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Integrated Project
Sustainable energy systems

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Review on existing studies and definitions of biomass provision chains

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CONTENT

ABBREVIATIONS

a	annum
app.	approximately
BtL	biomass to liquid
CHP	combined heat and power
DH	district heating
DM	dry matter
GP	gathering point
LHV	lower heat value
LR	logging residues
O&M	operation and maintenance
S1	Scenario 1: Maximized bio-fuel production ‘2020
S2	Scenario 2: Self-sufficient bio-fuel production ‘2020
Starting Point (SP)	situation for 2000-2004
t	tonne
w.b.	wet basis

TERMINOLOGY AND DEFINITIONS

Most of the terminology, definitions and description are based on CEN (2003).

agricultural residues
biomass residues originating from production, harvesting, and processing in agriculture areas

biomass residues
biomass originating from well defined side-streams from agricultural, forestry and related industrial operations

cereal crops
annual crops grown with the main purpose to use the seed for food production; e.g. wheat, rye, barley, oats, maize, etc.

energy crops, fuel crops
woody or herbaceous crops grown specifically for their *fuel* value. NOTE: See also *energy forest trees, energy grass, energy plantation trees*

energy forest trees; short rotation forestry SRF
woody biomass grown specifically for its *fuel* value in medium to long rotation forestry

felling
cutting down of a whole tree

final felling
felling which aims felling of all trees from the mature stand

forest chips
forest wood in the form of wood chips

forwarding
short-distance wood transport from the felling site to a roadside

fuel dust; saw dust
pulverised biofuel with a typical *particle size* of 1 to 5 mm; e.g. saw dust produced during wood sawing, straw dust – grinded straw

green chips
wood chips made of fresh *logging* and *thinning residues,* including branches and tops

logging residues
woody biomass residues which are created during harvest of merchantable timber (e.g. contains of trees tops and branches incl. leaves and needles)

NCV, GCV (MJ/kg)
Net calorific value, Gross calorific value of origin biomass (NCV refers to heating value as received during biomass harvesting or extraction)

root and stumps
underground mass of wood e.g. stump of tree and roots spread around left after the tree is felled in forest

selection felling
only single trees or small groups of trees are felled in the same time

stem wood; stem wood chips
1. part of tree stem with the branches removed, 2. *wood chips* made of *stem wood*, with or without *bark*

straw
stem of cereals such as wheat, rye, barley, oats

thinning residues; thinning wood; small-size trees
woody biomass residues originating from thinning operations (usually young trees with low diameter of stems <10-15 cm)

thinning operations
early pre-commercial and commercial thinning operations in young stands; goal of thinning operation is the improvement of species structure of stands and to improve the quality of trees (usually small-size diameter <10-15 cm trees are cut during thinning)

wood chips
chipped *woody biomass* in the form of pieces with a defined *particle size* produced by mechanical treatment with sharp tools such as knives, NOTE 1: wood chips have a sub rectangular shape with a typical length 5 to 50 mm and a low thickness compared to other dimensions

wood dust
fine particles created when sawing wood

wood powder
pulverised biofuel with a typical particle size less than 1 mm

wood processing industry residues; wood industry by-products
woody biomass residues originating from the wood processing as well as the pulp and paper industry. NOTE: See also bark, cork residues, cross-cut ends, edgings, fibre board residues, grinding dust, particle board residues, plywood residues, saw dust, slabs, and wood shavings

wood shavings; cutter shavings
shavings from woody biomass created when planning wood

GLOSSARY

biomass freight	biomass assortment (e.g. straw, forest residues, energy crops)
block train	freight line, usually based on one wagon type for uninterrupted transport of biomass freight from start to destination station
cargo handling	loading and discharging of a biomass freight between different means of transport or delivery of a container
combined transport	special form of multimodal transport involving the cargo handling of biomass freight in a container, swap body or tank (i.e. the biomass freight itself is not handled)
detour factor	Ratio of air-line and actual distance of road, train line and inland waterway (based on average sample)
forerun	transport of biomass freight by lorry e.g. between first gathering point to harbour or goods station, basic part of multimodal transport
frequency of cargo handling	amount of biomass freight handled per time unit (e.g. t/h); differences between slow-moving and fast-moving items
front end loader	a type of tractor that uses a wide square tilting bucket on the end of movable arms to lift and move material/loads; loaders used for handling straw bales or wood logs are equipped with specialized fork or claw respectively
full-container-load	container completely loaded during harvesting / at storage and discharged at conversion (BtL) plant gate
lift-on/lift-off system	vertical cargo handling by crane
loading platform	at-grade loading and discharging of a biomass freight of mean of transport
main run	transport of biomass freight between forerun and off-carriage
multimodal transport	combination of different two (i.e. bimodal) or more transport options for the provision of one biomass freight within the provision chain
multiple sourcing	multi-supplier principle, i.e. procurement strategy for the provision of similar biomass freight (or auxiliaries) from several suppliers
off-carriage	transport of biomass freight by lorry between e.g. inner harbour/dock side or goods station to the conversion plant; depending on BtL plant site infrastructure part of multimodal

	transport
roll-on/roll-off system	horizontal cargo handling by means of ascending
semitrailer	also tractor trailer or heavy goods vehicle (HGV), lorry combined with different types of trailer (e.g. open truck body with crane)
storage logistics	totality of logistic issues and measures of scheduling and operation of a storage
swap body	diminishable transport attachment for combined transport
toll	paying of a fee for the use of buildings, like roads, bridges, motorways and tunnels etc.
TEU	Twenty Feet Equivalent Unit, measure of capacity based on the number of transportable 20` (inch) container

1 INTRODUCTION

This deliverable D 5.3.5 "Review on existing studies and definition of biomass provision chains" is prepared by EC BREC and IEE within the WP 5.3 Micro-economics and socio-economic assessment in the European project Renewable Fuels for Advanced Powertrains (RENEW). The project is supported by European Commission within the 6th Framework Programme and coordinated by Volkswagen. This report includes a review of provision costs of agricultural and forest residues reported in some existing studies as well as definitions of biomass provision chains. Moreover, the general methodical approach for the cost calculation of biomass provision costs is presented.

For the production of liquid biofuels (BtL) several steps are necessary. The liquid biofuel production and provision chain is shown in Figure 1-1. The chain starts with biomass production and provision, which are the scope of this report and attached cost calculation matrixes.

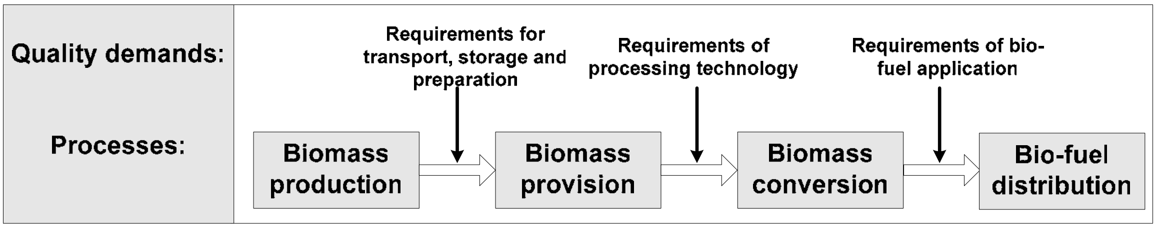

Figure 1-1 Elements of the liquid biofuel production and provision chain (D 5.3.1)

For the needs of this report and further works within WP 5.3 biomass provision chains are divided into two main stages: (i) from production site up to the 1st gathering point (performed by EC BREC) and (ii) from the 1st gathering point to the processing plant (performed by IEE).

The provision of the following biomass assortments will be investigated:

* energy crops,
* agricultural residues (straw and permanent crops residues),
* forestry wood (logging residues, thinning wood, root and stump wood),
* wood industry by-products.

For residue biomass (forestry and agricultural residues) as well as wood industry by-products both stages of the provision chain (up to the 1st gathering point and from the 1st gathering point) are analysed in this report[1]. On the contrary, energy crop provision chains up to the 1st gathering point were analysed in deliverable D 5.3.4 “Energy crop production cost in the EU”.

In addition to general assumptions (chapter 2), objectives of the following report are the review of existing biomass provision options and costs (chapter 3), the presentation of a methodical approach for biomass potentials (chapter 4) as well as the definition of the biomass provision chains (chapter 5 et seq.). The report ends with the approach for the RENEW scenarios S 1 and S 2 (chapter 7) as well as a prospect of the further approach (chapter 8).

[1] Some aspects of cereal straw provision costs were also included in D 5.3.4. The reason to include straw in the calculations was to make the calculations between energy crops and straw comparable. However, exact values for straw provision at all European regions were not included in D 5.3.4 and due to this fact are analysed within this report.

2 GENERAL ASSUMPTIONS

Many concepts for biomass conversion are subject system-inherent trade-off between preferably large-scale plants with regard to “economy of scale” – and thus a high biomass demand – and a small as possible catchment area for the supply of this feedstock demand. This is particularly true for so far not matured concepts that are designed for large-scale conversion of biomass (e.g. energy crops, straw and forestry wood). Within the RENEW project different scales of BtL production (i.e. biomass demand of 100 MW_{th} and 500 MW_{th}) are investigated. Depending on regional conditions, the overall biomass supply chain (i.e. starting from biomass production over biomass provision and biomass conversion) is coupled to different aspects on “biomass side” and “demand side” (Figure 2-1). As shown, the chain of biomass provision is divided into two stages: (i) up to the 1st gathering point and (ii) from the 1st gathering point to the BtL plant. No defined chain (e.g. transport distance of biomass production and biomass demand is about 150 km) is conferrable to different regions, because of e.g. (i) different distribution and size of biomass growing areas as well as their ratio to land area and (ii) different infrastructure in terms of transport and ownership structure of growing areas. Thus, for the analysis of biomass logistics following specific criteria are of importance such as:

* area specific technical potentials of biomass
* biomass assortment
* biomass treatment
* means of transport
* transport distance
* storage technology
* storage demand
* biomass demand
* plant site

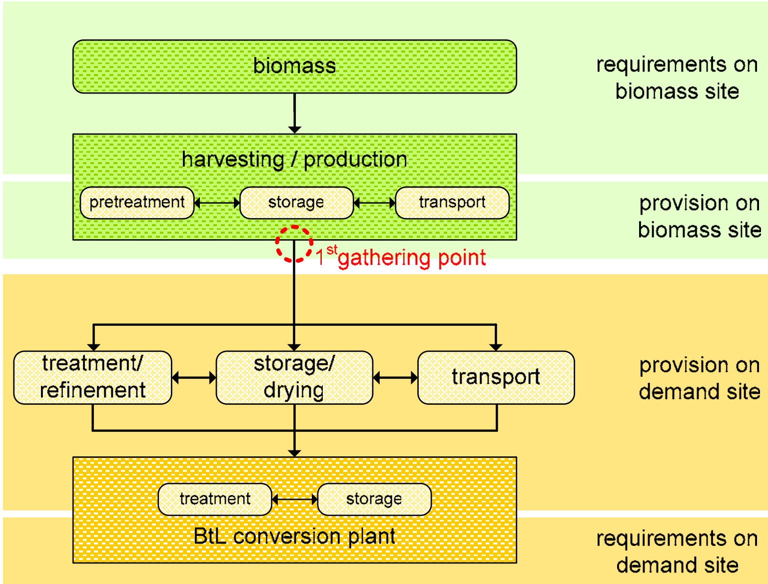

Figure 2-1 Overall biomass supply chain

While considering the types of biomass indicated below, the analysis of biomass production (i.e. cultivation) is only relevant for energy crops. Agricultural and forestry residues and by-products from wood industry belong to the category of residues/by-products, thus the production chains can be neglected here since they belong to the main product (i.e. grain, timber, wood industry goods) (D 5.3.1). Thereby, the responsibilities of the WP 5.3 partners are the following (Figure 2-2).

