Wood as a fuel & drying of wood chips

Mikko Helin
North Karelia Polytechnic

June 14th 2005, Joensuu, Finland

Why use wood as a fuel?

- a renewable energy source, grows by converting solar energy
- leaving wood to decompose releases as much carbon dioxide (CO_2) as when it is combusted

  → wood is therefore CO_2-neutral as a fuel
- mainly locally-produced energy sources

  → independence from exported fuels
- transportation distances are usually relatively short

Wood as a fuel

- carbon content ≈ 50 %, nitrogen content ≈ 6 %
- ash ≤ 1 % (typically)
- high volatile content (≈ 80 - 85 %)
  → long flames, big furnace size
- heating value of wood in average
  ≈ 19 MJ/kg ≈ 5,3 kWh/kg

- different forms of wood fuels, e.g. split billets, wood chips and pellets, saw dust, bark, etc.

Wood as a fuel…

- moisture lowers the net heating value
- at harvest the moisture content of wood is around 50 % (total weight)
- 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 net heating value of wood fuel (see tables 1 & 2)

NORTHERN WOODHEAT

Northern Periphery

NORTH KARELIA POLYTECHNIC

Net 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

NORTHERN WOODHEAT

Northern Periphery

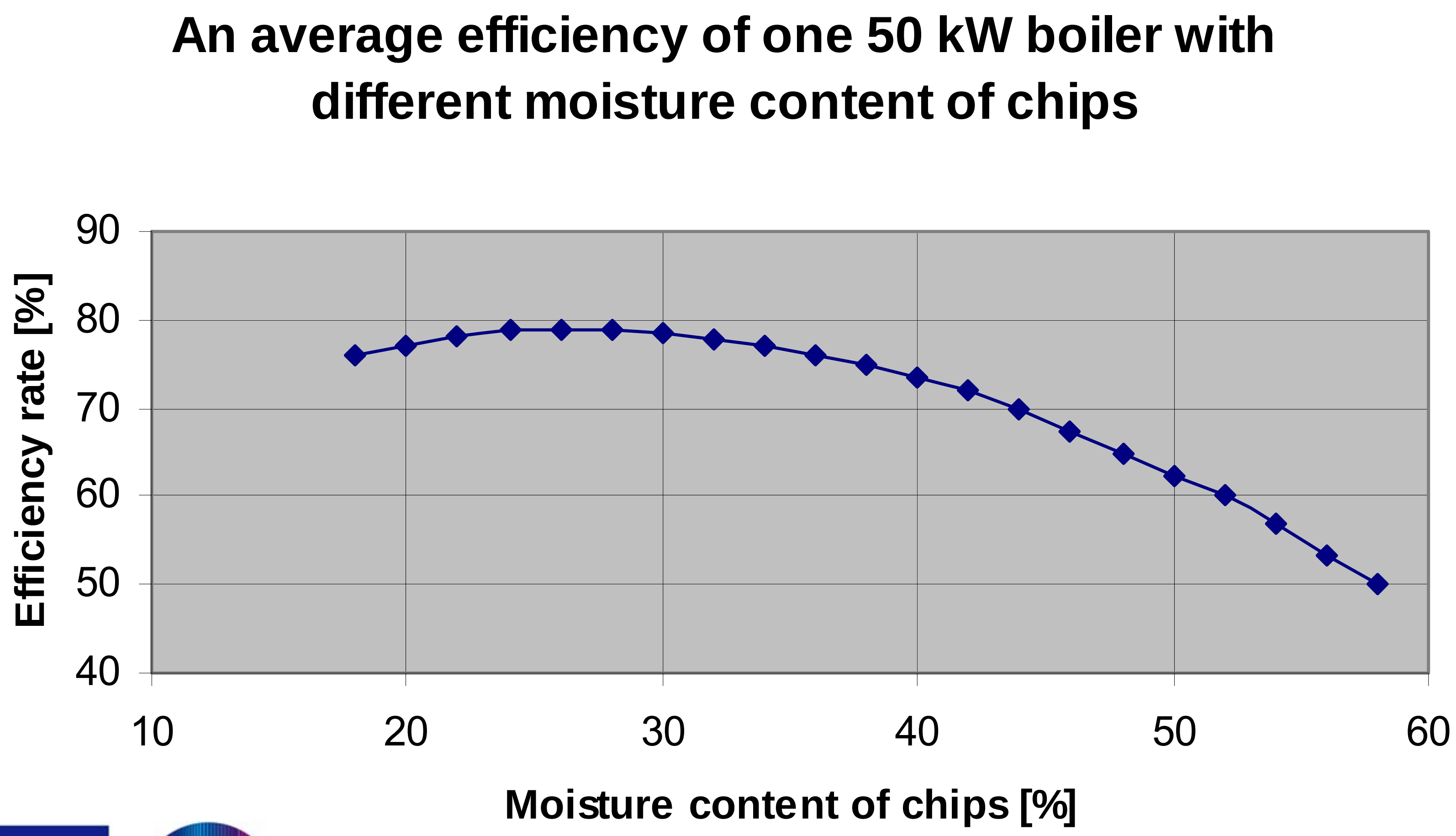
Small-scale boilers vs. moisture content

