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Moisture in wood fuels and drying of wood chips

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Joensuu 7.6.2005

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Wood as a fuel

- A high volatile content (≈ 80 – 85 %) and relatively low carbon content (≈ 50 %)
- At harvest the moisture content of wood is around 50 % (total weight)
- The moisture in the fuel lowers the net heating value
- Moisture content decreases conversion efficiency into energy and increases gaseous emissions (incomplete combustion)

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Wood as a fuel…

- Heating value of wood in average = 19 MJ/kg
- To evaporate 1 kg of water takes about 2,5 MJ/kg H_2O (0,8 kWh/kg H_2O)
- e.g. 2 kg of wood chips, moisture content 50 % = 1 kg dry-matter of wood + 1 kg water

  → net heating value = (19 – 2,5) MJ = 16,5 MJ

  → 8,25 MJ/kg of fuel
- Moisture content affects greatly on heating value of wood fuel (see tables 1 & 2)

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Heating value of wood

- Table 1. *Net heating value of wood in average*

Moisture content %	per kg of fuel MJ/kg	kWh/kg
0	19,0	5,3
10	16,9	4,7
20	14,7	4,1
30	12,6	3,5
40	10,4	2,9
50	8,2	2,3
60	6,1	1,7

- Table 2. *Net heating value of 1 loose-m³ of wood chips, dry matter weight 180 kg*

Moisture content %	kWh/loose-m³
10	940
20	920
30	890
40	850
50	800

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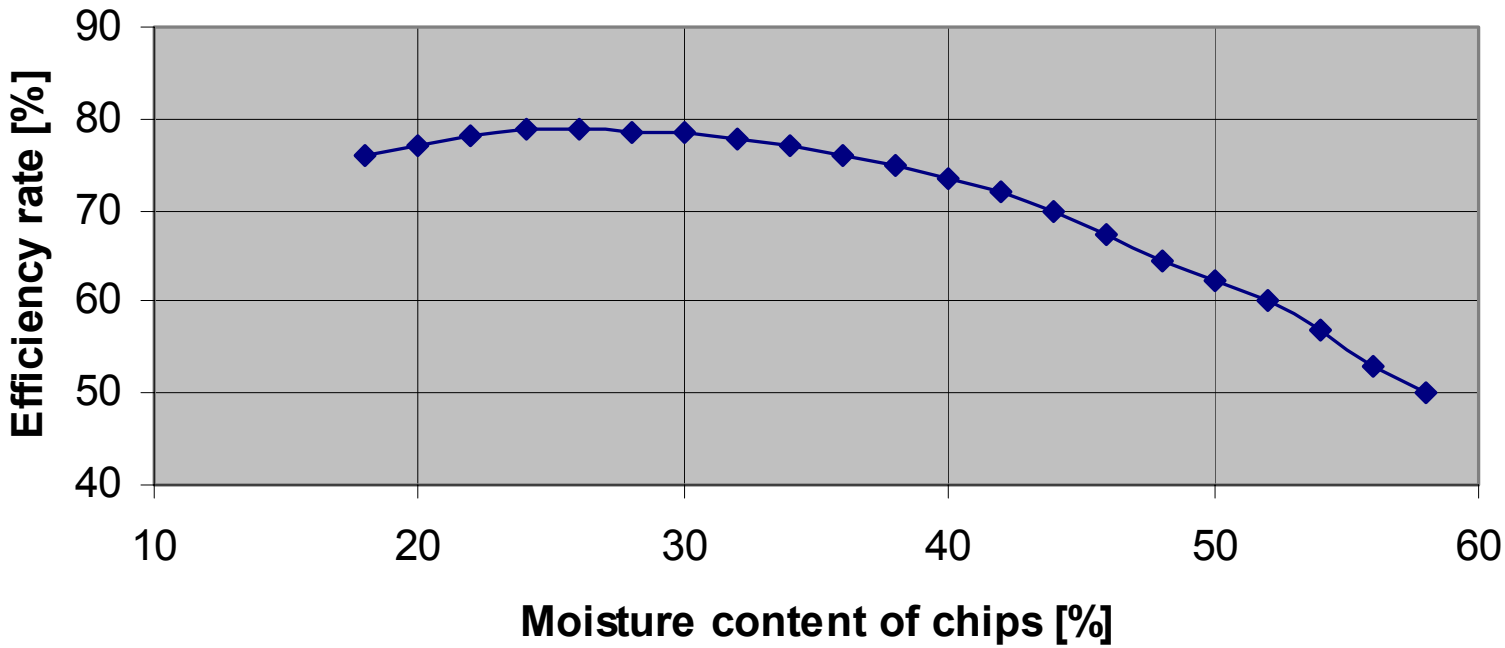
Small-scale boilers vs. moisture content