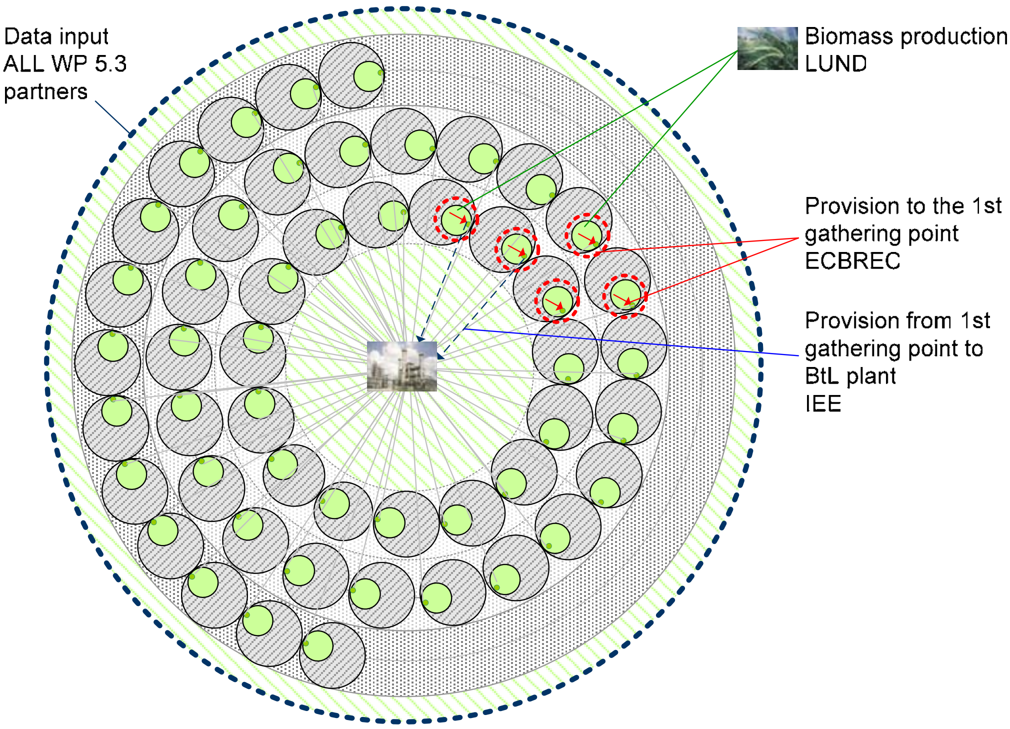

Figure 2-2 Responsibilities of WP 5.3 partners in terms of biomass production and provision

The definitions of provision chains provided are the background for the calculation of biomass provision costs. The structure of provision chain as well as the costs may be different for the six European regions (North, West, Alpine, the UK and Ireland, East and South) based on diversified resources, climatic, economic as well as agricultural conditions. Thus, the WP 5.3 partners responsible for the European regions (Table 2-1) are expected to revise the given provision chains and to deliver the economic data base typical for a particular region.

Table 2-1 WP 5.3 partners' responsibility for European regions and cost data provision

WP5.3 partner	Country	European region
EC BREC – EC Baltic Renewable Energy Center	Poland	East
IEE - Institute for Energy and Environment	Germany	West
LU – Environmental and Energy Sys. Studies Department, Lund University	Sweden	North
CRES – Center for Renewable Energy Sources	Greece	South
ESU – services	Switzerland	Alpine
UCD – National University of Ireland	Ireland	UK+IR

3 REVIEW OF EXISTING BIOMASS PROVISION OPTIONS

A short review of biomass provision chains' structures and costs are presented in this chapter. They are based on some sample studies with most coherent results. This is to present existing well developed biomass provision options for large-scale energy systems, such as DH or CHP plants. Cost data from the studies are referred in order to give the general overview of the level of costs for different biomass types' provision. Straw, forestry residues and permanent crops are analysed.

3.1 Agricultural residues

3.1.1 Straw

Provision options

Large-scale straw handling for energy purposes has developed into an independent discipline in agriculture with attachments in which particularly large farms and machines pools invest.

After combine harvesting the straw should be removed as quickly as possible to avoid rainfall and to allow the treatment of soil preparations begin for the next year's crops. Straw left in swathes is baled with balling machineries. Depending on the farm scale, following types of straw baling machines are used (CBT, 1998):

- A small baler produces bales of 46×36×80 cm, the weigh is app. 12 kg and bale density 90 to 100 kg/m^3.
- A round baler produces bales of width 1.2 m and diameter 1.5 m. Average bale density is 110 kg/m^3 (average weight 244 kg). It is primarily used for feeding and bedding and for burning in straw-fired farm-scale boilers.
- A medium-sized baler produces bales of 0.8×0.8×2.4 m. The bale weight is app. 235 kg, and the density 140 kg/m^3. Bales with lengths from 1.2 to 2.0 m are also possible. The baler often is equipped with a chaff cutter, thereby increasing the bale density to 165 kg/m^3.
- The bale is app. 1.2×1.3×2.4 m. The average bale density is 139 kg/m^3 and the weight 523 kg (450 to 600 kg). If the baler is equipped with a chaff cutter, the bale density may be increased up to 170 kg/m^3, however, this type of balers is not commonly used.

Large baler has been in market for app. 30 years. The baler is used primarily for baling straw for district heating-, CHP- and power plants.

The baling capacity depends on the technology of baling. The gross capacity (all operations in connection) is the highest when using a large baler; it is the lowest for a small baler and round baler.

Various loading/unloading and transportation techniques are used depending on local conditions. Small bales are loaded in the field by hand, bale fork, bale loader or a bale chute. Bales are unloaded by hand directly into the storage or en elevator or bale conveyor. Flat cars or special V shaped straw vehicles are used for transportation of small bales. They will contain from 75 to 250 straw bales.

Round bales and medium-sized bales are loaded and unloaded most commonly with a front-end loader; one or two bales are handled at a time (typically one bale). For transportation reconstructed trucks or truck trailers are used, but also ordinary farm trailers. One tractor trailer contains 8 to 14 round bales or app. 24 medium-sized bales.

Large bales are transported by reconstructed trucks or truck trailers. The size of the load is 6 to 18 bales. Over long distance the tractor is towing two trailers so the size of the truckload attains 24 bales per trail. Big bales are loaded and unloaded by front-end loader, trencher, loader tractor and telescope loader. The telescope loader is suitable for unloading, because it can reach high up when storing in stacks. The front-end loader is the commonest.

For large-scale systems haulage contractor using trucks is hired (CBT, 1998). The manpower required is lower and the capacity is higher when transporting by haulage contractor than by tractor (Figure 3-1 et seq.). When transporting by truck, there are typically 12 bales loaded on the truck and 12 bales on the truck trailer distributed in two layers. When the straw is delivered to the plant it is unloaded with forklift truck, overhead travelling crane or like.

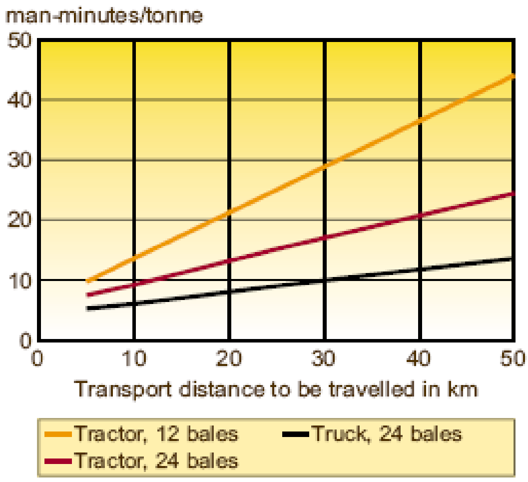

Figure 3-1 Manpower required for the delivery of big bales (CBT, 1998)

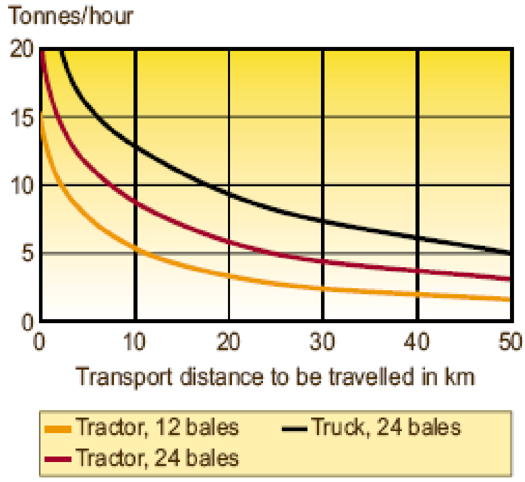

Figure 3-2 Capacity at the delivery of big bales (CBT, 1998)

Straw stacks left in the field are the most common type of straw storage. These are unprotected from wind, rain, birds and rodents. Dutch barns provide a good way of storing baled straw providing a hard standing to prevent ingress from ground water. However to provide Dutch barn at every potential storage area would require a huge capital investment.

As an example for DH plant of 6.5 MW_{th} in Frombork in Poland straw is kept in open-air stacks. The top of the stack is covered with a layer of loose straw, preferably rye straw. Coverage with plastic resulted in rotten straw layer under the plastic. Loose straw layer enable drying by wind and sun. The bales should be placed on very dry sod or concrete ground to protect the bales from water absorption from the ground. The stack width is 5 bales, the height is 7 layers and the length depends on the storage area available. It is always required to provide an easy access to the stack in case of fire.

Provision costs

The value of straw depends on demand and availability. If the demand for a certain type of straw is strong or the supply is short the straw cost will be higher.

The cost of straw provision is dependent on how it is baled. In general, the denser the bale and the less handling that is required will result in the lowest provision cost. Apart from baling costs, handling cost should be added for moving and stacking bales within the field. In many situations there will be a need to store straw on a temporary basis. This gives additional handling (RPS MCOS, 2004).

Transportation of straw in large square bales (1.2×1.3×2.4 m) is most efficient and it was calculated it is double the amount of straw per load compared to round bales (1.2×1.5 m).

In a study of Nilsson (1999) compact rolls system was evaluated as a new straw harvesting technology. The objective was to evaluate their potential to compete economically with large square bale system. A compact roller baler produced highly compacted rolls of a density of 250 to 350 kg/m3. The results showed that straw provision in compact rolls exceeded the costs for large square bales. The main costs (about 35 to 45 %), arose from the baling operation, which was not fully counterbalanced by the lower storing and transportation costs due to the higher bulk density of the rolls.

