		Asuinkerrostalot	Yhteensä	1469	2303127	6218442,9	248738	310922
26			Öljy, kaasu	61	72138	194772,6	7791	9739
27			Kivihiili	0	0	0	0	0
28			Puu, turve	13	6944	18748,8	750	937
29			Maalämpö	0	0	0	0	0
30			Muu, tuntematon	6	13032	35186,4	1407	1759
31							0	0
32		Liikerakennukset	Yhteensä	460	530969	1699100,8	67964	84955

Laske summat viimeisenä!
=SUMMA(ja klikkaa yhteenlaskettavat solut <Ctrl> pohjassa, sitten <Enter>

= Korkeus*Kerrosala-solu
esim. F14=2,7*E14

= Lämmitysala-solu / 80%
esim. I14=G14/0,80

= Omin.lämmönkulutus*Lämmitysala-solu
esim. G14=(40*F14)/1000

Liikenne

- VTT:n LIISA 2008 – laskentajärjestelmästä löytyy kuntakohtaiset liikennepolttoainemäärät/vuosi http://lipasto.vtt.fi/liisa/kunnat2.htm
  - Ei sisällä vesi-, rautatie- tai lentoliikennettä
- Avaa Vuoden 2007 laskentatulokset → Itä-Suomi
- Etsi kunnan kokonaispolttonestemäärä (tonnia/vuosi) ja määritä siitä primäärienergia.
  - Polttonesteen lämpöarvo 43MJ/kg
  - Merkitse arvo Energiatase-taulukkoon ("vasen puoli").
- Laske tuotettu energia.
  - Moottorin hyötysuhde 40%
  - Merkitse arvo Energiatase-taulukkoon Energian myynti –kohtaan ("oikea puoli").

1 kWh = 3,6 MJ

Polttoaineen määrästä energiaksi

- Energia = Polttoaineen määrä * Lämpöarvo
- Joitakin lämpöarvoja
  - Kevyt polttoöljy 43 MJ/kg
  - Raskas polttoöljy 41 MJ/kg
  - Kivihiili 27 MJ/kg
  - Turve 16 MJ/kg
  - Puu 15 MJ/kg
  - Maakaasu 50 MJ/kg (36 MJ/m^3)
  - Biokaasu 5,0-5,5 kWh/m^3
  - Maakaasu 10 kWh/m^3
  - Pelletti 3000-3300 kWh/m^3, 4,8 kWh/kg
  - Jyrsinturve 2,68 kWh/kg
  - Palaturve 3,31 kWh/kg
- 1 kWh = 3,6 MJ

Tiheys = Massa / Tilavuus

1 m^3 = 1000 l

APPENDIX B: EXCEL TEMPLATE OF ENERGY BALANCE

PROJEKTITYÖ: ENERGIATASEEN LAATIMINEN
POHJOIS-SAVON ENERGIATASE 2008

	PRIMÄÄRIENERGIALÄHTEET: ÖLJY [MWh] Raskas	Kevyt	Liikenne	KAASU [MWh] Maakaasu	Nestekaasu	Biokaasu	KIVIHIILI [MWh]	TURVE [MWh] Jyrsinturve	Palaturve	PUUPOLTTOAINEET [MWh] Metsähake	Teollisuuden sivutuotteet	Metsäteollisuuden jäteliemet	Pelletit & briketit	Kierrätyspuu	Ei eritelty	Polttopuu	KIERRÄTYS-POLTTOAINEET [MWh]	VESIVOIMA [MWh]	TUULIVOIMA [MWh]	SÄHKÖ [MWh]	MUUT [MWh]	POLTTOAINEET YHTEENSÄ [MWh]	ENERGIAN MYYNTI: SÄHKÖ [MWh]	LÄMPÖ [MWh]	PROSESSIHÖYRY / TEOLLISUUSLÄMPÖ [MWh]	LIIKENNE [MWh]	KOKONAISHÄVIÖT [MWh]	[%]
KUNTA 1																												
Voimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Lämpökeskukset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Teollisuuden prosessivoimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Erillislämmitys																						0		0			0	#JAKO/0!
																						0					0	#JAKO/0!
Liikenne																						0				0	0	#JAKO/0!
																						0					0	#JAKO/0!
Muut																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
KUNTA 2																											0	#JAKO/0!
Voimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Lämpökeskukset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Teollisuuden prosessivoimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Erillislämmitys																						0		0			0	#JAKO/0!
																						0					0	#JAKO/0!
Liikenne																						0				0	0	#JAKO/0!
																						0					0	#JAKO/0!
Muut																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
KUNTA 3																											0	#JAKO/0!
Voimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Lämpökeskukset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Teollisuuden prosessivoimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Erillislämmitys																						0		0			0	#JAKO/0!
																						0					0	#JAKO/0!
Liikenne																						0				0	0	#JAKO/0!
																						0					0	#JAKO/0!
Muut																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
KUNTA 4																											0	#JAKO/0!
Voimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Lämpökeskukset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Teollisuuden prosessivoimalaitokset																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
Erillislämmitys																						0		0			0	#JAKO/0!
																						0					0	#JAKO/0!
Liikenne																						0				0	0	#JAKO/0!
																						0					0	#JAKO/0!
Muut																						0					0	#JAKO/0!
																						0					0	#JAKO/0!
YHTEENSÄ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#JAKO/0!
%-osuus	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!	#JAKO/0!							

