Machinery and Labour Force for Forest Biomass Production in 2020 in Finland

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Abstract:
The research carried out by Metsäteho Oy and Pöyry Management Consulting Oy estimated how much machinery and labour would be needed for large-scale forest chip production if the use of forest chips increased extensively in Finland during the coming decade. If the production and consumption of forest chips are 25 to 30 TWh in Finland in 2020, then 1,900 to 2,200 machinery units, 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. The results of the study indicated that forest chip production resources will be a major bottleneck in reaching the consumption target of 25 TWh of forest chips in Finland by 2020.

Keywords: forest residues, production, resources, wood chip.

1 Introduction

The total primary energy consumption in Finland in 2010 was 401 TWh (1,444 PJ) (Anon., 2011). In 2010, wood-based fuels accounted for more than one fifth (85 TWh) of the total energy consumption in Finland, and were the second most important source of energy after oil (Anon., 2011). This makes Finland one of the leading countries in the World in regards to the utilisation of wood for energy generation. In Finland, wood-based fuels are divided into industrial waste liquors – mainly black liquor produced by the pulping industries – and solid wood fuels. Solid wood fuels are further divided into: 1) wood fuels consumed in heating and power plants, and 2) fuelwood consumed by small-sized dwellings, i.e. private houses, farms, and recreational dwellings (Anon. 2011; Ylitalo 2011).

In 2010, 37 TWh of wood-based fuel consumption was covered by waste liquors (Anon. 2011). A total of 48 TWh, or 22.7 million m^3 of solid wood fuels were consumed, of which the heating and power plants accounted for 31 TWh, 16 million m^3 (Ylitalo 2011). Small-sized dwellings currently use a total of 17 TWh, or 6.7 million m^3 of wood, for heating (Ylitalo 2011).

The total consumption of forest chips for energy generation in Finland in 2010 was equivalent to 13.8 TWh (6.9 mill. m^3) (Ylitalo 2011) (Fig. 1). Of the forest chips used in heating and power plants (12.5 TWh), 41% came from small-diameter ($d_{1.3}$<10 cm) thinning wood produced from the tending of young stands (Ylitalo 2011). Of the total amount of commercial forest chips used for energy generation, more than one third was produced from logging residues in final cuttings in 2010 (Ylitalo 2011). Forest chips derived from stump and root wood totaled 16%, while 8% came from large-sized (rotten) roundwood.

According to the EU's Climate and Energy Policy, the renewable energy target is to increase the consumption of renewable energy sources to 20% of total final energy consumption by the year 2020. In Finland, this target means increasing the proportion of renewable energy sources to 38% (Anon. 2008a). Wood-based fuels are the most important renewable energy source in Finland, and forest chips are considered to be one of the most important wood fuel sources in the future (Anon., 2008a). The overall target set for forest chips is 13.5 million m^3, i.e. 25 TWh by 2020 (Pekkarinen 2010) (Fig. 1).

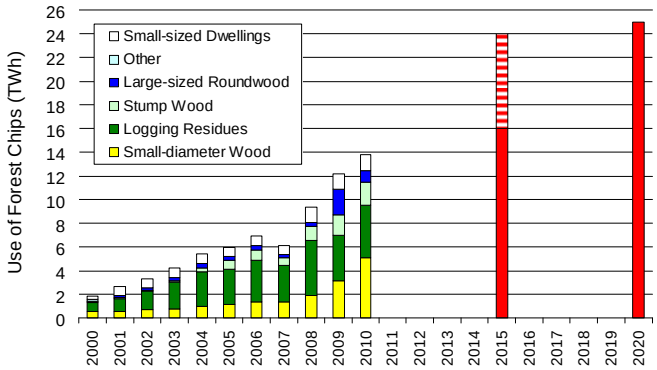

Figure 1: Use of forest chips in 2000–2010 in Finland (Ylitalo 2011), and the targets set for the usage of forest chips in Finland in the years 2015 and 2020 (Anon. 2008b; Pekkarinen 2010).

The research carried out by Metsäteho Oy and Pöyry Management Consulting Oy estimated how much machinery and labour would be needed for large-scale forest chip production if the use of forest chips increases extensively in Finland during the coming decade. The cost of acquiring the required machinery was also calculated. This conference paper presents the main results of the resource calculations.