Conclusions for the RENEW project:

* Large square bales guarantee the highest gross capacity when all operations in connection are taken into account (e.g. handling, transportation, storage).
* The less handling is required, the lowest provision costs. Any additional handling such as a need to store straw on a temporary basis results in higher provision costs.
* To minimise the manpower needed and to increase the capacity of the whole straw provision system contractors using high-capacity machinery are hired.

3.1.2 Permanent crops residues

Among the most important permanent crops residue resources are grapevines and olive-oil prunings. Prunings are already a very common source for heat production, especially in rural and remote areas in various EU regions (Dalianis & Panatsou, 2000).

Field prunings are divided in two distinct categories. Large stem cuttings (more than 3 cm in diameter) and small branches (less than 3 cm in diameter) with the leaves attached on them. Approximately 1/2 of olive prunings are the large stem cuttings, which have already a high market demand since they are used in stoves and chimneys and they are sold at high prices. Small branches and leaves in certain areas are partly utilized for own energy purposes of farmers. However, the large majority of them remain unused and are burned at fields. The same is for grapevines pruning.

Pruning is a crucial practice to maintain olive or grapevines productivity. Olive prunings and grapevines are done manually. Chain-saws are used to perform manual pruning.

Tests with mechanical pruning were performed in olive yards. A cutting bar with six hydraulic-driven circular disc-saws mounted on a front loader of a four wheel drive tractor was used. It showed that mechanical pruning makes very high work rates possible, which justifies the lower operating costs in comparison with manual pruning (Peca et al., 2002).

In Italy two techniques of harvesting and collection of agricultural pruning from peach, vine grape and olive trees were tested (Pari, 2004). These were on-field chipping and on-field compacting, which are subsidiary.

Peach and grape vine grow respectively as Y training system and trellised vines. These systems affect the maximum machines height, length and width. On the contrary, in olive grounds the restricting issue is not equipment size (the distance between trees of over 8 m), but the branch size.

On-field chipping derives from common shredders, adjusted for the on-field management of the biomass. The on-field compacting derives from forages equipment (square and round balers machine).

For on-field chipping hammer-mill based machines for crushing and creating the air flow for biomass transfer to the loading bin were tested. For on-field compacting round balers were tested. The machines were provided with a rotary feeder and knives.

The structure of the orchard affects the type of the machinery, which can be used for pruning harvesting. Trellised vines have very little space for machinery, thus it can be harvested only with small round baler. However, this type of machinery is of very low capacity and can be acceptable for household biomass use only. Another crucial factor is the amount of the biomass in the ground, which plays a key role in machines performance. If the biomass yield is high the hourly production is also high, even if the machinery has low capacity.

The on-field chipping and on-field compacting are subsidiary, however the physical characteristics of the final product affect the next steps of the biomass energy chain: storage, transport and management in site the energy plant.

<u>Conclusions for the RENEW project:</u>

* Typically olive prunings and grapevines are done manually. This present relatively low work rates.
* Mechanical pruning makes high work rates possible, which justifies the lower operating costs in comparison with manual pruning.
* While the pruning collection is considered the amount of biomass in the ground affects much the capacity and the overall costs of the operation. The higher amount of biomass the more efficient is the operation.

3.2 Forestry wood

Provision options for energy purposes

Scandinavian countries are the leaders in the development of wood provision both for wood industry and energy production. Large-scale production of forest chips from logging residues from regeneration cuttings and small-sized trees from early thinnings has been developed and promoted in Sweden and Finland recently. A particularly rapid increase took place in the use of logging residues from final felling.

In Finland, which is the market leader in forest engineering technology, several types of logging residue supply chains for energy have been developed. Most promising options are described below (Hakkila & Aarniala, 2004):

* Comminution at landing – wood chipping is done at the felling site; it is a prevailing system for the production of chips from logging residues and whole trees, biomass is stored at the roadside, truck-mounted chippers and chipper truck do the chipping operation in the forest.

* Baling technology – logging residues are compressed into bundles ("slash logs") approximately 3-metr long with a diameter of 70 cm, one bundle weight is about 600 kg and it contains about 1 MWh of energy; baling technology allows the integration of fuel production in the industrial timber procurement systems; it is preferred by forest owners due to flexible logistics, easy process control, reliability and cleanliness; at the moment this technology is only feasible in large-scale forestry operations.

* Stationary crushers – placed at intermediate terminals or at plants allows moving work from the forest end to easier conditions; solid biomass fuels in almost any form can be delivered to the stationary crusher, i.e. residue bales, uncomminuted loose residues, undelimbed treesections, stump and root wood, and recycled wood; it became possible to broaden the raw material base, streamline the procurement logistics.

* Accumulating feller-heads – used for harvesting small-diameter tree chips from early thinnings in young forests; the use of accumulating feller-heads improved the productivity of work and has paved the way for cost reductions.

Provision costs

Following effects of key cost factors of forest chips production can be identified (Hakkila, 2004):

* The costs of forest biomass recovery depend on the yield of biomass per hectare. The recovery of logging residues of the final felling of mature spruce stand is 20 % of the recovery of round wood. For pine it is little more than 10 %. Halving the recovery raises the cost of off-road transport by 10 %. The cost of harvesting is thus lowest in spruce-dominated stands.

* If the plant's demand for forest fuels increases, the average cost of production increases as well, because the operations must be extended to less favourable stands and at greater distance.

* The small size of timber sales from private forest holdings is also a serious cost factor. Proper timing and coordination of operations with neighbouring holdings could reduce the average costs by 4 to 6 %.

* A significant gap exists between cost of wood from early thinnings and that from logging residues of final felling. This is caused by the high cost of cutting and bunching of small-sized trees from thinnings, while in the other stages of chain cost differenced are modest (Figure 3-3).

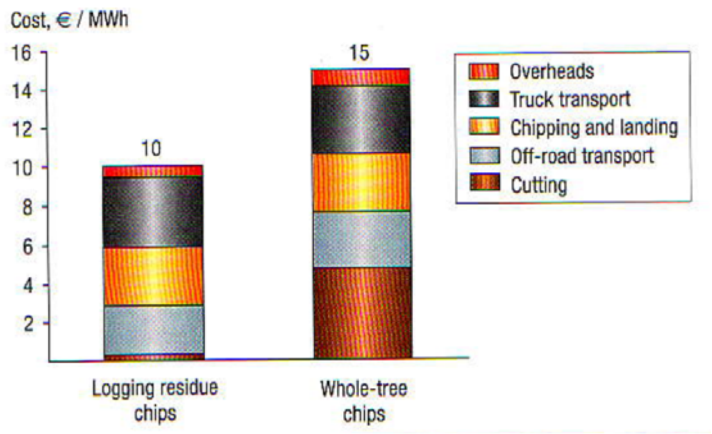

Figure 3-3 Cost structure of forest chips from logging residues and small-diameter trees from early thinnings (Hakkila 2004)

A single productivity factor, stem volume affects the costs of cutting and consequently the cost of entire provision chain. The effect is steeper in mechanized than in manual cutting (Figure 3-4). For very low stem volumes (< 15 cm^3) manual cutting is chipper then mechanized, for larger stem volumes mechanized felling gives lower costs compared to manual.

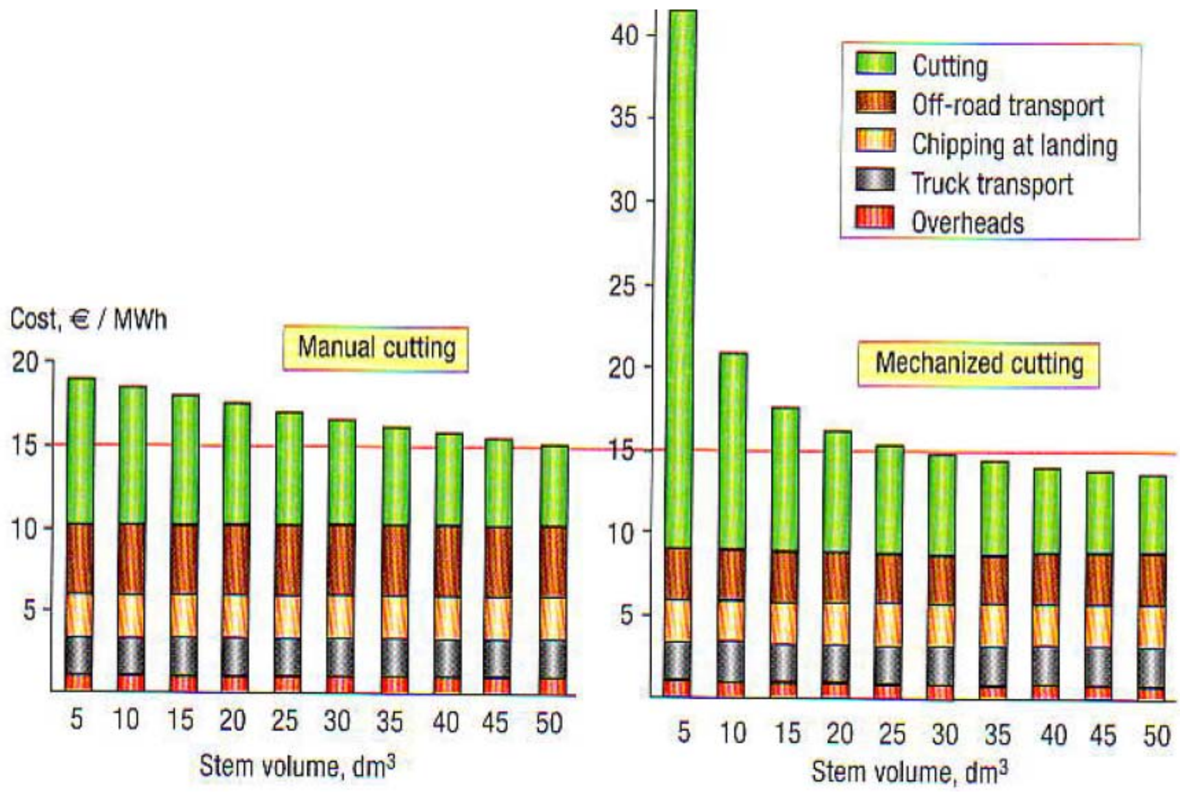

Figure 3-4 Cost structure of whole-tree chips (early thinning) as a function of stem volume (Asikainen, Laitila 2003)

Transportation distance is a crucial factor for the overall provision costs and affects the choice of biomass provision option. In Finnish conditions it was calculated that when the transportation distance is app. short, under 60 km, the costs of loose residue supply chain are the cheapest provision option. Respectively, when the transportation distances are longer, over 60 km., the bundling production chain and roadside chipping chain are the most competitive. The bottleneck in the loose residues supply chain is the long distance transportation. It is not possible to increase the energy content of loose residue loads to the level of logging residue chip loads (Karha 2005).

