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Prediction models for moisture content of fuel wood

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General

- The raw material properties of biofuel feedstock change during the storage according to storage practices and weather conditions.
- The most important quality factor of the forest biomass is moisture, which affects the heating value, and thus the amount of usable energy.
- The quality management of the delivered fuel can be improved by better know-how of the moisture content ‘management’.
- The forecast models describe the moisture changes of raw materials in various storages.

Raw material stockpiles

Type of material	Tree species	Drying environment
1. Forest residues	Norway spruce	Open, gravel pit
2. Shortwood (d 3 – 10 cm)	Pine & Birch	Open, edge of forest
3. Shortwood (d 3 – 10 cm)	Pine	Shadow, roadside
4. Shortwood (d 3 – 10 cm)	Pine	Open, edge of forest
5. Stumps	Norway spruce	Open, edge of forest
6. Whole trees	Pine	Open, roadside
7. Whole trees	Pine & Birch	Open, roadside

Drying and weather monitoring

- Monitoring of drying: taking moisture samples about once a month, oven drying.
- Weather monitoring: using local weather stations and weather data from the Finnish Meteorological Institute
  - Air temperature
  - Relative humidity
  - Solar radiation
  - Wind speed
  - Net evaporation
  - Precipitation

= > Prediction models for moisture of fuel wood.

Prediction model for moisture content of fuel wood 1

- General form of the model to calculate water content in wood:

$$w_{i+1} = w_i + a*\Sigma P/(w_i - w_{eq}+b) + c*\Sigma E(w_i - w_{eq})$$

where

w_i = water content of the material (kg_{H2O}/kg_{dm})

w_{eq} = water content of the material in equilibrium, depending on the relative air humidity and temperature

ΣE = cumulative evaporation (mm) during the period i – (i+1)

ΣP = cumulative precipitation (mm) during the period i – (i+1)

a, b, c = experimental coefficients

Calculation starts at $w_i = w_0$ = initial moisture of the material

Prediction model for moisture content of energy wood 2

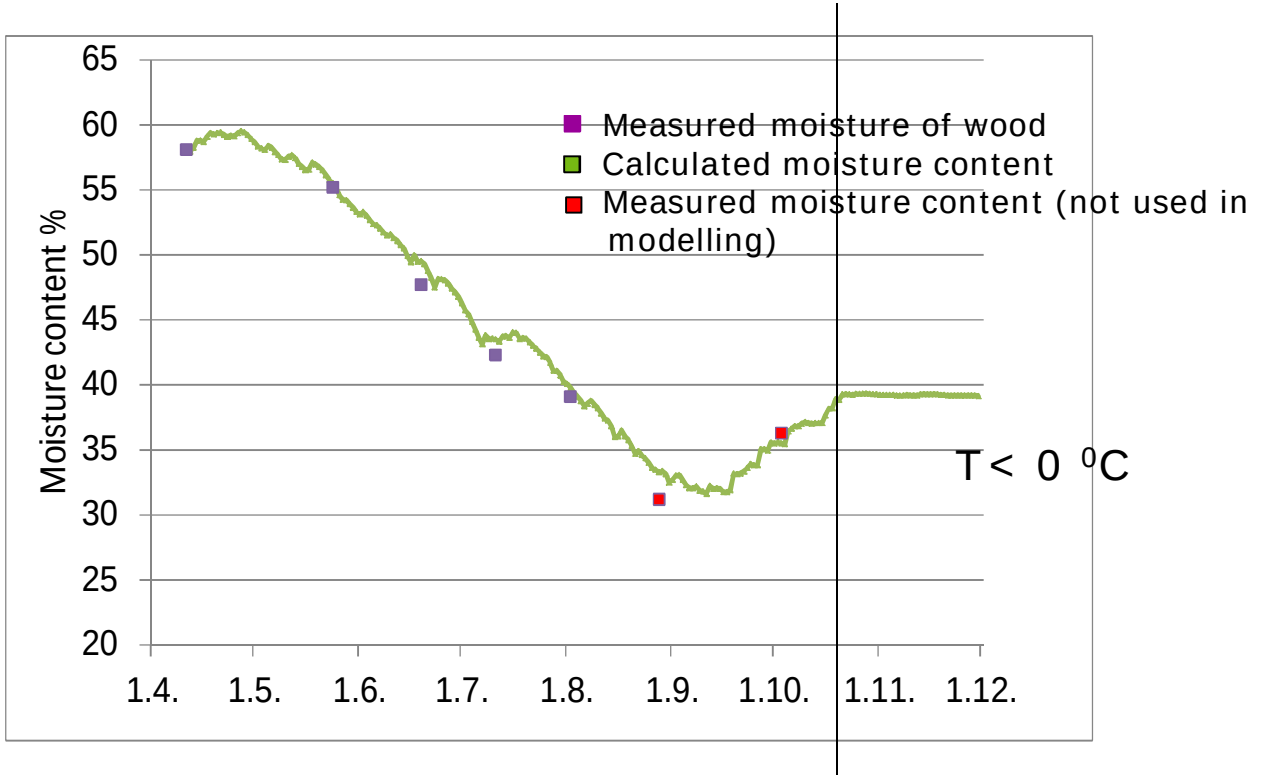
Moisture content of wood (M_{mat}) in per cents from W_i ⟹

