Pre-feasibility study of supply systems based on artificial drying of delimbed stem chips

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Content of the presentation*

- Backgroud
  - Natural drying versus artificial drying
  - Examples about energysystems based on artificial drying of wood chips
- Aim of the study was to compare supply chains based on natural & artificial drying of delimbed stem chips
  - The harvesting potential and procurement cost of alternative fuel chip production systems were compared at the stand and regional level
  - To define the maximum cost level of artificial drying required for cost efficient operation
- Results
  - Harvesting potential and energy content of fuel chips
  - Cost structure of supply chains & maximum cost level of artificial drying required for cost-efficient operation
- Conclusions

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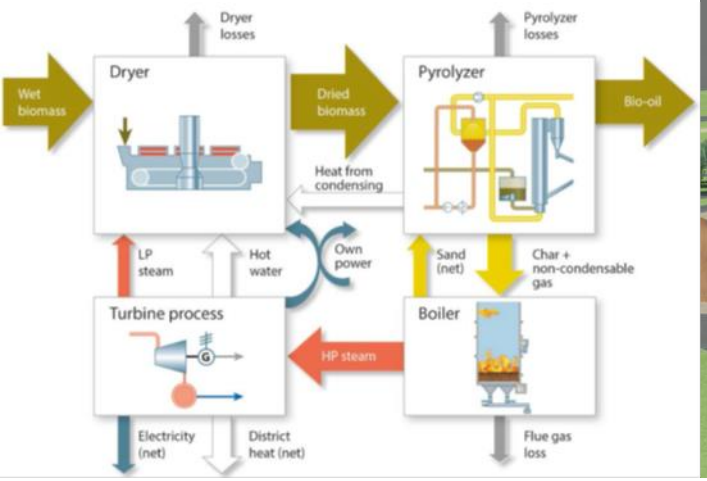
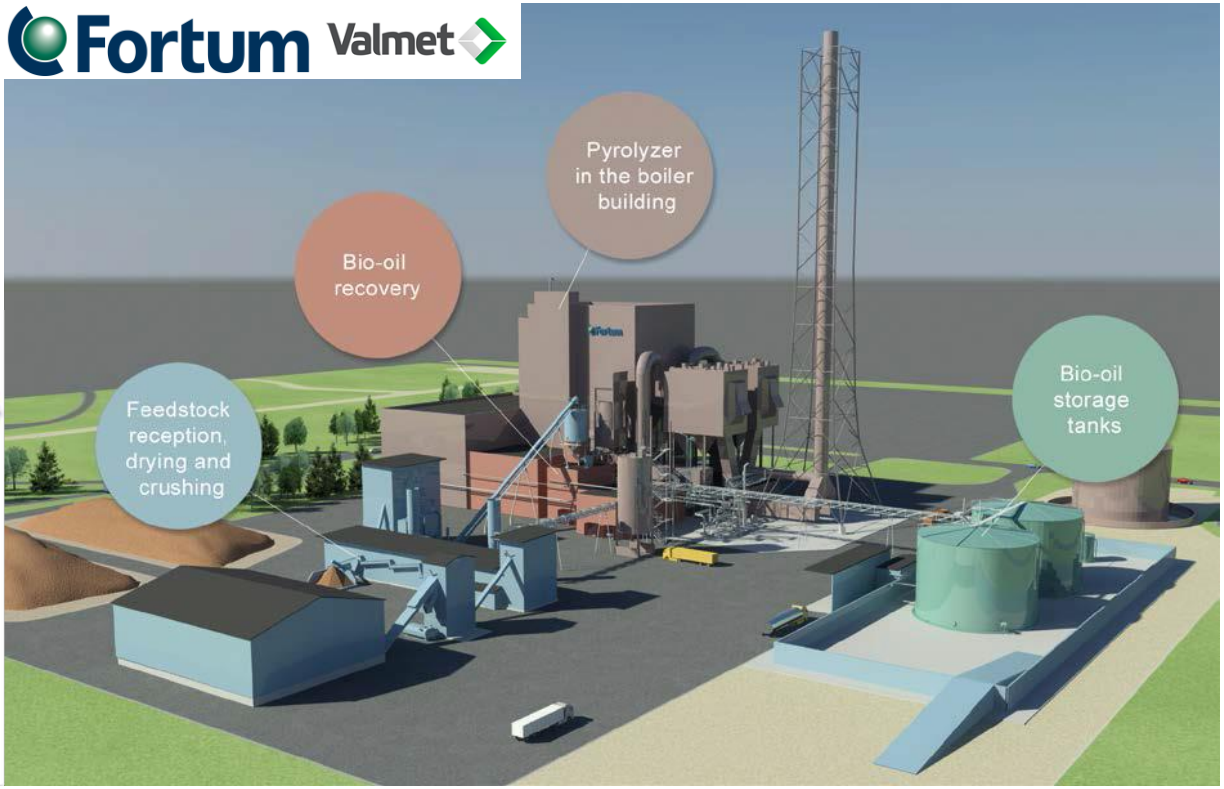
Natural drying versus artificial drying

- Natural drying during storing is an inexpensive way to decrease the moisture content of harvested timber
  - The effect of the natural drying is hardly predictable or controllable & during storing biodegradation leads to loss of dry matter and loss of energy-rich extractives
  - Covering the storage piles at roadside landings is essential to prevent remoistening in autumn and winter, but covering piles requires extra work leading to increased costs
  - Timber is often kept in storage too long in order to guarantee that it is dry enough. This increases storage levels and due to that, also the capital costs of procurement
- Artificial drying ensures a fast supply of fuel chips with the desired moisture content
  - Artificial drying is an additional process and cost to the supply chain and thus not common practice in the supply of fuel chips
  - Transporting cost of fresh timber are higher compared to timber dried during storing
  - As a result of drying, energy input into the boiler may be increased without increasing the fuel input, or the fuel input into the boiler may be decreased to get the same energy input as in the case of moist fuel