Researches in Southern Europe (North Greece) on forestry harvesting operations which are still commonly done manually showed that labour is the most important productive factor because it is a part of every stage of harvesting method. Another result was that more than the half of the observed man-hours was spent in the stage of skidding[2]. The collection and balling of thin material needs a lot of time as well as moving of chainsaw operators from the forest field to the forest road for felling and delimbing. The key to cost reduction is to increase mechanization (Eleftheriadis and Chatziathanassiou 2004).

[2] The term skidding is used when all or a portion of the tree is dragged on the ground. Skidding can be carried out manually by people, by other kinds of animals, by motor manual equipment or by machines.

Conclusions for the RENEW project:

* Stem volumes strongly affects cutting costs. If the volume is low, the costs are high. This results in higher overall provision costs of wood from thinning operations than from final felling (logging residues).

* Forest residues have relatively low bulk density. Loose logging residues provision options are appropriate only for low transportation distances (below 50 to 60 km). For longer transportation distances woodchips or bundle systems are most efficient.

* Bundling of logging residues is justified especially for large-scale forest felling operations, due to high bundling machinery costs.

* Manual provision chains are less cost effective at the stages of tree felling and forwarding to roadside while compared with mechanised provision chains. They are also highly labour consuming. Manual felling is only appropriate for very low stem volumes (e.g. early thinning of stems below 15 cm^3 of volume).

4 AREA SPECIFIC TECHNICAL POTENTIALS

For the analysis of biomass provision chains the area specific technical potential of biomass has been identified to be one of the most important criteria (cf. chapter 2). As the analysis of biomass potentials (WP 5.1) still continues, regional potentials are not available for the current work on biomass provision chains. Thus, for the development of the cost calculation model (cf. section 6.2) another methodical approach will be used for the first instance. In the following a definition of the area specific potential and the named approach are introduced.

The potential of the different bioenergy sources to be used for energy can be categorised as theoretical, technical, economic and realisable potential (Kaltschmitt et al., 2003). They potentials to be analysed within the RENEW project are defined within D 5.1.1. The area specific potential is defined as technical available biomass potential per area land and significantly vary for the different European regions addressed within the RENEW project. According to first estimations large technical biomass potentials are not inevitably also represented by large area specific potentials; shares of agricultural or forestry land provide a limited indication for that potentials.

As mentioned above, to continue the development of the cost calculation model, the area specific potentials will be appraised based on the technical potentials elaborated by and available at IEE for different time horizons (Thraen et al., 2006) relating to the area land. The required size and distribution of 1st gathering points will be then estimated using the following parameters, that will be ask from the WP 5.3 partners in the data and cost inventory, and a typical transport distance (e.g. of 15 km to a local storage):

- total area land for different EU countries,
- forestry areas (i.e. typical size of forest enterprise) and share on total area land (in Northern Germany for example about 1,500 ha with a share of 21 %),
- agricultural areas (i.e. typical size of farm land) and share on total area land (in Northern Germany for example about 400 ha with a share of 58 %).

Basically the same methodology will be applied when the results of the potential analysis will be available from WP 5.1.

5 BIOMASS PROVISION UP TO THE FIRST GATHERING POINT

The first step of biomass provision includes all operations, which take place from the biomass production site up to a local gathering point (i.e. the 1st gathering point). Such operations include e.g.: (i) biomass harvesting, (ii) biomass handling, (iii) field transport, (iv) road transport to storage.

For agricultural residues such as straw the 1st gathering point is assumed to be located up to 15 km from the straw field. It can be open air storage, possibly with top cover. For forestry wood the 1st gathering point is the storage at the roadside in the forest. The capacity of the storage at the first gathering point is to some extend dependant on the area specific potential.

The general structure of the provision chain up to the 1st gathering point is presented in

Figure 5-1.

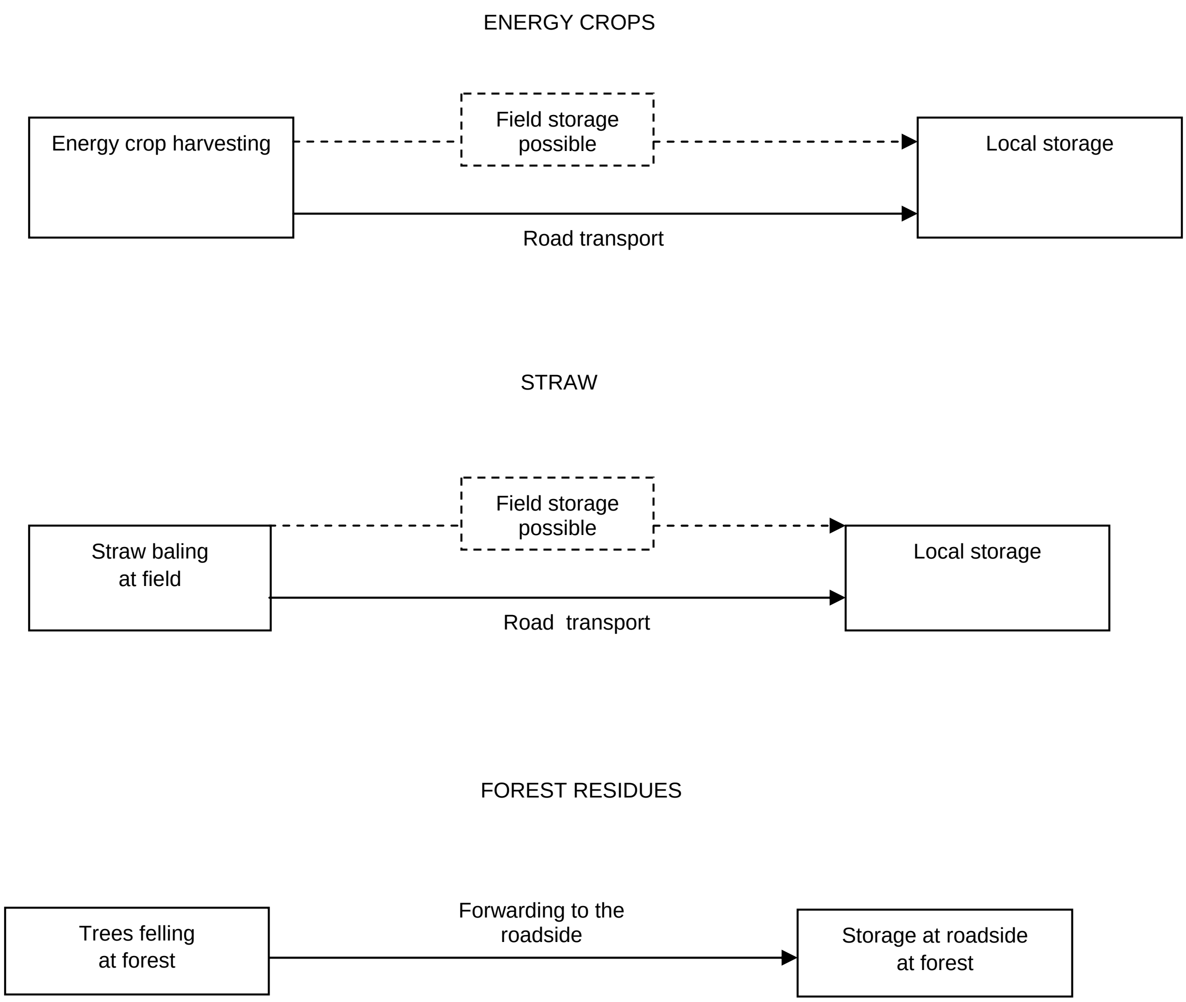

Figure 5-1 Structure of provision chains for energy crops, straw and forestry residues up to the local storage

The methodology of the biomass provision cost calculation is based on standard provision chains, which are presented as common frame conditions. The structure of the chains up to the 1st gathering point comprises of operations, which have to be performed to supply the biomass from production site to a local storage. The structure defines the boundary conditions for the provision analysis; however, it gives place for regional modification of particular operations in the provision chain.

The structure of biomass chains are defined as most typical biomass supply systems used for large-scale DH or CHP plants in Europe (cf. Chapter 3). Considering the RENEW project assumption on BtL plants sizes of 100 MW_{th} and 500 MW_{th}, large amounts of biomass will be required as a raw material. Due to this fact it is assumed that only areas of significant biomass potential are regarded as supply areas for BtL production. Regions with low biomass potential such as small, scattered fields (for straw and energy crops) or regions with low wood harvesting rates will not be regarded as supply areas for BtL production, since they can produce biomass for local, smaller-scale energy facilities.

Based on the above assumption and practical experiences from existing biomass provision systems, e.g. for CHP plants, only provision options with the usage of high-capacity machinery will be analysed for BtL production. This is consistent with the fact that biomass provision for energy systems is typically done by contractors, who operate high capacity machinery to ensure cost efficiency of the biomass provision. These rules are especially applicable for agricultural biomass such as energy crops or straw (see also D 5.3.4).

For forestry biomass it must be noted that in countries of Central-East and Southern Europe wood felling is still done to a great extend manually. This results from socio-cultural and economic conditions as well as from forestry management policy (e.g. complex felling, nest felling). Due to this fact both manual (chainsaws) and mechanical (harvesters) wood harvesting will be analysed for these regions for the Starting Point scenario. For Western, Northern Europe and Alpine countries only mechanical wood harvesting will be analysed. Agriculture residues

The provision chain and costs will be investigated for cereals straw, as it is the agricultural reside produced in most significant amounts all over Europe (D 5.1.1). The production cost of cereal crops are excluded from the analysis, as they are allocated to the main product costs (grain).

For straw the provision costs embrace: (i) straw harvesting (i.e. swathing and baling), (ii) cargo handling, (iii) transportation and (iv) storage at the intermediate terminal. Large-scale provision options (with large square bales) are analysed.

5.1 Agricultural residues

5.1.1 Straw

Straw provision chain will be analysed for all European regions as straw is the residue of the primary agricultural crops – cereals. The provision chain for cereal straw is defined as typical large-scale system (Figure 5-2).

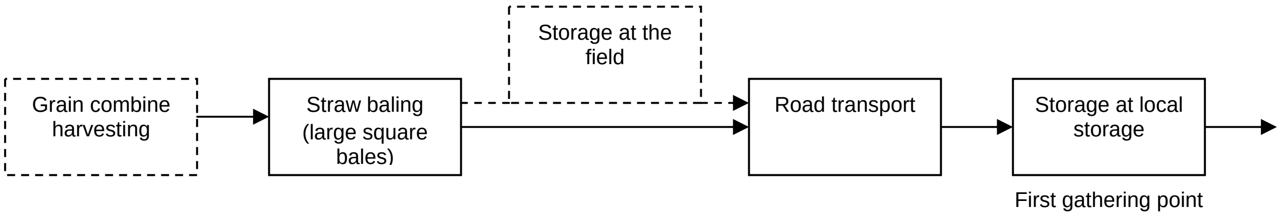

Figure 5-2 Straw provision chain up to the 1st gathering point.