$M_{mat,\, i+1} = 100 * w_{i+1}/(w_{i+1} + 1)$

Prediction model takes into account the :

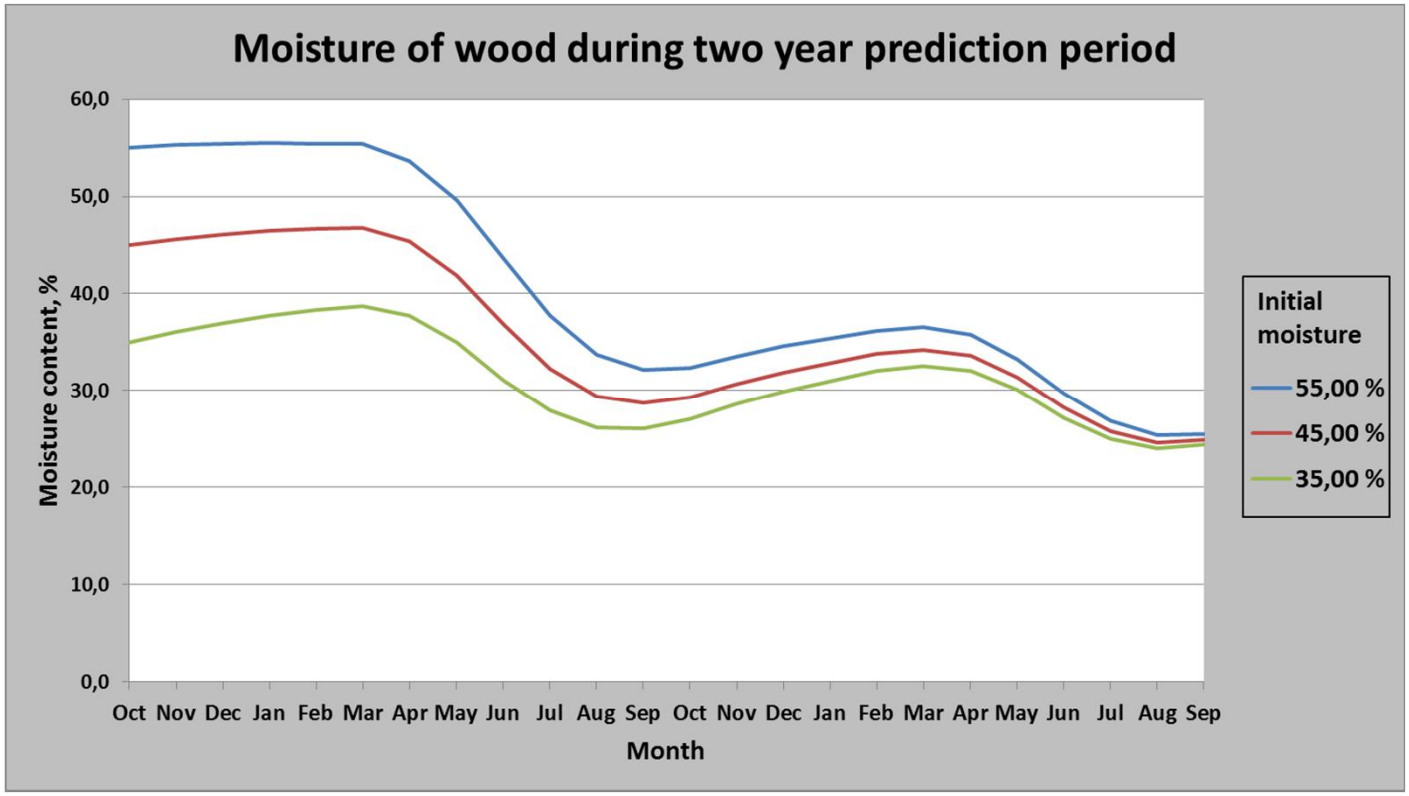
- evaporation and precipitation
- relative air humidity and temperature
- difference between transient and equilibrium moisture contents of the material
- coefficients, which are based on experimental data

