

# Implementation of National Renewable Energy Obligations at the Regional Level

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Den Access

## Abstract

The aim of the paper described here was to clarify the potential of decreasing the use of fossil fuels regionally. According to Finnish national obligations, the use of oil and other fossil fuels should be minimised by 2030. The study combines the regional consumption of primary energy sources with national obligations introduced in the national climate and energy strategy. This set up a basis when evaluating the regional state of future energy supply for 2030. The paper utilises the region of South Savo as a case study. In the region, the consumption of renewable energy sources is already above the national average, but it can be increased further by 2030. Wood fuels and especially forest biomass have regionally a major role. Local and national targets, support schemes and willingness to invest play key roles when increasing the use of renewable energy sources in the future.

## **Keywords**

Regional, Biomass, Forest Residues, Renewable Energy

## **1. Introduction**

This template, created in MS Word 2007, provides authors with most of the formatting specifications needed for the European Union (EU) has raised the target for final consumption of renewable energy sources from 20% by 2020 to 27% by 2030 [1]. In 2015, the share of renewable energy from gross final energy consumption was 16.7% in the EU-28 [2]. According to the Finnish national energy and climate strategy, the share of renewable energy from final energy consumption will rise to over 50% by 2030. The physical share of biofuels sold to road transport will increase to 30% by 2030 from the current 8% (2015) [3]. For Finland, the long-term goal is to introduce a carbon-neutral energy system, which will be based on renewable energy sources. The share of renewables from

gross final energy consumption in Finland was already 39.3% in 2015 [4]. The most important renewable energy sources were biomass fuels, which were consumed nationally mainly in heat and electricity production.

Total consumption of energy in Finland was 1301 PJ in 2015, and the most significant energy sources were wood fuels, which included solid biomass fuels and black liquor, at 26%. The share of oil was 24% and nuclear energy 19% [5]. **Figure 1** presents the total energy consumption by source and **Figure 2** presents the total consumption of renewable energy sources in Finland in 2015.

EU and national obligations must always be adapted into the local and regional level, where concrete actions and investments on carbon-free technology are carried out. In some cases, national support from the government and authorities is crucial in the investment decision to reinforce the existing investment motivation [6]. This study analyses how national renewable energy obligations can be met in the region of South Savo.









In South Savo, forest biomass is currently the most interesting renewable energy source, and it is utilised widely. In the future, it should also retain a major role in energy supply [7]. Figure 3 presents the development in the use of forest biomass in South Savo from 2000 to 2015 [8]. Forest biomass includes small-diameter energy wood, logging residues, stumps and uncommercial stem wood. Today, it is mainly consumed in power plants and the heating of communities. In the future, the consumption of solid wood fuels and forest biomass will further increase especially in small-scale applications such as municipal heating plants, farm enterprises, small-scale industry and single dwelling houses especially in rural areas.

The South Savo region has significant forest resources nationally. Annual regional roundwood removals were about 7.0 million solid-m<sup>3</sup>, consisting of logs (3.2 million solid-m<sup>3</sup>), pulpwood (3.3 million solid-m<sup>3</sup>) and energy wood (0.5 million solid-m<sup>3</sup>) [9]. According to a recent study [7] and a regional forest programme [10], annual roundwood removals could be increased sustainably by 1.0 million solid-m<sup>3</sup> in South Savo. At the national level, annual roundwood removals were 68 million solid-m<sup>3</sup> and the total drain of roundwood was about 82 million solid-m<sup>3</sup> in 2015 [9]. Based on the latest National Forest Inventory (NFI12), the total annual forest growth in Finland is about 110 million solid-m<sup>3</sup> [11].

The focus of the paper described here was to clarify the progress in the utilisation of primary energy sources between the years 2006 and 2015 in the region of South Savo (**Figure 4**) and how national renewable energy obligations can be met regionally by 2030. The region of South Savo was chosen as a case example because the initial data about energy consumption was available and the region has long traditions to develop the use of local renewable energy sources. The study utilised a regional energy balance method introduced in an article [12]. **Table 1** presents a summary of key South Savo facts.

The Finnish national energy and climate strategy for 2030 introduces guidelines and objectives for the consumption of renewable energy sources by 2030. In the baseline scenario, the Finnish final energy consumption will be 1134 PJ







Figure 4. Location of South Savo.

