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IMPACT OF ENERGY DEVELOPMENTS ON THE FORESTRY AND FOREST PRODUCTS SECTOR IN FINLAND

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BACKGROUND

The use of wood as fuel has all over the world its long well known history in which it was the dominating energy source until the era of fossil resources coal and oil. The annual use of fuel wood in the world did in fact increase up to around 1950 when it reached the level of 1 070 mill. m^3, the level of which has now stabilized (1). Man is still burning wood in the globe: about 0.3 m^3 per capita per year, but most of it is today burned in the developing countries where fuel wood has kept its main role as a source of energy.

One half of the annual forest cut in the world still produces fuel. The other half produces raw material. Raw material for timber and pulp is today needed more and more for the forest industry. In most of the industrialized countries, especially in Western Europe and Japan, the need for raw material is actually today so high, that it demands all the possible stem wood production. Therefore a return to conventional, fuel wood system burning stem wood is no longer possible without endangering the procurement of raw material for forest industry. Where then to produce the fuel wood in future?

What is the role of the industrial waste wood and bark as raw material or alternatively as an energy source for the forest industry in the future? Can the efficiency in utilizing the pulp industry's waste liquor for energy still be improved?

Is there anything left in the forest after harvest which could be utilized as fuel? What is the energy value of logging residues? Is it possible to grow energy wood on marginal land outside present forestry? Could we establish special short rotation energy forest plantations? Around these questions the principles of energy forestry were developed in late 1970s in Finland as well as in other western countries with scarce fossil fuel reserves but with abundant forest resources.

ROLE OF WOOD IN THE FINNISH ENERGY SITUATION

Drain of wood for fuel and raw material

According to the first available Finnish statistics from 1860 the consumption of wood was then 16 mill. m^3. The fuel wood consumption out of the total is estimated to be 12 mill. m^3, about 75 per cent. The corresponding estimates for 1900 were 26 mill. m^3 and 13 mill. m^3 (50 per cent) for total and fuel wood respectively. At this time transport based on the steam engine consumed annually 0.8 mill. m^3 of fuel wood. The consumption of fuel wood proper reached its maximum value 21 mill. m^3 per annum during the 2nd World War. Domestic energy sources, i.e. wood, peat and hydro power, covered almost all the needs for primary energy between 1940-45.

In 1950 the total drain of wood was 50 mill. m^3 out of which the fuel wood comprised 16 mill. m^3 (32 per cent). During the past 30 years rapid industrialization and great structural changes have taken place in the Finnish society. The utilization of the forest resources has also changed its form, although the actual volume of the drain of the stem wood has not increased essentially. The annual consumption of the fuel wood proper has decreased to 4 mill. m^3 (about 8 per cent of total drain). On the other hand the energy produced by the forest industry from wood, cooking and washing residues has increased. The amount of residual wood material used as raw material for energy in the industry has in fact risen far over the amount of fuel wood proper, into 20 mill. m^3 per annum, 35-40 per cent of the total raw wood consumption for pulp and timber. The energy consuming forest industry derives in Finland more than half (57 per cent in 1980) from its own wood materials (2).

Energy management has been based on wood far longer in Finland than in most of the industrialised countries. Finland has a high production potential for forest biomass, and the large peat deposits offer another substitute for imported fuels. The technical know-how connected with the production, harvesting and conversion of forest biomass for energy has been maintained and developed over the years.

Forest energy after the oil embargo

The total annual consumption of energy in Finland has remained quite stabile, 21-25 Mtoe/a for the past ten years after the oil embargo. Out of it the foreign oil has accounted for the greatest part, although there exists a clear trend to diminish that part. The proportion of oil has dropped by 15 %-units during the past ten years (Table 1). The alternative was not however wood or the other Finnish indigenous fuel peat, but nuclear power, which has increased by the same amount.

Table 1. Different sources in the consumption of energy in Finland in 1973, 1978, 1982 and forecast for the year 1983 (3).