It is assumed that the combine harvester width is at least 4.5 m, thereby avoiding windrows having to be brought together. Large square bales are produced; the dimensions are 1.2×1.3×2.4 m, the average weigh is 540 to 600 kg. The density of baled straw expressed on a per volume basis is 140 to 180 kg/m^3 (CTB, 1998; RPS MCOS, 2004; Kowalik, 2003, Nilsson, 1999). Front-end loaders (folk loaders) are used for straw field loading (telescope loader can also be used). Bales are collected and loaded up on the trailers or trucks.

Large square bales are transported by a tractor with trailer or truck. A standard type truck will carry 24 bales (Nilsson, 1999; CBT, 1998). The assumed transport distance is up to 30 km by road haulage to the local storage point (assumption in line with energy crops – see D 5.3.4).

Because of the relatively low bulk density, significant storage capacity will be required (RPS MCOS, 2004). Covered storage can be used to minimize damage from precipitation, but also adds to the cost of storage. Methods to store biomass without cover are assumed to reduce storage costs. Dobie and Haq (1980) reported that rain penetrates only the outer 15 cm of the bales in a stuck (rice straw). This was also proved by the experiments with the open-air small-grain cereal straw storage in Poland and the UK.

To minimise the storage costs it is recommended that the local storage is organized as straw stacks open-air. To protect the straw losses from rain the top of the stack is covered with a layer of loose straw. Bales are placed on well dried sod or concrete ground to reduce moisture absorption through the bottom of the bale.

5.1.2 Permanent crops residues

Costs of permanent crops residues, such as olive, vine and orchard pruning, will be taken into account only for Southern Europe as they are produced there in the greatest amounts compared with other parts of Europe. Market values of the prunings at the field edge (i.e. prunings harvested, collected and formed at piles) will be taken as an equivalent of provision costs up to the 1st gathering point.

5.2 Forestry wood

There are several types of forest wood provision chains, which are common in different European regions depending e.g. on forest type and harvesting mechanisation level. In this report provision chains of three wood fractions or assortment are defined (wood fractions commonly used for heat and electricity production, with regard to the existing provision chains of energy wood) (Table 5-1):

* Logging residue from final felling,
* Thinning wood from operations in young forest,
* Roots and stumps from clear felling areas.

Table 5-1 Forestry wood fractions considered in biomass provision chain cost calculations

Biomass assortment	
LR (logging residues)	All kind of wood from final felling, which is not classified as a merchantable wood (tops, branches of trees, etc)
TW (thinning wood)	Small-diameter wood (usually below 6-7 cm) from pre-commercial and commercial thinning, which is not used for other forest industries
S&R (stumps & roots)	Stumps and roots (produced from final felling)

WP 5.3 partners will choose the most typical forestry biomass provision chains for each of the European countries and provide costs for them.

Root and stump wood is commercially used for large-scale energy systems only in Finland (OPM 2003). However, it might be investigating option for other countries for scenarios S1 and S2.

Considering the type of harvest operations performed in European forests there are three different levels of mechanisation:

* Full mechanisation; i.e. felling is done by harvesters, forwarders take the harvested wood to a roadside,

* Manual-mechanic; i.e. workers with chainsaw carry out the felling, then machines like skidders or forwarders are used for wood carrying to the roadside,

* Manual; i.e. wood felling is done by manpower, both harvesting and skidding (for short distance) or with a horse use.

In the Northern and Western Europe there is a higher level of mechanisation of wood harvesting technology compared to Central-East and Southern Europe. Integrated operations of wood felling are used, while in the Central-East and South manual felling practices are dominant and lower rate of mechanised harvesting operations is used (mainly due to low labour costs). Short-distance transportation is usually done by tractors or less-advanced skidders.

5.2.1 Loose logging residues

Loose logging residue provision chain starts with residue collection at heap (Figure 5-3). While there's manual felling done, workers collect branches and trees' tops removed from the stumps in one place. If felling is done with harvesters, the operator collects residue next to a previously formed round-wood pile. Short distance transportation is done to the roadside (usually up to 700 m). Forwarders, tractor-based trailers or tractor-based compaction-trailers might be used.

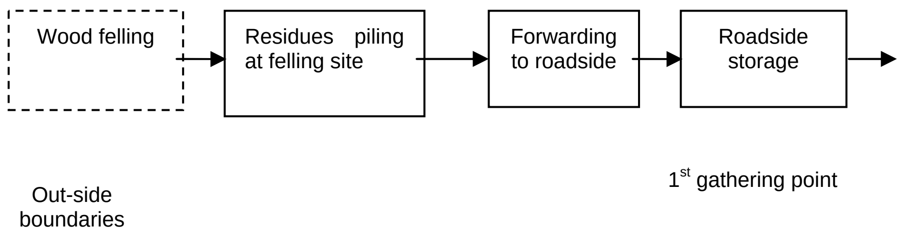

Figure 5-3 Definition of loose logging residue provision chain

Residues are stored at forest roadside formed in 4 to 6 m high heaps. Storage for 4 to 6 months enables reducing the moisture content with 20 to 30 %.

5.2.2 Logging residues chipping at roadside

Chipping at roadside provision chain consist of five steps. Logging residues are forwarded to roadside, and then stored in heaps until they are chipped (Figure 5-4). If they are stored over wintertime it is recommended to cover them with a paper cover (Hillebrand & Nurmi, 2001). The residues are chipped with different optional chippers types and efficiency. Those might be tractor based chippers, mobile manual fed chippers, mobile integrated chippers with containers, truck-based chippers integrated with wheelbase for truck transportation. The chipper and the chip truck work in close connection with each other. Loose bulk chips are transported with containers trucks to intermediate storage point.

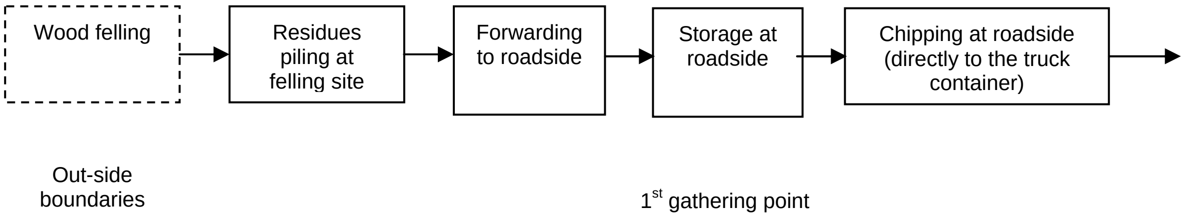

Figure 5-4 Definition roadside chipping provision chain

The main advantage of roadside chipping is its flexibility. It is suitable for almost all types of harvesting condition (Karha, 2005). Moreover, there is already considerable experience of roadside chipping, and also a lot of harvesting machinery (i.e. forwarders, chippers, chip trucks) is available for a roadside chipping. When the transportation distances are long roadside chipping chain is a competitive option.

5.2.3 Bundling of logging residues

Bundling of logging residues provision chain requires the use of special pressing technology. Residues left behind after round-wood removal are bundled with forwarder-based machines, which forms 500 to 600 kg bundles of brunches wrapped with string. Bundles are transported with typical forwarder to roadside.

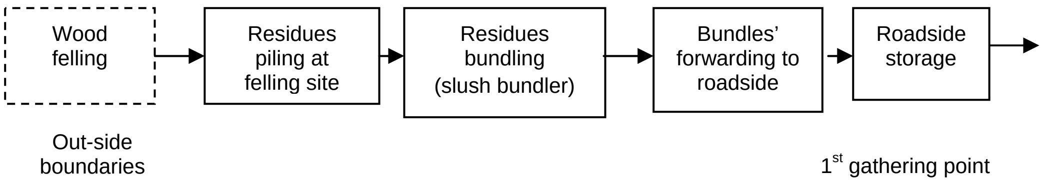

Figure 5-5 Definition of logging–residue bundling provision chain

An ordinary timber truck can be used for the long-distance transportation of bundles. The load size is usually 60 to 65 bundles. After delivery to the intermediate storage point bundles are stored or/and crushed with stationary wood crushers or recycling-crushers.

In the bundles provision chain the main problem is high bundling costs. On the other hand, it enables usage of conventional timber forwarders and trucks – integration with typical timber procurement system. Forest haulage and the long-distance transportation of bundles (> 60 km) are more cost efficient than the other supply chain. The residue bundle storages need also less storage place (Karha, 2005).

5.2.4 Thinning wood

Thinning wood is produced in the process of early pre-commercial and commercial thinning in young stands, which is perform in order to improve the structure of species and to improve the quality of wood in the forest.

Thinning operations produce thinning wood (small-diameter wood), usually from young trees of low stem diameter (small-size trees). There is no common definition of thinning wood in Europe[3]. Usually the stems, which do not meet the minimum dimensions of saw logs, are used for chips.

Thinning is done in two ways nowadays in Europe:

* manual felling with chainsaws and manual piles' formation,
* mechanised felling with forwarders equipped with special felling-bunching heads, which enable harvesting several trees located in close space.

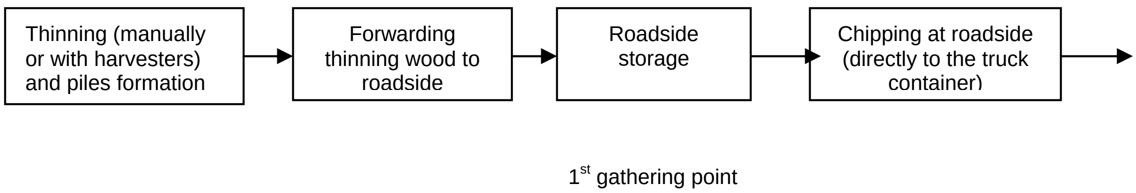

Figure 5-6 Definition of thinning wood provision chain

The structure of thinning wood provision chain is presented in Figure 5-6. After harvesting operations forestry workers or tractors or forwarder's do the short-distance transportation in the forest area up to roadside (forwarding or tractor skidding). Storage in high piles enables decreasing the moisture content and prevents the piles from snowfalls penetration. Roadside chipping is done with tractor-pulled chippers, mobile chippers, and integrated mobile-container chippers or by truck-based chippers. Thinning wood chip loads are transported with containers trucks.

Loose thinning wood transportation option is also used, however it is less common. It will not be analysed in this report.

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[3] In Poland the normative definition PN - 93/D-2002 classify all stems of a diameter below 7 cm as small-size wood, however thinning operation produce also stems with diameters > 7 cm, which are used for milling.

5.2.5 Root and stump wood

Forestry operations in Finland, prove that the root and stump biomass from final felling areas can be as reliable bio-energy resource as other woody biomass (Leinonen et al., 2005; UPM, 2003). In 2003 root and stump wood extraction was performed on app. 1000 ha felling areas located in economically profitable transportation distances from CHP plants (Hakkila et al., 2004). Supply costs of root and stumps for energy are higher compared to logging residue supply chain, but lower compared to full chain of thinning wood supply (harvesting operations of thinning wood create higher costs) (Laitila, 2005). Root and stump wood can be only salvaged from clear-cutting areas. They are usually exploited from spruce and pine stands on light-fresh mineral soils while other stands are not recommended for extraction due to environmental restrictions (Leinonen, 2005).

