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Bioeconomy & Cleantech Opportunities

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Sustainable Bioenergy Solutions for Tomorrow (BEST) program-final seminar

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Effective biomass handling – predicting models & fast track supply

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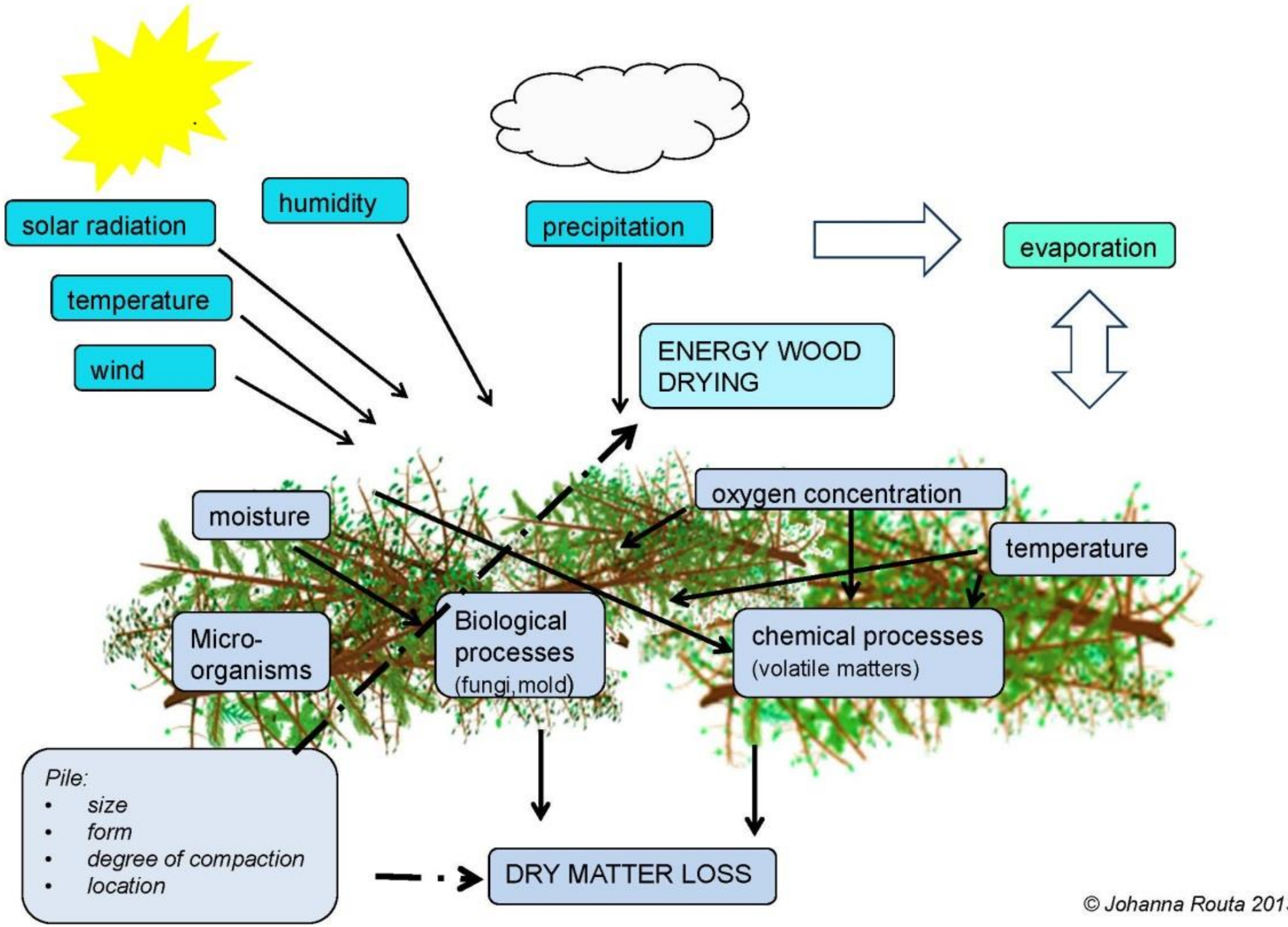
- The most important factor influencing the quality and calorific value of fuel wood is moisture
- The latest methodology for moisture change monitoring has been constant weighing of piles in racks built on load cells.
- Drying models for estimating the optimal storage time based on average moisture change in fuel wood stacks stored outdoors have been developed for different energy wood piles.

- Modelling is an easy option to make an estimate of the moisture content of an energy wood pile if compared with sampling and measuring the moisture of samples.
- Models are also a considerably more reliable method for allocation and prioritisation of piles than the “educated guesses” used earlier.
- In practice, piles are often kept in storage too long “just to be sure” that they are dry enough. This increases storages levels and due to that, the capital costs of supply. In addition, dry matter losses increases due to too long storage times.


