Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste

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Outline of the presentation

- Vision for renewable energy in Europe
- Potential for wood-energy, example Germany
- Wood-energy in the timber industry
- Use of wood for energy in households
- Pellets: technology and economics
- Medium sized heat/heat + power plants: Technology and Economics
- Logging residues: harvesting and costs
- Ecological aspects
- Summary

Selected countries in the EU: Electricity Generation from Biomass (all biomass: wood + agric. biomass) in GWh

	Electricity Share of renewables %	Solar	Wind	Biomass	Hydro-energy
Austria	64	86	79	3452	3132
Denmark	27	9	566	2154	2
Finland	27	1	10	7556	1296
France	12	19	49	12007	5179
Germany	11	269	2173	9367	1812
Great Britain	4	25	166	2863	424
Italy	14	19	159	3145	3671
Sweden	56	5	73	8883	5170
Spain	16	62	1341	4853	2713

European Union: Renewable Energy for Electricity Generation 2006 compared to 2020 (source: EC DG JRC, 2007)

in Terrawatt-hours (TWh)	2006	2020	increase per year	contribution to el-generation 2020
Wind	95	856	17 %	35 %
Biomass	55	209	10 %	9 %
Solar	2,5	150	34 %	6 %
Total	152,5	1250	15 %	
pred. consumption	3040,0	2432 (!)		
Share of renewables	5 %	50 %		