PRIMÄÄRIENERGIALÄHTEET

	ÖLJY [MWh] Raskas	Kevyt	Liikenne	KAASU [MWh] Maakaasu	Nestekaasu	Biokaasu	KIVIHIILI [MWh]	TURVE [MWh] Jyrsinturve	Palaturve	PUUPOLTTOAINEET [MWh] Metsähake	Teollisuuden sivutuotteet	Metsäteollisuuden jäteliemet	Pelletit & briketit	Kierrätyspuu	Ei eritelty	Polttopuu
KUNTA 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KUNTA 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KUNTA 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KUNTA 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YHTEENSÄ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Puuttuva																

	KIERRÄTYS-POLTTOAINEET [MWh]	VESIVOIMA [MWh]	TUULIVOIMA [MWh]	SÄHKÖ [MWh]	MUUT [MWh]	POLTTOAINEET YHTEENSÄ [MWh]	Primäärienergia %-osuus
KUNTA 1	0	0	0	0	0	0	#JAKO/0!
KUNTA 2	0	0	0	0	0	0	#JAKO/0!
KUNTA 3	0	0	0	0	0	0	#JAKO/0!
KUNTA 4	0	0	0	0	0	0	#JAKO/0!
YHTEENSÄ	0	0	0	0	0	0	#JAKO/0!
Puuttuva						Ilman liikennettä	

ENERGIAN KULUTUS / MYYNTI

	SÄHKÖ [MWh]	LÄMPÖ [MWh]	PROSESSIHÖYRY / TEOLLISUUSLÄMPÖ [MWh]	LIIKENNE [MWh]	TUONTISÄHKÖ [MWh]
KUNTA 1	0	0	0	0	lisätään
KUNTA 2	0	0	0	0	lisätään
KUNTA 3	0	0	0	0	lisätään
KUNTA 4	0	0	0	0	lisätään
YHTEENSÄ	0	0	0	0	0
Puuttuva	#JAKO/0!	#JAKO/0!	#JAKO/0!		

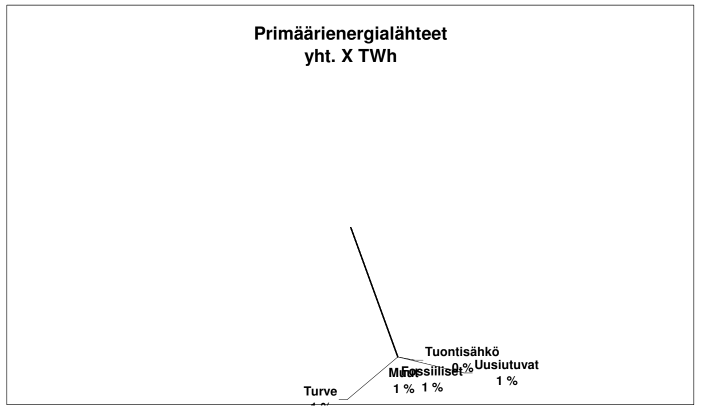
KOKONAISHÄVIÖT

	[MWh]	[%]
KUNTA 1	0	#JAKO/0!
KUNTA 2	0	#JAKO/0!
KUNTA 3	0	#JAKO/0!
KUNTA 4	0	#JAKO/0!
YHTEENSÄ	0	#JAKO/0!
Puuttuva	Ilman liikennettä	

		[%]	Ilman liikennettä
Uusiutuvat	0	#JAKO/0!	#JAKO/0!
Fossiiliset	0	#JAKO/0!	#JAKO/0!
Turve	0	#JAKO/0!	#JAKO/0!
Tuontisähkö		#JAKO/0!	#JAKO/0!
Muut	0	#JAKO/0!	#JAKO/0!
Liikenne	0	#JAKO/0!	
YHTEENSÄ	0	#JAKO/0!	#JAKO/0!

Sähkö lämmityskäytössä	0

TASEJAOTTELU	[MWh]	[GWh]	[TWh]	[%]	Ilman liikennettä
Puuperäiset	0	0	0,0	#JAKO/0!	#JAKO/0!
Maakaasu	0	0	0,0	#JAKO/0!	#JAKO/0!
Polttoöljyt	0	0	0,0	#JAKO/0!	#JAKO/0!
Kivihiili	0	0	0,0	#JAKO/0!	#JAKO/0!
Turve	0	0	0,0	#JAKO/0!	#JAKO/0!
Tuontisähkö	0	0	0,0	#JAKO/0!	#JAKO/0!
Vesivoima	0	0	0,0	#JAKO/0!	#JAKO/0!
Ref	0	0	0,0	#JAKO/0!	#JAKO/0!
Muut	0	0	0,0	#JAKO/0!	#JAKO/0!
Liikenne	0	0	0,0	#JAKO/0!	
YHTEENSÄ	0	0	0,0	#JAKO/0!	#JAKO/0!



