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Availability and Use of Wood-based Fuels in Finland in 2020

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Abstract
In the context of the Government's Climate and Energy Strategy, it is estimated that the primary use of wood-based fuels in Finland will be about 100 TWh by the year 2020. The overall target set for forest chips is 25 TWh. The objective of the research carried out by Metsäteho Oy and Pöyry Energy Oy was to produce as realistic as possible a total analysis of the possibilities of increasing the use of solid wood-based fuels, and especially forest chips, in Finland by 2020. The study showed that the growth objective set in the Government's Climate and Energy Strategy can be attained through the supply and consumption of wood-based fuels. The emission trade had a strong influence on the competitiveness of wood-based fuels and the use of such fuels in energy plants. Increasing the proportion of wood-based fuels is very difficult at the current pricing level of emission rights (about 15 €/t CO_2). Considering the huge resources required by the forest chip production system and the current low competitiveness of forest chips, it is estimated that the use of forest chips in Finland will reach the level of 20 TWh at the earliest by the year 2020.

Keywords: Energy wood, Fuelwood, Forest chips, Pontentials, Finland.

1. Introduction

The total energy consumption in 2008 was 389 TWh (1,400 PJ) in Finland (Anon., 2009). The most important energy source in 2008 were oil products which made up about one fourth (98 TWh) of the total energy consumption in Finland (Anon., 2009).

In 2008, wood-based fuels covered more than one fifth (82 TWh) of the total energy consumption in Finland, and hence they were the second most important source of energy after oil (Anon., 2009). This makes Finland one of the leading countries in the World when it comes to utilizing wood for energy generation. In Finland, wood-based fuels are divided into industrial waste liquors – mainly black liquor produced by pulping industries – and solid wood fuels. Further, solid wood fuels are divided into 1) wood fuels consumed by heating and power plants and 2) fuelwood consumed by small-sized dwellings, i.e. private houses, farms, and recreational dwellings.

In 2008, half of the wood-based fuel consumption (41 TWh) was covered by waste liquors (Anon., 2009). Solid wood fuels were consumed to the total of 41 TWh, or 20.5 million m^3, of which the heating and power plants accounted for 27 TWh, 14 million m^3 (Ylitalo, 2009). The small-sized dwellings use currently a total of 14 TWh, or 7 million m^3 of wood for heating (Ylitalo, 2009).

The total consumption of forest chips for energy generation in 2008 was equivalent to 9.2 TWh (4.6 mill. m^3) in Finland (Ylitalo, 2009). Of the forest chips used in heating and power plants (8.0 TWh) in 2008, the majority (58%) was produced from logging residues in final cuttings (Ylitalo, 2009). 14% came from stump and root wood, and 4% from large-sized, rotten roundwood. Twenty-four per cent of the total amount of commercial forest chips used for energy generation came from the small-diameter ($d_{1.3}$<10 cm) thinning wood produced in the tending of young stands (Ylitalo, 2009).

According to the EU Climate and Energy Policy, renewable energy target is to increase the renewable energy sources to 20% of total final energy consumption by the year 2020 in EU. In Finland, this target means increasing the proportion of renewable energy sources to 38% (Anon., 2008). In Finland, wood-based fuels are the most important renewable energy source, and forest chips are considered as a one of the most significant wood fuel source in the future.

In the context of the Government's Climate and Energy Strategy (Pekkarinen, 2010), it is estimated that the primary use of wood-based fuels in Finland will be about 100 TWh by the year 2020. The overall target set for forest chips is 25 TWh, i.e. about 13.5 million m^3. Are these targets realistic?

The objective of the research carried out by Metsäteho Oy and Pöyry Energy Oy was to produce as realistic as possible a total analysis of the possibilities of increasing the use of wood-based fuels, and especially forest chips, in Finland by 2020. The research was carried out on the boiler and supply source levels. The main findings of the project (Kärhä et al., 2009a) will be presented in this conference paper. In addition, the paper will answer the question is it possible to achieve the set targets of renewable energy with wood-based fuels in Finland?

2. Material and methods

Two different scenarios for the forest industry production of the year 2020 were created in the research. The scenarios were Basic scenario and Maximum scenario. The roundwood consumption and demand of forest industry were constructed based on the scenarios. Domestic industrial roundwood cuttings were 57 million m^3 in the Basic scenario and 68 million m^3 in the Maximum scenario in 2020 (Table 1). It was assumed that the import of roundwood to Finland will be significantly at the lower level (Table 1).

Table 1. The assumptions related to roundwood supply and the production of forest industry in 2020 in Finland in the research.