Source	Proportion of the total, per cent			
	1973	1978	1982	1983
Foreign sources				
- oil	55	50	40	39
- nuclear power	0	3	16	15
- coal	9	15	8	10
- natural gas	5	4	3	3
- electricity import	5	2	2	2
Domestic sources				
- wood	20	15	16	16
- hydropower	11	10	13	12
- peat	0	1	2	3
Total, per cent	100	100	100	100
Total, Mtoe/a	23	23	25	25

Despite the steep decrease in the use of wood fuels during the period of cheep oil and expansion of forest industries, wood is still a more important source of energy than in any other developed country. The proportion of wood-based energy in Finland was as high as 20 per cent in 1973, but dropped quickly down to 15 per cent by 1977. Then the trend changed and now the corresponding proportion is in steady, although slight rise. All this development has taught that big changes in the trends of national energy consumption figures take their time; transfer from fossile to renewable sources needs apparently a transit period of ten years in a national scale.

In 1982 the proportion of wood-based fuels out of the total energy consumption was 16 per cent. On the other hand, compared with many developing countries which derive on average 43 per cent (4) of their total energy consumption from wood and other biomass, the role of wood-based fuels is rather moderate. The most distinguished difference in the forest energy use between industrialized and developing countries is and will apparently be in the composition of wood-based energy. When the firewood is still utilized in the original way in developing countries, industrialized country like Finland derives most of the wood-based energy by the industry (cf. Table 2).

Table 2. The composition of wood-based fuels of the primary energy in Finland in 1979 (5).

Source	Mtoe
Fuel wood proper for space heating	1.5
Industrial waste wood and bark	0.5
Waste liquor in pulp industry	2.1
Wood-based fuels, total	4.1

IMPACT ON SILVICULTURE

The basis of all forest use is the total allowable cut of forest biomass. In Finland it would ensure an annual energy production of about 8 Mtoe without touching the raw material drain to the forest industry. This utilization of presently unmerchantable forest residues would, at least in theory, happen in connection with ordinary silviculture.

However, a total recovery of the potential fuel wood reserve is not possibe for ecological, technical and economical reasons. According to calculations by the Finnish Forest Research Institute only 15 mill. m^3 of unmerchantable logging residue and small-sized trees out of 43 mill. m^3 possible can be classified as annually harvestable (Table 3).

Table 3. The annual technically harvestable forest biomass of the total unmerchantable forest residues in Finland (6).

Source	Mill. m^3/a		Mtoe/a	
Chips made of slash from clearcuttings	3.0		0.61	
Stumps and roots	2.4		0.48	
Chips made of small-sized trees	9.8		1.78	
- From precommercial thinnings		3.3		0.58
- From first thinnings		1.0		0.19
- From unproductive hardwood stands		5.5		1.01
Total	15.2		2.87	

Two aspects of both energy forestry and silviculture arise from Table 3. The precommercial and first thinnings could provide altogether 0.7 Mtoe/a as chips for energy. In fact, the amount of such thinnings carried annually out in Finland at the end of 1970's has been according to our scale too little, only 80 000 ha. The result has been that the young or middle-aged stands, which have not been thinned, have become over-stocked and stands, which have earlier been under-stocked, have been filled up. It has been estimated that the annual need for thinnings in young or middle-aged stands at the present time is almost 4-fold, 300 000 ha, and the need for first thinnings will reach a peak in the 1990's.

Increasing precommercial and first thinnings is the most urgent task to be carried out if the structure of future stands is to be favourable from the point of view of the quantity and quality of the wood being produced. In addition to the quantitative development of wood production, forest management should be aimed at obtaining high-quality, large trees at the final cutting. These preconditions form a favourable basis from the point of view of developing the use of small-sized wood for energy. But on the other hand, if the use of small-sized wood from thinnings cannot be used for energy at corresponding scale, the thinning programs are in danger to be delayed. And this would have an unfavourable effect on the level of silviculture in those stands which ought to produce the high-quality timber after 30-50 years.

The last row in Table 3 (forest biomass) "From unproductive hardwood stands" in the key to understand the second silvicultural aspect, the potential of coppicing energy forestry in Finland. In addition to the most common coniferous forests there is an abundant resource of hardwood stands in the country. For instance, the Finnish birch (Betula pendula and B. pubescens) reserves only, amount to 224 mill. m^3 and their annual increment to 10 mill. m^3 (2), which is about 18 per cent of the present total allowable cut (merchantable).

