SKOGFORSK REVIEW OF SYSTEMS FOR LOGGING RESIDUES HANDLING IN SWEDEN*

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PRESENT CONSUMPTION OF BIOENERGY

Bioenergy provides more power than either hydroelectric or nuclear power, accounting for 87 TWh per annum (1996) and nearly 20% of the total power generated. The total consumption of energy wood amounts to 20 million m^3 solid including biomass direct from the forest, by-products from the forest products industry, and a small quantity of recycled timber. This should be seen in the context of a total annual cut of some 60 million m^3 roundwood for industrial consumption.

The energy wood that is available on the open market consists largely of wood straight from the stand, wood reduced to chips, and other comminuted biomass. We utilise annually roughly 4 million m^3 biomass, mainly logging residue from final felling.

The energy-wood sector is currently in a state of high activity. The demand is heavy in the vicinity of large towns in some parts of the country. There is also an increasing awareness of the need, for ecological reasons, for well-thought-out recommendations as to where and how energy wood should be exploited.

MARKET

The demand of forest fuel has increased rapidly during the last few years, and several new bioenergy plants have been built. In spite of that the price of forest fuel has not risen. One reason is the relatively low oil price. Another reason is the low price at which wood-based residues from torn down buildings are being sold on the Swedish market periodically.

SYSTEMS FOR HANDLING LOGGING RESIDUES

Final fellings account for most of the approximately 4 million m^3 logging residues from conventional forestry.

Final Fellings

Logging-residue systems are based on modification of the main logging to meet the needs and requirements of the fuelwood users. This means adaption of a harvester's working

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techniques in such a way that the residue is collected in piles that the machines are not allowed to drive over. This helps to prevent the fuelwood from becoming contaminated, which is often the key factor in producing fuelwood of an acceptable quality.

These biomass piles are left to dry on the cutover during the spring and early summer, when a large proportion of the nutrient-rich needles are also shed. Thereafter, they are generally forwarded to the landing and covered over with paperboard to keep the moisture content down prior to combustion of the fuel sometime later in the winter. The forwarder should be modified for carrying larger loads. Fitting a removable frame and an extra stake at the back can increase the load capacity by 30–50%.

The logging residue is either chipped at the landing or transported to a terminal or to the heating plant for chipping. Chipping the biomass directly on the cutover is becoming quite rare for logistical and cost reasons.

Thinnings

As mentioned, the volume of logging residues from thinnings is quite small today. However, with increasing demand for forest fuel, together with changes in silviculture regimes, interest is growing in collecting logging residues from commercial thinnings and even precommercial thinnings.

Today there are two systems for handling logging residues from thinnings,

- A striproad operating chipper such as the Chipset 536 C and Erjofanten 7/65 RC chipping tops after roundwood logging or whole trees that have been felled motor-manually orwith a mechanised system
- Whole-tree logging systems with mechanised felling by a single grip harvester followed by a forwarder with a crane-mounted grapple saw.

The two striproad operating chipping machines are flexible enough to handle both small trees in young thinning stands and logging residue on clearcuts or at the roadside. The important technical advantage with these machines is that they are equipped with a slewable infeed opening, allowing efficient working in dense stands. It also gives better opportunities for chipping logging residue in a final felling stand where seed trees should be left. When the residue is piled up at roadside the machine does not need a lot of space on the road for the comminution.

The Transport System

Transport of fuelwood assortments occurs today almost exclusively by truck. The Swedish vehicles have a length of 24 m and a gross weight of 60 tonnes. The Scandinavian winters often reduce the usability of the road network, owing to snow and thawing of the frozen soil. To obtain the reliability required, parts of the volume must be temporarily stored at a terminal or along a road not affected by the spring thaw.

Wood chips

The main way of transporting wood chips is a container rig. Three containers are placed on the vehicle, each container with a volume of 35 m^3, giving a total payload of 35 tonnes. In general, nine containers are used in a system for chipping and transport to the heating plant or storage site. It takes about 45 min to load three containers and 25 min to unload them.