- 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)
- moisture content decreases conversion efficiency into energy and increases gaseous emissions (incomplete combustion)
- when using dry fuels the boiler stays cleaner, malfunctions and need for maintenance decreases → uptime increases

NORTH KARELIA POLYTECHNIC
NORTHERN WOODHEAT
Northern Periphery

Moisture content vs. boiler efficiency

- Figure 1



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 two different moisture contents using the boiler in the previous slide:

a) chips: moisture content 50 %, net heating value ≈ 800 kWh/loose-m^3, boiler efficiency: $\eta \approx 62$ %
b) chips: moisture content 30 %, net heating value ≈ 890 kWh/loose-m^3, boiler efficiency: $\eta \approx 78$ %

a) $E_{heat} = 0{,}62 \times 800 \text{ kWh} \approx 500 \text{ kWh}$

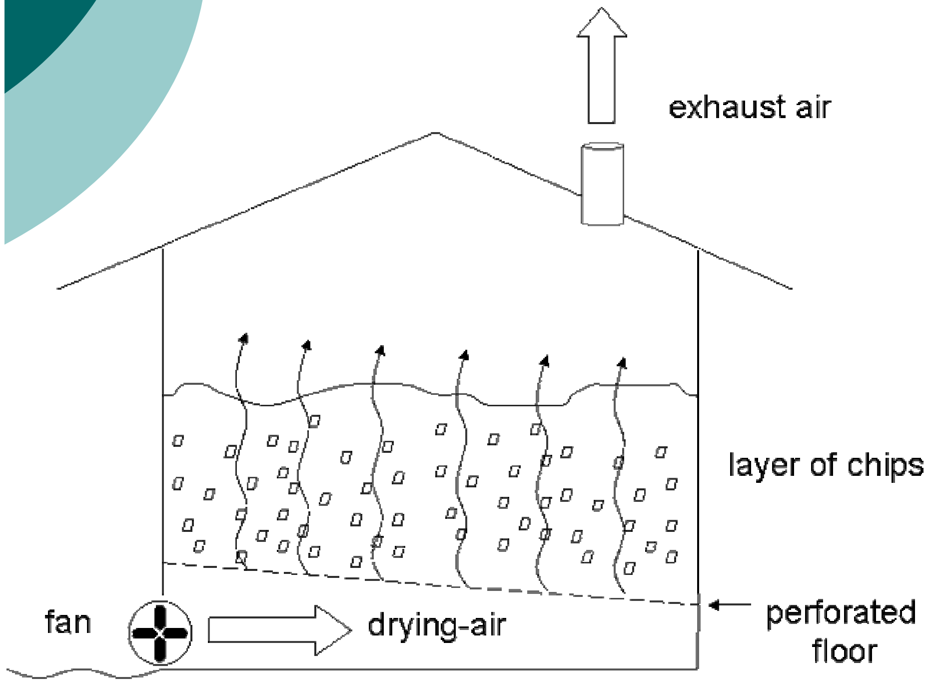
b) $E_{heat} = 0{,}78 \times 890 \text{ kWh} \approx 700 \text{ kWh}$

You get 40 % more heating energy!