2 Material and methods

The study included an Excel calculation model for defining the amount of machinery and labour resources required in the production of forest chips. In the resource calculations, the production and consumption of forest chips was estimated at 15 to 30 TWh in 2020. It was assumed that 43% of the forest chips used in 2020 would be produced from logging residues, 29% from stump and root wood, and 28% from small-diameter thinning wood harvested in young stands (cf. Kärhä et al. 2010). The main supply chain of chips from logging residues and small-diameter thinning wood was roadside chipping, and for stumps crushing at the plant (cf. Kärhä 2009; 2010).

In the resource calculations, one man-year for forest machines and comminution machines was equal to 1,712 hours and for transportation machinery 1,700 hours. These figures were obtained from the Trade Association of Finnish Forestry and Earth Moving Contractors, and Finnish Transport and Logistics SKAL. The indirect labour requirement was determined by multiplying the direct labour demand by 0.4 (cf. Ahonen 2004).

It was assumed in the calculations that the forest chip production machinery was used exclusively in forest chip production. Fifteen percent of the harvesting volumes of small-sized thinning wood (whole trees) were assumed to be harvested with energy wood harwarders, and the rest with two-machine (i.e. harvester and forwarder) harvesting systems (cf. Kärhä 2007; 2011). All the transportation of chips from the terminal to the energy plant was assumed to be carried out by means of chip trucks. All chipping at the plant was assumed to be carried out with fixed stationary crushers.

In the calculations, the results of the latest productivity studies and empirical productivity data were used as the productivity and performance basis for machine and truck units (e.g. Asikainen et al. 2001; Korpilahti & Suuriniemi 2001; Halonen & Vesisenaho 2002; Ranta et al. 2002; Rieppo 2002; Korpilahti 2004; Kärhä et al. 2004; 2006; 2009; Ranta et al. 2006; Laitila et al. 2007; Kärhä 2008; Kärhä & Mutikainen 2008). The price levels of early 2009 were used for the acquisition costs of machines and trucks. The acquisition costs were determined by interviewing machine and truck manufacturers and vendors (Table 1).

Table 1: The acquisition costs of machines and vehicles used in the calculations.

Machine/vehicle unit	Acquisition cost (€, VAT 0%)
Harvester	280,000
Energy wood harwarder	250,000
Slash bundler	400,000
Stump-lifting machine	150,000
Forwarder	210,000
Mobile chipper/crusher	570,000
Chip truck	270,000
Energy wood truck	320,000
Fixed stationary crusher	1,500,000

3 Results

3.1 Production and consumption of 25–30 TWh of forest chips

If the production and consumption of forest chips in Finland is 25 to 30 TWh in 2020, then:

- 1,900 to 2,200 units of machinery, i.e. machines and trucks, would be needed (Fig. 2). Numerically speaking, the largest number of machines needed in the forest chip supply system would be forwarders, energy wood and chip trucks, and stump-lifting machines (Fig. 3).
- This would mean total investments in production machinery of 530 to 630 million € (VAT 0%) (Fig. 4). Most of the capital would be invested in forest haulage and long-distance transportation machinery, as well as in the acquisition of mobile chipping equipment. The acquisition costs of this machinery would be 69% of the total investments.
- The labour demand would be 3,400 to 4,000 machine operators and drivers (Fig. 5). The greatest number of operators and drivers would be required for forwarders, energy wood and chip trucks, stump-lifting machines, and harvesters for small-diameter wood cutting (Fig. 6).
- The labour demand would be 4,200 to 5,100 labour years, including indirect labour (Fig. 7).

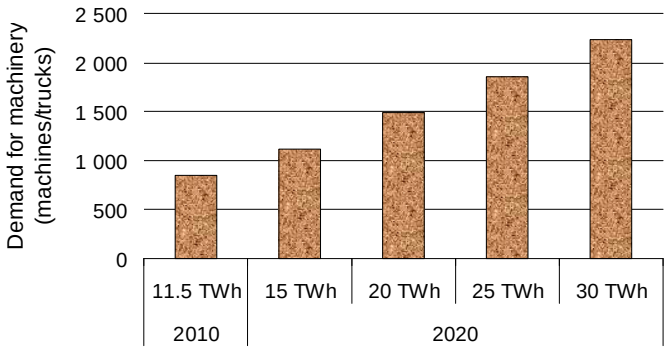

Figure 2: Estimated total amount of forest chip production machinery required in 2020, if the production and usage of forest chips is 15 to 30 TWh. It is assumed that the machinery is only used for the production of forest chips.