Bio-oil production through integrated fast pyrolysis – a key factor of the pyrolysis process is the artificial drying of the pyrolysis feed





Gasification technology enables to generate biomass based power in existing coal boilers – before gasification biomass must be dried artificially

Belt dryer

for drying biomass like bark, wood chips, sawdust, bagasse etc

The belt dryer is designed to remove water efficiently by evaporating moisture from wet biomass. Its proven drying technology ensures the high dryness of the end material.

Dried biomass can be utilized for

- Gasification
- Pelletizing
- Power boilers
- Purolusos oil production
- Wood powder firing

Benefits

- Utilization of waste waste heat
- High availability
- Non-destructive drying
- Low emissions
- Automatic operation

Valmet

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”In all gasifier types an increase in the average moisture content of the feed results in greater energy requirement for evaporation and correspondingly lower reaction temperature, which in turn results in a poorer quality product gas with increased levels of tar and lower overall conversion efficiency”

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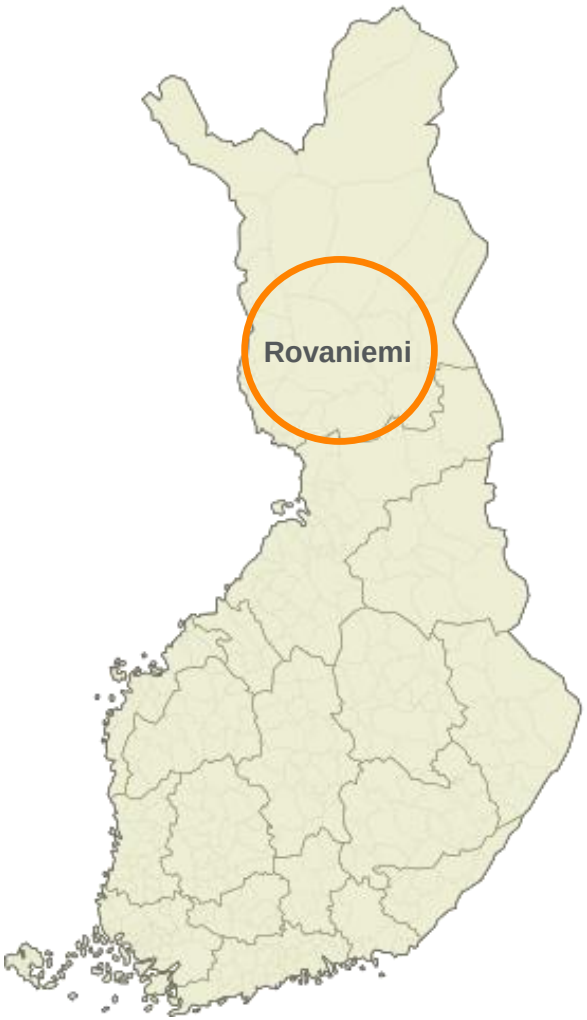
Availability and procurement cost analysis of delimbed stem chips in Northern Finland

- Availability of delimbed stems were based on the sample plot data from the Finnish National Forest Inventory (NFI)
  - Moisture content of artificially dried fuel chips made of fresh (55%) timber was set to 20%, 30% and 40%.
  - Moisture content of fuel chips based on natural drying during storing was 40%.
  - Dry matter loss of delimbed stems during nine month storage time was set to be 6,75%. The interest rate was 5% for stored timber
- Maximum transportation distance of fuel chips was 100 km via existing road network
- Productivity and cost parameters were linked with the inventory and GIS data
  - Costs of production stages were first defined per solid volume (€/m^3), and in final summing the costs were converted into euros per megawatt hour (€/MWh)
  - The payload was restricted by the frame volume of load space, load carrying capacity of the truck-trailer and bulk density of transported material (=degree of filling)