solar radiation
humidity
precipitation
evaporation
temperature
wind
ENERGY WOOD DRYING
moisture
oxygen concentration
temperature
Micro-organisms
Biological processes (fungi,mold)
chemical processes (volatile matters)
Pile:
size
form
degree of compaction
location
DRY MATTER LOSS
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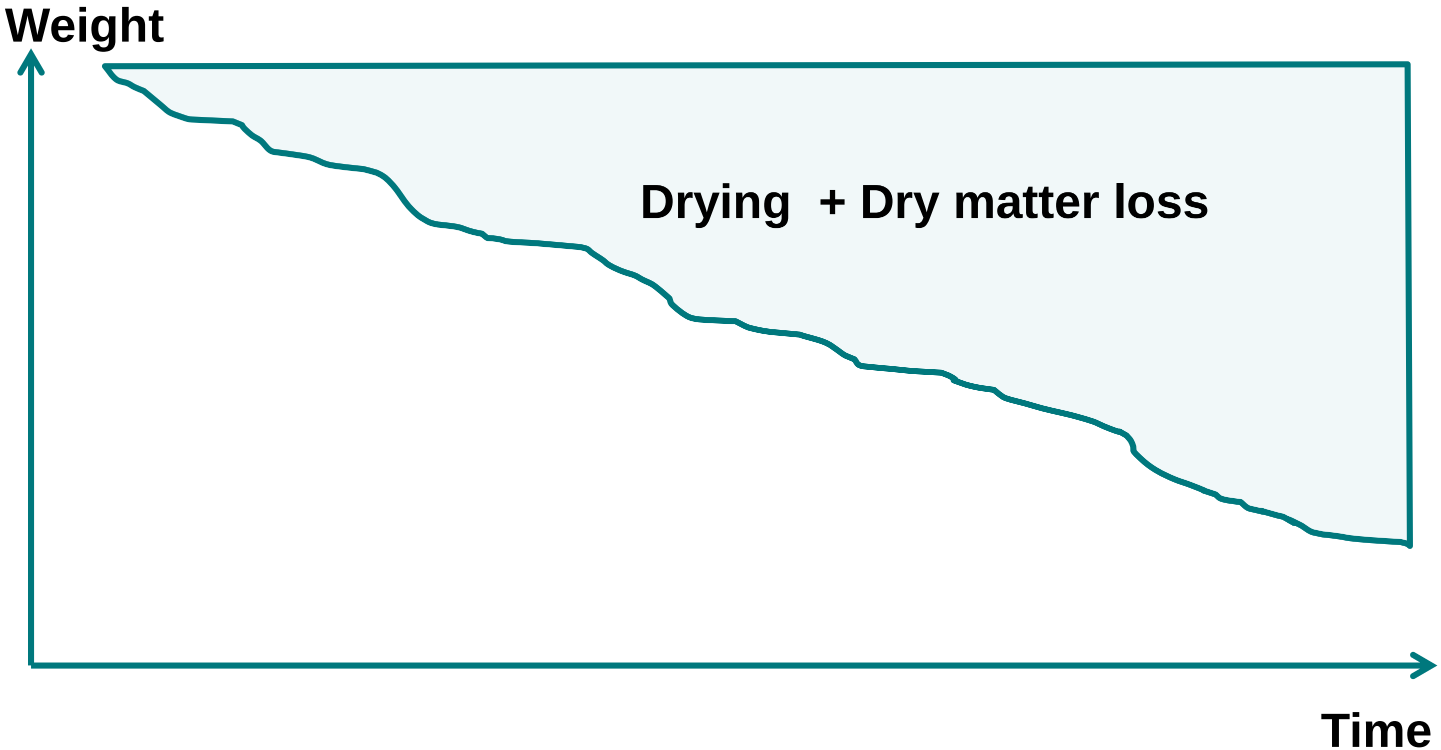
Change in the weight is not only drying of energy wood in long term…



Dry matter losses

	Pile 1	Pile 2	Pile 3	Pile 4	Pile 5	Pile 6	Pile 7
Dry matter in the beginning of experiment, kg	1048.8	1508.2	1213.8	1915.5	1548.0	1140.2	1394.7
Moisture in the beginning of experiment, %	54.5	46.8	46.6	35.7	48.0	20.1	53.4
Dry matter in the end of experiment, kg	845.0	1141.7	944.7	1503.2	1439.6	1140	1235.4
Moisture in the end of experiment, % (3 samples, average)	45.5	51.2	36.6	37.8	49.2	35.8	57.5
Change in moisture, % units	- 9	+4.4	-10	+2.1	+1.2	+15.7	+4.1
Dry matter loss, kg	203.8	366.5	269.1	412.3	108.4	0	159.3
Time in storage, months	20.0	8.4	8.4	8.0	8.0	8.0	8.0
Dry matter loss, %	19.4	24.3	22.2	21.5	7.0	0	11.4
Dry matter loss per month, kg	10.2	43.6	32.0	51.5	13.6	0	19.9
Dry matter loss per month, %	1.0	2.9	2.6	2.7	0.9	0	2.5

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Drying models

Roadside storage models				
DMC = coef * (evaporation – precipitation) + const				
Moisture content (i) = moisture content (i-1) – DMC				
Model	coef	const	R^2	**SE**
Stem wood, covered (pine)	0.062	0.051	0.70	**0.2**
Stem wood, uncovered (pine)	0.062	0.039	0.64	**0.2**
Logging residues, covered	0.105	-0.072	0.44	**0.36**
Logging residues, uncovered	0.17	-0.076	0.64	**0.57**
Stand model, logging residues				
Drying, during the period %= coef* $\sum \frac{\text{precipitation}}{\text{evaporation}}$ **+ const**				
	-16.397	20.64	0.73	**7.9**

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Validation data

Stemwood:

- The validation data for covered small diameter pine stem wood has been collected in Central Finland.
- The sampled stem wood piles were selected so that they represent average energy wood storages in Finland. The materials of the piles were typical of first thinning.
- All the storage piles were covered with the Walki cover paper.
- Uncovered pine stem wood validation data was from Eastern Finland.