Appendix b_Excel template of energy balance
Kunnittain

Yhteensä

Vasen		MWh	GWh	Oikea		MWh	GWh	
Puuperäiset		0	0	Lämmönkulutus		0	0	
	mustalipeä	#JAKO/0!			teollisuuslämpö	0	0	
Maakaasu		0	0		kaukolämpö	0	0	
Tuontisähkö		0	0		erillislämmitys	0	0	
Vesivoima		0	0		sähkölämmitys	0	0	
Turve		0	0	Sähkönkulutus		0	0	
Polttoöljyt		0	0		yksityiset	lisätään	#ARVO!	
Kierrätyspolttoaineet		0	0		maatalous	lisätään	#ARVO!	
Kivihiili		0	0		jalostus	lisätään	#ARVO!	
Muu		0	0		julkinen ja palvelu	lisätään	#ARVO!	
				Häviöt		0	0	+ sähkönsiirto häviöt
Maakunnan sähköntuotanto		0	0	Maakunnan sähkönvienti		0	0	
YHTEENSÄ		0	0	YHTEENSÄ		0	0	

Tase	**0 GWh**
Virhe	#JAKO/0!

Kunta 1

Vasen		MWh	GWh	Oikea		MWh	GWh	
Puuperäiset		0	0	Lämmönkulutus		0	0	
	mustalipeä	#JAKO/0!			teollisuuslämpö	0	0	
Maakaasu		0	0		kaukolämpö	0	0	
Tuontisähkö		lisätään	#ARVO!		erillislämmitys	0	0	
Vesivoima		0	0		sähkölämmitys	0	0	
Turve		0	0	Sähkönkulutus		0	0	
Polttoöljyt		0	0		yksityiset	lisätään	#ARVO!	
Kierrätyspolttoaineet		0	0		maatalous	lisätään	#ARVO!	
Muu		0	0		jalostus	lisätään	#ARVO!	
					julkinen ja palvelu	lisätään	#ARVO!	
				Häviöt		0	0	+ sähkönsiirto häviöt
Kunnan sähköntuotanto		0	0	Kunnan sähkönvienti		0	0	
YHTEENSÄ		0	0	YHTEENSÄ		0	0	

Tase	**0 GWh**
Virhe	#JAKO/0!

Kunta 2

Vasen		MWh	GWh	Oikea		MWh	GWh	
Puuperäiset		0	0	Lämmönkulutus		0	0	
	mustalipeä	#JAKO/0!			teollisuuslämpö	0	0	
Maakaasu		0	0		kaukolämpö	0	0	
Tuontisähkö		lisätään	#ARVO!		erillislämmitys	0	0	
Vesivoima		0	0		sähkölämmitys	0	0	
Turve		0	0	Sähkönkulutus		0	0	
Polttoöljyt		0	0		yksityiset	lisätään	#ARVO!	
Kierrätyspolttoaineet		0	0		maatalous	lisätään	#ARVO!	
Muu		0	0		jalostus	lisätään	#ARVO!	
					julkinen ja palvelu	lisätään	#ARVO!	
				Häviöt		0	0	+ sähkönsiirto häviöt
Kunnan sähköntuotanto		0	0	Maakunnan sähkönvienti		0	0	
YHTEENSÄ		0	0	YHTEENSÄ		0	0	

Tase	**0 GWh**
Virhe	#JAKO/0!

Kunta 3

Vasen		MWh	GWh	Oikea		MWh	GWh	
Puuperäiset		0	0	Lämmönkulutus		0	0	
	mustalipeä	#JAKO/0!			teollisuuslämpö	0	0	
Maakaasu		0	0		kaukolämpö	0	0	
Tuontisähkö		lisätään	#ARVO!		erillislämmitys	0	0	
Vesivoima		0	0		sähkölämmitys	0	0	
Turve		0	0	Sähkönkulutus		0	0	
Polttoöljyt		0	0		yksityiset	lisätään	#ARVO!	
Kierrätyspolttoaineet		0	0		maatalous	lisätään	#ARVO!	
Muu		0	0		jalostus	lisätään	#ARVO!	
					julkinen ja palvelu	lisätään	#ARVO!	
				Häviöt		0	0	+ sähkönsiirto häviöt
Kunnan sähköntuotanto		0	0	Maakunnan sähkönvienti		0	0	
YHTEENSÄ		0	0	YHTEENSÄ		0	0	

Tase	**0 GWh**
Virhe	#JAKO/0!