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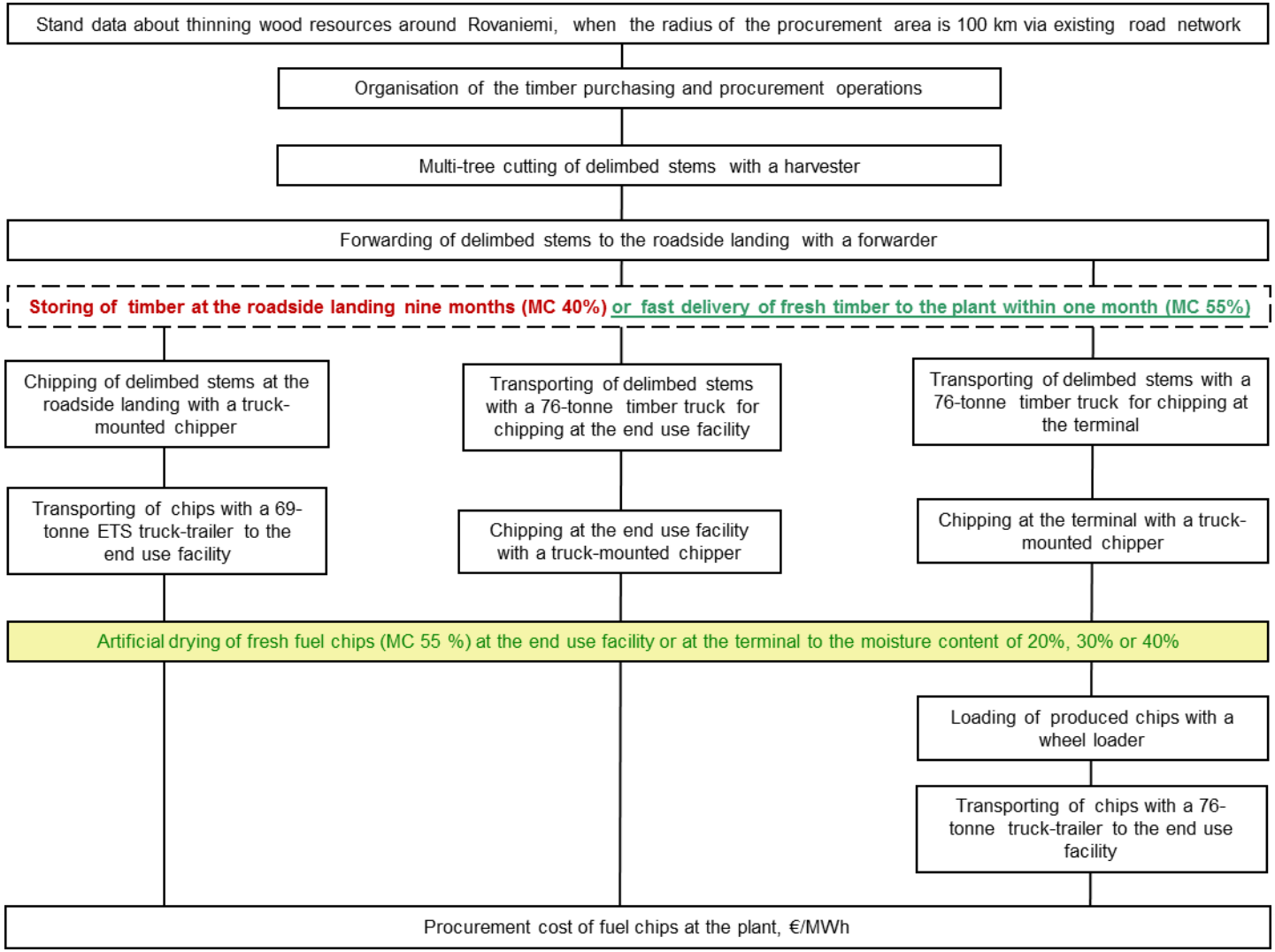
The basic stand data estimates for delimbed stems around Rovaniemi

Parameter, average	Rovaniemi
Forwarding distance, m	234 (SD 24)
Transportation distance, km	79 (SD 27)
The volume of stems harvested, dm^3	35 (SD 14)
Removal, number of stems per hectare	1385 (SD 565)
Removal, m^3 of stems harvested per hectare	43 (SD 13)
The percentage of Scots pine of total removal, %	43 (SD 44)
The percentage of Norway spruce of total removal, %	14 (SD 25)
The percentage of birch of total removal, %	41 (SD 39)
The percentage of other broadleaf trees of total removal,%	2 (SD 12)
The weight of delimbed stems as fresh (MC 55%), kg m^{-3}	950 (SD 82)
The weight of delimbed stems after storing (MC 40%), kg m^{-3}	662 (SD 57)
The weight of produced chips after artificial drying (MC 40%), kg m^{-3}	710 (SD 61)
The weight of produced chips after artificial drying (MC 30%), kg m^{-3}	609 (SD 52)
The weight of produced chips after artificial drying (MC 20%), kg m^{-3}	533 (SD 18)