Logging residues:

- The validation data for logging residues has been collected in Central and Eastern Finland.
- Both stand and roadside storage models were validated
- In roadside were both covered (Walki paper) and uncovered piles

- The moisture samples were taken from piled chips; 6–8 samples were taken with ladle sampling to a big plastic tub.
- All the samples were spilled onto a table, where chips were divided into four parts. One part was put into a duplicate plastic bag (5 litres). Plastic bags were delivered immediately to the laboratory, where the moisture content was measured using the oven dry method.
- Analysis of moisture content is carried out according to standard EN ISO 18134-2:2015

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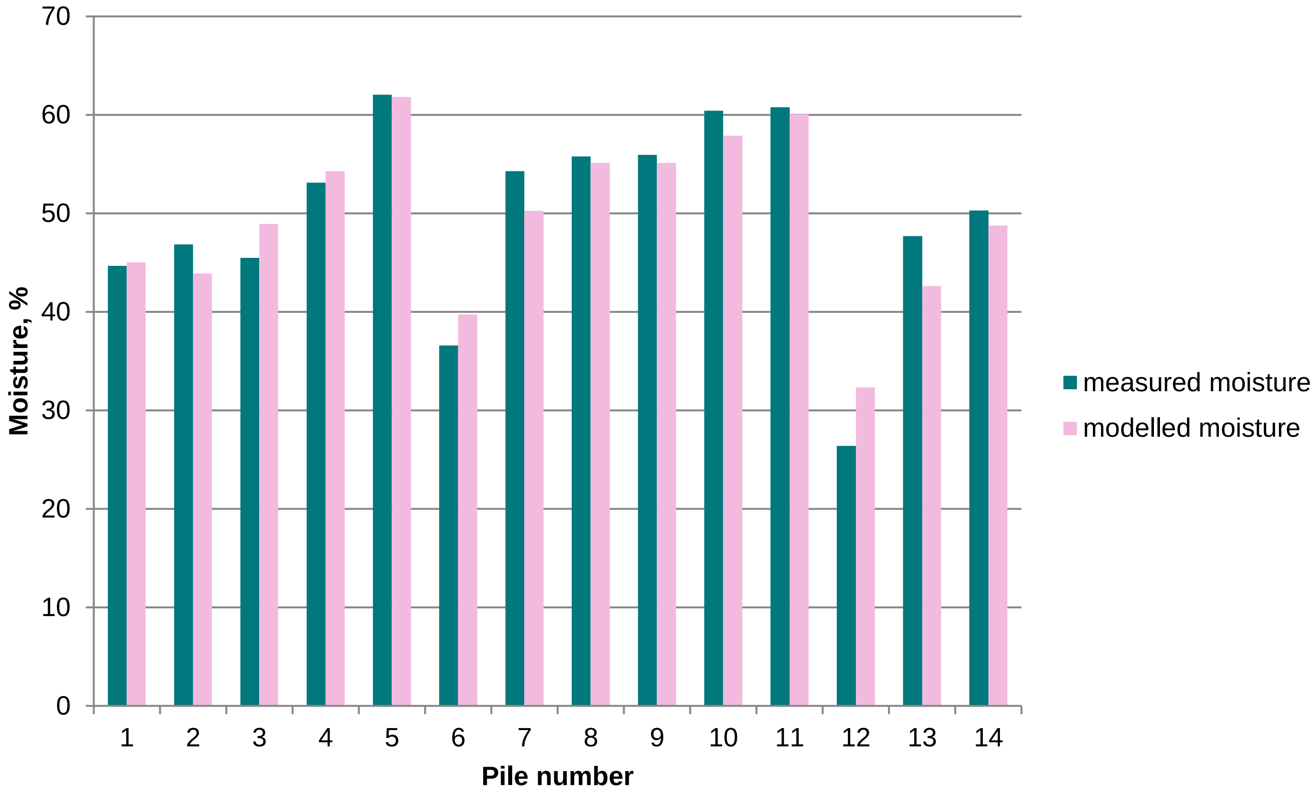
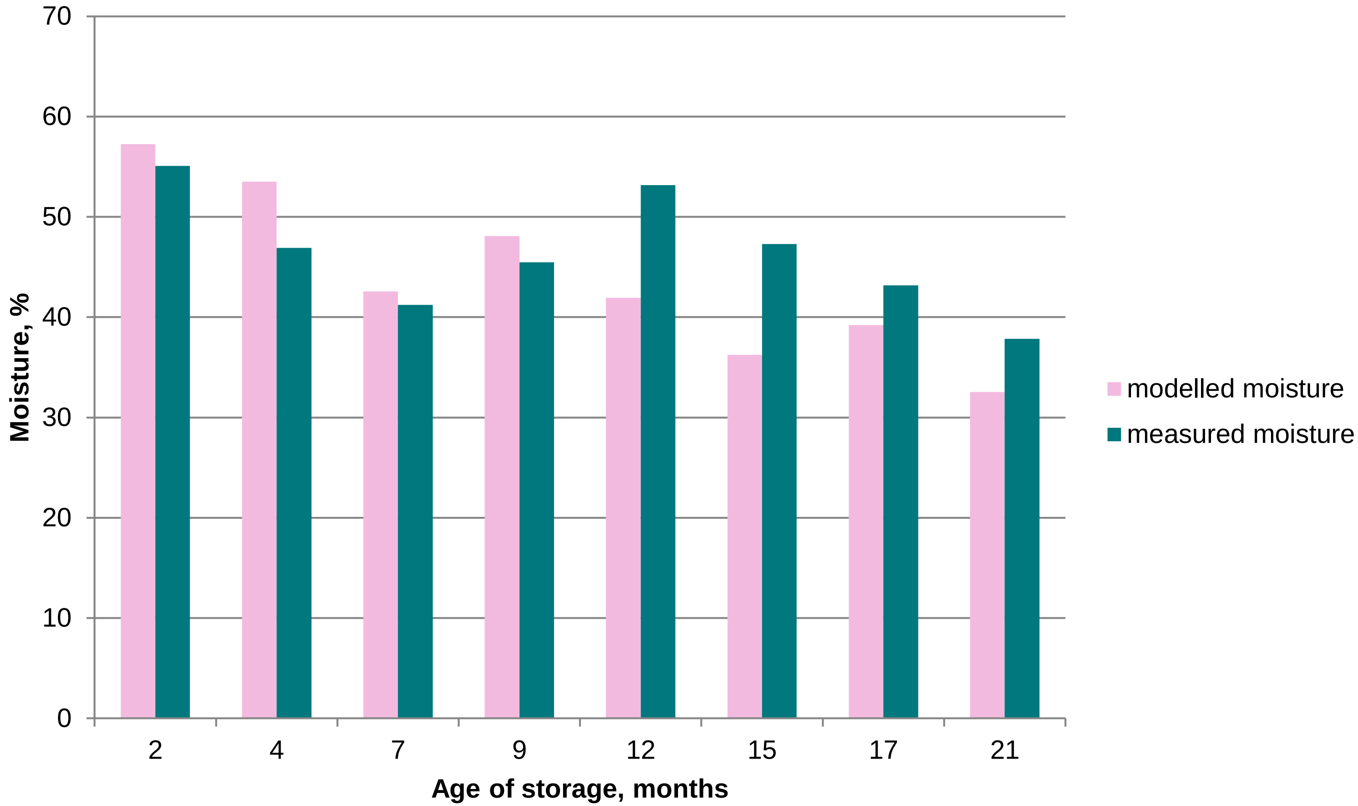
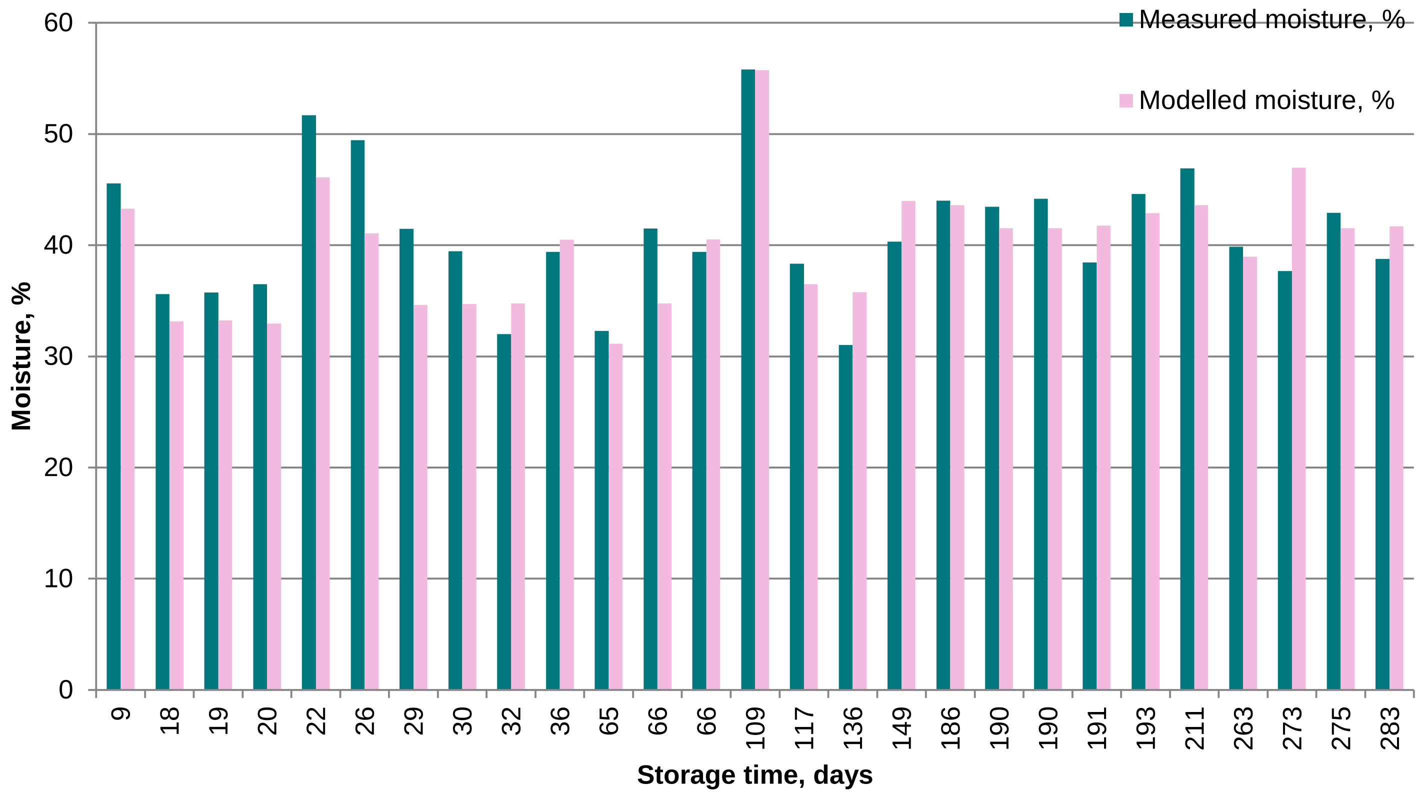
Results of validation covered stem wood piles