The container-transport system is a hot system in which the containers tend to be the bottleneck. Chips cannot be stored for too long since they deteriorate rapidly.

Unchipped logging residues

Unchipped logging residues can be transported either all the way to the consumer or to a temporary storage site for central chipping, whereafter a special chip vehicle is used for further transport.

The normal vehicle for transporting logging residues consists of a logging truck equipped with sideboards fitted inboard of the stakes, and a sheet-steel deck over the bunk.

To increase the degree of compaction of the unchipped logging residues, the truck can be equipped with a heavy-duty crane with double-acting lift cylinders. The load can also be compacted by the heavy crane on an independent loader.

The transport cost is lower for chip fuel transported in containers owing to the larger payload and cheaper vehicle. To reduce transport costs for unchipped logging residues the degree of compaction needs to be increased.

ONGOING DEVELOPMENT

Compaction of Residues in Final Felling

Probably the main innovation for the recovery of logging residues from final felling is the technique of compacting material to bales or logs.The baling machine from Bala Press has been working well for three seasons. There are also two new processes in which the residues are compacted to "logs" with a diameter of some 70 cm and length of 3–4 m.

Compression of logging residues makes it possible to increase handling efficiency along the whole chain from harvest until arrival at the end-user. The increase can be ascribed mainly to increased payloads on the forwarder, truck, and train, possibilities for efficient long-distance transport by train, lower chipping costs through centralised conversion, and simplified logistics since the compressed unit can be stored at several points along the path from clear-cutting area to heating plant.

A fully functional technique for compressing logging residues offers interesting possibilities for a system transition, new ways of thinking, and associated opportunities for increasing efficiency in the development of a delivery system.

System analysis shows that, compared with the conventional system, compaction can reduce costs by 10–20% over long transport distances (160 km). The largest cost reduction is realised in terms of lower costs for forwarding and further transport. An advantage of rail transport is reduced impact on the environment.

Bales of logging residues

The companies Trädenergi Väst AB and Bala Press AB have developed a mobile machine for compressing logging residues. The residues are compressed into cylindrical bales with a diameter of 1.2 m. The technique is based on Bala Press AB's technology for compressing waste products, among other materials.

A prototype model of the baler was test run during autumn 1995, and today there are two balers operating. The baling machine was mounted on a medium-sized forwarder and run on clear-cut areas as well as roadsides. SkogForsk has carried out a number of studies on the Bala baler. Bale production reaches some15 bales per working hour. The bale mass varies with tree species and moisture content between 350 and 800 kg. On average we make a bale of some 450 kg with a moisture content of 30–40%, containing approximately 1.7 m^3 loose volume or 1.5 MWh.

Residue logs

In 1998 two different technical solutions were presented by the companies Fiberpac and Wood Pac for compacting logging residues into residue logs. Foresters have shown keen interest in the new compaction technique, since it is possible to use conventional forwarders, logging trucks, and comminution equipment without any modification at all.

Preliminary findings from studies of the two different machines indicate production capacity similar to that of the Bala Press baler.

Changing topping diameter of pulpwood bolts

It is an attractive option for a forest owner to be able to vary the topping diameter of and the relative proportions of pulpwood and energy wood stems in accordance with changes in demand and prices. But to do this, we need to know in advance how it will affect costs and revenue. Tentative findings from SkogForsk suggest that, for diameters of 6–10 cm, the impact on productivity is marginal and the costs for pulpwood and sawlogs would not be affected significantly if a bucking diameter within this range were chosen.

Thinnings

Multitree-handling felling heads

There are currently three interesting new felling heads and machine concepts, all of which are based on multitree-handling to increase productivity in thinning of young stands.

The first studies of the Bror Hult felling and bucking head operating in thinning of small-dimension hardwoods point to productivity of about 200 trees per productive (G_{15}) hour. Approximate mean stem volume in the hardwood-dominated stand studied was 0.03 m^3 (solid i.b.). An average of 2.8 trees were handled per felling cycle, which represents a productivity level some 40% higher than that achieved in single-tree handling.

