

## Testing new tools and innovative operating systems for wood energy harvesting in French Alps

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**Abstract:** Forests on slope areas represent more than a quarter of the French forest resource. As France is committed to produce more energy from renewable sources, this wood reservoir may become a significant contributor provided that economically and environmentally sound harvesting systems could be implemented with positive contribution to operators' safety as a bonus. For 3 years, a research project tested different harvesting systems. The systems are based on extraction of whole trees, mechanized delimiting and topping and slash chipping. 18 tests with cable-yarder were conducted. This extraction technique offers the best opportunities to harvest the wood unreachable to skidders. Then, 3 scenarios were considered and compared to prepare the chips from the slash: chipping in the forest at the roadside, chipping in a working place outside the forest after transportation of the slash, either loaded in bulk or after bundling. As a results, the technical cost for supplying forestry chips (green woodchips, 50% humidity, delivered at the heat boiler) was estimated to be between 17 and 22 €/ MWh. This range is compatible with the current market in France.

**Keywords:** logging residues, chipping, cable yarding, mountain forests

### 1 Introduction (context)

In France, mountain forest is considered as a resource that could be more intensively harvested as it represents about 25% of the French forested area, but 35% of the National wood stock volume (2 465 Million m<sup>3</sup>). This situation is the result of several decades of under-harvesting. Clearly, the ration between the harvested volume and the annual increment is lower in steep terrain than in plain (Barthod, 1995). Public forest owners (French State and local communities) want to develop the utilization of wood both as an energy source and as a material for building products with "harvesting more while improving biodiversity protection" as a leitmotiv (Assises de la forêt et du bois, 2008). For the French bioenergy policy the target is to supply an additional 20 Mtep renewable sources including 7.2 Mtep from agricultural and forest biomass.

In this favourable context, mountain forest may become a significant contributor provided that economically and environmental sound harvesting systems could be implemented.

One way to develop logging in mountain area is to promote the use of efficient harvesting systems, like the whole tree system with extraction by cable yarding, which is not a so common system in France. Indeed, the golden era of cable yarding in France used to be from 1940 to 1960 as in the whole Alpine space. In the 1960's, the rural exodus, increasing wages and the development of ground based harvesting system -forest roads openings and wood extractions with cable skidders- led to the decline of cable yarding in France. Since 1990, forest managers are trying to create a new dynamic for cable yarding with the support of public subsidies (Grulois, 2007). Today, 15 French teams are working. Each year, 2-3 foreign enterprises are joining their work capacities to the French ones.

In 2007, in the frame of a national R&D program for bioenergy, FCBA launches a 3 years research project (MOBIPE) whose purpose is to study the production of chips for energy in mountain area especially after extraction of whole trees with cable yarders. Technical, economical and environmental aspects are to be analysed. The associated purpose is to foster this technology amongst the logging

contractors and foresters and to show how to use this "new" logging systems coming from the other Alpine countries in the French context.