Results of validation uncovered stem wood piles



Results of validation of stand piles of logging residues.



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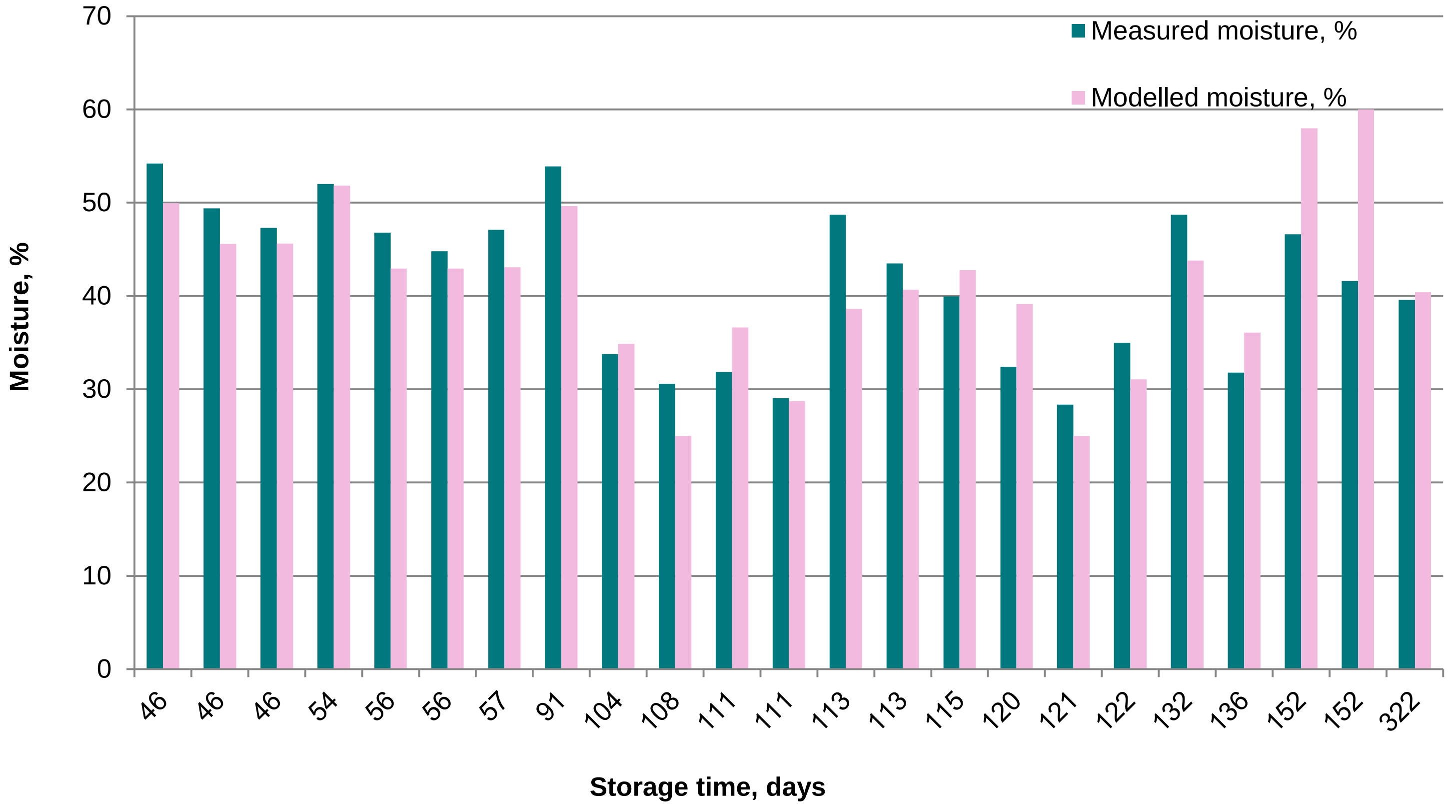
Results of validation of roadside piles of logging residues.



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- The results of the validation of developed models are promising.
- The difference between measured and modelled moisture was on average only 0.3% with covered stem wood piles and 2.5% with uncovered stem wood piles.
- The difference between measured and modelled moisture of logging residues was on average only 0.4 %.
- The models presented can be implemented in every location in Finland, because the Finnish Meteorological Institute has a database for interpolated meteorological observations covering whole country in a 10 km x 10 km grid.
- For international use, model parameters need to be estimated case by case, but it should also be possible to implement the approach itself worldwide.