Tab	le	1.	Key	South	Savo	statistics	[13]	].
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Unit	Value	
	Mikkeli	
	14	
	150,305	
	140,000	
РJ	25.4	
Km	414	
$\mathrm{PJ}_{\mathrm{th}}$	3.3	
РЈ <sub>е</sub>	1.3	
	– Unit РЈ Кт РЈ <sub>th</sub> РЈ <sub>e</sub>	

and the proportion of renewables from gross final energy consumption will be 47% by 2030. This is 3% below the Finnish government target for 2030. The self-sufficiency rate, which includes also peat fuel, regarding energy supply should be 51% by 2030, and the use of imported oil products will be cut to half by 2030. One national priority area will be decentralised electricity and heat production based on renewable energy sources [3]. This is an important message for the South Savo region, where energy production based on decentralised biomass will be a feasible option regarding future energy supply. Forest biomass will be an important raw material for renewable energy, both nationally and in South Savo. Forest biomass has replaced and will further replace fossil primary energy sources in combined heat and power production (CHP), heating and transport.

The use of coal in Finland has been declining in recent years; depending on the demand for condensing power, and according to the basic scenario, coal use will be mainly phased out by 2030. The national aim is that coal should only be used as a backup fuel in sudden situations so that national supply security can be guaranteed [3]. This study analyses the possibilities to achieve national climate and energy targets and obligations in the region of South Savo and gives an overview about of energy sources in the South Savo region.

#### 2. Material and Methods

The study employed a regional energy balance method, and specifically its left side, for evaluating the possibilities to achieve Finnish national obligations regionally by 2030. The method presents the use of primary energy sources and final consumption of energy in a defined area, such as a municipality or region. In energy balance, primary energy sources contain all energy and fuels consumed in the area during the period under analysis [12]. Data about the consumption of primary energy sources was mainly gathered from operating energy producers and from statistics, introduced more detailed in Chapter 2.1. The principle of regional energy balance is presented in **Figure 5**.





The aim of the study is to evaluate how much it would be realistic to utilise renewable energy sources considering current energy supply and demand. Study also evaluates possibilities to achieve goals set in national climate and energy strategy in regional level. In this case, three energy balances are used and compared: 2006, 2015 and a scenario for 2030. The energy balance of 2006 was analysed in the previous study [16], and the implementation of the current energy balance (2015) will be presented in the results. 2030 is a scenario about the state of the regional energy supply. The estimation assumes that the use of wood fuels will maintain their key role in the regional and national energy supply. This is also base hypothesis in national climate and energy strategy [3]. Detailed assumptions about the calculation will be introduced in Chapter 2.2.

There are no comprehensive regional obligations on increasing the consumption of renewable energy in South Savo. However, regional development research has occurred in the past few decades, along with strong regional willingness and support to increase the use of regional fuels such as forest biomass. When evaluating the growth potential of renewable energy sources, this study focuses mainly on biomass fuels, with a division into forest industry by-products, forest biomass, small-scale firewood, recycled wood fuels and wood pellets. In the future, refining biomass could be one feasible solution for future energy needs.

The regional energy balance method is utilised consistently in Eastern Finland where five different regions (Kainuu, North Savo, South Savo, North Karelia, South Karelia) are compared to each other. The study indicated that the highest share of renewables from fuels used was in South Karelia (72%) in 2014. This is due to the large-scale forest industry concentration situated in South Karelia [17]. In this study, the results are presented by comparing different primary energy sources (left side of the energy balance). This is also because the national climate and energy strategy does not include detailed goals for the end use of energy.

#### 2.1. Consumption of Primary Energy Sources in 2015

The paper defined the consumption of energy sources of South Savo in 2015. The present regional consumption of energy was studied by directly contacting all regionally significant energy producers whose fuel output was more than 0.5 MW. Typically, these units were combined heat and power plants and industrial or community heating plants.

Fuels used in district heating and power plants were gathered from national district heating statistics [18]. The energy consumption of smaller consumers was evaluated and collected from regional and national statistics such as national building and free-time residences database [19]. Finnish Petroleum and Biofuels Association Finland provided data about the regional consumption of light and heavy fuel oil [20]. The consumption of light fuel oil was divided between the heating sector (45%), forestry and agriculture (28%) and construction sector (27%) [21]. The regional production and end use of electricity were received

from Finnish Energy statistics [15] and regional electricity producers. The end use of electricity included the electricity consumption by municipality and by sector, divided to housing and agriculture, industry, and service and building [15].