	2007	2020	
		Basic scenario	Maximum scenario
Industrial roundwood supply, mill. m^3	75.4	59.4	73.7
- Domestic roundwood cuttings	57.7	56.6	67.9
- Import of roundwood	17.7	2.8	5.7
By-products of forest industry (i.e. bark, sawdust, and waste wood chips) in energy generation, TWh	19.2	17.1	18.5
Waste liquors of forest industry in energy generation, TWh	42.5	38.1	44.2

The consumption of by-products (bark, sawdust and waste wood chips) and black liquor in energy generation was estimated to decrease in the Basic scenario compared with the year 2007. In the Maximum scenario, the energy use of by-products also lowered but the use of black liquor increased slightly (Table 1).

The cuttings by Forestry Centre and further by municipality in 2020 were allocated applying the latest National Forest Inventory data by the Finnish Forest Research Institute and the Stand Data Base by Metsäteho Oy. Metsäteho Oy Stand Data Base included more than 150,000 thinning and final cutting stands harvested by Metsäliitto Group, Stora Enso Wood Supply Finland, UPM Forest, and Metsähallitus in 2006 and 2007. The calculated small-diameter wood supply potentials were based on the 10th National Forest Inventory data of the Finnish Forest Research Institute.

Three different levels of potentials were determined in the study (Fig. 1). In the research, the theoretical potential was the amount of:

- Logging residues and stumps, which are produced in regeneration cutting areas in the Basic and Maximum scenarios, and
- Small-diameter wood (whole trees) produced when tending and cutting operations in young stands are carried out on time.

The techno-ecological supply potential was the forest chip material raw base, which is harvestable when the following limitations are taken into consideration:

- Recovering percentage is less than 100,
- Substantial amounts of pulpwood are not burnt,
- Recommendations in the Guide for Energy Wood Harvesting (Koistinen & Äijälä, 2006) are followed when choosing harvesting sites, and
- All energy wood does not come onto the market (forest owners' willingness to supply energy wood).

And techno-economical use potential included the total supply costs and the willingness to pay of energy plants (Fig. 1).

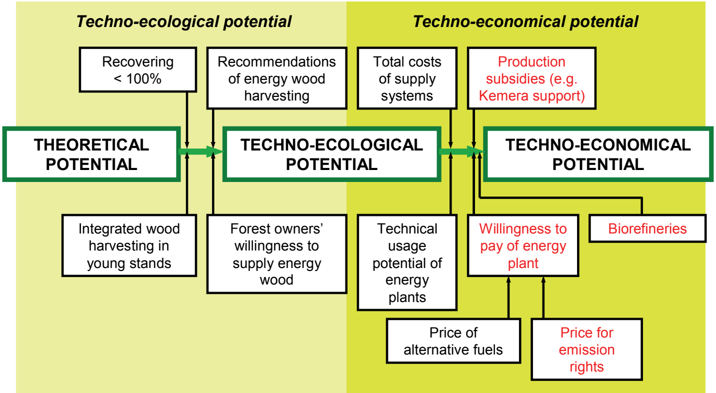

Fig. 1. The principle picture of the supply potentials determined in the research.

The harvesting conditions for recovering sites were created applying Metsäteho Stand Data. The total supply system costs for forest chip quantities were calculated by Metsäteho Energy Wood Procurement Calculation Models. It was assumed that in 2020 the total supply system costs are 20% higher than currently.

Pöyry Energy Oy's Boiler and Energy Plant, Pellet, and Forest Industry Data Bases gave a possibility to research the use of wood-based fuels in the study. Pöyry Energy Data Bases included almost all current plants and factories, as well as those under planning and contracting.

3. Results

3.1. Theoretical and techno-ecological potential

According to the calculations, the technical use potential of solid wood fuels in energy plants was 53 TWh in 2020 in Finland. The proportion covered by logging residues and small-sized thinning wood was estimated to be 28 TWh. Theoretical supply potential of forest chips was 105 TWh in the Basic scenario and 115 TWh in the Maximum scenario of the research (Fig. 2). Correspondingly, the techno-ecological supply potential was 43 TWh in the Basic scenario and 48 TWh in the Maximum scenario in the year 2020.

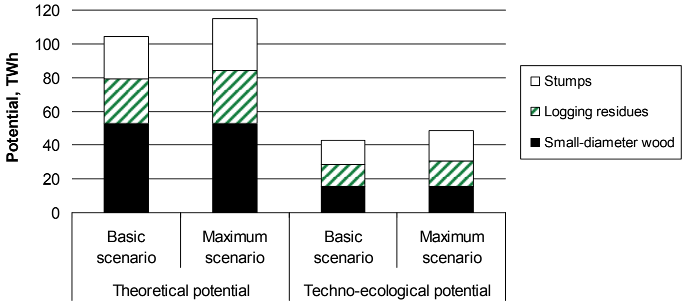

Fig. 2. Estimate of theoretical and techno-ecological supply potential of forest chips in 2020 based on the Basic and Maximum scenarios of the research. The calculated small-diameter wood supply potentials were based on the 10th National Forest Inventory data of the Finnish Forest Research Institute.