- In practice the heating effect of small-scale boilers decreases even more
- The total efficiency of the boiler (see figure 1) decreases rapidly when the moisture content rises (boiler tests are usually made with fuel that contains 30 % or less moisture/water)
- It should also be considered that the boiler stays cleaner, malfunctions and need for maintenance decreases → uptime increases

Moisture content vs. boiler efficiency

- Figure 1

An average efficiency of one 50 kW boiler with different moisture content of chips



Example of a small-scale boiler

- We can calculate the amount of heat we will get out of 1 loose-m^3 of wood chips with different moisture content:

a) chips: moisture content 50 %, net heating value 800 kWh/loose-m^3, boiler efficiency: η = 62 %

b) chips: moisture content 20 %, net heating value 920 kWh/loose-m^3, boiler efficiency: η = 77 %

a) E_{heat} = 0,62 x 800 kWh = 496 kWh

b) E_{heat} = 0,77 x 920 kWh = 708 kWh

You get 43 % more heating energy!

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Drying of wood chips

- Traditional drying
  - Whole tree or chip pile
  - In the open or covered
- Artificial/forced drying of wood (usually a fan is been used to produce a high drying-air flow)
  - Un-heated drying-air
  - Heated drying-air e.g.
    - Solar energy
    - boiler water energy
    - Flue gas energy

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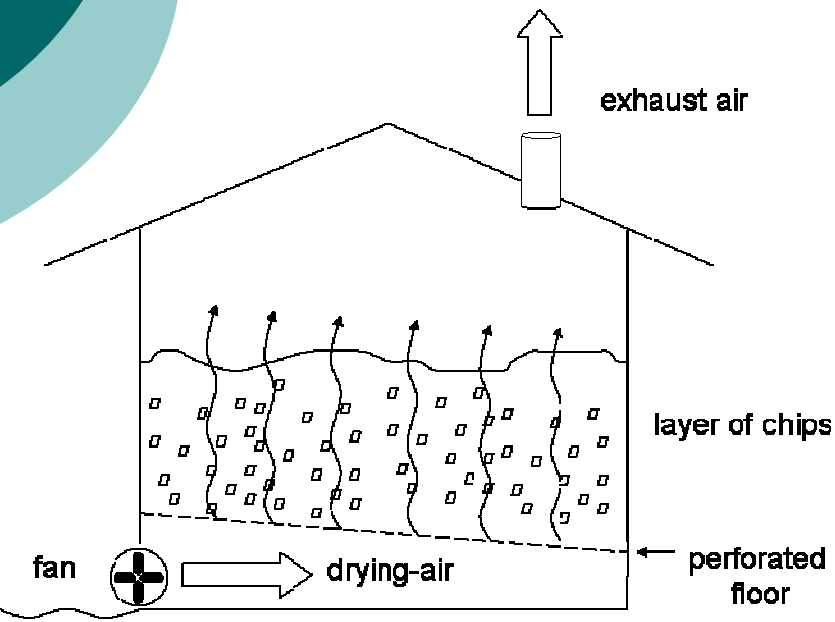
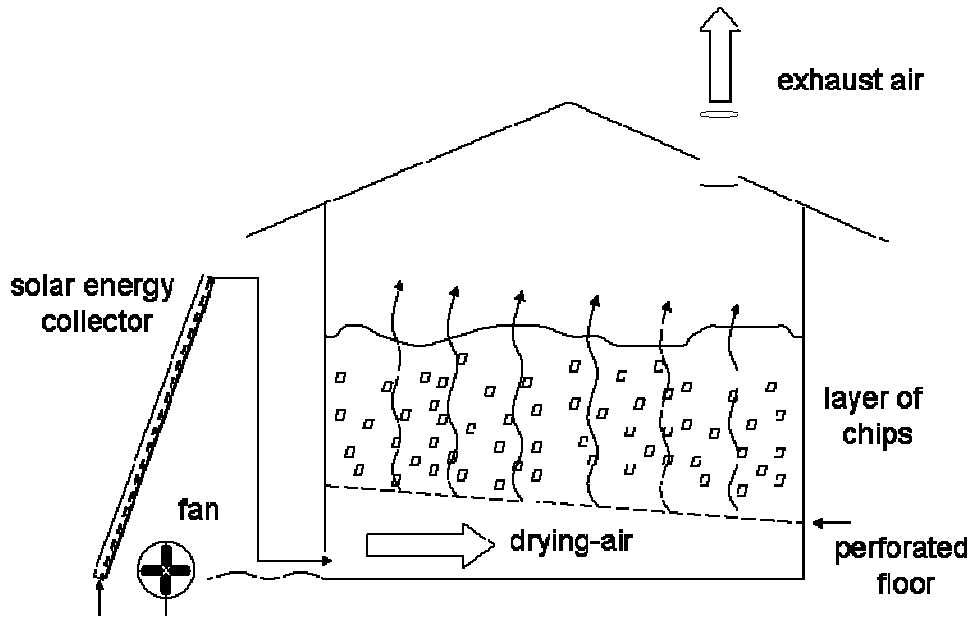
Dryer models