EnHar's marketing literature claims that productivity is about 250 trees per productive (G_{15}) hour—a plausible figure given the design of the felling head and the fact that only the smallest trees are being handled. The first studies of EnHar showed a productivity of about 160–200 trees per productive (G_{15}) hour.

Recent studies carried out by SkogForsk show interesting economical results in harvesting hardwood such as beech with an EnHar mounted on a forwarder. Since the fuel content is high in hardwoods such as beech and oak, it is feasible to promote thinnings by taking out fuelwood.

Compaction of residues from thinning

Development is proceeding and field tests are being carried out on compacting techniques for residues from thinnings. Elmek, the constructor of EnHar, is responsible for this development. The technique is to be used with the harvesting of small trees for fuel use.

Large-scale Comminution

There is a marked trend in Sweden for comminution to take place late in the flow, close to the consumer, to keep comminution costs as low as possible. Of course, this structural change to the system makes new demands on the machinery, which must have a high capacity and be capable of handling a variety of raw material. A standard requirement is that the comminuted material shall not contain any long slivers. Most users prefer to receive chipped rather than ground wood, as they see this as a guarantee that the material will be free from contaminants.

Both the manufacturers and the chipper contractors have heavy-duty, high-capacity machines available. A recently launched machine is the Bruks 1004 CT terrain chipper, which is the largest mobile chipper built. It is a drum chipper, which has an intake opening measuring 113 × 67 cm and a 500-hp engine. The side-tipping chip bin has a capacity of 30 m^3, which is the same as a container used for secondary haulage. The machine will be modified for chipping baled logging residue as well.

Another recent development in Sweden has seen the forestry contractors importing large comminution machines from the USA. One example is the top-fed PWG 1260 Tub Grinder from Diamond Z Manufacturing. The machine is designed primarily for bark and demolition timber. It grinds the raw material to fractions of various sizes and has magnets for separating out any bits of iron. Another is the CBI Magnum Force designed to operate at large wood terminals. This machine has a horizontal feed and is therefore able to handle long pieces. The feed opening measures 150 × 120 cm, and the engine rating is more than 800 hp. This machine also has magnets for separating out iron contaminants. According to the contractor, the comminuted material resembles wood chips. The machine can be used to comminute logging residue, bales, demolition wood, bark, and compost.

New Regulations

A large Environmental Impact Study will soon be finished. This study will probably give forestry a new regulation for handling logging residues. An important factor will probably be spreading regimes for wood ash. If we can find an effective way of returning the ash to the forest land, we can build up a cyclical system and yet another incentive for using wood raw materials as a source of energy in a sustainable way.

COSTS AND REVENUE

A study of the costs in three supply systems for three assortments has shown that it is becoming increasingly difficult for the conventional haulage system, comprising removable containers for chips, to remain cost-effective (Table 1). This is mainly because of the high costs incurred in comminution at the landing and in secondary haulage.

The study shows that the costs for systems handling uncomminuted or baled logging residue are substantially lower, even taking into account the extra materials-handling costs to be incurred by the user.

The container system is the most expensive option throughout the range, while uncomminuted logging residue is the most cost-effective over haulage distances up to about

TABLE 1–Cost of procurement for the alternative systems of residue recovery at a haulage distance of 60 km (Kr/m^3)

Cost item	Fuel chips	Uncomminuted residue	Bales
Extra cost in logging	1	1	1
Baling	–	–	28
Forwarding	20	20	10
Paperboard covering	3	3	–
Storage	2	2	3
Chipping at roadside	33	–	–
Management & admin	5	5	5
Landowner (stumpage)	5–15	5–15	5–15
Total cost before haulage	69–79	36–46	52–62
Haulage (60 km)	19	27	16
Admin: profit and risk	10	10	10
Comminution	–	12	9
Total cost	98–108	85–95	87–97

70 km. Over greater distances, it appears that baling of the residue could be the cheapest system.

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