Predicted and measured moisture content for shortwood



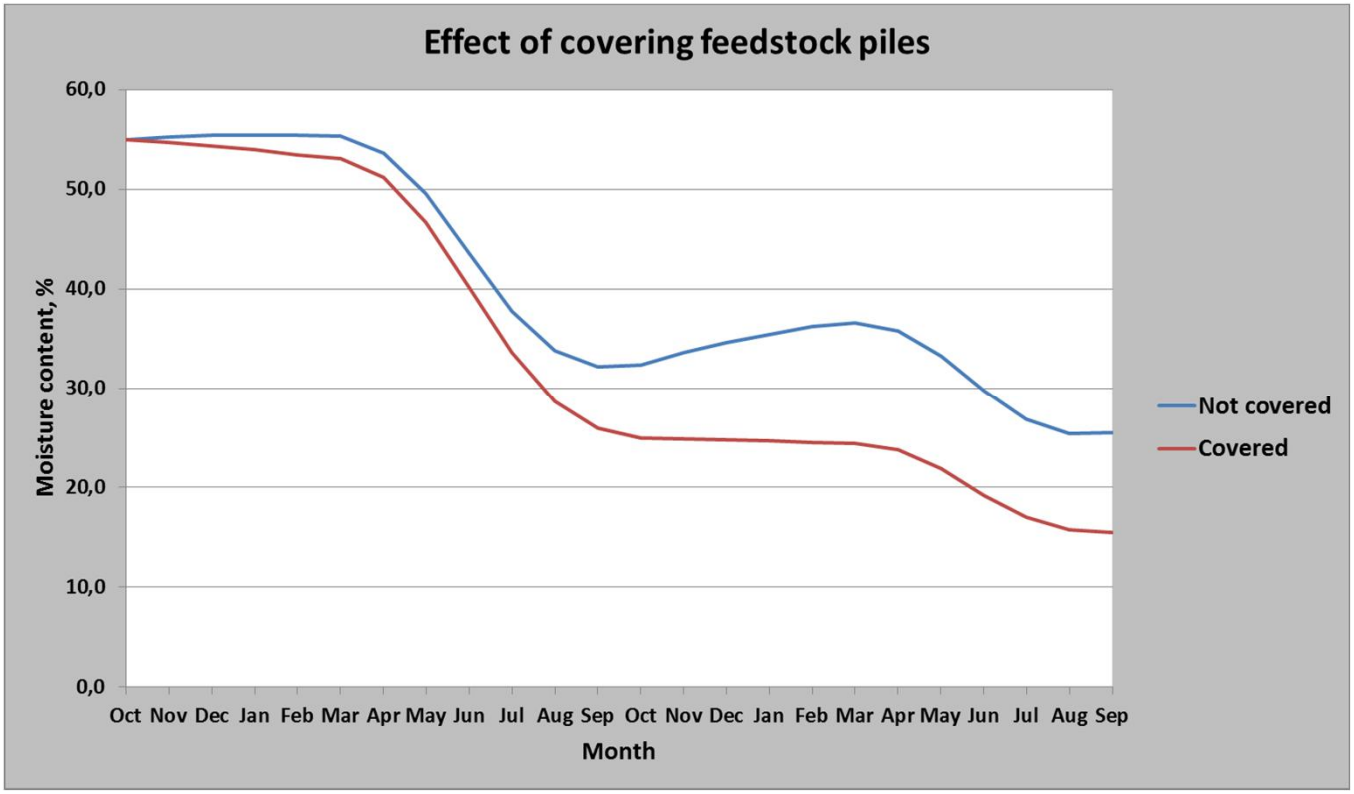
- Moisture sampling from actual fuel wood storages piles were used to create the model (purple dots)
- Model was verified by taking samples from other fuel wood piles (red dots)