Kunta 4

Vasen		MWh	GWh	Oikea		MWh	GWh	
Puuperäiset		0	0	Lämmönkulutus		0	0	
	mustalipeä	#JAKO/0!			teollisuuslämpö	0	0	
Maakaasu		0	0		kaukolämpö	0	0	
Tuontisähkö		lisätään	#ARVO!		erillislämmitys	0	0	
Vesivoima		0	0		sähkölämmitys	0	0	
Turve		0	0	Sähkönkulutus		0	0	
Polttoöljyt		0	0		yksityiset	lisätään	#ARVO!	
Kierrätyspolttoaineet		0	0		maatalous	lisätään	#ARVO!	
Muu		0	0		jalostus	lisätään	#ARVO!	
					julkinen ja palvelu	lisätään	#ARVO!	
				Häviöt		0	0	+ sähkönsiirto häviöt
Kunnan sähköntuotanto		0	0	Maakunnan sähkönvienti		0	0	
YHTEENSÄ		0	0	YHTEENSÄ		0	0	

Tase	**0 GWh**
Virhe	#JAKO/0!

APPENDIX C: CHARACTERISTICS OF EACH MUNICIPALITY OF NORTHERN SAVONIA

Town of Kuopio

- The 9th biggest city of Finland and the centre of Northern Savonia
- University Hospital and University of Eastern Finland
- Lot of people working on health and social services, education and services
- Haapaniemi power plant of Kuopion Energia
- Savon Sellu fluting cardboard mill of Powerflute
- Honeywell industrial automation supplier
- Bella Boats boat manufacturer
- Junttan hydraulic piling equipment producer
- Karelia-Upofloor floor material factory
- Fenestra window and Jeld-Wen door manufacturers
- Atria and Apetit Kala food factories

Town of Varkaus

- Town is created around industrial companies.
- Stora Enso paper mill: Three operating paper machines at the moment, two paper machines producing printing paper shall be closed down by the end of September 2010. Also saw mill and sulphate pulp production plant.
- Corenso cardboard factory
- Hartmann cardboard packaging factory
- Carelian Caviar fish farming company
- Warkaus Works, SSG Sahala, AFT Aikawa Group metal works
- Energy technology: Foster Wheeler and Andritz
- Hydropower plant of Huruskoski
- NSE Biofuels which is the joint venture of Stora Enso and Neste Oil have constructed the pilot plant of biofuel gasifier. The test phase of the plant is ongoing. The plant shall replace oil in the lime kiln of pulp mill. Following trials, the joint venture shall assess the viability of building a commercial production plant at one of Stora Enso's mills. (Stora Enso 2009, NSE Biofuels joint venture)

Town of Iisalmi

- Normet manufacturer of equipment and vehicles for mining and underground construction.
- Olvi beer brewery
- Componenta Suomivalimo cast component supplier
- VR railway company
- Genelec speaker manufacturer
- Profile Vehicles special vehicle manufacturer
- Finnritilä maintenance platform factory
- Soinlahti sawmill of Finnforest has been closed down in the end of year 2008.
- Savon Voima power plant

Municipality of Siilinjärvi

- 20 km from Kuopio
- Location of Kuopio Airport
- Low median age: 23% is under 15 years old
- Yara Suomi fertilizer and phosphoric acid factory
- Lujabetoni concrete factory
- Hydroline hydraulic cylinder manufacturer

Municipality of Leppävirta

- Agriculture is an important industry.
- Several factories producing equipment for heating:
    - Gebwell ground source heat pump and district heating substation manufacturer
    - HögforsGST district heating system manufacturer
    - Danfoss LPM heat exchange manufacturer; Danfoss LPM shall close down the factory by the end of March 2011.
- Iittala steel pottery factory
- Lot of summer cottages

Town of Kiuruvesi

- Location of several administrational units of Northern Savonia and Eastern Finland
- MW Biopower, supplier of small and medium scale power and heat plants
- Fibox tested systems plastic enclosure manufacturer
- Kiurumet manufacturer of metal and steel structures

Town of Suonenjoki

- Official strawberry centre of Finland
- Agriculture and especially strawberry growing is an important industry.
- Elsor manufacturer of LED lighting systems
- Finnsäiliö company to inspect, coat, construct and demolish tanks and piping

Municipality of Lapinlahti

- Valio manufacturer of cheese and milk and whey powders
- Mellano manufacturer of household fixture components and MDF doors
- Nelko manufacturer of kitchen, bathroom and hallway fixtures and cabinets
- Lametal manufacturer of tools for property maintenance machines, tractors and wheel loaders
- VAK manufacturer of transportation systems
- Power plant of Fortum Heat and Power in Valio dairy

Town of Nilsiä

- Agriculture is an important industry.
- Tahko downhill skiing and holiday resort is an important employer.

Town of Juankoski

- Agriculture is an important industry.
- Tamfelt manufacturer of paper machine clothing
- Stromsdal cardboard factory was closed down in 2008 and is looking for new owner.
- Two hydro power plants of Karjalankoski and Juankoski

Municipality of Pielavesi

- Agriculture is an important industry.

Municipality of Sonkajärvi

- Agriculture is an important industry.
- Talvivaara Mining Company producer of base metals, especially nickel and zinc
- Finndomo industrial manufacturer of one-family houses

Municipality of Vieremä

- Agriculture is an important industry.
- Ponsse manufacturer of cut-to-length forest machines
- Jokeri Talot industrial manufacturer of one-family houses
- Finnritilä grating factory

Municipality of Maaninka

- 45 km from Kuopio
- Agriculture is an important industry.