Drying system using unheated drying-air



Drying system using solar energy to heat the drying-air

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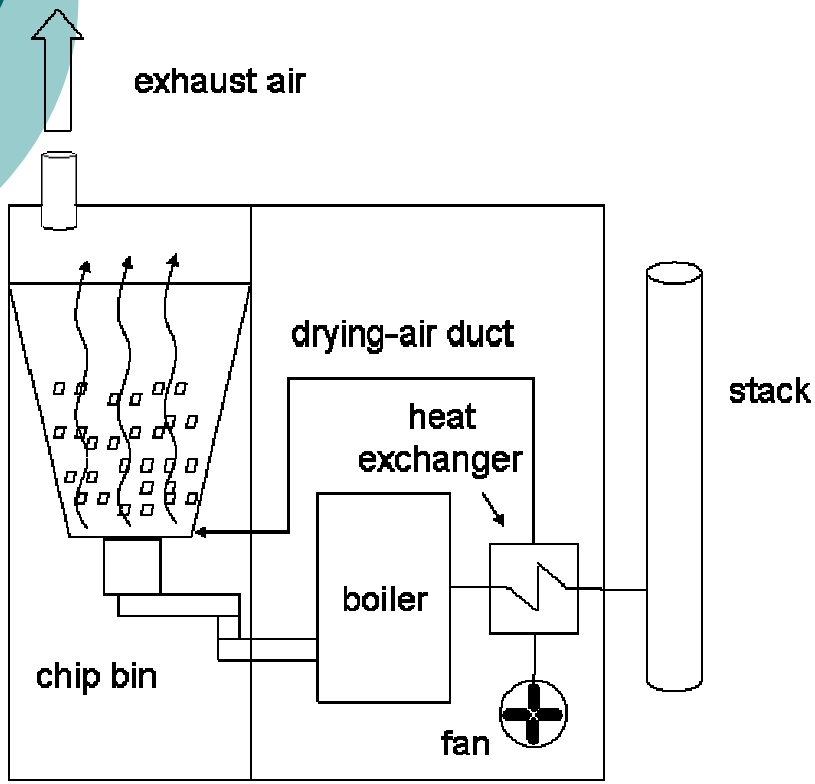
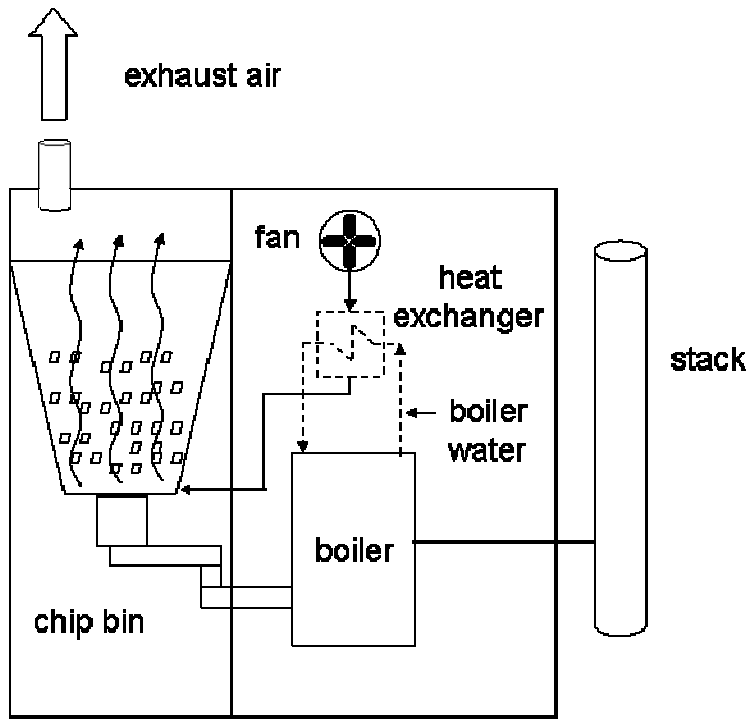
Dryer models...