3.2. Techno-economical potential

When modelling the use of solid wood fuels in energy generation in the Basic scenario in 2020, the consumption of solid wood fuels was 44 TWh of which the use of forest industry by-products lowered from the current level to 17 TWh and the consumption of forest chips increased up to 27 TWh (Fig. 3). Particularly stumps raised significantly their proportion of total forest chip volumes (Fig. 4). The most expensive forest chip quantities delivered to energy plant were more than 20 €/MWh in the study. In this case, pulpwood starts to be cheaper than that kind of very expensive forest chip volumes.

In the Maximum scenario, the use of solid wood fuels increased to 48 TWh in 2020 (Fig. 3). Especially in the Maximum scenario the delivered quantities of logging residue chips and stump wood chips increased and the quantities of small-diameter thinning wood chips delivered decreased (Fig. 4).

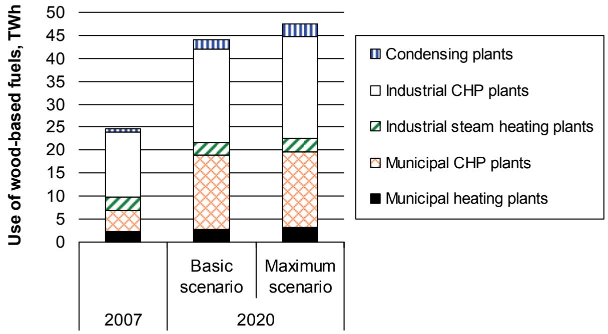

Fig. 3. Use of solid wood-based fuels in energy plants in 2007 and the estimated use in 2020 in the Basic scenario (domestic industrial roundwood cuttings 57 million m^3) and in the Maximum scenario (68 mill. m^3). In these calculations, the price for emission rights is 30 €/t CO_2 and the support for chips from small-diameter thinning wood from young forests 4 €/MWh (average stem size of removal as whole trees < 55 dm^3) in 2020.

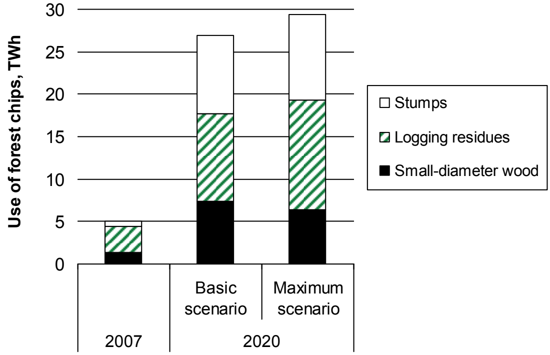

Fig. 4. Use of forest chips in energy plants in 2007 (Ylitalo, 2009), and the estimated techno-economical potential of forest chips in the Basic and Maximum scenarios in 2020. The price for emission rights is 30 €/t CO_2 and the support for chips from small-diameter thinning wood from young forests is 4 €/MWh in 2020.

The emission trade had a strong influence on the competitiveness of wood-based fuels and the use of such fuels in energy plants. When the price of emission rights lowered to the level under 20 €/t CO_2, the deliveries of wood fuels for energy plants decreased significantly (Fig. 5). Respectively, when the price of emission rights increased to over 30 €/t CO_2, the use of wood fuels by energy plants did not significantly increase any more. The effect of emission trade focused particularly on the most expensive wood fuel fractions, i.e. small-diameter thinning wood and stump and root wood (Fig. 5).

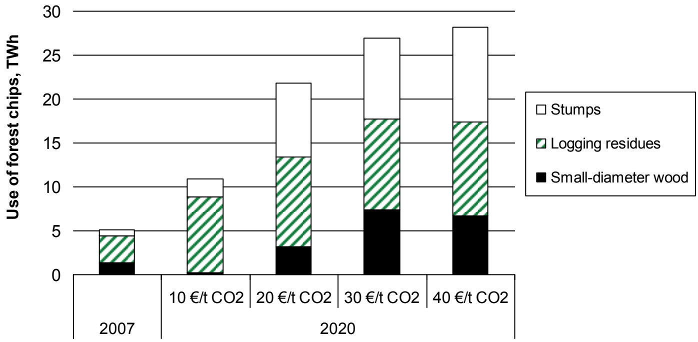

Fig. 5. Use of forest chips in energy plants in 2007 (Ylitalo, 2009), and the estimated techno-economical potential of forest chips in the Basic scenario in 2020 when the price of emission rights in the calculation is 10 to 40 €/t CO_2. The support for chips from small-diameter wood from young forests is 4 €/MWh in 2020.