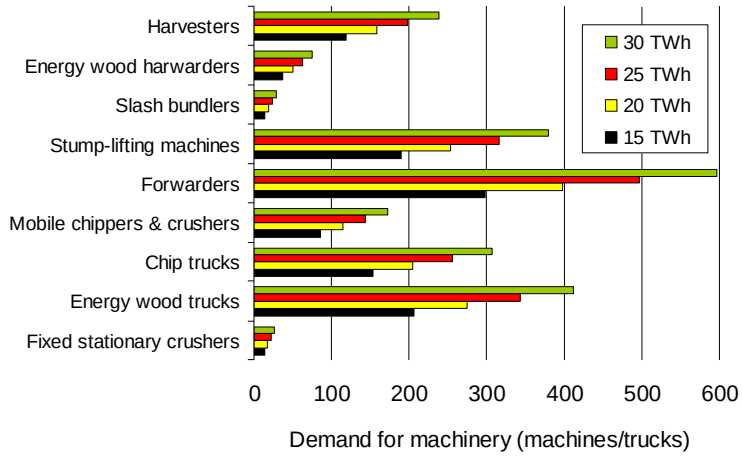

Figure 3: Estimated forest chip production machinery by machinery type required in 2020, if the production and usage of forest chips is 15 to 30 TWh.

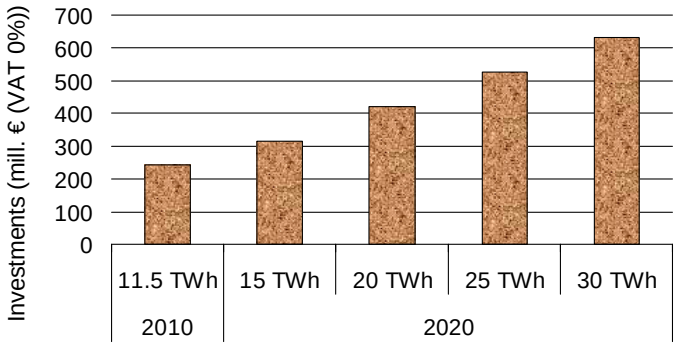

Figure 4: Estimated total investment requirement for forest chip production machinery in 2020, if the production and usage of forest chips is 15 to 30 TWh.

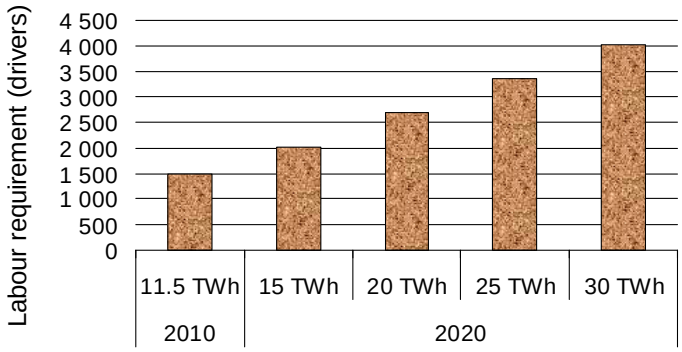

Figure 5: Estimated machine and truck driver requirement for forest chip production in 2020, if the production and usage of forest chips is 15 to 30 TWh.

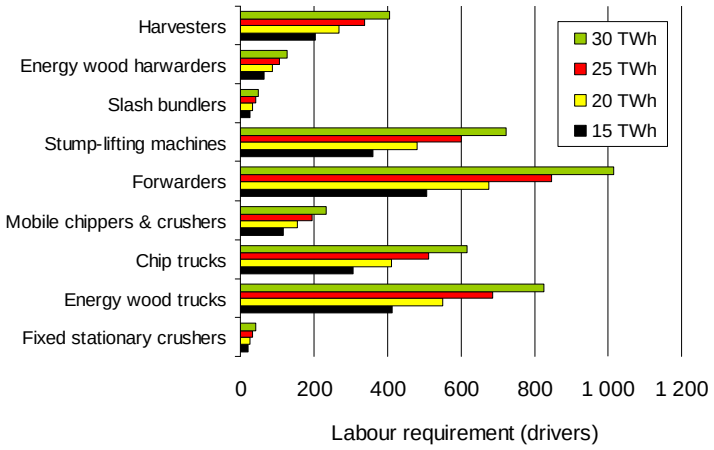

Figure 6: Estimated machine and truck driver requirement for forest chip production by machinery type in 2020, if the production and usage of forest chips is 15 to 30 TWh.