Routa, J., Kolström, M., Ruotsalainen, J., and Sikanen, L. 2015. Validation of prediction models for estimating the moisture content of small diameter stem wood. Croatian Journal of Forest Engineering, 36 (2): 111-119.
Routa, J., Kolström, M., Ruotsalainen, J., and Sikanen, L. 2016. Validation of prediction models for estimating the moisture content of logging residues during storage. Biomass & Bioenergy, 94: 85-93.

- The practitioners of the forest energy business have stated that their requirement of the moisture estimate accuracy for enterprise resource planning purposes would be ±5% of the moisture content. In this study, 77% (stemwood) and 80% (logging residues) of moisture forecasts meet this limit.
- Some forest companies have already started to use models as a part of their Enterprise Resource Planning (ERP) systems, and the feedback has been encouraging; models work well enough to give added value.
- A need for further development is still recognized, especially concerning the varying weather conditions of autumn and effects of snow. Some fuel chip reception stations on heating plants are already using automated continuous moisture metering. If the chain-of-custody is proof, this information can be used effectively to develop models in the future.

Fast track - an alternative operational model

Results by:
Jyrki-Pekko Kinnunen,
Kari Väätäinen,
Juha Laitila and
Lauri Sikanen
Slides: Lauri Sikanen

Fast track- what is that?

Part of the feedstock is taken to the CHP-plant directly from forest without drying and storing.

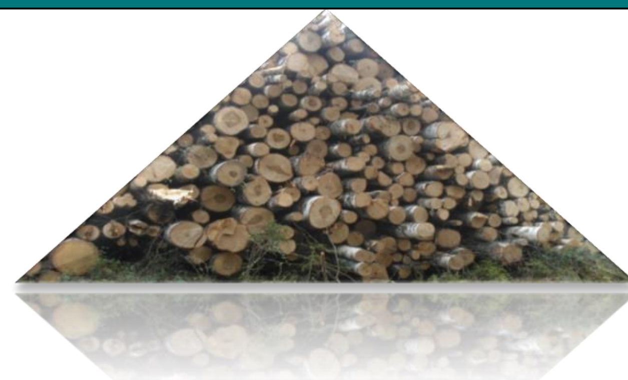
Fast Track is focused on summer and early autumn harvests because top performance of boilers is not needed that time yet.

Changes in the legislation of road transportation and progress in the scrubber technology have enabled the use of more moist feedstock in Finland.

Storage Dilemma

Dry matter losses
Capital costs
Covering costs
Other storage costs

Balancing supply
Smaller transportation costs
Better heating value
Smooth running of the plant



Dry matter losses and capital costs

- **Fast Track-results has been calculated by decays of 1%, 2% and 3% per month.**
- **When wood is in roadside storage, already stumpage price, harvesting, transportation and 7-10% of general costs has been ”paid”.**

- **What is the cost of that money during the storage period? What is the right interest rate? 3% like foresters tend to think? 8% like the CFO of the firm would like to think? Or 12% like the owner of the company would like get as an interest of invested capital.**

- **We calculated costs with all of those interests.**

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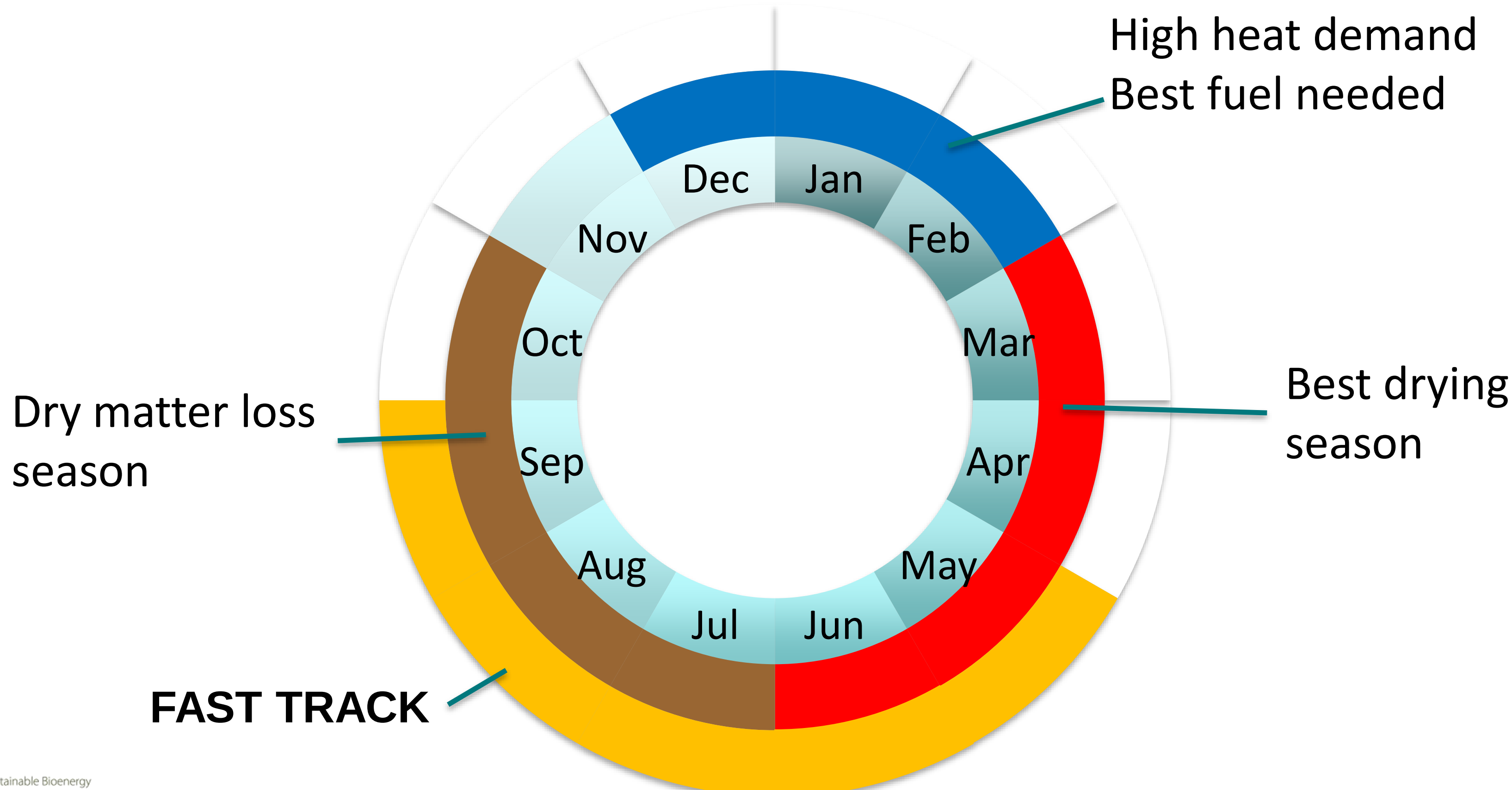
Fast Track year clock in Finnish operational environment