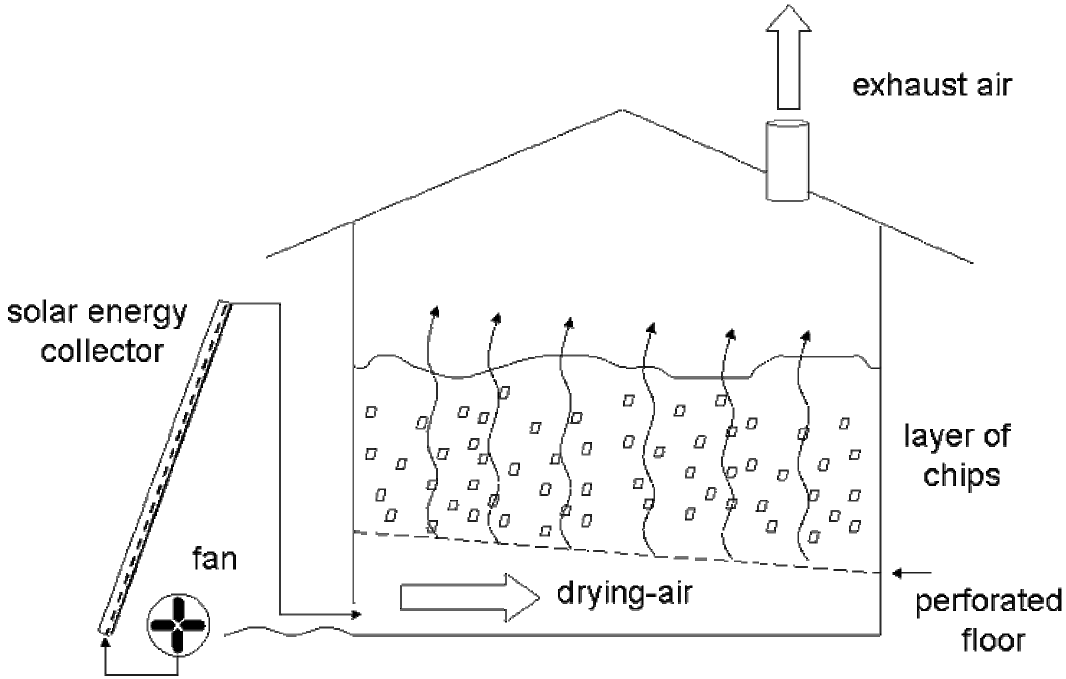
Drying of wood chips

- 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

Dryer models

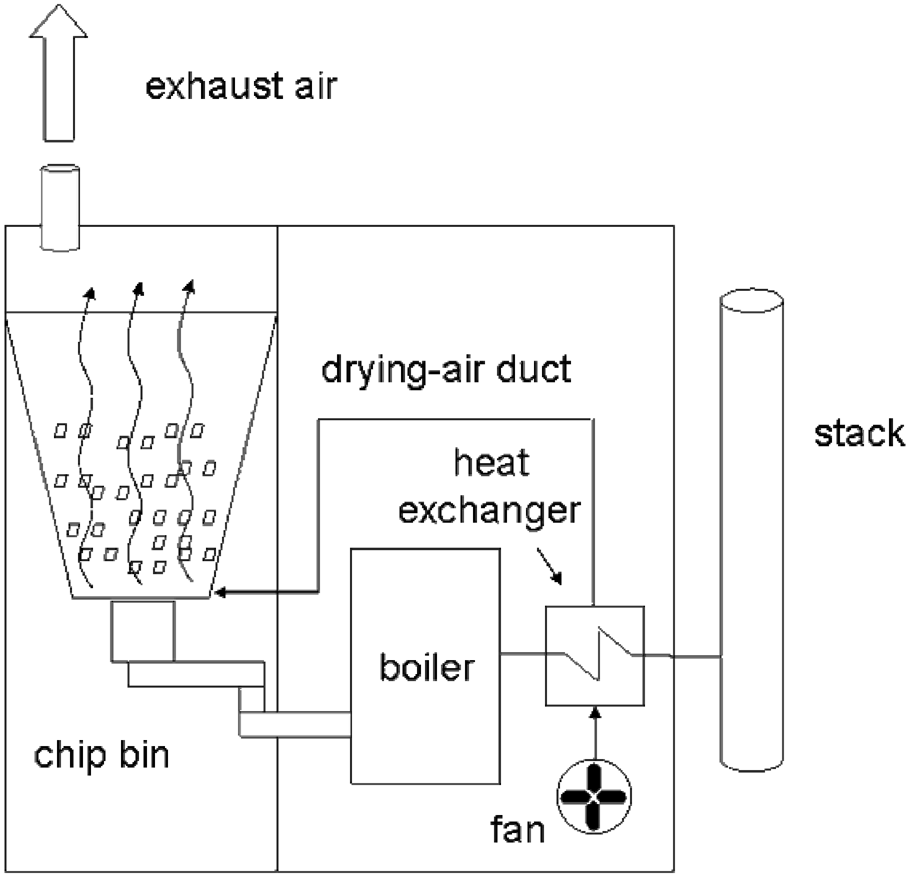


Drying system using unheated drying-air

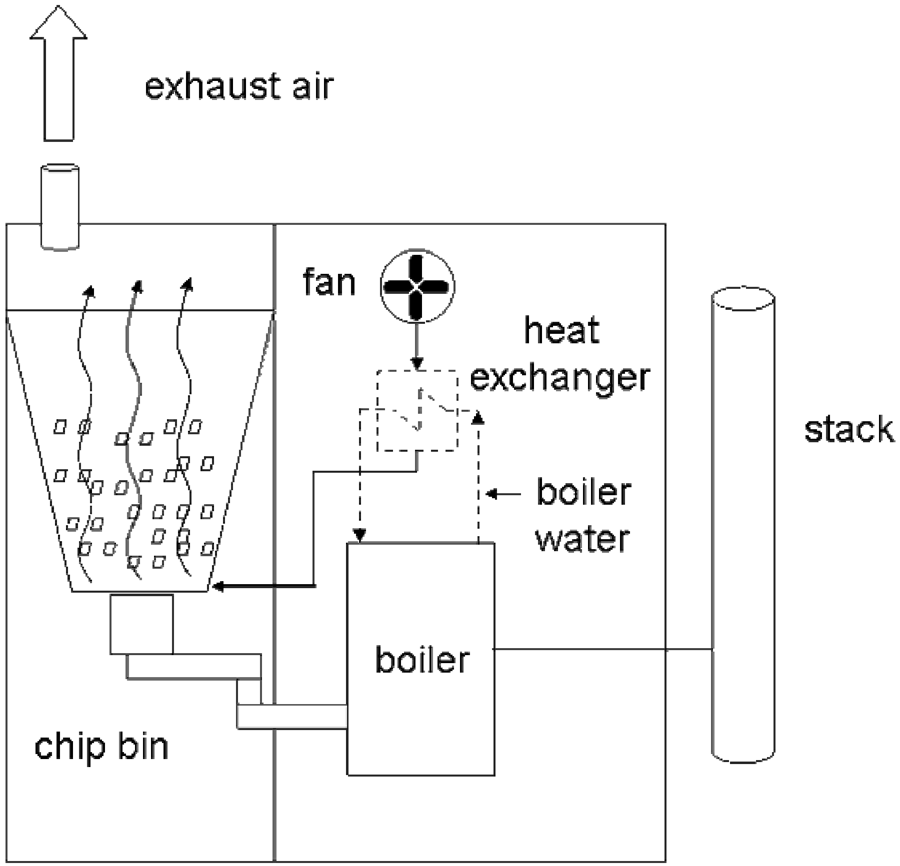


Drying system using solar energy to heat the drying-air

Dryer models…



Drying system using flue gas to heat the drying-air



Drying system using boiler water to heat the drying-air

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 €

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

It would take

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

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

NORTH KARELIA POLYTECHNIC

NORTHERN WOODHEAT

Northern Periphery

Conclusion

- drying of wood chips might be beneficial if
  - charged by the amount of wood chips
  - troubles with boiler when using wood chips with high moisture content
  - existing building for the dryer (smaller investment)
  - ???

Thank you for your attention!