Root and stump extraction as a raw material for BtL production might be developed on a commercial scale in other European countries in the future, however this will be verified by forestry experts (WP5.3 partners).

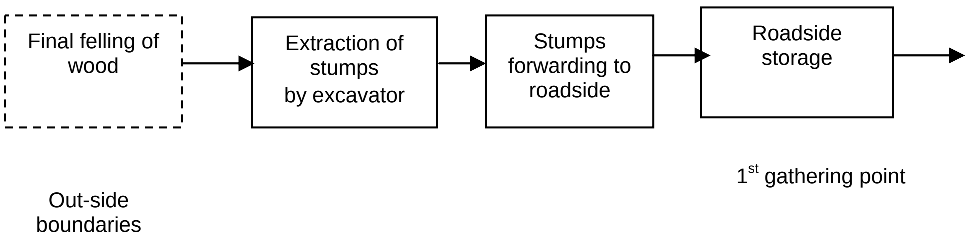

Figure 5-7 Definition of provision chain for root and stump wood

The provision chain of root and stump wood is presented in Figure 5-7. Stumps are extracted from a final felling site with an excavator (16 to 25 t) equipped with a pulling head-rake. An operator cuts the stump into smaller pieces, extract and quake the stump out of minerals and form piles in the felling area. The stumps are forwarded (500 to 700 m) with typical timber forwarders to a roadside, where they are stored. Rain and snow-fall wash out impurities; storage period causes moisture decrease. Full trailer combination trucks transport the stumps (25 to 35 t payloads) into the storage point, where the stumps are crushed with high-efficiency stationary crushers (Hakkila, 2004).

5.3 Wood industry by-products

The provision costs of residue wood material (e.g. chips, shavings, bark, etc.) produced in wood processing industry are investigated as market values at the place of origin (e.g. sawmill, etc.)

Market values from 2004 or 2005 for wood industry by-products are used for estimates of provision costs up to the 1st gathering point. By-products are produced in sawmills, pulp and paper industry, joinery industry, furniture industry and wood board industry (Figure 5-8). However, in this report the focus is on sawmills and pulp&paper industries, as most common branches. The residues from sawmills and pulp and paper industry are of the greatest concern, due to a significant share of these industries in wood market.

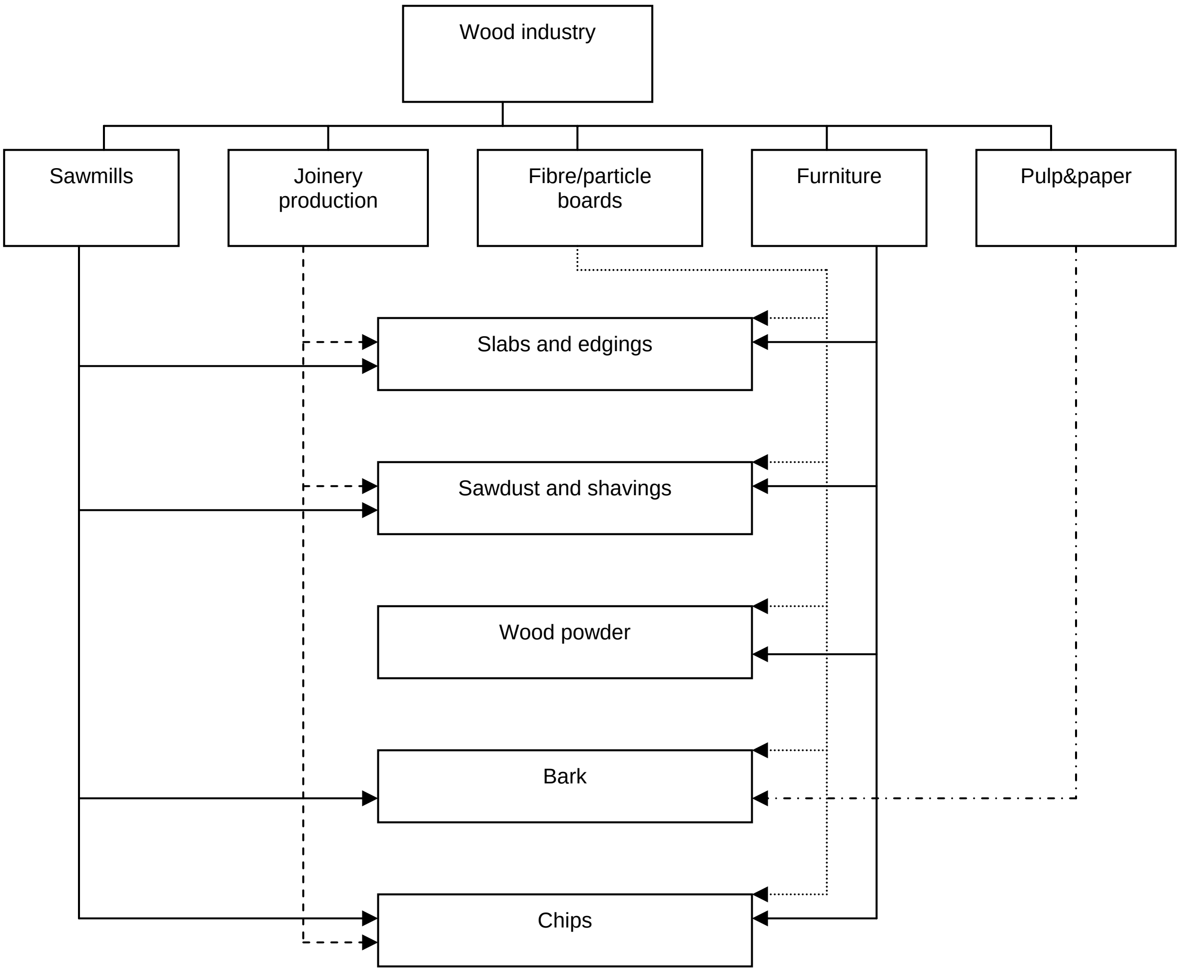

Figure 5-8 Scheme of wood industry by-products production

5.4 Economic analysis

The cost analysis will be carried out for provision chains with frame conditions defined above. A general view on the methodical approach for the cost analysis for the provision up to the 1st gathering point is given as follows.

5.4.1 Calculation approach

The provision chains include a set of operations with are in sequence to provide the biomass to the 1st gathering point. At first, costs will be allocated to the respective steps of the provision chains. This will ensure to assess the cost parameter along the provision chain which cause the most impacts to the total costs.

Then a sensitivity analysis will be performed for several technical and economic factors - see Figure 4.2. These parameters are necessary to be defined for the provision operations (see the Annex: Data Collection Sheet) as they are crucial for the provision costs levels. Among technical parameters there are: efficiency/payload, specific fuel consumption, annual use of the specific machinery and personnel demanded. Following economic parameters will be taken into account:

* capital investment,
* service life,
* personnel costs,
* fuel cost and
* other operation and maintenance costs (O&M) (e.g. conservation, repairs).

The parameters should be provided for the machinery currently available on the market and commercially used in the EU regions for biomass supply.

The range of the technical and economical parameters used for the sensitivity analysis will be defined by comparing provision chains in different European regions and also consultancy with the forestry and agricultural experts.

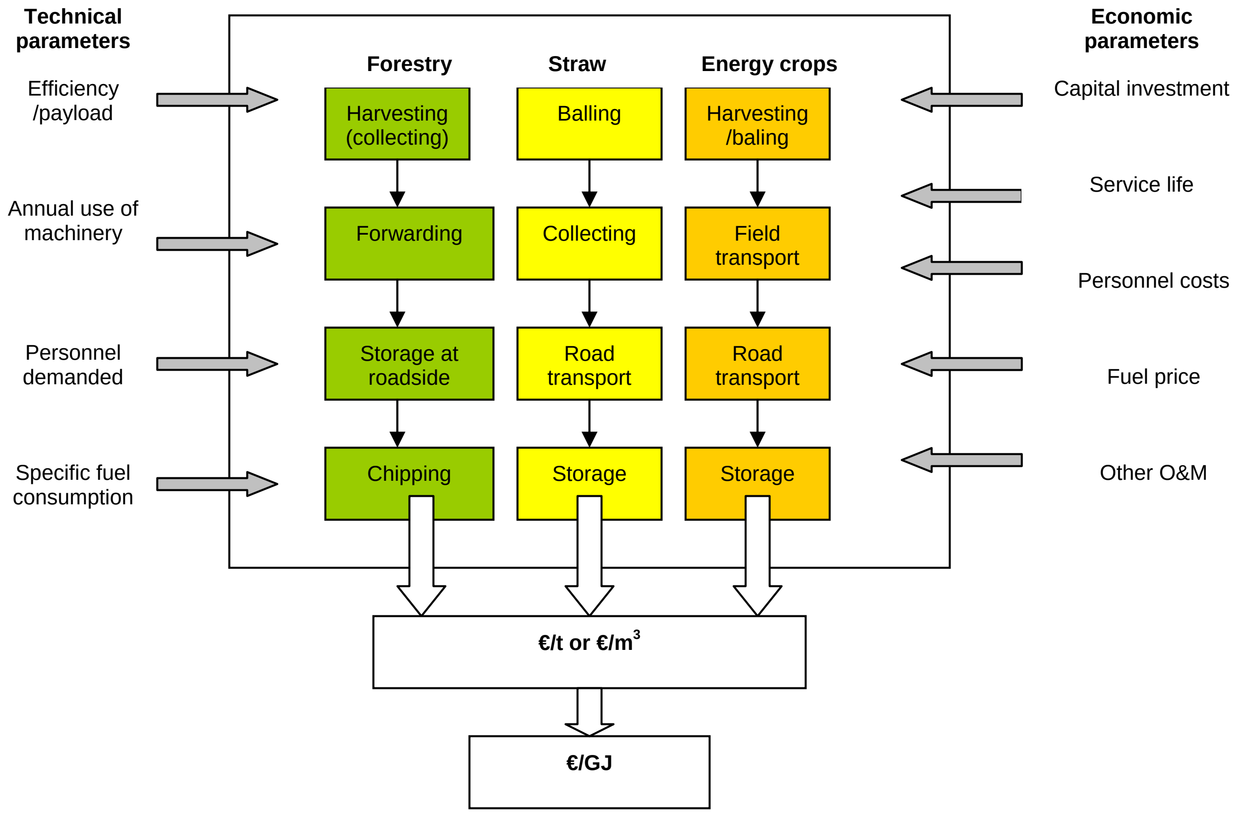

Figure 5-9 Cost calculation approach of the biomass provision to the 1st gathering point

5.4.2 Data collection

For modelling biomass provision costs data are required in terms of e.g.:

* Typical costs for each operation in the biomass provision chains,
* Technical parameters for each provision operation,
* Economic parameters for each provision operation,

All WP 5.3 partners will find a cost inventory matrix attached to this report.

6 BIOMASS PROVISION FROM THE FIRST GATHERING POINT

Biomass provision chains are highly complex. No defined chain (e.g. transport distance of biomass production site and biomass demand site is about 150 km) is conferrable to different regions, because of e.g. (i) different distribution and size of biomass growing areas as well as their ratio to land area and (ii) different infrastructure in terms of transport and ownership structure of growing areas.