Municipality of Rautalampi

- Savon Taimen and Savo Lax fish farming companies
- Sepon Kaluste furniture factory
- Ecomet metal works
- Morehouse producer of living containers
- Easydoing manufacturer of Salli saddle chairs
- Remarkable amount of summer and leisure cottages compared to constant houses

Municipality of Karttula

- Karttula will be consolidated with the city of Kuopio in January 2011.
- Agriculture is an important industry.
- Livakka manufacturer of slurry and cattle feeding equipment
- Ergo Kalusteet manufacturer of furniture for public premises

Municipality of Kaavi

- Agriculture is an important industry.
- Mondo Minerals talc powder factory in Luikonlahti mine
- Elemenco producer of prefabricated buildings
- M-Plast manufacturer of expanded polystyrene insulation products

Municipality of Varpaisjärvi

- Agriculture is an important industry.
- Savon putkihitsaus metal works
- Lameco LHT producer of laminated logs, log blanks and glued-timber components
- FinePine producer of pine glue-laminated board
- InCap Furniture manufacturer of furniture has closed down the factory in the beginning of year 2009.

Municipality of Tuusniemi

- Agriculture is an important industry.
- Paakkilan Konepaja and Lekasteel metal works
- Remarkable amount of summer and leisure cottages compared to constant houses

Municipality of Keitele

- Agriculture is an important industry.
- Keitele-Forest sawmill
- Sepa manufacturer of roof trusses
- M.A.S.I. Company clothing manufacturer

Municipality of Vesanto

- Agriculture is an important industry.
- Only small industrial companies.

Municipality of Rautavaara

- Agriculture is an important industry.
- Only small industrial companies.

Municipality of Tervo

- Agriculture is an important industry.
- Lohimaa fishing resort in Äyskoski
- Fisheries Research and Aquaculture station of Tervo (Finnish Game and Fisheries Research Institute 2010, Research and Aquaculture Stations)
- Remarkable amount of summer and leisure cottages compared to constant houses

APPENDIX D: ENERGY BALANCE CALCULATIONS

Northern Savonia

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		3 651 718	3 652	Heat consumption		5 469 732	5 470
	Black liquor	43 %			Industrial heat	3 410 295	3 410
Natural gas		0	0		District heat	1 054 401	1 054
Imported electricity		2 896 992	2 897		Private heating	1 005 036	1 005
Hydropower		145 217	145		Electrical heating	502 417	502
Peat		2 086 726	2 087	Electricity consumption		3 912 000	3 912
Oil fuels		1 093 765	1 094		Housing and agriculture	1 072 000	1 072
Recovered fuels		207 920	208		Industry	2 131 000	2 131
Coal		243 322	243		Service and building	709 000	709
Others		1 379 394	1 379	Transportation		946 522	947
Gasoline and diesel fuel		2 368 306	2 368	Losses		2 865 061	2 865
Electricity production		1 015 008	1 015	Imported electricity		-2 896 992	-2 897
TOTAL		14 073 360	14 073	TOTAL		13 193 315	13 193

Balance 880 GWh

Iisalmi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		195 000	195	Heat consumption		232 270	232
	Black liquor	0 %			Industial heat	40 100	40
Natural gas		0	0		District heat	95 758	96
Imported electricity		167 055	167		Private heating	96 412	96
Hydropower		0	0		Electrical heating	46 248	46
Peat		148 503	149	Sähkönkulutus		298 339	298
Oil fuels		89 451	89		Housing and agriculture	93 000	93
Recovered fuels		0	0		Industry	67 000	67
Others		3 668	4		Service and building	70 000	70
Gasoline and diesel fuel		170 848	171	Transportation		68 339	68
				Losses		184 814	185
Electricity production		63 945	64	Imported electricity		-167 055	-167
TOTAL		603 677	604	TOTAL		548 368	548

Balance **55 GWh**

Juankoski

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		103 282	103	Heat consumption		138 136	138
	Black liquor	0 %			Industial heat	89 245	89
Natural gas		0	0		District heat	19 415	19
Imported electricity		66 234	66		Private heating	29 476	29
Hydropower		59 740	60		Electrical heating	15 615	16
Peat		17 410	17	Sähkönkulutus		137 020	137
Oil fuels		25 883	26		Housing and agriculture	30 000	30
Recovered fuels		0	0		Industry	81 000	81
Others		354	0		Service and building	9 000	9
Gasoline and diesel fuel		44 551	45	Transportation		17 020	17
				Losses		50 046	50
Electricity production		53 766	54	Imported electricity		-66 234	-66
TOTAL		272 902	273	TOTAL		258 968	259