Statistics Finland provided the number of buildings by intended use and heating fuel, which was used for evaluating the regional share of different heating systems [22]. Regional shipment volumes of wood pellets were inquired directly from local wood pellet producers and end users. The amount and energy produced by heat pumps were evaluated from regional heat pump statistics [19]. By knowing the number of heat pumps per municipality [19], and the average amount of energy produced by a single heat pump [23], the total annual production was defined. Annual need for heat in Finnish detached house is about 80 GJ per annum [22]. The use of traffic fuels was evaluated from the VTT Technical Research Centre of Finland databases that included information about annual traffic performance by municipality and the amount of fuel used annually by municipality [24].

#### 2.2. Consumption of Primary Energy Sources in 2030

The analysis of future energy consumption and the significance of renewable energy were studied by knowing the current facts of the structure of regional energy supply and national guidelines introduced in the Finnish national climate and energy strategy [3]. The main points of the national climate and energy strategy by 2030 are the following:

- Domestic use of oil products should be halved;
- Total use of renewables should be increased;
- Share of renewables in road transport should be increased;
- Use of coal should be phased out.

These national obligations directly affect the region of South Savo, for example through taxation. Also, different regional research and development projects, strategies and schemes could also increase the use of renewable energy in South Savo.

The future consumption of primary energy sources will be guided regionally by economic facts, taxation, national legislation and obligations, production volumes of the regional energy-intensive industry, investment on new energy technology (e.g. biogas and solar power) and numerical growth of fossil-free transportation methods and vehicles. In this study, it was assumed that regional industrial production volumes in energy intensive industry, such as plywood mills and sawmills, will endure their level to 2030. Especially transport fuels are affected by national legislation and obligations while regional heat and power production can be guided by local and regional policymaking. In the transport sector, national distribution obligations for road transport (diesel oil and gasoline) and heavy machinery (light fuel oil, LFO) will be 30% and 10%, respectively, by 2030. In heating sector, distribution obligation will be also 10% [3]. In space heating sector, 3% of light fuel oil will be replaced annually by renewables in the region South Savo.

When increasing the total use of renewables, wood fuels will have the most significant role in the 2030 energy supply not just in South Savo but also in Finland [3] [7]. The volume of solar energy will increase extensively because the investment cost has decreased significantly, and consumers' public awareness has increased. It was assumed that inland wind power has only a minor role in South Savo regional electricity production. There are three ongoing wind farm projects in the region, but they are all currently on hold because the national feed-in tariff capacity is currently full [25]. Likely in the future, new wind power installations will be concentrated on Finnish coastal area. There are also plans to start producing torrefied wood pellets in the city of Mikkeli in South Savo [26]. If the investment is realised, the new plant could utilise up to 2.5 PJ of forest biomass as a raw material. This kind of investment will significantly affect regional forest biomass markets and re-direct regional biomass flows to new end users. The effects of large-scale investment are not included in this study because there is no concrete decision of investment yet.

### 3. Results and Discussion

**Figure 6** summarises the regional consumption of primary energy consumption in South Savo in the reference years of 2006 and 2015 and introduces the scenario for 2030. Total primary energy consumption will decrease from 2006 (26.3 PJ) to 2015 (25.4 PJ) and to 2030 (25.0 PJ), respectively. The results concentrate on the consumption of primary energy.



**Figure 6.** Use of primary energy sources in South Savo, TJ. \*Including hydropower, solar power, heat pumps, biogas, coal, etc. \*\*Physical share of renewables in transportation: 2006: 0%; 2015: 8%; 2030: 30.0%, also including electric cars (0.04 PJ) [3].

Wood fuels have been distinctly the most dominant primary energy source in South Savo, and they will retain their primary role in the future. It was analysed that the key role of wood fuels will stay on to 2030 and that the use of oil products and peat fuel will further decrease. This trend is also national and Finnish baseload energy supply will rely on domestic wood fuels. However, solar power and other renewables will strengthen their role in the future as well, as mentioned in national climate and energy strategy [3].