Based on the important provision criteria (i.e. area specific potential, biomass assortment, biomass treatment, means of transport, transport distance, storage technology and demand, biomass demand and plant site), there are a multitude of conceivable routes for biomass provision from 1st gathering point. Thus, it is a challenge to identify substantial biomass provision routes for each European region. Therefore, typical reference concepts with regard to biomass resources are developed. The cost analysis for these reference concepts will be based on an elaborated calculation tool.

Generally, within this analysis only macro-logistic aspects (i.e. means of transport, distances) are considered; micro-logistic aspects (i.e. biomass provision just in time, number of access at BtL plant, variations in weekly biomass demand or biomass quality etc.) are disregarded.

6.1 Reference concepts

The definition of relevant reference concepts is made by integrating the provision criteria in an application-oriented calculation model. Figure 6-1 shows the general structure of reference concepts to be considered. The relevant provision criteria (i.e. biomass assortment, biomass demand and BtL plant site) are integrated as input data. In addition, criteria such as biomass treatment, means of transport and storage technology are coupled within the reference pathways. The parameter transport distance and storage volume are represented as output data.

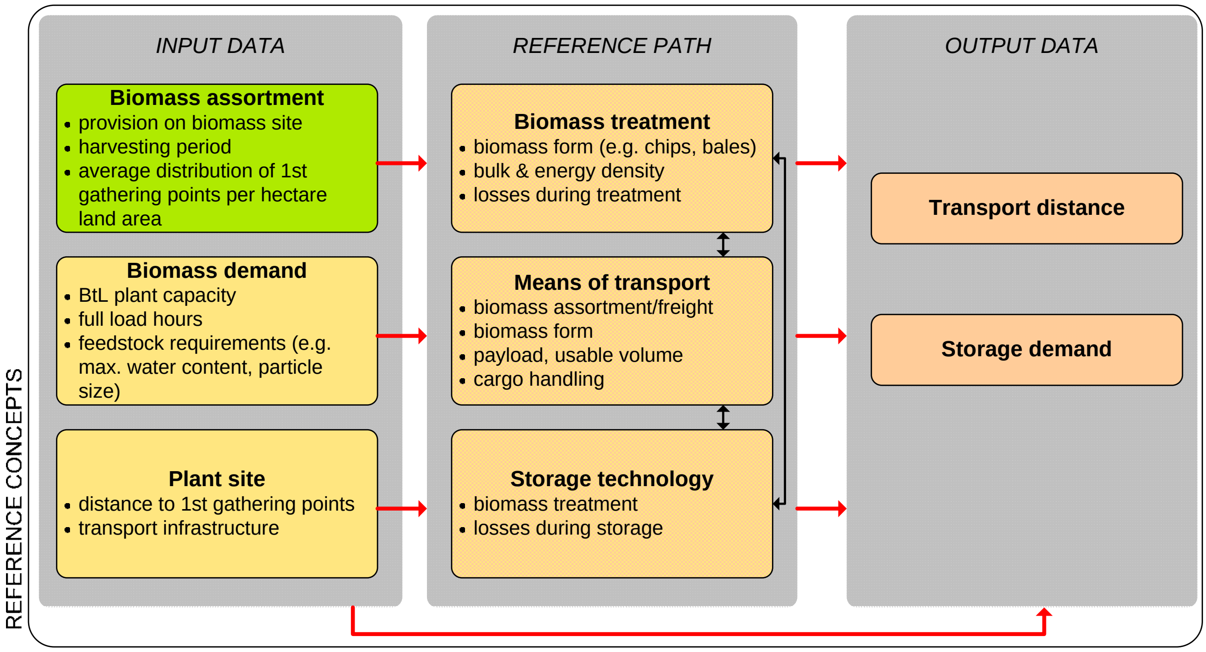

Figure 6-1 General structure of reference concepts

With regard to the different BtL concepts in terms of the reference pathways two approaches will be investigated: (i) direct biomass provision and (ii) provision including decentralised steps such as local storages and/or pyrolysis. The direct transportation (i.e. using a lorry or semitrailer respectively) from 1st gathering point to the BtL plant is the simplest way of biomass provision. Though to include decentralised provision steps increase the complexity of the biomass provision chain, it offers, however, to uncouple the respective requirements on biomass and demand site (see Figure 2-1). Thus, preliminary and downstream provision steps can be targeted to these requirements. In particular the pyrolysis step can be targeted to the requirements on biomass demand site. Local storages and pyrolysis plants are coupled by appropriate transport steps.

The following assumptions are valid for the analysis of relevant reference pathways in order to exclude scenarios far from practice and to be transparent:

* The reference pathways start from the 1st gathering point; thus the agrarian / forestry transport is assigned to the provision on biomass site.

* Based on typical conditions in terms of infrastructure, in case of transportation by train or inland navigation vessel forerun and off-carriage (cf. Glossary) occur in general; thus the direct provision from biomass site to demand site can only be realised by semi-trailer.

* The selection of means of transport takes place in terms of effective payload. Additionally, transport vessels (e.g. swap bodies) are considered for unimodal and combined transport (cf. Glossary).

* Generally, multimodal transport is applied as bimodal transport (i.e. combination of road and railway or road and waterway). The respective nearby terminal of cargo handling is assumed to be the arrival point for the main run (cf. Glossary).

* In addition to the storage at BtL plant (i.e. for bridgeover of delivery-free days), either storage at biomass or demand site is considered. This is due to identify assets and drawbacks in terms of storage within the provision chain. For demand site (cf. Figure 2-1) biomass storage occurs depending on the relevant downstream means of transport at the respective terminal of cargo handling (e.g. goods station or railway siding, inner harbour).

* For storage at demand site decentralised and central storages are distinguished. Decentralised storages are preliminary to rail- or waterway transport and are applied for pre-concentration of biomass freight. Centralised storages are downstream to transport by train or inland navigation vessel; they represent the temporal uncoupling of forerun and off-carriage.

* For BtL concepts involving pyrolysis the pyrolysis step is regarded as self- contained conversion plant. The transport of pyrolysis slurry occurs either direct in tank-semitrailers or as combined transport in 20'(inch)-swap bodies. Thus, within the provision chain downstream to the pyrolysis plant there is no further storage.

Figure 6-2 gives a survey of optional reference pathways. These pathways are structured into sections (alphabetical) and routes per section (numerical). Gathering points, such as for decentralised or centralised storage, cargo handling (e.g. at a harbour or rail station) or decentralised pyrolysis plant for biomass pre-conversion to pyrolysis slurry (see also Figure 6-3) are indicated as white rectangle; means of transportation are indicated orange. With regard to this, - starting from the 1st gathering point to the BtL plant – some examples are given as follows (cf. Figure 6-2):

* direct provision of a biomass assortment via lorry (i.e. main run; cf. Glossary) is just "A 1"

* direct provision of a biomass assortment via lorry to a rail station (i.e. forerun), transport via train to a central storage (i.e. main run) and final transportation via lorry (i.e. off carriage) is "A 1-B 2-C 1-D 1-E 1"

* biomass provision including pyrolysis with direct provision of a biomass assortment via lorry to the pyrolysis plant and transport of pyrolysis slurry via lorry and inland navigation vessel is "A 1-F 1-G 1-H 1-I 2"

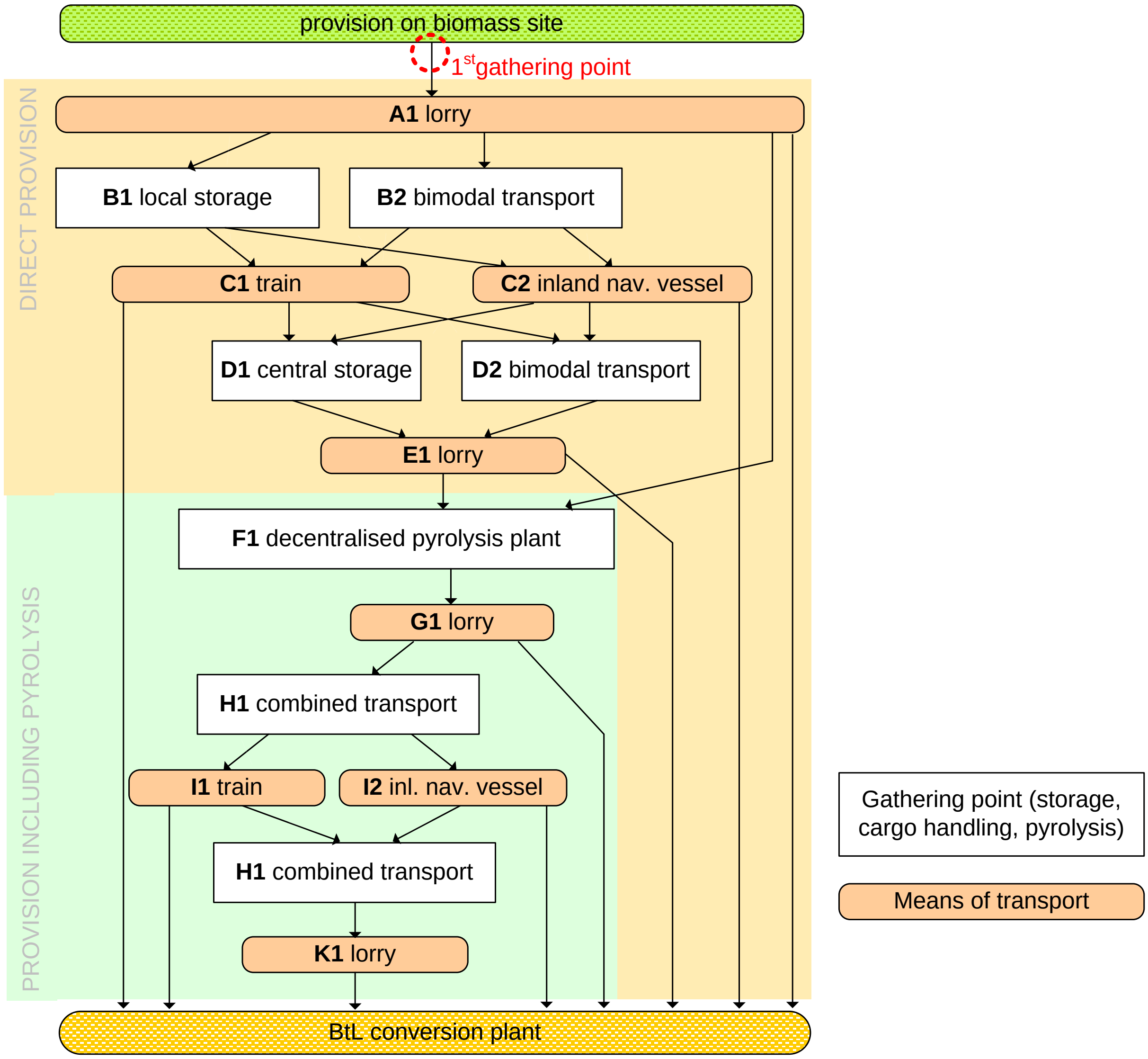

Figure 6-2 General reference pathways within the reference concepts

In addition to Figure 2-2 the principle of different provision levels is shown in Figure 6-3. The different provision levels will be analogues modelled which is presented in different provision processes (i.e. cargo handling, transport and if necessary biomass conversion in a pyrolysis plant) from decentralised gathering points (e.g. 1st GP) to a centralised gathering point (i.e. BtL plant). Points in between such as cargo handling or storages as well as pyrolysis plants will be modelled either as decentralised or centralised gathering points.

