00-09: The use of wood chips for energy…

Availability and competition aspects
Opposed to what many people think, the production wood chips do not compete with "normal" use of wood for paper production, building purposes and carpentry. Instead, the fractions used for fuel are those finding no other use; the top, the crown and the branches, extracts from thinning operations and other residuals. Also stumps can be used – if extracted.

As an approximate value, about 75 % of the mass of a tree after felling is represented by the stem and the remaining 25 % are found in the crown. Leaving out the foliage still leaves 15-20 % of the tree mass (15 % for conifers and 20 % for deciduous trees) for the branches. These are of course very approximate numbers, varying with the age of the tree, but they will serve to give a first indication of the resource.

But not only may the felling site itself provide a fuel resource. The sawing operation results in bark, raw chips, waste from the debarked log after sawing into planks, root reduction chips, low quality logs and similar residues – again best suited for energy.

In total, only about 50 % of the tree mass entering a saw mill finally leaves the mill in the form of sawn goods – the remainder becomes residues. Parts of the residues, saw dust and shavings, are best used for pellet or briquette manufacturing while a significant amount is better used as chips; the shorter the refinement chain, the cheaper the fuel.

Also – to make full use of the primary residues, i.e. the branches, at the felling site, a complete energy system must include techniques and supply chains for wood chips, so there will be possibilities to handle and deliver wood chips also produced in the saw mills.

Aspects on the production chain
Chips from felling sites are best produced through the following process chain:
1. The harvester driver should be carefully instructed to put all branches and tops (*brash*) that are not necessary to reinforce the soil to the side of the main driveway at the site. If possible, brash from several trees should be put in the same pile, so as to minimize the driving distance during the subsequent building of windrows – but at least should the brash be clearly piled so that it is not driven upon.
2. The brash is then collected into windrows using a forwarder with a grapple. The brash is taken from the piles, shaken a few times so as to get rid of as much contaminants as possible and it is placed in a long, bread-loaf-like and porous pile up to 3 or 4 m in height. Best is if the windrow can be organised along the roadside but most crucial is that it is not placed in a depression where rain water may accumulate and that it is oriented so that wind has access to its broadside. The material in the windrow should be organised as parallel as possible.
3. The windrow top shall then be covered with waxed paper as a primitive – but effective – rain protection. It is important that the long broadsides of the windrow are left open for wind to have free access.

4. The windrow shall then be left at the site for a number of months for open-air drying. Since the windrow is a porous structure neither moist nor temperature can accumulate in it so microbiological deterioration of the material is not a big problem. Hence it can be left for a period of 6-12 months without significant losses of material while, at the same time, the moisture content goes down from 40-60 % in the fresh material towards 30 % - depending, of course, on climate.
5. Once the fuel is desired, the material should be chipped using a mobile chipper, the chips loaded directly into containers on the lorry and the material transported directly to the energy plant. As the chipper uses its grapple to lift the material from the windrow, it should be shaken a few times so as to make the dry foliage fall off to the highest possible extent. Leaving the foliage at the site not only contributes to maintain the nutrient and mineral balance – it also lowers the ash content of the fuel delivered, see chapter 00-02.
6. In case the chipping operation takes place during a dry season, it is crucial that the containers be covered with a tight cover. The dust from a dry dirt road may significantly increase the total ash content of the fuel in the containers if only a net is used as a cover.

The above process chain is based on the “just-in-time” concept and cannot usually be realized in full. Instead of transporting all material directly from chipping to the energy plants (5 above) it is quite common that a significant fraction of the material is instead transported to an intermediate store at a fuel terminal. The deliveries to the energy plant are then to a great extent organised from the terminal. There will also be a need for buffer storage at or near the energy plant.

Baling the brash in direct connection with the felling is an alternative to the storage in windrows (2-4 above). Typically, the bales would be produced in shapes and sizes that make them possible to handle with the same equipment as the timber is. For example: In Sweden, the bales will typically be 3 m long and approximately 50-100 cm in diameter so that they can be transported on ordinary timber trucks.

The advantage with baling is that the handling is simplified and that it improves transport economy. However, the baling machine is a specialized kind of equipment and the capital cost for the baler will increase the cost during the felling. The disadvantage is that since the bales are produced in direct connection with the felling, the material baled is “green” so that the foliage is enclosed in the bales. This increases the amount of nutrients and minerals that is withdrawn from the felling site and it also increases the ash content of the fuel.

Experiments performed at the Swedish University for Agricultural Sciences indicate that bales can be stored for long times without any significant loss of material due to micro-biological activity. It has also been reported that the material dries almost as good as it does in covered windrows.

<u>Chips from demolition sites</u> and industrial residues may be dry and is typically produced from de-barked material. The problem in this case is generally not the biological activity but the eventual presence of chemical contaminants – paint, glue, anti-rot agents, metallic objects like screws or nails or alike. The presence of contaminants may render the material to be classified as waste and to fall under the rules specified in the federal “waste directive” (2000/76/EC).

Hence, the crucial factor for this kind of materials is the sorting. Demolition wood and industrial residues are typically dry and are crushed rather than chipped using cutting chippers as is the case with virgin forest material. This means that demolition wood chips will have a slightly different surface structure, the friction between individual particles become different, the repose angle changes and the handling equipment may behave differently for demolition wood chips than it does when handling virgin wood chips.