The supply chains by the main work stages



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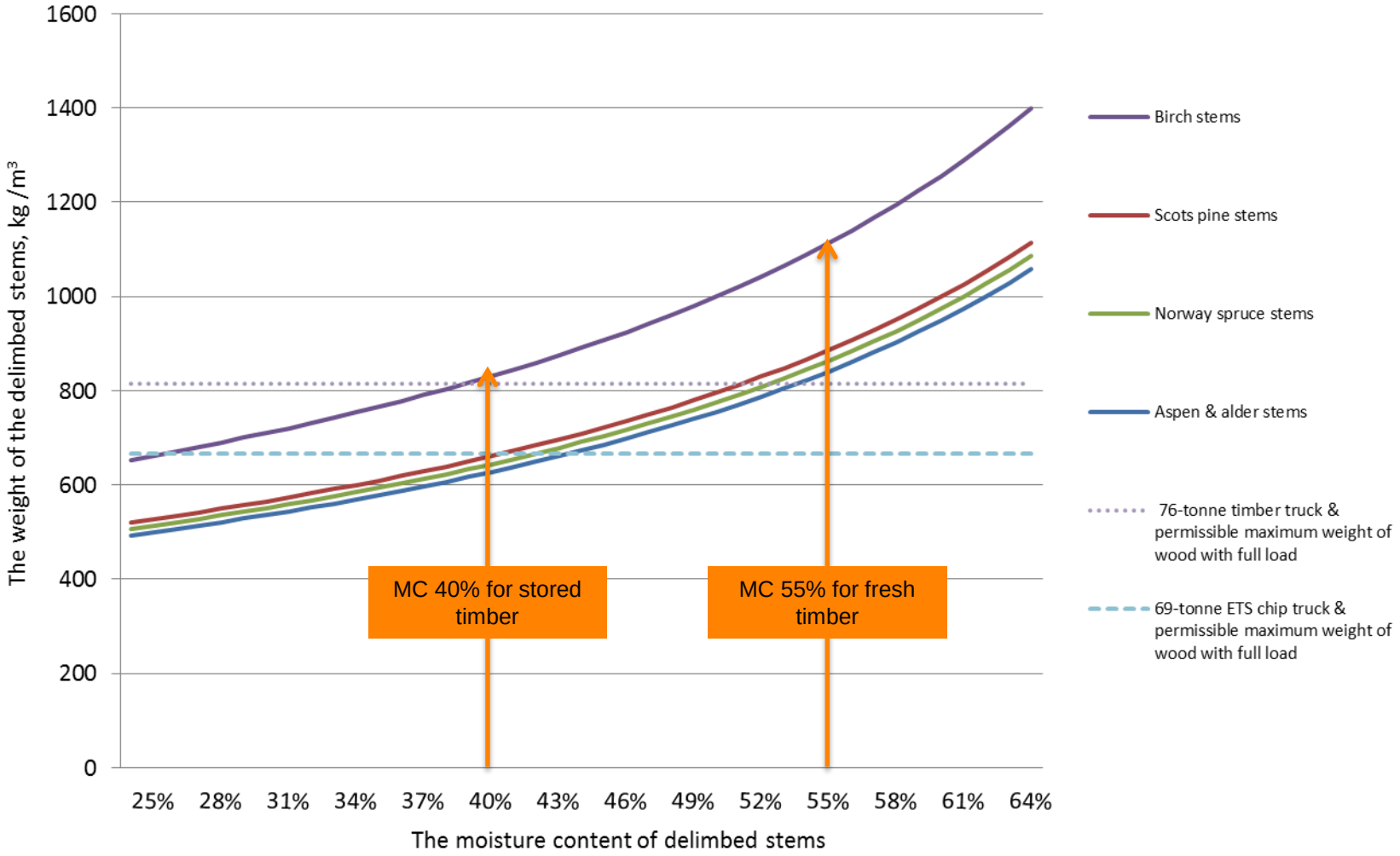
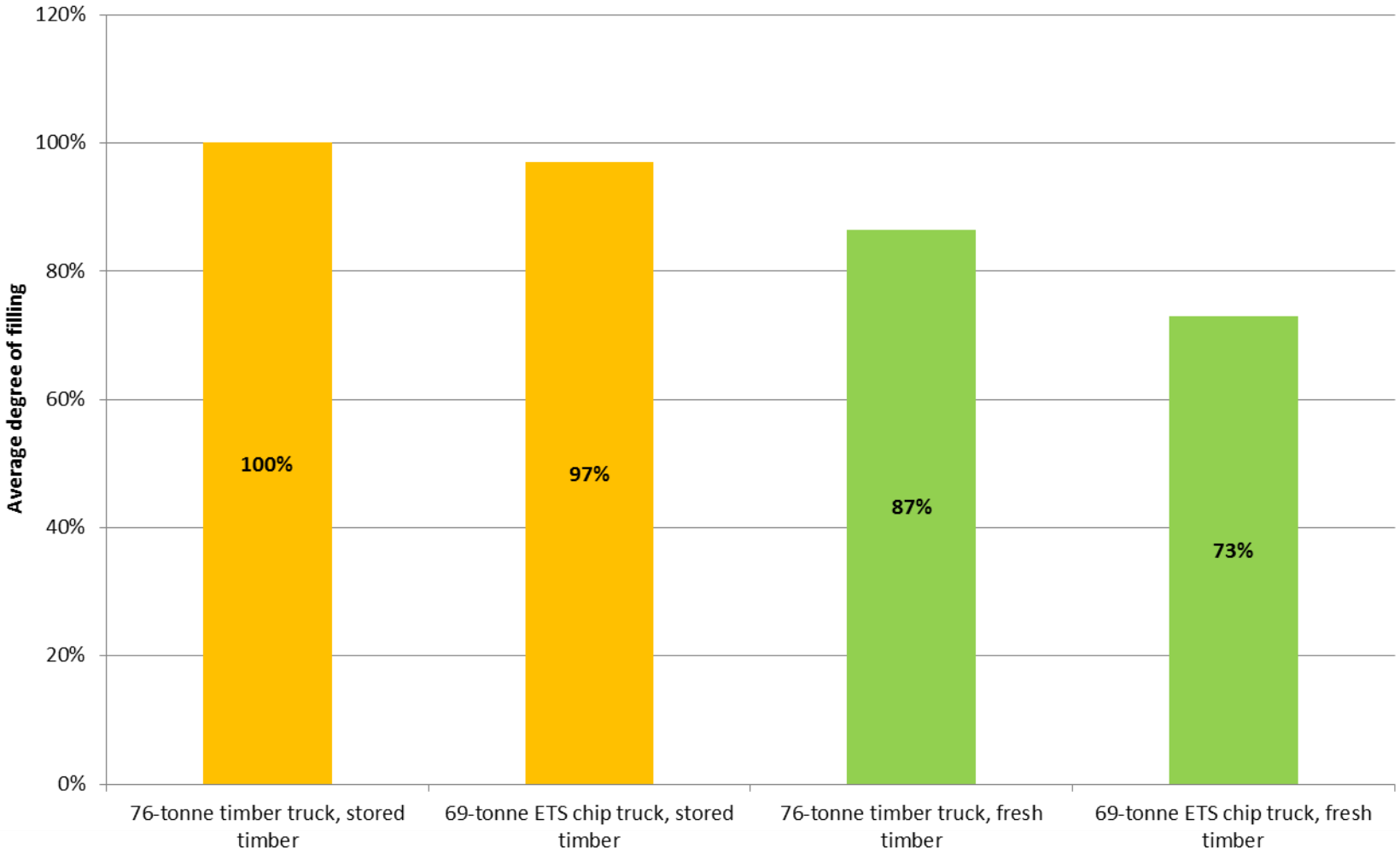
The productivity and cost parameters for the supply chains