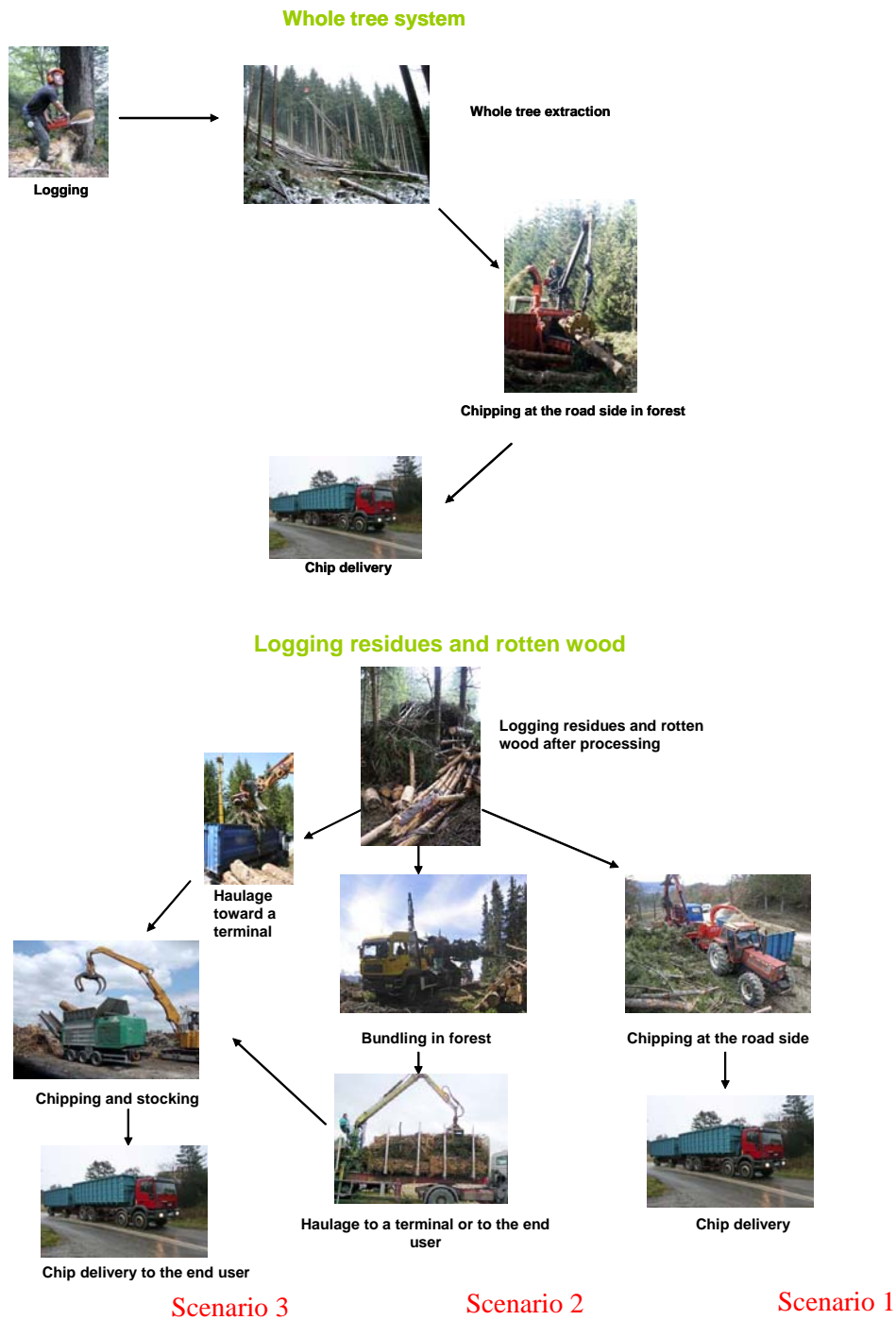
## **2 Description of the harvesting systems (material and methods)**

In slope area, the production of chips for energy is generally combined with the harvesting of timber for sawmills because logging companies consider that it is often not possible to reach an economic equilibrium with the only production of energy products. The main exceptions are (i) the harvesting of beautiful beech stand for wood fuel (in billets) located close to cities with a dynamic demand for fuel wood and (ii) logging after a windstorm or wildfire as it may occur in the Mediterranean area. For both situations, the total extracted volume is large enough to provide good harvesting productivities and some benefit to the logging company.

Finally, four harvesting scenarios have been considered in our study:

1. For the use of forest residues (top and branches after tree length bucking with a processor at roadside)
  - chipping at the road site in the forest (S1)
  - chipping at the mill after bundling in the forest (S2)
  - chipping the residues outside the forest, on a terminal (S3)
2. For the use of whole tree:
  - manual felling and whole tree extraction by cable yarder and chipping at the road side (S0).

While S1, S2, S3 have been implemented in field trials, a theoretical approach has been used to study S0.



**Figure 1: The four harvesting systems**

**2.1 Study protocol**

The productivity have been analysed on 23 harvesting sites during the project. Time and productivity studies were made according to the harmonized protocol defined by the AIR3-CT94-2097 concerted

action. On 7 sites, a "stopwatching" study was made. On 5 sites, tree damage and soil disturbances have been made according to the protocol defined by the same Concerted Action.

Daily costs have been calculated for each individual operation according to FAO recommendations (FAO, 1999). They include:

- fixed costs i.e cost related to insurance, depreciation of the material, interest (cost of using funds),
- Operating costs: maintenance and repair, fuel, lubricants, tyres ...
- Labour costs: salaries, indirect payments, travel and accommodation costs.

## 2.2 Harvesting sites

In the following, we focus mainly on 18 timber yards with cable yarding. Note that in the figures, some of them have been excluded because they are too atypical: long winch skyline, large cable crane (prototype), or with particular harvesting conditions. So, the core of our data base is 13 sites in spruce stands with extraction by a "medium" cable crane. The line lengths range between 350 to 600 m. Two teams with experienced employees were involved.

Cable crane: Valentini V600M3 with a Wyssen HY2 carriage (payload: 3 tonnes) or Konrad KMS U with Wyssen HY2 or woodliner 3000 carriage (for downhill extraction).