Calculated example 1



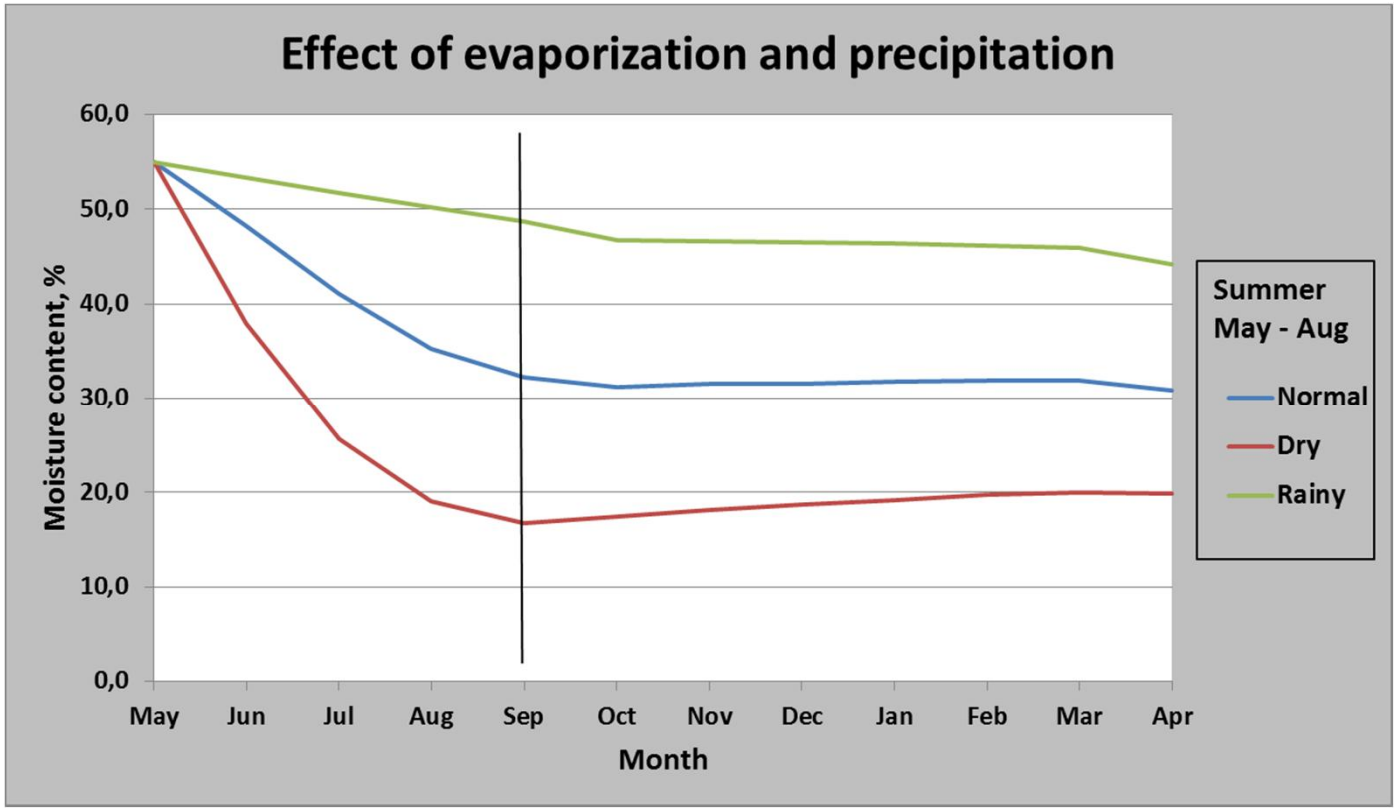
- This example was calculated by using average values
  - It is typical that moisture increases after the first drying period (spring-summer) in the fall

Calculated example 2



- Covering of feedstock piles can effectively prevent wood from getting wet again
  - Preventing from snow and ice is particularly important in Finland

Calculated example 3



- This example shows that an average situation may substantially differ from actual weather conditions
  - Therefore up to date weather data is needed for the accuracy of the model

Utilisation of the prediction model

- Model is a general model that utilises local weather data for any given case
- In addition, model parameters can be determined to correspond to other local conditions like storage conditions by using coefficients (site, covering of the pile, snow and ice, type of the raw material, etc.)
- Enables to forecast how moisture content of storage piles will change →
  - Furthermore this can be used in optimisation of the fuel use in power plants →
  - To minimise operational problems, maximise the efficiency of the boiler/power plant, and enable to maximise plant's output at any time when required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Thank you for your attention !