Also, the support by the Finnish State for producing chips from small-diameter wood from young stands had very strong impact on the use volumes of small-sized wood chips in 2020. The effect of supports on the harvesting volumes of small-diameter wood chips pointed out when the price for emission rights was at the low level. When the price was low (10 €/t CO_2) and there was no support for energy wood harvested from young stands, there were no possibilities to harvest small-sized wood chips for energy generation (Fig. 6).

Correspondingly, when the support for small-sized wood chips was 8 €/MWh under low price of emission rights, it made possible to rise the use of small-diameter wood chips to 2.7 TWh (Fig. 6). Respectively, when the price for emission rights was high (30 €/t CO_2) and the support for small-diameter wood chips recovered from young stands was 4 €/MWh, it made possible to increase the use of small-sized wood chips up to 7.4 TWh in 2020 (Fig. 6).

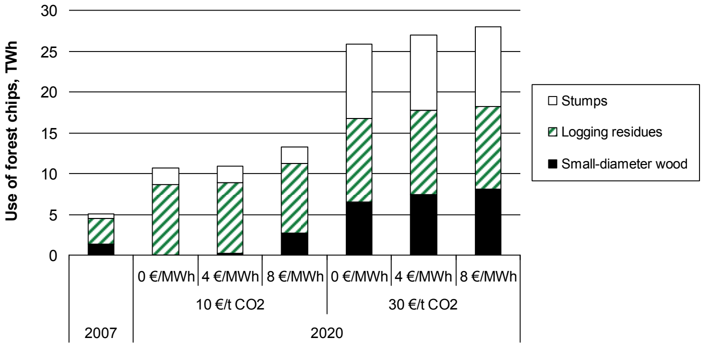

Fig. 6. Use of forest chips in energy plants in 2007 (Ylitalo, 2009), and the estimated techno-economical potential of forest chips in the Basic scenario in 2020 when the price of emission rights in the calculation is low (10 €/t CO_2) and high (30 €/t CO_2), and the Kemera support for chips from small-diameter thinning wood is 0 to 8 €/MWh in 2020. The presuppositions for the Kemera support claimed for small-diameter wood cut in young forests are:
- When the average stem size of removal as whole trees is less than 55 dm^3 in stands, the Kemera support is at three different levels in the calculations (8, 4 and 0 €/MWh).
- When the average stem size of removal as whole trees is more than 55 dm^3 in stands, the Kemera support is always 0 €/MWh in the calculations.

4. Discussion and conclusions

The study showed that the growth objective set in the Government's Climate and Energy Strategy (Pekkarinen, 2010) can be attained through the supply and consumption of wood-based fuels because, for instance, in the Basic Scenario the techno-economical supply potential was 27 TWh of forest chips in 2020. Realizing this potential would, however, require major investments throughout the entire forest chip production system, because the competitiveness of wood-based fuels in energy generation is currently not at a sufficient level. Industrial roundwood cuttings and the production of forest industries will also have to be at the level before the year 2009.

Also we have to pay attention to the fact that the forest chip production resources are very huge. Kärhä et al. (2009b) mapped how much machinery and labour would be needed for large-scale forest chip production if the use of forest chips increases extensively in Finland. According to Kärhä et al. (2009b) calculations, if the production and consumption of forest chips are 25 to 30 TWh in Finland in 2020, 1,900 to 2,200 units of machinery, i.e. machines and trucks, would be needed. This would mean total investments in production machinery of 530 to 630 million (VAT 0%). The labour demand would be 3,400 to 4,000 machine operators and drivers, and 4,200 to 5,100 labour years including indirect labour.

We clarified forest chip procurement potentials in the study using only as a raw material for forest chips so called traditional raw material sources, i.e. logging residues, stumps, and small-diameter wood. On the other words, we assumed that pulpwood is primarily utilized in pulping industry. Nevertheless, it can be estimated that when the total supply costs of most expensive forest chip volumes are about 18–22 €/MWh, the pulpwood will remove this kind of the most expensive forest chip quantities.

Considering the huge resources required by the forest chip production system and the current low competitiveness of forest chips, it is estimated that the use of forest chips in Finland will reach the level of 20 TWh at the earliest by the year 2020. Therefore, in practice there are no possibilities to achieve the set targets of renewable energy with wood-based fuels in Finland if the competitiveness of wood-based energy does not improve strongly.

We will need certain measures for improving operation environment in the field of forest chip production. And we need measures very fast because we have time only ten years for our targets of 2020.

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