Balance **14 GWh**

Kaavi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		11 691	12	Heat consumption		28 021	28
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	489	0
Imported electricity		34 000	34		Private heating	27 532	28
Hydropower		0	0		Electrical heating	12 231	12
Peat		0	0	Sähkönkulutus		45 174	45
Oil fuels		14 557	15		Housing and agriculture	18 000	18
Recovered fuels		0	0		Industry	9 000	9
Others		0	0		Service and building	6 000	6
Gasoline and diesel fuel		30 434	30	Transportation		12 174	12
				Losses		23 861	24
Electricity production		0	0	Imported electricity		-34 000	-34
TOTAL		60 247	60	TOTAL		63 056	63

Balance **-3 GWh**

Karttula

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		7 128	7	Heat consumption		17 730	18
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	2 694	3
Imported electricity		27 000	27		Private heating	15 036	15
Hydropower		0	0		Electrical heating	12 545	13
Peat		0	0	Sähkönkulutus		40 656	41
Oil fuels		13 965	14		Housing and agriculture	21 000	21
Recovered fuels		0	0		Industry	1 000	1
Others		225	0		Service and building	5 000	5
Gasoline and diesel fuel		34 140	34	Transportation		13 656	14
				Losses		24 717	25
Electricity production		0	0	Imported electricity		-27 000	-27
TOTAL		48 318	48	TOTAL		56 102	56

Balance **-8 GWh**

Keitele

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		126 804	127	Heat consumption		89 574	90
	Black liquor	0 %			Industial heat	52 500	53
Natural gas		0	0		District heat	14 881	15
Imported electricity		48 000	48		Private heating	22 193	22
Hydropower		0	0		Electrical heating	7 028	7
Peat		0	0	Sähkönkulutus		57 861	58
Oil fuels		5 426	5		Housing and agriculture	13 000	13
Recovered fuels		0	0		Industry	31 000	31
Others		0	0		Service and building	4 000	4
Gasoline and diesel fuel		24 652	25	Transportation		9 861	10
				Losses		31 370	31
Electricity production		0	0	Imported electricity		-48 000	-48
TOTAL		180 230	180	TOTAL		130 805	131

Balance **49 GWh**

Kiuruvesi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		99 428	99	Heat consumption		70 126	70
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	24 759	25
Imported electricity		68 788	69		Private heating	45 367	45
Hydropower		0	0		Electrical heating	17 033	17
Peat		0	0	Sähkönkulutus		101 673	102
Oil fuels		15 266	15		Housing and agriculture	50 000	50
Recovered fuels		0	0		Industry	6 000	6
Others		0	0		Service and building	15 000	15
Gasoline and diesel fuel		76 682	77	Transportation		30 673	31
				Losses		73 226	73
Electricity production		2 212	2	Imported electricity		-68 788	-69
TOTAL		183 482	183	TOTAL		176 237	176

Balance **7 GWh**

Kuopio

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		573 011	573	Heat consumption		810 076	810
	Black liquor	60 %			Industial heat	0	0
Natural gas		0	0		District heat	634 743	635
Imported electricity		268 934	269		Private heating	175 333	175
Hydropower		0	0		Electrical heating	88 450	88
Peat		1 636 531	1 637	Sähkönkulutus		1 021 118	1 021
Oil fuels		318 590	319		Housing and agriculture	275 000	275
Recovered fuels		0	0		Industry	172 000	172
Others		17 935	18		Service and building	329 000	329
Gasoline and diesel fuel		612 796	613	Transportation		245 118	245
				Losses		738 962	739
Electricity production		507 066	507	Imported electricity		-268 934	-269
TOTAL		2 815 000	2 815	TOTAL		2 301 222	2 301

Balance 514 GWh

Lapinlahti

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		34 521	35	Heat consumption		239 999	240
	Black liquor	0 %			Industial heat	181 000	181
Natural gas		0	0		District heat	6 509	7
Imported electricity		96 800	97		Private heating	52 490	52
Hydropower		0	0		Electrical heating	22 565	23
Peat		168 000	168	Sähkönkulutus		151 634	152
Oil fuels		64 372	64		Housing and agriculture	40 000	40
Recovered fuels		0	0		Industry	44 000	44
Others		0	0		Service and building	20 000	20
Gasoline and diesel fuel		119 085	119	Transportation		47 634	48
				Losses		92 555	93
Electricity production		7 200	7	Imported electricity		-96 800	-97
TOTAL		363 693	364	TOTAL		387 388	387

Balance **-24 GWh**

Leppävirta

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		31 179	31	Heat consumption		82 418	82
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	26 867	27
Imported electricity		97 000	97		Private heating	55 551	56
Hydropower		3 333	3		Electrical heating	32 475	32
Peat		19 317	19	Sähkönkulutus		170 601	171
Oil fuels		48 533	49		Housing and agriculture	56 000	56
Recovered fuels		0	0		Industry	21 000	21
Others		291	0		Service and building	23 000	23
Gasoline and diesel fuel		176 503	177	Transportation		70 601	71
				Losses		123 478	123
Electricity production		3 000	3	Imported electricity		-97 000	-97
TOTAL		199 653	200	TOTAL		279 497	279