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The Fast Track -study

A real harvesting data of one company, 749 harvesting sites, 145 900 m^3 of harvesting residues with real locations were allocated to supply according the traditional procedure and according to Fast Track.

Moisture content change was modelled according to moisture change models developed earlier. All costs were calculated according to harvesting and transportation variables and biomass characteristics.

Total costs of traditional supply and Fast Track were compared.

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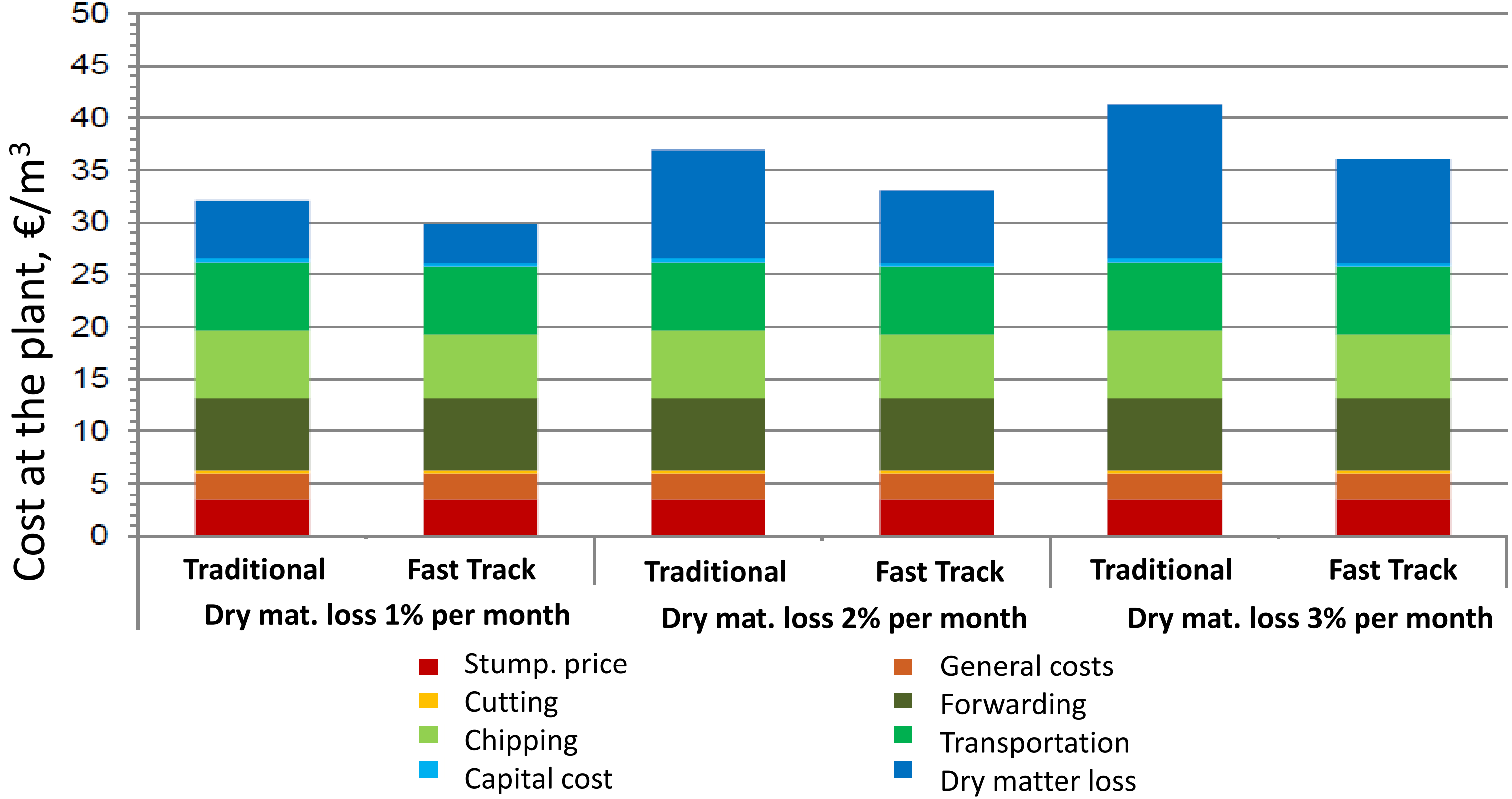
Cost comparison with 3% interest for capital