The cost of organization, € m^{-3}	3.2
The stumpage price of delimbed stems, € m^{-3}	5.5
Hourly cost of the harvester equipped with multi-stem devices, € $E_{15}h^{-1}$	102.3
Gross effective time ($E_{15}h$) coefficient for multi-stem cutting	1.39
Hourly cost of the forwarder, € $E_{15}h^{-1}$	81.0
Payload of the forwarder, m^3	9.0
Gross effective time ($E_{15}h$) coefficient for forwarding	1.3
The cost of chipping at the terminal or end use facility, € m^{-3}	5.5
The cost of chipping at the roadside landing, € m^{-3}	8.0
Payload of the 76-tonne timber truck with fresh timber (MC 55%), m^3	47.6 – 60.6
Payload of the 76-tonne timber truck with stored timber (MC 40%), m^3	63.8
Payload of the 69-tonne chip truck with fresh timber (MC 55%), m^3	38.5 – 48.9
Payload of the 69-tonne chip truck with stored timber (MC 40%), m^3	55.2 – 63.0
Payload of the 76-tonne chip truck in the chip deliveries from the terminal (MC 20 - 40%), m^3	61.1 – 63.0

The weight of delimbed stems (kg/m³) as a function of moisture content & tree species



The average degrees of filling, when transporting delimbed stems and chips



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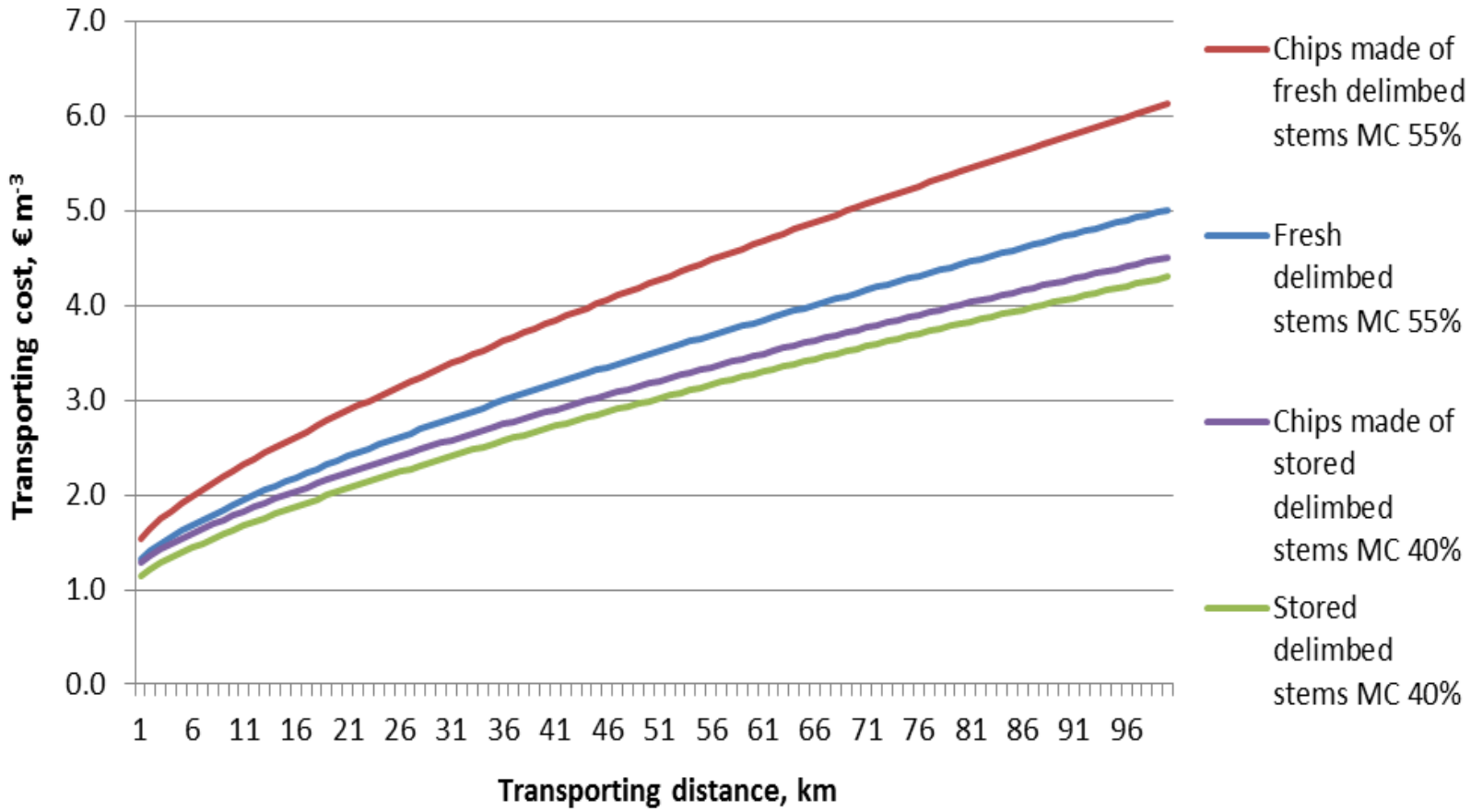
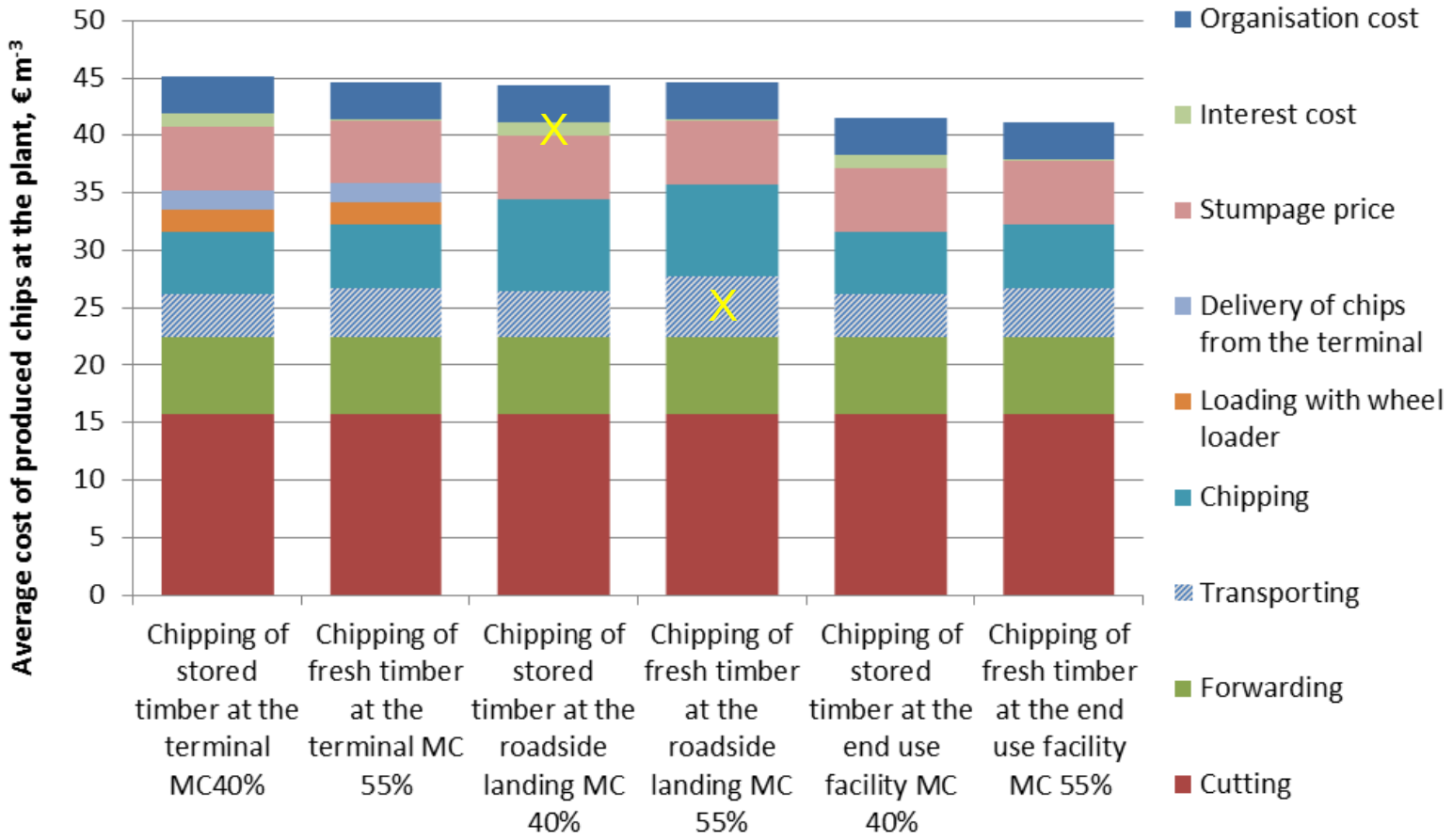
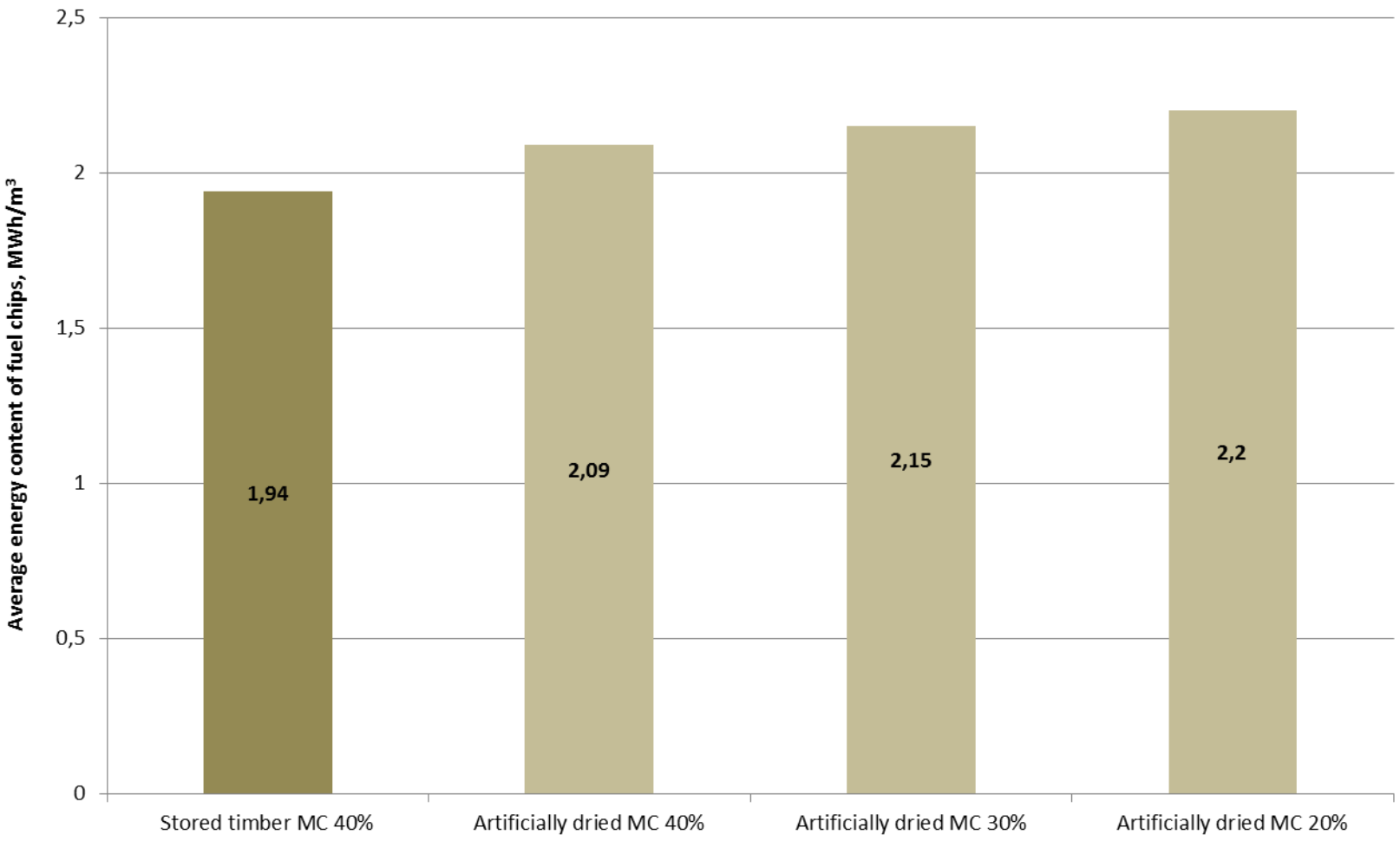
Transporting costs of delimbed stems and chips, when the moisture content is either 40 % or 55%