Figure 6-3 Principle of biomass provision level

6.2 Economic analysis

The cost analysis will be carried out for the different reference concepts for different biomass assortments such as energy crops, agricultural residues and forestry wood presented above. Thereby, the total biomass provision costs will be allocated to respective steps of provision chain. This is due to assess that cost parameter along the provision chain which cause the most impacts to the total costs. In addition, frame conditions of importance can be identified. Furthermore, regional differences will be emphasised. A general view on the methodical approach for the cost analysis for the provision from the 1st gathering point to the BtL production plant is given as follows.

6.2.1 Calculation model

Based on the different steps for the biomass provision to BtL production plant, specific level are included in the cost calculation model. The main principle of this model is shown in Figure 6-4. Relevant costs of each level are added or summarised respectively to total biomass provision costs (given in €/GJ_{LHV}). The comparison of these total costs of the different reference concepts will be categorised in (i) biomass production and provision to the 1st gathering point (GP), (ii) storage, (iii) transport, (iv) cargo handling, (v) pyrolysis, (vi) swap body for bimodal transportation as well as (vii) storage and pre-treatment of the biomass freight at the BtL plant site.

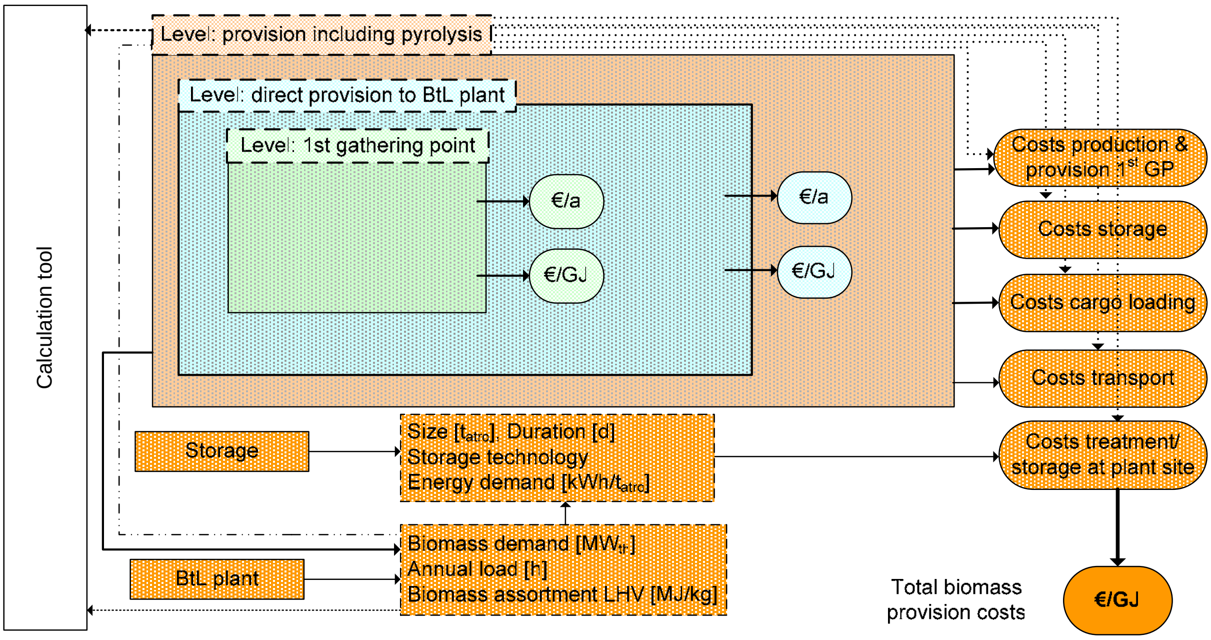

Figure 6-4 Calculation model – biomass provision cost

6.2.2 Data collection

For modeling biomass provision costs free BtL plant regional specific data are required in terms of e.g.:

* average distribution of 1st gathering points per hectare land area,
* provision costs at the 1st gathering point,
* transport infrastructure (e.g. detour factor),
* typical costs for means of transport (e.g. capital investment for train, lorry, inland navigation vessel),
* typical technical data and costs for means of storage
* personnel,
* auxiliaries (e.g. transportation fuel, electricity),
* toll or road tax.

For cost calculation meaningful assumptions with regard to insurances, administration and capital costs have to be done. Data such as payload, usable volume for means of transport and swap body as well as technical data cargo handling are assumed to be similar for all regions.

Attached to this report all WP 5.3 partners find the Annex with data inventory matrix that will be the basis for cost modelling.

7 ASSUMPTIONS FOR S1 AND S2

The following assumptions are made for the scenario analysis in terms of the biomass provision chains.

Agricultural residues

The straw provision chain operating nowadays for large-scale energy systems is not expected to change much in the future. However, in future scenarios (S1 and S2) a slight increase of the overall straw provision chain efficiency can be assumed. The individual parts of biomass provision chains should work more effectively and become linked to each other better (e.g. minimisation of waitings). Also high density bale systems may be implemented, e.g. compact rolls of the density of 250 to 350 kg/m^3 (Nilsson, 1999).

Forestry wood

For future scenarios S1 and S2 defined for 2020, it is assumed that forest operations providing raw biomass for BtL production will be performed mechanically. Manual wood harvesting, which probably still will be performed in some stands (sensitive or hardly available stands), will not be considered as raw material for BtL large-scale systems.

Based on the Scandinavian forest technology experiences it is assumed that the logging residues bundle system will become a common option for logging residues provision in Europe. Now the technology has been tested and demonstrated in several European countries within the FORENERGY (NNE5/395/2000). The tests covered a wide geographical areas and a large variety of different wood material and tree species. The research and development would have to be probably more concentrated on organization of logging site and transportation. It seems that the bundle technology itself works very well.

Thinning wood will be typically harvested with harvesters equipped with felling-bunching heads, which makes the multi-tree handling possible. Currently the manual wood harvesting is performed on a wide scale especially in the Central-East Europe, which is mainly due to very low cost of labour compared to Western and Northern countries (Bialystok, 2005). Also in Southern countries manual wood felling is still very common. However, in 10 to 15 year time it is expected that wide-scale mechanization of forest operations will develop in whole Europe.

Commercial root and stump extraction is currently performed only in Finland. For the future scenarios it is considered that root and stump extraction may develop in other European regions, however this assumption must be verified by forestry experts from specific countries (WP5.3 partners role).

<u>Biomass provision from 1st gathering point</u>

Different to biomass production (particularly of energy crops), for biomass provision from the 1st gathering point only effects (e.g. through technical development, prospected price evolution) will be considered that will cause a reasonable change of provision cost parameters.

For the scenario S1 an overall state of the art is expected in all Member States; a significant modification of that biomass provision chains are not expected (e.g. a doubling of transportation fuel costs is only of minor influence to the total provision costs and thus to the BtL production costs). For the scenario S 2 it is assumed that BtL is used as transportation fuel.

8 SUMMARY AND PROSPECTS

Objectives of this deliverable were the review of existing biomass provision chains and the definition of reference concepts and a methodical approach for the calculation of biomass provision costs.

Due to the fact that BtL production will require considerably large amounts of biomass as a raw material, only most efficient provision options are analysed based on existing biomass provision chains for large-scale energy systems.

* For straw it can be concluded that large square bales guarantee the highest gross capacity when all operations in connection are taken into account (e.g. handling, transportation, storage) and the less handling is required, the lowest provision costs. Typically contractors using high-capacity machinery are hired to minimise the manpower needed and to increase the capacity of the whole straw provision system.

* For permanent crops residues the following can be revealed from existing studies: Typically olive prunings and grapevines are done manually at low work rates. Mechanical pruning with high work rates justifies the lower operating costs. While the pruning collection is considered the amount of biomass in the ground affects much the capacity and the overall costs of the operation.

* The following can be concluded for forestry wood. Stem volumes strongly affects cutting costs; thus, if the volume is low, the costs are high resulting in higher overall provision costs of wood from thinning operations than from final felling (logging residues). Forest residues have relatively low bulk density. Loose logging residues provision options are appropriate only for low transportation distances. For longer transportation distances woodchips or bundle systems are most efficient. Bundling of logging residues is justified especially for large-scale forest felling operations, due to high bundling machinery costs. Manual provision chains are less cost effective at the stages of tree felling and forwarding to roadside while compared with mechanised provision chains. They are also highly labour consuming. Manual felling is only appropriate for very low stem volumes.

Common frame conditions are defined for biomass provision of energy crops, agricultural residues and forestry wood to the 1^{st} gathering point and from the 1^{st} gathering point to the BtL production plant.

For a comparative analysis between different European regions WP 5.3 partners are expected to provide basic parameters (e.g. technical and infrastructure) as well as cost data respectively that are relevant to the different provision steps (i.e. harvesting machinery, storages, means of transport). The guidelines presented in Table 8-1 should be taken into consideration in terms of the data and cost questionnaires in Annex 1 of this report.

Table 8-1 Guidelines for biomass provision cost data delivery for WP 5.3 partners

Biomass assortment	Relevance	Comments
Cereal straw	Whole Europe	Systems based on large square bales (1.2×1.3×2.4 m).
Permanent crops residues	Southern Europe	Market prices
Logging residues	Whole Europe	Cost for the most typical option of LR provision chain, namely: a) loose LR, b) LR chipping at roadside, c) LR bundles. Depending on regional conditions manual or mechanical harvesting and forwarding cost will be investigated; provide costs for both options if are developed.
Thinning wood	Whole Europe	Depending on regional conditions manual or mechanical harvesting and forwarding cost will be investigated; provide costs for both options if are developed.
Root and stump wood	Finland	Only mechanical extraction
Wood industry by-products	Whole Europe	Market prices

Based on the given methodical approach regarding reference concepts of biomass provision chains and the economic analysis model in the next stage data collection in the Annex 1 (cost inventory) have to be completed for the different European regions. Furthermore, best candidate energy crops[4] (e.g. willow, triticale, miscanthus) as well as reasonable assumptions for straw and forestry wood have to be validated for the calculation of biomass provision costs. This is also relevant to the area specific technical potentials of the named biomass and the distribution of first gathering points.

[4] According to the SP 5 definition of scenarios and boundary conditions, energy crops to be considered are short rotation coppice such as willow and miscanthus (and if not usable also straw). However, there are also less production cost intensive energy crops (cf. D 5.3.4.)

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ANNEX

Please see the (attached) MS Excel file for data and cost inventory that will be the data base for the economic analysis of biomass provision chains.