Chips from energy forestry – SRC/SRW (*short rotation coppice or short rotation willow*) – are very scarce because of economic reasons, but in some locations they are grown and used. Energy coppice differs from common silviculture in that the “trees” are harvested at an age of 2-3 years, once the “stem” has achieved a diameter of a few centimetres. The harvesting of SRC occurs by aid of a mowing-machine similar to those used in agriculture but with the knife and the engine dimensioned to handle the thicker and stronger material represented by the stems. The stems are then oriented in parallel on the table and cut into pieces 3-10 cm in length.

The harvesting machine is a specialized kind of equipment that basically has no other use than for harvesting of SRC and hence – to keep the capital cost for the machine down – SRC plantations must be large enough to carry the cost for specialized machinery.

If the cutting is done in well-maintained cutter, so that the cut is clean, the “chips” will still be covered with bark after the cutting. This means that the chips will dry only very slowly so that SRC chips are usually mo re moist at delivery to the energy plant than chips produced through the above process chain for felling residues. Also will SRC chips have a high proportion of bark as compared to the stem wood, and hence a higher ash content (see chapter 00-02).

Storage

At the terminal, the fuel may be stored for significant times in the form of chip piles. Such piles provide the best possible conditions for micro-organisms, bacteria, mould and fungi, which feed on the organic substance as outlined in chapter 00-03. This may apply also at larger energy plants. In case of baling, the bales may be stored in piles up to about 5-6 m height without adverse effects.

The biological activity in chip piles will release heat and the central parts of the piles may – unless the excess heat is ventilated away – finally reach ignition temperature and catch fire. The risk for auto-ignition depends on the porosity in the pile as well as on the material stored, and Swedish insurance companies have worked out a table of recommended values for storage. The table indicates the maximum recommended height and the maximum recommended storage time in meters and in months for different types of materials when stored in chipped form in piles.

Material	Not compacted Height	Not compacted Time	Compacted Height	Compacted Time
De-barked stem wood	20	12	16	9
Stem wood mixed with bark	15	9	12	6
Whole-tree chips – deciduous – including SRC	12	9	9	6
Whole-tree chips – coniferous	10	9	7	6
Felling residues	7	6	NOT ALLOWED	
Bark	7	3	4	3
Saw dust	15	6	12	4
Cutter shavings	8	6	6	4
Contaminated material	6	3	NOT ALLOWED	

- Compaction – i.e. driving the front-loader on top of the pile – reduces the permeability and hence reduces the ventilation and increases the risk for auto-ignition.
- The risk for auto-ignition is radically increased in case the pile contains any metal objects that may catalyze the ignition process.
- Each assortment should be put in separate piles and they should not be mixed.
- For piles of bark, felling residues and contaminated material, it is recommended that the piles are manually inspected every 4 hours. This also applies to all the other materials in case the temperature in the central pats of the pile exceeds 70 °C.

For material containing a large fraction of bark, there are also sanitary problems arising because of the establishment of mould in the piles.

The risks and problems outlined above do generally not apply, or are much less pronounced, to dry materials and to demolition wood chips.

Cost structure
Wood chips from felling sites – the main part of the potential volume – should mainly be produced in direct connection with the felling operation. Hence, the costs for the harvesting operation shall be split between the major assortments, timber, pulp-and-paper chips and fuel. The marginal costs associated with the fuel fraction will be connected to the additional work imposed on the forwarder to collect the brash (branches and treetops) in windrows adjacent to the roadside, the covering of the windrow and the capital cost arising from the windrow during one year open-air drying. To this comes the additional cost for a mobile chipper once the fuel shall be transported and delivered. Depending on the actual conditions at the felling site may the windrow in itself also be a hindrance for cultivation and re-forestation, and this will also impose an indirect cost.

In the case stumps are used as the raw material for chips, it is questionable whether the extraction of the stumps should be considered a cost for the fuel or should be considered part of the cultivation. For stumps, the open-air storage in windrows is of utmost importance since the fraction of soil in the material is always significantly higher than in brash and the stumps should be exposed to rain to be somewhat washed clean during the open-air storage. Still will the amounts of soil and stones in stumps be significant and the comminution will typically best be done using crushing instead of cutting. Hence, the machinery for chip production from stumps will be more specialized and this will reflect on the total costs. As with brash may the presence of a stump windrow at the felling site delay re-forestation and that will impose an additional, indirect cost to the fuel.

Wood chips produced from energy forestry will have to carry the full cost for cultivation, harvesting, forwarding, comminution, drying and transport and there will be no part of the costs that can be split onto any other assortment like timber or cellulose chips.

Wood chips from demolition wood will to some extent resemble the production from stumps. While stumps will be contaminated by stones and soil may the demolition wood contain residues of concrete, nails, screws and other constructional elements. Hence will demolition wood typically be best produced using crushers and the full cost for the crusher will have to be assigned to the fuel since it has no real alternate use. Thus there is a volume demand set on the production of crushed chips so as to fully utilize the capacity of the crusher.

Relevant standards
Wood chips are the most abundant biofuel but at the same time the least well-defined. Hence, standardisation of wood chips (see the FOREST StandardGuide) is complicated and there are several standards already in effect or upcoming. The most relevant are EN 14961-4 for general classification and EN 15234-4 for the quality assurance.