Balance **-80 GWh**

Maaninka

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		11 810	12	Heat consumption		25 740	26
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	3 507	4
Imported electricity		29 200	29		Private heating	22 233	22
Hydropower		889	1		Electrical heating	11 094	11
Peat		0	0	Sähkönkulutus		46 660	47
Oil fuels		8 883	9		Housing and agriculture	24 000	24
Recovered fuels		0	0		Industry	0	0
Others		0	0		Service and building	5 000	5
Gasoline and diesel fuel		44 150	44	Transportation		17 660	18
				Losses		31 279	31
Electricity production		800	1	Imported electricity		-29 200	-29
TOTAL		50 782	51	TOTAL		74 479	74

Balance **-24 GWh**

Nilsiä

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		20 566	21	Heat consumption		42 478	42
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	10 214	10
Imported electricity		89 000	89		Private heating	32 264	32
Hydropower		0	0		Electrical heating	27 515	28
Peat		11 752	12	Sähkönkulutus		122 505	123
Oil fuels		23 794	24		Housing and agriculture	60 000	60
Recovered fuels		0	0		Industry	6 000	6
Others		229	0		Service and building	24 000	24
Gasoline and diesel fuel		81 262	81	Transportation		32 505	33
				Losses		59 228	59
Electricity production		0	0	Imported electricity		-89 000	-89
TOTAL		145 341	145	TOTAL		135 211	135

Balance	10 GWh

Pielavesi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		37 950	38	Heat consumption		41 340	41
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	13 334	13
Imported electricity		37 000	37		Private heating	28 006	28
Hydropower		0	0		Electrical heating	9 993	10
Peat		0	0	Sähkönkulutus		61 070	61
Oil fuels		74 592	75		Housing and agriculture	27 000	27
Recovered fuels		0	0		Industry	1 000	1
Others		0	0		Service and building	10 000	10
Gasoline and diesel fuel		57 676	58	Transportation		23 070	23
				Losses		43 331	43
Electricity production		0	0	Imported electricity		-37 000	-37
TOTAL		149 542	150	TOTAL		108 740	109

Balance **41 GWh**

Rautalampi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		16 500	16	Heat consumption		25 936	26
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	2 678	3
Imported electricity		29 000	29		Private heating	23 258	23
Hydropower		0	0		Electrical heating	12 047	12
Peat		642	1	Sähkönkulutus		44 307	44
Oil fuels		13 305	13		Housing and agriculture	20 000	20
Recovered fuels		0	0		Industry	1 000	1
Others		661	1		Service and building	8 000	8
Gasoline and diesel fuel		38 268	38	Transportation		15 307	15
				Losses		29 483	29
Electricity production		0	0	Imported electricity		-29 000	-29
TOTAL		60 108	60	TOTAL		70 726	71

Balance -11 GWh

Rautavaara

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		13 721	14	Heat consumption		16 274	16
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	2 191	2
Imported electricity		15 000	15		Private heating	14 083	14
Hydropower		0	0		Electrical heating	4 913	5
Peat		0	0	Sähkönkulutus		24 918	25
Oil fuels		6 159	6		Housing and agriculture	10 000	10
Recovered fuels		0	0		Industry	0	0
Others		534	1		Service and building	5 000	5
Gasoline and diesel fuel		24 794	25	Transportation		9 918	10
				Losses		18 781	19
Electricity production		0	0	Imported electricity		-15 000	-15
TOTAL		35 414	35	TOTAL		44 973	45

Balance **-10 GWh**

Siilinjärvi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		26 151	26	Heat consumption		902 621	903
	Black liquor	0 %			Industial heat	767 450	767
Natural gas		0	0		District heat	47 943	48
Imported electricity		494 634	495		Private heating	87 228	87
Hydropower		0	0		Electrical heating	65 638	66
Peat		6 900	7	Sähkönkulutus		617 302	617
Oil fuels		107 650	108		Housing and agriculture	97 000	97
Recovered fuels		0	0		Industry	366 000	366
Others		899 704	900		Service and building	58 000	58
Gasoline and diesel fuel		240 755	241	Transportation		96 302	96
				Losses		251 388	251
Electricity production		25 366	25	Imported electricity		-494 634	-495
TOTAL		1 535 039	1 535	TOTAL		1 276 677	1 277

Balance **258 GWh**

Sonkajärvi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		16 043	16	Heat consumption		38 527	39
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	6 005	6
Imported electricity		37 000	37		Private heating	32 522	33
Hydropower		9 166	9		Electrical heating	8 777	9
Peat		11 500	12	Sähkönkulutus		63 456	63
Oil fuels		14 335	14		Housing and agriculture	25 000	25
Recovered fuels		0	0		Industry	2 000	2
Others		0	0		Service and building	10 000	10
Gasoline and diesel fuel		66 140	66	Transportation		26 456	26
				Losses		49 206	49
Electricity production		0	0	Imported electricity		-37 000	-37
TOTAL		88 044	88	TOTAL		114 189	114