Wood fuels in South Savo are mostly utilised in communities' energy production in heating and CHP plants. The total consumption of wood fuels was 11.1 PJ in 2006, 10.4 PJ in 2015 and it was estimated that in 2030 it would be 11.1 PJ. The utilisation of forest biomass has growth most significantly in past ten years and the consumption will further increase to 3600 TJ by 2030. Sixty-one per cent of solid wood fuels are utilised in communities' district heat and electricity production, and 39% of solid wood fuels are utilised in industrial heat and power production, e.g. forest industry and greenhouses. The use of wood fuels in industry is expected to stay at the same level by 2030, but the use of peat fuel in CHP production, both in the production of district heat and process steam, will be replaced by forest biomass. The use of wood pellets has not become as common as predicted a decade ago, and by 2030, the use of wood pellets should only increase slightly in district heating as a backup fuel.

The use of peat fuel has been decreasing nationally for the past decade [27]. This has also been reflected in South Savo, from 2.7 PJ (2006) to 1.4 PJ (2015). The reduction has mainly occurred in large CHP plants where wood fuels have replaced the use of peat and the volume condensing power production has decreased. According to the Finnish national climate and energy strategy, the competitiveness of peat fuel will be guided by taxation by 2030. Compared to coal, peat use will be retained, but its significance will be less compared to forest biomass and forest industry by-products [3]. However, peat fuel is a controversial energy source nationally because it has higher CO<sub>2</sub> emissions than coal, but it is an important domestic reserve fuel and a creator of domestic employment in rural areas. In the future, prolonged environmental impact assessments for peatland energy use and the vulnerability of older peatlands to rainfall could complicate domestic peat production [28]. It seems that peat fuel will be mainly used as a reserve fuel for CHP production in the future, but if regional investments on new combustion and boiler technology are made, the use of peat fuel could be completely replaced by wood fuels.

In South Savo, only three CHP plants and four heating plants use peat fuel, but only two of these utilise it as a primary fuel. Peat fuel is and will continue to be an important regional fuel in South Savo, but due to national pressure its use should decrease by 2030 in the region. It was analysed that the use of peat fuel will decrease from its current level of 1.4 PJ to 0.9 PJ by 2030.

In 2006, the annual consumption of electricity in South Savo was 5.9 TJ, while 2.0 TJ of electricity was generated in the region. In 2015, 1.3 TJ of electricity was

generated in the region and the regional total consumption was 6.0 TJ. During the period, regional electricity generation has decreased because of the decreased market price of electricity and the unprofitability of condensing power production with domestic fuels. The amount of imported electricity in South Savo highly depends on the profitability of regional electricity production. Small-scale electricity production, for example solar power and small-scale CHP, could expand in the future, thereby increasing local supply security. This kind of production has usually local influence but the total volume in regional level remains minor.

The study assumed that no new large-scale investments in electricity production would be made in South Savo by 2030 because of the aforementioned facts. The use of electricity will remain at the current level, being 6.0 TJ in 2030. Regional power generation will be based on biomass fuels, and the total annual production will be about 1.3 TJ.

According to the Finnish national climate and energy strategy, domestic consumption of oil should be halved by 2030. Oil consumption includes light and heavy fuel oil, as well as diesel oil, gasoline, kerosene and other jet fuels used in domestic markets. Climate and energy strategy obligations exclude fuels used in foreign transports. The main national targets for decreasing the use of oil are the transport sector and space heating in rural areas outside of the district heating network. In South Savo, the consumption of oil in the transport sector was 5.9 PJ in 2015, whereas the share of renewables was 8%. The consumption of light fuel oil in space heating was 1.0 PJ, while in agriculture, forestry and construction it was 1.3 PJ in 2015. According the results, halving the oil consumption seems to be challenging in South Savo, unless lack of fossil oil occurs or significant increase in oil pricing. 0.2 TJ of light fuel oil consumed in 2030 should be renewable according to national distribution obligations. Distribution obligation for light fuel oil used in heavy machinery and heating is 10% [3].

The distribution obligations for transport sector will be enacted in South Savo, and the amount of renewables in road transport and heavy machinery will increase to 30% and 10%, respectively, by 2030. In South Savo, the use of heavy fuel oil will be phased out by 2030 because of nationally tightening emission limits [29]. Light fuel oil is and will still be widely used in the heating sector and in heavy machinery such as tractors, excavators and forest machinery. The total reduction in the use of light fuel oil is 360 TJ by 2030, when 3% of heating oil is replaced annually by bio-oils or other heating sources. This three per cent annual reduction rate is a feasible pace that can be met. Reducing the use of light fuel oil nationally could be hastened by political decisions and laws such as tightening taxation or emission-based fees. In addition, local and regional schemes or programmes could encourage individual consumers to re-evaluate their existing methods of using and producing energy.