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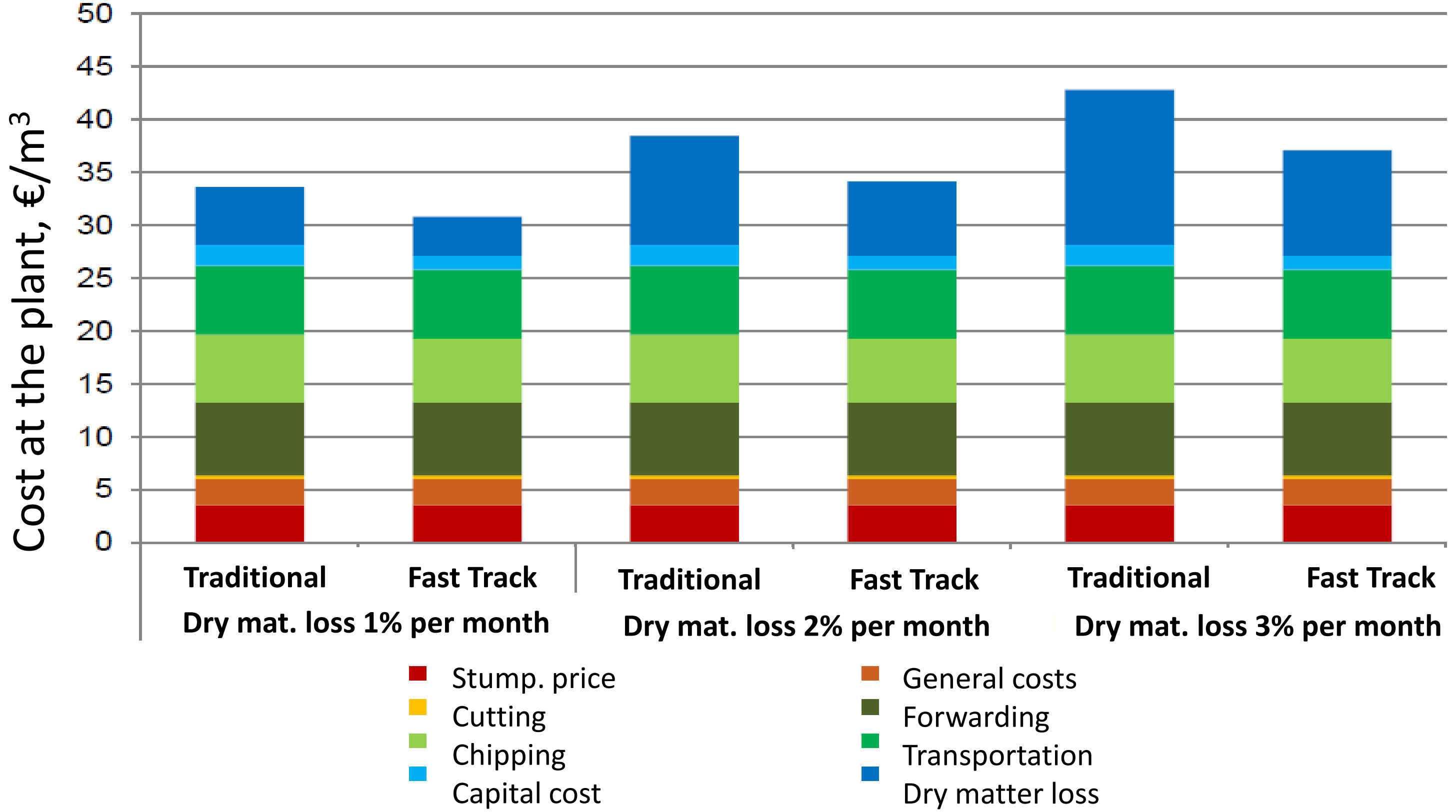
Cost comparison with 12% interest for capital



Notions:

Artificial drying?

Fast-Track –chips are not the same than traditional chips, moisture is higher => Pricing can be different.

Chlorine content and corrosion risks are under vigorous research. We do not know yet, is there any real risk for increased corrosion with Fast-Track chips.

Demand of the plant defines, how big percentage of annual chips can be Fast-Tracked.

Where else we can increase the efficiency of supply chain with 10-20%

Can we skip the whole storing?

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Thank you!

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