For more details on the study sites please go to our website on [www.mobipe.fr](http://www.mobipe.fr)

## 3 Results

### 3.1 Cable yarding productivity and operational costs

Productivity figures range from 30 to 70m<sup>3</sup> of saw logs per day. The mean value is 44m<sup>3</sup>/day. On average 20 tons of associated by-products for 100 m<sup>3</sup> of saw logs must be added in order to have the global production. Times devoted to the settlement of the line and its removal are included in the time taken into account.

The "yield index" which represents the ratio of extracted volume to the total length of the line (m<sup>3</sup>/linear meter) is the main parameter influencing the productivity of cable yarding.

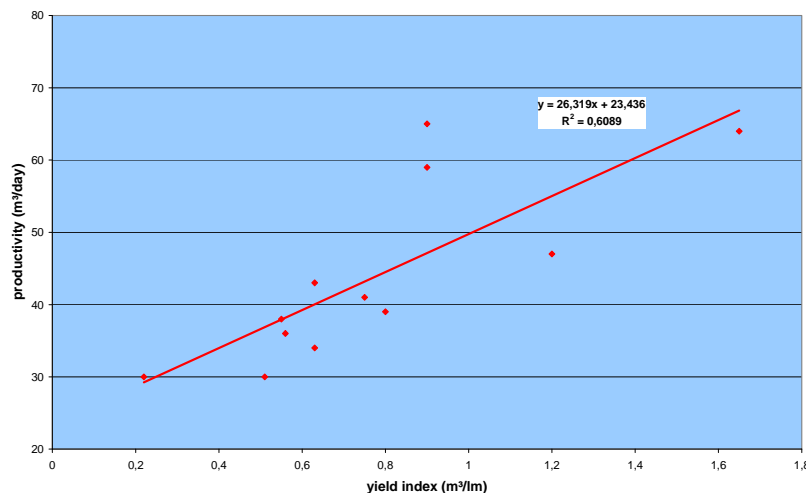


Figure 2: Productivity (in m<sup>3</sup> of saw logs) as a function of the yield index

The unit cost, expressed in €m<sup>3</sup> of saw logs, is the ratio between the daily production and the daily operating cost.

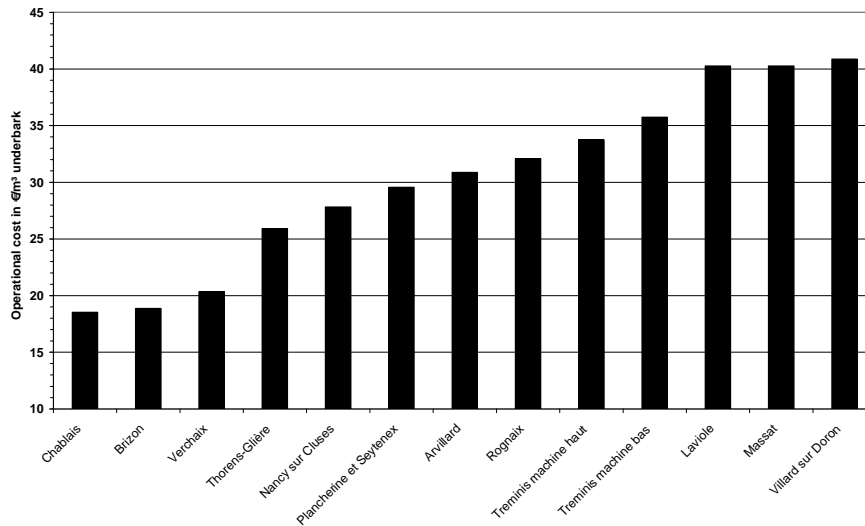


Figure 3: Operational cost of cable yarding (€m<sup>3</sup>)

Operational costs of cable yarding range from 18.5 to 41.0 €m<sup>3</sup> (underbark) of saw log.

### 3.2 Costs of forestry chip production

For forestry chips produced from top and branches, we consider that only chipping, bundling and transportation costs are to be taken into account. It means that all the costs related to logging (felling, mechanized delimiting) and extraction are paid by the selling of saw logs. The value of the residues at the road side is zero.

The results of cost calculation for forest chips are summarized in the following graphs:

The costs in scenarii S1, S2 and S3 – between 17 and 22 €MWh – are compatible with the current price for green forestry chips on the French market (Centre d'Etude de l'Economie du Bois. 2011). Overheads and a commercial margin must be added to the operating costs. Currently, the final result is rather superior to the market price. But as chips of this quality are sold to large heating station (more than 1 MW), they are usually mixed with some other cheaper biomass (by-product of wood processing, used pallets ...). Costs in scenario S4 are too high because the decrease of chipping cost – the productivity is better when chipping whole tree than residues - do not compensate the cost of felling and extraction of the trees.