Traffic fuels amount to about 20% of the total fuel consumption annually. In the future, electric cars will partly replace traditional diesel oil and petrol-driven cars. This trend will lead to the increase in the need for electricity and decrease in the consumption of liquid fossil fuels. According to the national climate and energy strategy, the number of electric vehicles will be about 250,000 in Finland by 2030. This means that in the South Savo region the number of electric cars would be about 7500 in 2030, and their estimated annual electricity consumption would be 0.04 PJ [30].

The other primary energy sources in **Figure 6** include hydropower, solar power, heat pumps, biogas and coal, for example. The hydropower capacity is already fully utilised in South Savo. The use of coal, which was 0.2 PJ in 2016, should be phased out by 2030. A few new biogas plants will be operational by 2030, and the production of biogas could be doubled from its current level of 0.02 PJ [31] [32]. The number of different types of heat pumps has increased rapidly during the past decade, and this technology will continue to increase in popularity by 2030 [3] [23]. New solar electricity installations will be adopted widely because of technological development and decreased procurement costs [3]. In total primary energy use, these new renewable energy sources will account for 0.6 PJ.

In total, there are 87 heating and power plants (fuel output over 0.5 MW) in South Savo and 48 heating and power plants that mainly utilise local forest biomass. Percentwise, 55% of heat and power plants already utilise forest biomass as a primary fuel, which is a rather high share. A new possibility to increase the use of biomass is the replacement of oil and peat fuel in existing plants. In addition, the use of biomass fuels can be expanded in rural areas.

When increasing the use of renewables in South Savo by 2030, forest biomass still has the greatest increase potential regionally. It can replace 450 TJ of peat fuel in large-scale CHP plants. Because of forthcoming legislation, the use of heavy fuel oil will be minimised by the end of 2017 [29]. Forest biomass can technically replace half of the heavy fuel oil used (54 PJ). It was evaluated that the use of light fuel oil would decrease 3% per annum by 2030, which equals 360 TJ. Thirty per cent of this total reduction can be technically replaced by forest biomass, and the rest will be replaced e.g. by heat pumps and wood pellets in heat production.

When comparing these regional results with the Finnish national obligations introduced in the climate and energy strategy, it seems that the rise in percentages in the use of renewable energy sources will not be as high as the Finnish average [3]. However, the consumption of renewable energy in South Savo has been greater than the national average, and pressure for increasing the use of renewables will exist elsewhere. The national target for renewable energy from gross final energy consumption is set to be about 50% for 2030 [3]. The proportion of renewables from final energy consumption in South Savo was 47% in 2006, 46% in 2015 and, according to the study, 54% in 2030. It seems that the region of South Savo should meet the national target for the consumption of renewable energy. The main reason behind this is the long and focused regional work on decreasing the consumption of fossil fuels and replacing them with re-

newable fuels. In addition, regional authorities and decision-makers have created a positive operating environment for the renewable energy business.

Utilising local renewable energy sources improves local employment and generates income in the region [33]. International and national renewable energy targets create relevant guidelines that must be considered regionally, where concrete actions and investments are realised. Therefore, these kinds of studies are valuable for the decision-making processes in urban and rural areas. Results of this study could have limitations especially in energy consumption of housing sector because exact data is not available locally. For example, the consumption of light fuel oil and firewood are partly determined on national statistics. Currently, there is also lack of regional research studies of this topic which makes comparing the methodology challenging. Introducing small-scale heat and power production improves energy and supply security particularly in rural areas. Decentralised production will be promoted nationally by research and development, and financially by agricultural investment subsidies [3]. Possible biomass refinery investments could significantly increase the demand for biomass.

## 4. Conclusion

Increasing the utilisation of renewable energy regionally is essential when aiming towards obligations defined in the national energy and climate strategy. Based on the study, the region of South Savo should meet national obligations and be an exemplary region in the consumption of domestic renewable energy sources. Wood fuels and especially forest biomass already have important roles in regional energy supply, and according to the paper their roles will only strengthen by 2030. Carbon-free energy production, electric vehicles and the utilisation of solar energy could replace traditional ways of producing and utilising energy in the future.

## **Conflicts of Interest**

The authors declare no conflicts of interest regarding the publication of this paper.

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