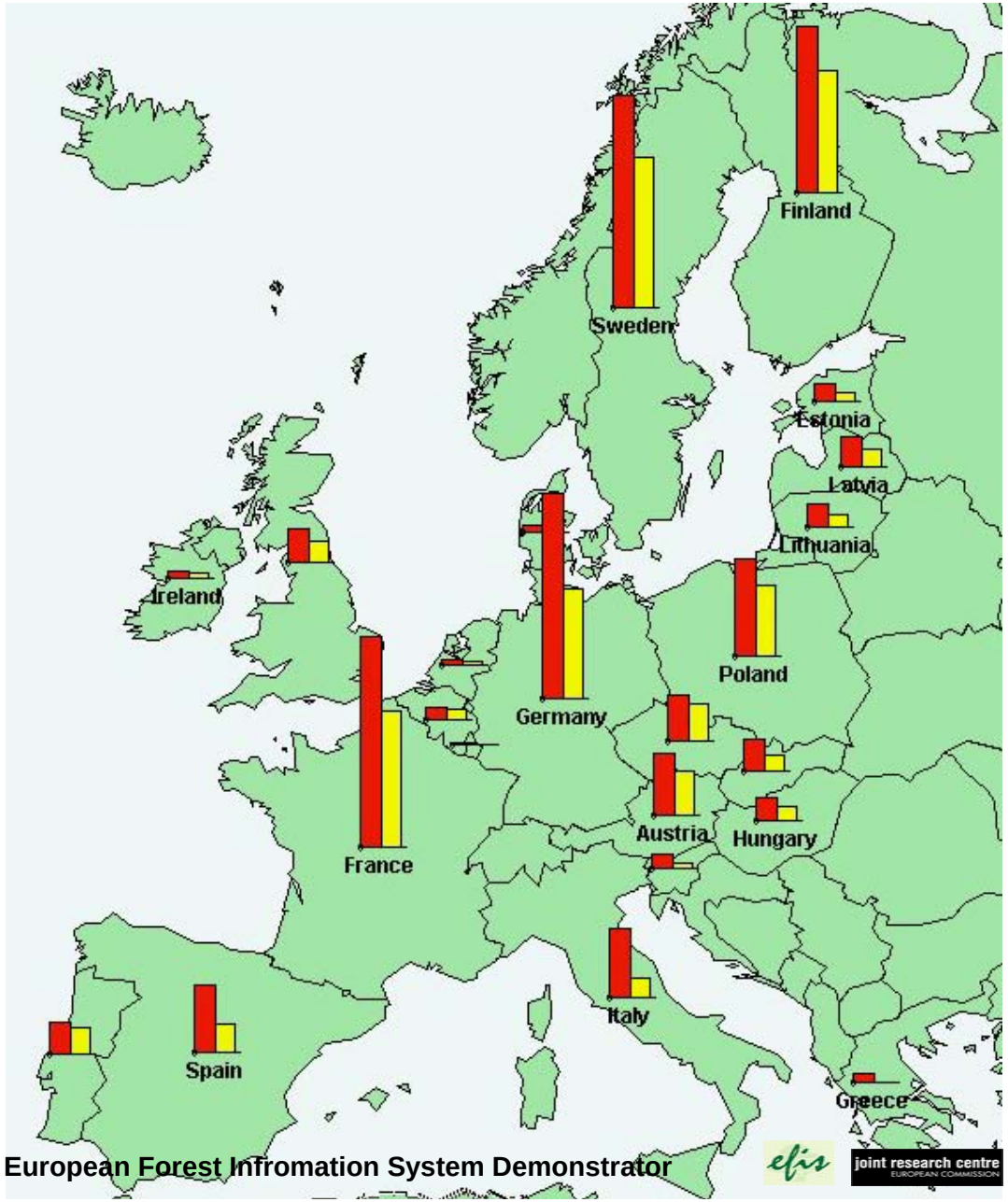
Example Europe

Net annnual increment > fellings

EU 15 (mill m^3):
483 ⇔ 302

Additional 10 EU states (mill m^3):
125 ⇔ 81

Source: UNECE/FAO, 2000; no data for Greece, Luxembourg and Malta)



Germany: Forest, Wood Utilization, Potentials

Forest area ~ 11 Mio ha (~ 30 % of land area)

annual increment (long term)

logs ~ 80 Mio m³

residues ~ 20 Mio m³ (solid volume)

harvests and uses (m³/y)[1)]

logs ~ 70 Mio m³

of which ~ 36 Mio m³ saw logs

~ 15 Mio m³ firewood (priv. households)

~ 8 Mio m³ wood bases panels

~ 6 Mio m³ pulp and paper

~ 5 Mio m³ energy (incl. CHP)