As a general rule for practical silviculture the unproductive hardwood stands ought to be regenerated into conifers. Several nationwide silvicultural programmes have been carried out to fulfill this task, with partial success, but the problem still exists. But growth vigour of those coppicing stands has raised the possibility to grow them for energy. So far there are no practical instructions available for the management of coppices for energy use. It was only in 1978 when research in Finland in this field was initiated. Coppices have, however, been traditionally harvested and managed in a small scale for fuelwood. The most common species used have been pubescent birch, aspen (Populus tremula) and grey alder (Alnus incana).

Pubescent birch is the most widely spread broadleaved tree in Finland. Drained peat soils alone are covered by 700 000 ha dominated by birch forests. Therefore the coppice yield of birch for energy is particularly interesting. There is still, however, only little knowledge on the yield of birch coppice forests, although this is one of the oldest forest utilization methods. The reason may be that the development of sprouting has been investigated in mineral soils with rather discouraging results. In fact, before the concept of energy forestry in its present form was born, there was no serious need to grow birch stands which could produce biomass as rapidly and abundantly as possible.

It is obvious that coppice forestry is suitable only in restricted areas and sites. It is probably not suited for oligotrophic sites. A significant yield potential, however, has been measured in the thickets growing in the so called marginal areas.

A productive coppice forest requires a sufficiently dense parent tree stand, and the coppices must in fact be grown considerably more densely than traditional forests. The stand regenerating from root suckers can be considerably more sparsely stocked than that regenerating from coppice shoots. An advantage of coppice forests over stands regenerated through coppicing, is a quick site capture and initial sevelopment, and a rapid development of leaf mass.

The growing of birch coppices in Finland is still, and will remain for several years, at research level. The whole idea is not yet mature for practice because owing to the laws governing the forestry in Finland it is difficult, or even impossible, to find such cut-over forest areas, in which coppice forestry would be classified productive enough instead of conventional coniferous option.

IMPACT ON HARVESTING

Harvesting of timber in Finland, both harvesting of conventional merchantable industrial wood and smaller sized energy wood, happens nowadays by methods which have been mechanized as far as possible. The timber can be harvested as tree lenghts or chips but in both cases the critical question is the minimum size at breast height which is regarded as econimic limit. The possibility to use chips for energy has dropped this minimum size, and today the diameter of 4-5 cm at breast height is accepted. The development of harvesting methods of small-sized wood has therefore assisted the outcarrying the silvicultural programmes.

The future development of the harvesting systems in combined procurement of industrial wood and energy wood can be examined in the light of the existence of the potential energy wood (Fig. 1). Conventional harvesting operations have happened in the unshaded area, in harvesting bigger-sized timber. But if energy wood resources are to utilized more in the future, the harvesting systems must adapt on the other hand to smaller-sized wood but also to branches, foliage, stumps and roots.