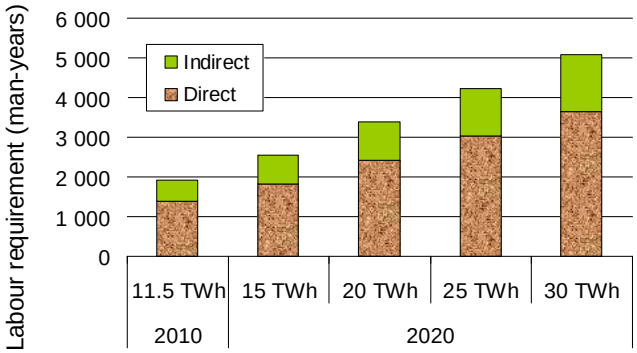

Figure 7: Estimated total forest chip production labour requirement in man-years in 2020, if the production and usage of forest chips is 15 to 30 TWh. The indirect labour requirement was determined by multiplying the direct labour demand by 0.4 (cf. Ahonen, 2004).

3.2 Production and consumption of 15–20 TWh of forest chips

However, if the production and consumption of forest chips in Finland is 15 to 20 TWh in 2020, then:

- The production machinery requirement would be 1,100 to 1,500 machines and trucks (Figs. 2 and 3).
- The total machinery investment cost would be 320 to 420 million € (VAT 0%) (Fig. 4).
- The calculated labour demand would be 2,000 to 2,700 machine operators and drivers (Figs. 5 and 6).
- The calculated labour demand would be 2,500 to 3,400 labour years, including indirect labour (Fig. 7).

In the calculation, the average labour demand in forest chip production was 0.17 labour years (l.y.) per megawatt hour (MWh) produced, i.e. 5,900 MWh/l.y. in 2020. The labour demand in the production of logging residue chips was smaller than the average (8,100 MWh/l.y.). The labour demand in the production of stump wood chips and chips from small-diameter wood was significantly higher than that in the production of logging residue chips (4,870 MWh/l.y. with stump wood chips, and 4,910 MWh/l.y. with chips from small-diameter thinning wood).

4 Discussion and conclusions

It was calculated in the study that, if the production and usage of forest chips in Finland would be 25 TWh in 2020 in accordance with the target set of Government's Climate and Energy Strategy (Pekkarinen 2010), then the demand for new production machinery would be nearly 1,900 units. Acquisition of the required production machinery would cost over half a billion euros (VAT 0%). One should bear in mind that almost none of these investments have been made so far. If the production and consumption of forest chips in 2020 is to reach the targeted level of 25 TWh, then the labour demand would be approximately 3,400 machine and truck drivers.

As regards the specified production resource requirements, it should be noted that the resource demand calculations were based on efficient, large-scale forest chip production. Production of forest chips at a smaller scale is more labour-intensive and, consequently, the labour demand is considerably higher than that presented in this study (cf. Ahonen 2004). The need for resources presented here is the minimum amount required to reach the production volumes in large-scale forest chip procurement.

Furthermore, the following calculation hypothesis has to be taken into account: the forest chip production machinery was only used for producing forest chips; production capacity was thus directed only at the production of forest chips. This is not, however, true in practice, because the same machinery is used in procurement operations, such as industrial roundwood cutting and forest hauling, long-distance transportation of fuel peat, and the comminuting and long-distance transportation of industrial wood-based by-products (cf. Kärhä 2007; 2011).

Kärhä (2007) conducted a study on the forest chip production machinery in use in 2007. In this study (Kärhä 2007), it was estimated that there was a total of 1,100 machine and truck units in Finland involved in the production of forest chips used in energy plants in 2007. Thus the "real" number of machines and operators in forest chip production is higher, conservatively speaking about double the amount indicated in this research.

It was also assumed in the study that all forest chip raw material, as well as forest chips, are long-distance truck transport. Rail and water transport will be made better use of in 2020 than at present, and this will reduce the specified demand for truck transport resources.

Further development of machine and equipment technology, new technical and mechanical innovations and rationalisation of working methods, will reduce the necessity to multiply production resources. In contrast, however, less favourable harvesting conditions and lengthening transportation distances will increase the resource demands in the future.

The reported forest chip production resource demands are so high that it is highly unlikely that they will actually materialize. We can therefore predict that forest chip production resources will be a major bottleneck in reaching the usage target of 25 TWh of forest chips in Finland by 2020.

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