Balance **-26 GWh**

Suonenjoki

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		31 131	31	Heat consumption		62 049	62
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	23 964	24
Imported electricity		80 000	80		Private heating	38 085	38
Hydropower		0	0		Electrical heating	21 441	21
Peat		27 683	28	Sähkönkulutus		122 173	122
Oil fuels		26 638	27		Housing and agriculture	35 000	35
Recovered fuels		0	0		Industry	21 000	21
Others		3 432	3		Service and building	25 000	25
Gasoline and diesel fuel		102 932	103	Transportation		41 173	41
				Losses		80 236	80
Electricity production		0	0	Imported electricity		-80 000	-80
TOTAL		168 884	169	TOTAL		184 458	184

Balance **-16 GWh**

Tervo

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		7 745	8	Heat consumption		13 839	14
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	266	0
Imported electricity		19 000	19		Private heating	13 573	14
Hydropower		0	0		Electrical heating	5 325	5
Peat		0	0	Sähkönkulutus		25 845	26
Oil fuels		6 327	6		Housing and agriculture	16 000	16
Recovered fuels		0	0		Industry	0	0
Others		0	0		Service and building	3 000	3
Gasoline and diesel fuel		17 112	17	Transportation		6 845	7
				Losses		13 407	13
Electricity production		0	0	Imported electricity		-19 000	-19
TOTAL		33 072	33	TOTAL		34 091	34

Balance **-1 GWh**

Tuusniemi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		15 632	16	Heat consumption		18 463	18
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	1 607	2
Imported electricity		25 000	25		Private heating	16 856	17
Hydropower		0	0		Electrical heating	9 404	9
Peat		0	0	Sähkönkulutus		42 831	43
Oil fuels		5 996	6		Housing and agriculture	18 000	18
Recovered fuels		0	0		Industry	2 000	2
Others		0	0		Service and building	5 000	5
Gasoline and diesel fuel		44 577	45	Transportation		17 831	18
				Losses		31 375	31
Electricity production		0	0	Imported electricity		-25 000	-25
TOTAL		46 628	47	TOTAL		67 669	68

Balance -21 GWh

Varkaus

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		2 227 830	2 228	Heat consumption		2 514 752	2 515
	Black liquor	56 %			Industial heat	2 280 000	2 280
Natural gas		0	0		District heat	118 103	118
Imported electricity		1 082 000	1 082		Private heating	116 649	117
Hydropower		31 111	31		Electrical heating	62 090	62
Peat		32 488	32	Sähkönkulutus		1 482 780	1 483
Oil fuels		184 603	185		Housing and agriculture	87 000	87
Recovered fuels		207 920	208		Industry	1 282 000	1 282
Others		695 661	696		Service and building	59 000	59
Gasoline and diesel fuel		136 950	137	Transportation		54 780	55
				Losses		759 402	759
Electricity production		347 000	347	Imported electricity		-1 082 000	-1 082
TOTAL		4 461 613	4 462	TOTAL		3 674 934	3 675

Balance **787 GWh**

Varpaisjärvi

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		10 068	10	Heat consumption		23 009	23
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	4 552	5
Imported electricity		29 000	29		Private heating	18 458	18
Hydropower		35 809	36		Electrical heating	8 842	9
Peat		0	0	Sähkönkulutus		39 490	39
Oil fuels		6 376	6		Housing and agriculture	17 000	17
Recovered fuels		0	0		Industry	7 000	7
Others		0	0		Service and building	5 000	5
Gasoline and diesel fuel		26 226	26	Transportation		10 490	10
				Losses		23 072	23
Electricity production		0	0	Imported electricity		-29 000	-29
TOTAL		81 253	81	TOTAL		56 572	57

Balance 25 GWh

Vesanto

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		10 889	11	Heat consumption		21 466	21
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	712	1
Imported electricity		20 000	20		Private heating	20 754	21
Hydropower		0	0		Electrical heating	6 396	6
Peat		0	0	Sähkönkulutus		28 508	29
Oil fuels		9 385	9		Housing and agriculture	14 000	14
Recovered fuels		0	0		Industry	2 000	2
Others		0	0		Service and building	4 000	4
Gasoline and diesel fuel		21 270	21	Transportation		8 508	9
				Losses		17 091	17
Electricity production		0	0	Imported electricity		-20 000	-20
TOTAL		40 274	40	TOTAL		47 064	47

Balance **-7 GWh**

Vieremä

LEFT		MWh	GWh	RIGHT		MWh	GWh
Wood fuels		23 641	24	Heat consumption		34 305	34
	Black liquor	0 %			Industial heat	0	0
Natural gas		0	0		District heat	12 628	13
Imported electricity		37 348	37		Private heating	21 678	22
Hydropower		5 169	5		Electrical heating	10 366	10
Peat		6 000	6	Sähkönkulutus		988 522	989
Oil fuels		9 680	10		Housing and agriculture	26 000	26
Recovered fuels		0	0		Industry	9 000	9
Others		22	0		Service and building	7 000	7
Gasoline and diesel fuel		49 781	50	Transportation		19 912	20
				Losses		114 754	115
Electricity production		4 652	5	Imported electricity		-37 348	-37
TOTAL		81 859	82	TOTAL		1 100 234	1 100

Balance **-16 GWh**