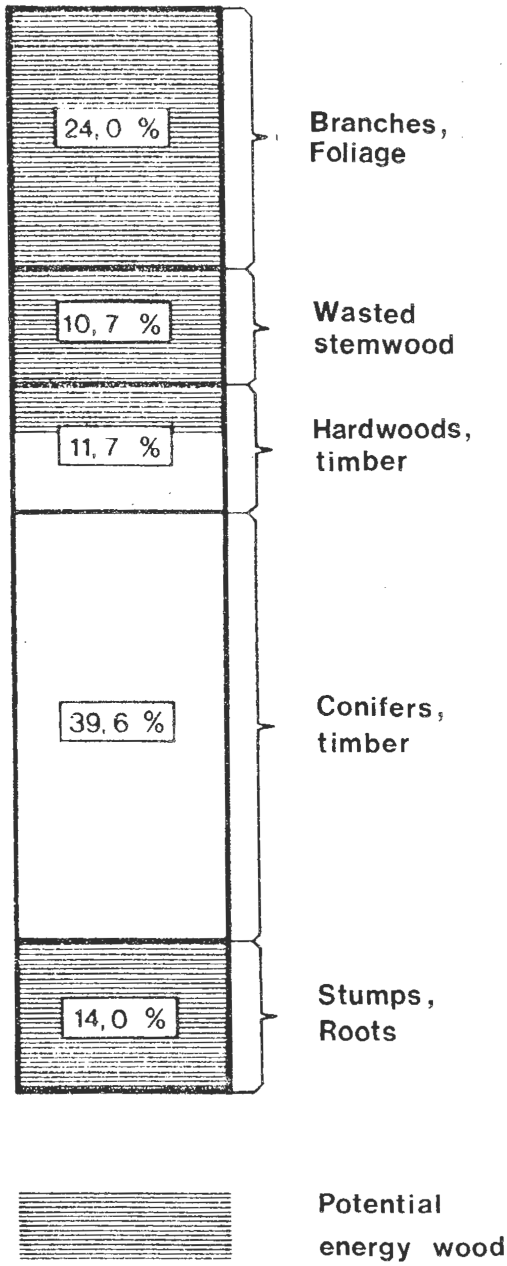

Figure 1. A regional Finnish example (Northern Ostrobothnia) on the division of forest biomass between industrial use and potential energy use (7).

Different harvesting systems

Fuel wood for farm use is still harvested primarily by manual methods. Haulage from the forest is generally done by farm tractors, occasionally by horse. Farm tractors are sometimes equipped with a hydraulic grapple loader. Simple mechanical loaders are also available. A great number of tractor-driven splitting machines have been marketed in Finland during recent years. Conventional furnaces often require, that the wood is cut finally into lenghts of 30-50 cm.

Chipping makes it technically possible to harvest, transport and burn almost any kind of small-sized wood. Because a farmer needs the chipper only 5-10 days annually, it is often owned by 2-3 farmers jointly. Farmers make chips primarily of small-sized trees with a breast height diameter of 3-12 cm. The trees can be chipped with or without the branches. Feeding to chipper is manual, but the manual work can be lightened with a hydraulic feeding device. Using a chain saw, farm tractor, tractor trailer and tractor-mounted light chipper the farmer would need 6-12 days to produce the chips needed for the annual heating of his own buildings (5).

The medium-sized, 1-10 MW (megawatts) wood combustion boilers in rural districts often need a special organisation for their fuelwood procurement. VAPO, the State Fuel Centre delivered about 80 000 m^3 (solid) of fuel chips in 1980 to state-owned institutions such as garrisons. Some forest industry enterprises have made long-term chip delivery contracts with local district heating centres, large dairies and hospitals. The chipping of fuel wood for medium-sized systems happens usually on a contractor basis. The chipping and transport are usually combined so that the same organization takes care of both of them.

Large-scale chipping operations are presently restricted to the forest industry which uses forest chips not only as fuel but also as raw material for pulp, particle board and fibre board. The aim of some enterprises is an integrated system in which the forest chips will be sorted and divided between process and fuel uses. The quantities of forest chips used by the forest industries are still modest, about 250 000 m^3 annually. The main source of wood, again, is unmerchantable trees less than 10 cm in diameter, but the chipping equipment can handle up to 25 cm trees if necessary. The forest industry always chips small-sized trees complete with braches (5).

Different chipping systems have been developed in the Finnish Forest Research Institute both for small-sized wood and logging residue. The research and development work has been carried out in the so-called PERA-project since 1978.

IMPACT ON FOREST INDUSTRY AND FOREST PRODUCTS

Energy developments in the forest industry have steered the development so that all such waste which have energy value, like saw dust, bark and waste liquor are also efficiently utilized for energy unless a better processing route exists. The situation is slightly different in mechanical and chemical forest industry.

Saw timber and veneer industry

Saw timber industry produces as by-products both chips and saw dust. They both have an energy value and they could be burned to cover the energy needs of the factories. But they both have also a value as raw material for further processing (chip board, pulp industry). The energy price will determine how the by-products are allocated between energy and raw material uses. In 1979 the allocation was as follows (Table 4). The total drain into saw timber and veneer industry was 20.4 mill. m^3 (8).