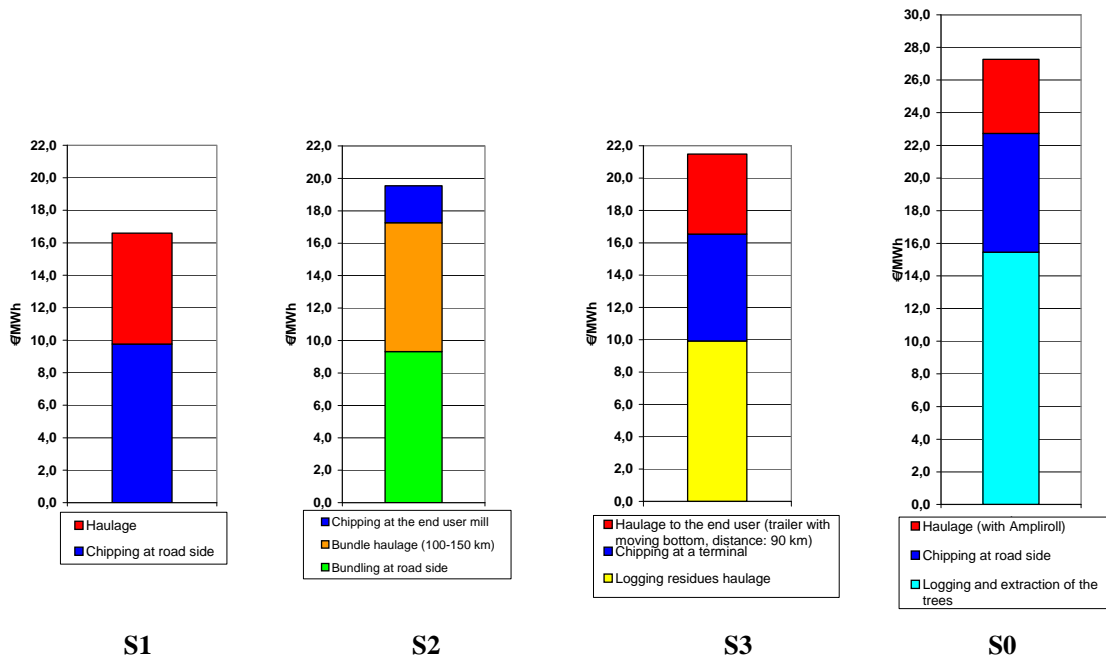


Figure 4: Cost of chip production

3.3 Environmental aspects

The benefits of cable yarding vs. extraction with a cable skidder rely upon a very low level of soil disturbances. Less than 5 % of severe disturbances – with more than 5 cm depth ruts - have been counted on the 3 investigated cable yarding sites.

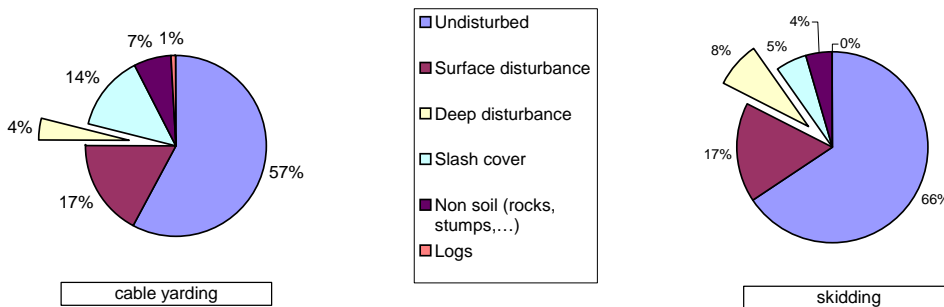


Figure 5: Soil disturbance for cable yarding or skidding of whole tree

In terms of soil fertility, the potential risk of fertility loss of the logging sites due to forest residues extraction have been evaluated through the classification of the French guide " La récolte raisonnée des rémanents en forêt" (Cacot, 2006). The main parameters to take into account are soil acidity, type of humus and soil texture. The studied woodlots, in the northern Alps, are all located in rather "low sensitive" areas. In this category, extraction of forest residues is permitted two times during the life of the stand (in flat area with shorter clear cut age). As a result, using the whole tree system in the Alps seems to be not problematic.