Drying system using flue gas to heat the drying-air



Drying system using boiler water to heat the drying-air

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Approximate investment costs

- small movable dryer using un-heated drying-air (capacity 70 loose-m^3)
  - dryer building 2 000 €
  - fan 700 €
- medium size dryer using solar energy heated drying-air (capacity 300 loose-m^3)
  - dryer building 15 000 €
  - fan 2 000 €

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General specification for artificial drying

- Air flow should be steady in the dryer and there is always a counterpressure when blowing trough a chip layer.
- Air flow rate with un-heated air is about 400 – 500 m^3/h per loose-m^3 of chips. Height of the chip layer in the dryer is 0,8 – 1,5 m.
- hole/opening density on the dryer floor should be at least 5 – 10 % of the floor area
- It is evenly important to make sure that exhaust air flow rate is big enough to remove the moisture from the dryer (otherwise the moisture condensates in the dryer).

Example…

- The drying time can be calculated approximately:

- chips: 80 loose-m^3; moisture content: 50 %; bulk density 350 kg/loose-m^3
- drying-air fan: 5,5 kW; 400 m^3/h_{air} per loose-m^3 of chips
- desired value of moisture: 20 %; amount of water to be evaporated: 130 kg/ loose-m^3 of chips
- air: density = 1,2 kg/m^3; temperature = 20 C; relative humidy = 60 %; 1 kg of air binds about 2,0 g of water (2,40 g/m3 = 0,0024 kg/m^3)
- drying efficiency: 90 %

It would take $$\frac{130 \frac{kg_{H2O}}{loose - m^3}}{0{,}9 \cdot 400 \frac{m^3_{air}}{h} / loose - m^3 \cdot 0{,}0024 \frac{kg_{H2O}}{m^3_{air}}} = 150\,h$$

- Consumption of electric power is 828 kWh (10,3 kWh/loose-m3)
- If drying-air is been heated (solar energy) +2 °C, water binding capacity will increase to 2,6 g/ m^3 and it would take now 116 hours. Consumption of electric power would decrease 191 kWh (consumption of electricity: 637 kWh, 8,0 kWh/loose-m3).

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Conclusion

- Drying of wood chips might be beneficial if
  - Charged by the amount of wood chips
  - Troubles with boiler when using moist wood chips
  - Existing building for the dryer (smaller investment)
  - ???

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Thank you for your attention!