Table 4. Use of by-products from Finnish saw timber industry for raw material and fuel in 1979 (8).

Source	For raw material mill. m^3	For fuel mill. m^3	For fuel of total per cent
Saw timber	11.9	-	-
Chips	6.0	-	-
Saw dust	1.7	0.8	32
Together	19.6	0.8	4

At present practically all by-products, chips and saw dust, from saw timber industry are used as raw material.

The second by-product which comes both from saw timber and pulp industry, is bark. Bark has not such value as raw material than chips and saw dust, and therefore practically all bark is today burned in the forest industry itself (Table 5).

Table 5. Use of bark for raw material and fuel in the Finnish forest industry in 1979 (8).

Source	Mill. m^3	Per cent
Drain of raw timber	39.3	100 (total)
Produced bark for raw material	0.046	0.1 (of total)
Produced bark for fuel	3.36	8.5 (of total)
Produced bark together	3.41	8.7 (of total)
Theoretical bark production	4.98	12.7 (of total)
Actual bark production	-	69.0 (of theoretical)

Only about one per cent of the produced bark volume was used for raw material, and 99 per cent was burned. Table 5 has also the information that part, about 30 per cent of the incoming bark is still wasted in the process. Therefore the energy efficiency based on bark burning could still be raised in the Finnish forest industry. Increased use of bark as raw material is not obvious in the next coming ten years.

The third by-product coming from the forest industry, from pulp industry, is waste liquor. The level of recovery in the Finnish pulp industry is already very high: 96-97 per cent in sulphate process and 90-92 per cent in sulphite process. Due to the high energy value of lignin, all the waste liquors can be efficiently burned by the pulp industry itself.

Since the recovery in waste liquor utilization is already now so high, no big changes are foreseen in this area. In 1980 the energy potential of waste liquors was about 1.75 Mtoe, and it is expected to increase - with the increase in cellulose production - only slowly, to 1.90 Mtoe by 1990.

POLICY ASPECTS AND FUTURE PROSPECTS

It is unanimously agreed in Finland that the increasing use of wood for fuel must not endanger the drain of wood for raw material to the forest industry. It is also known that all the bark, slabs, saw dust and other wood residues from forest industry are already utilized by the industry itself either as raw material for pulp and boards or for fuel. Practically no unutilized industrial waste wood or even bark is available for energy purposes.

In order to meet the future demands of industrial saw and pulp timber, and also growing demand of fuel wood for residential and large scale heating systems, the silvicultural policies must be directed so that both needs can be satisfied. This has been planned to happen in three different sections: (i) by improving the techniques and economics in harvesting small-sized wood and logging residue, (ii) by developing silvicultural methods for producing simultaneously coppicing hardwoods for pulp and energy needs, and (iii) by establishing energy forest plantations on marginal land areas, such as abandoned agricultural fields and cutaway fuel peat bogs.

From the point of view of forest industry the competition between pulp and energy options for raw wood is no desired situation. Therefore the forest industry is seriously investigating the possibility to integrate the procurement of pulp and energy wood. This would happen by the system of chipping whole trees in the forest in the landing site, by transporting them to the factory as chips, and by sorting them out into pulp and fuel fractions. This integration may steer the policy of forest industries in their procurement of raw material in the future.

The sharp rise in the cost of oil has put serious strain on the balance of payments in Finland. As a result of the reconsideration of national energy policy in the late 1970s, energy conservation and increased utilization of indegenous energy were taken as the main objectives of the Finnish energy policy. Wood and peat are the most important indegenous fuels, which can be regarded as a specific feature of the Finnish energy system. However, it must be emphasized that Finland is heavily dependent on imported energy, even if the energy policy programme would be rapidly accomplished. The present share of the indigenous energy is about 30 per cent of the total primary energy utilization. It should be raised to 35-40 per cent at the end of this decade according to the energy policy programme.

In addition to energy conservation, among the steps foreseen is an increase in the utilization of wood for fuel annually by 6-12 mill. m^3 or by 1-2 Mtoe. Therefore the different branches of energy forestry: the conventional procurement of hardwood coppices and short rotation energy forest plantations are now under intensive research in the country.

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