The procurement cost structure of the supply chains and raw material options of this study



The average energy content of fuel chips



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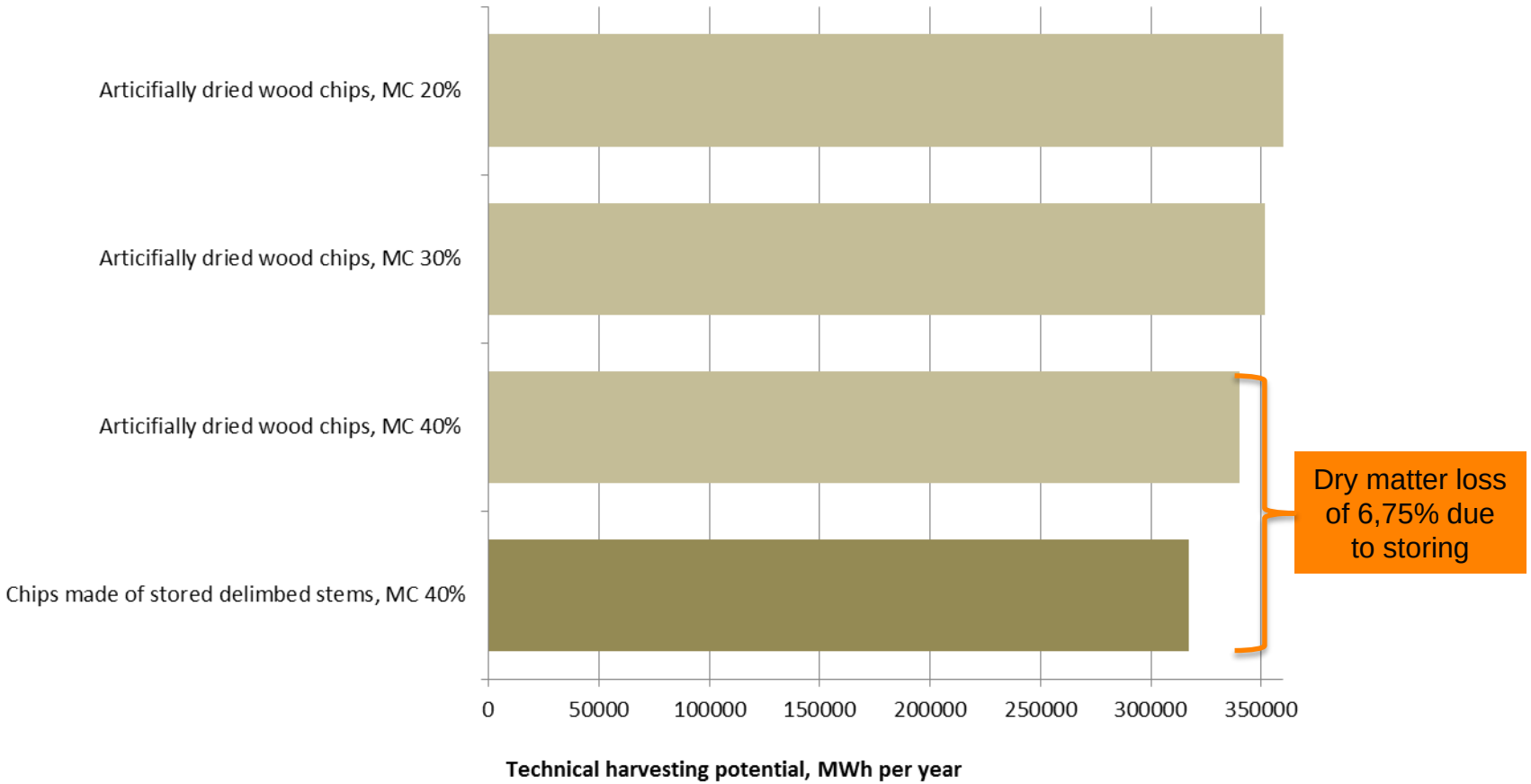
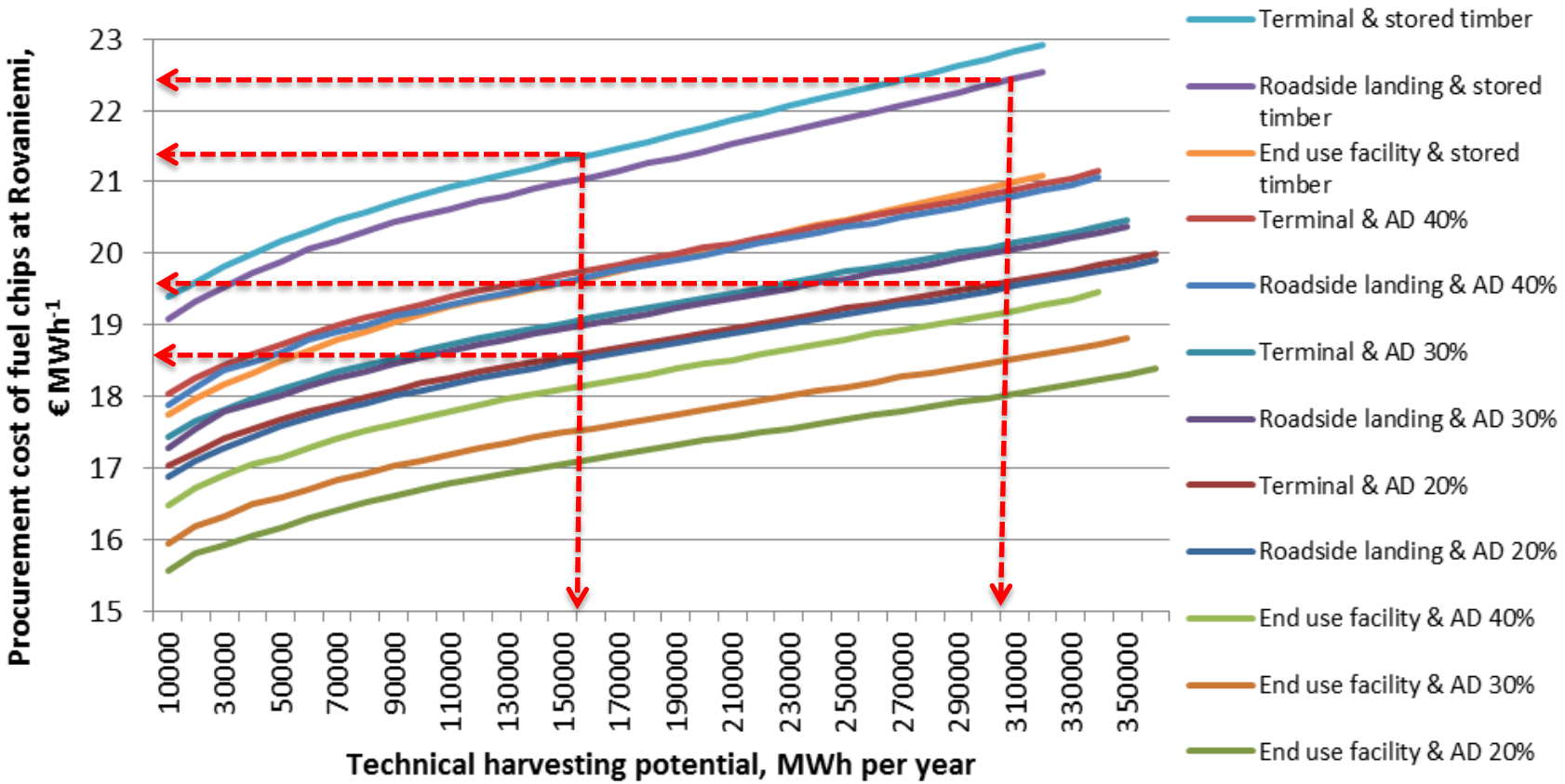
The technical harvesting potential of delimbed stems around Rovaniemi



The procurement cost of fuel chips, when using alternative moisture contents and storing options for produced chips



Conclusions

- With artificial drying and quick delivery, avoiding dry material losses of harvested timber, it could be possible to reduce the current costs of the prevailing procurement system based on natural drying of stored timber at roadside landings
- The results indicated that the maximum cost level of artificial drying ranged between 1.2 – 3.2 €/MWh depending on the supply chain, moisture content and procurement volume of fuel chips
- The investment and running costs of an artificial dryer as well as the quality requirements of consumer determine how feasible such a drying method is a part of fuel chip supply chain
- There is a need to conduct an experiment which demonstrates in practice the actual costs of artificial drying, because state-of-the-art information is not available

Thank you for your attention!

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