Moreover, some characteristics of mountain harvesting bring additional insurance in comparison to flat area situations:

Trees are always partially delimbed in the forest even in the whole tree system. So there is always a good amount of biomass abandoned in the forest. Partial delimiting is necessary both to reach the bottom of the trees for extraction and because the trees are too large or with too large branches to be fully futher on, at road side, delimbed with a processor. Nevertheless, this situation could evolve if the demand for raw forestry chips would increase: in the future, contractors would also invest in processing heads with higher capacities,

Harvesting in French mountains is generally rather "extensive" with a system of small area cuttings (1000 to 2500 m<sup>2</sup>) equally spread over the whole surface of the parcel.

So, considering the way logging is practised in France and soil types, the risk of affecting fertility with whole tree extraction is rather low in French Alps. Nevertheless, some measured field data would be very useful to convince some stakeholders that, in most situations, there is no risk to damage the fertility.

#### **4 Ergonomic**

Whole tree system and the associated mechanization of delimiting offer huge advantages in terms of ergonomics and safety for the operators. No specific assessment has been carried out during our project, but automatic chokers have been tested and shown to the cable contractors who took part to the project. These devices are now used by almost all of them.

#### **5 Discussion**

##### **5.1 How can loggers improve productivity and reduce operating costs?**

Increasing the utilization rate of the equipment is the main way to improve the operating costs. Traditionally in France, the forest contractors and their workers in mountains areas have a double job: they are employed by ski resort during the winter. More and more entrepreneurs are now trying to work all the year round which means that they have to move toward regions with better climatic conditions (South Alps and Massif-Central). In 2000, the average number of machine hours was only 800 hours/year, with long winch skyline. Nowadays, it is around 1200 h/year with a shift toward more cable cranes.

The utilisation rate of the equipment could also be improved by more working hours each day. It depends mainly on the available place for roundwood storage at landings in the forest and/or the good articulation with the truck transportation to the mills. When there isn't anymore place to stack the wood, logging must be stopped with an important impact on the operational costs. Considering this logistic aspects, there are some important discussions in France about the advantages of bucking short logs at the road side versus tree length (in both cases, after whole tree extraction). The later still prevails. Could the CTL system be more efficient and cost effective in term of global logistic? And what are the consequences for sawmills?

Considering chip production, the 3 scenarios we tested are based on logging residue chipping. Chipping tops, branches, rotten wood offers rather low productivities. The feeding devices on small to medium chippers – more often lateral desks - are not suitable for slashes.

##### **5.2 Forest management**

Forest management and logging activities are linked. In French mountains, uneven-aged forest with numerous improvement cuttings is the dominant system. But with the increasing costs of forestry work, there is a shift toward a simpler system with less work during the stand life. More and more, forest management consists in harvesting small clear cut openings with a surface area comprised between 1000 to 2500 m<sup>2</sup>.

This evolution could lead to a better renewing of forest stands but also a reduction of injured trees during harvesting. In small clear cuttings, harvesting conditions are improved, particularly for cable yarding, as it is easier to get a larger amount of volume along the cable line.

Increasing the volume of wood on each woodlot is also an important lever to improve the productivity. Once again, we show on our 13 timber-yards the impact of this factor (expressed in cubic meter of extracted wood divided by the length of the installed line – m<sup>3</sup>/lm –linear meter) (see figure 2). The forest managers who are contracting with the entrepreneurs have to be informed of this important parameter.

This trend toward the extraction of whole trees in small openings is really a strong "cultural" change in the mind of forest managers and it will probably take a long time before being fully adopted.

## 6 Conclusion and perspectives

The MOBIPE project shows that it is possible to produce forest chips from forest residues in mountain forest fitting to the French market price. The more we will extract saw logs from the forest the more we can produce chips from the forest residues. The main bottlenecks are in the field of the transportation of the products (logs and chips, or loose branches) from the road side to the end-users or to a terminal. As loose forestry remnants are concerned, their transportation to a terminal for chipping could be improved if specific trailers are available and usable in the mountain areas where the road network is particularly difficult and with climatic constraints reducing the working period. For this reason, the bundling operation may find a place with some valuable advantages in terms of organisation.

The future works in the field of biomass for mountains forest are to:

- Develop the utilisation of cable yarding for the extraction of logs. This technology must be fostered after years of decreasing to a dramatically low level in France. A particular emphasis is needed for the harvesting of hardwood, with well known difficulties for bucking mechanization (in mountains as in flat areas).
- To reassure the stakeholders on the possibility to harvest and extract whole tree from the forest by bringing scientific data on the impacts on soil fertility sustainability of such practices (what is the real amount of extracted biomass? What is left in the forest stand? What are the soils suitable for whole tree extraction?)

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## **8 Acknowledgements**

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