Potentials ~ 10 Mio m³ logs more

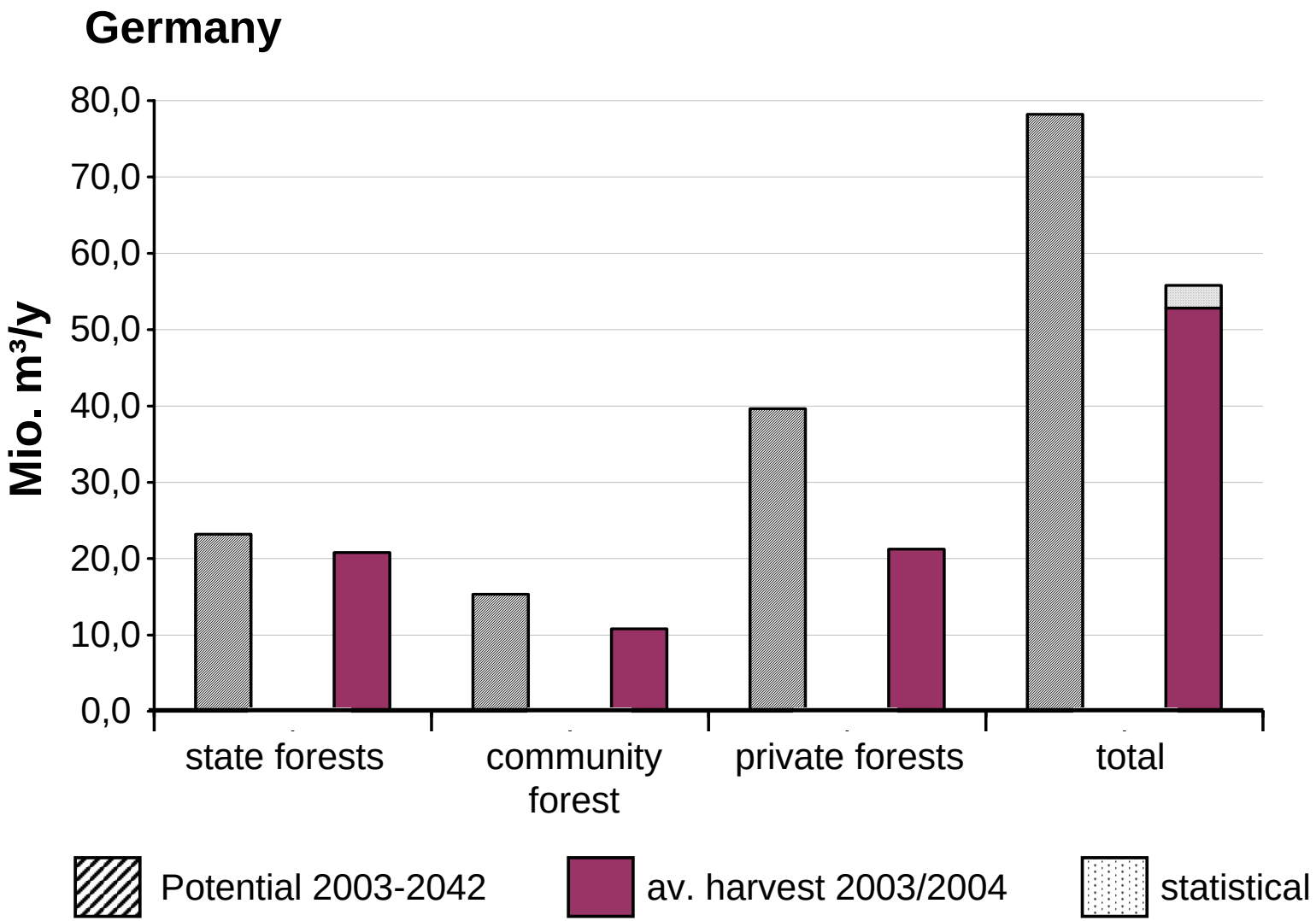
~ 10 – 15 Mio m³ forest residues

(actually 3 – 5 Mio m³ used)

Main problem: private forest owners!

1) Source: Mantau 2007

Potential and Harvest



Wood prices in Germany in Euro/ton (dry)

logs: softwood	80 - 120 +
hardwood	70 – 150 +
forest residues wet, chipped	60 – 80
industrial residues	
chips	70 – 90
sawdust	50 – 70
others	40 – 60
recycled wood	50 – 70 (less if contaminated)
pellets	160 – 220
oil equivalent	230 – 250

1 Euro = 1.35 US$

Germany: Wood Industry, Use of Wood-Energy

		% wood energy of total energy	
		1994	2004
Sawmills	heat	75	80
	power	20	40
Plywood mills	heat	86	90
	power	10	20
Particle- and Fiberboard mills	heat	75	90
	power	5	40
Furniture mills	heat	60	80
	power	5	10

Germanys system to generate more “renewable electricity”

“Renewable Energy Act”

Electricity generated from Renewable sources

Wind

Solar

Biomass

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receives a premium market price (~ 0,10 €/KWh) which is granted for 20 years

Energy Generation in the Timber Industry

120.000 t/a
(240.000 m³/a)
waste wood
forest/industrial residues

Co-generation
wood firing system
Steam 38 bar steam
turbine 120 Mio. KWh/y

Energy

2.500 MJ/m³
100 KWh/m³

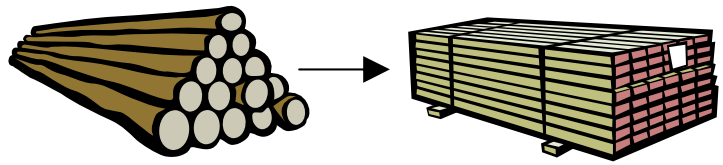
120.000
(240.000 m³/a)
t/a for Energy

Sell electricity
for 9 € cent/KWh

buy electricity
for 4 € cent/KWh

Example Wood Based Panels

Logs 600.000 m³/a
Residues 700.000 m³/a



Boards

i.e. 400.000 m³/a OSB
600.000 m³/a PB

turn over 120 Mio. KWh 0,09 € = 10.800.000 € → 12 €/m³ of board
Invest 50 Mio. €, annual running costs 2 Mio. → total costs 6 Mio €/y

1 Euro = 1.35 US$

Energy from Wood in Households

- fire place (open, closed), efficiency 10-50 %
- simple oven (with heat storage) efficiency 50-70 %

- pellet heating-system (single/double family houses efficiency 80-90 %
- woodchip heating system (dry or wet chips)

  multi-family houses (small installations)

  living quarter (up to i.e. 500 houses)

  or community buildings

Fuel costs for a single family house, Euro/year, 150 m2, built ~ 1980, oil consumption 3000 light fuel oil per year (heating and hot water)

	light fuel oil	natural gas	equivalent wood[1)]
1981 - 1985	1150	1250	750
1986 - 1990	700	1000	750
1991 - 1995	700	1000	750
1996 - 2000	800	1000	750
2001 - 2005	1300	1500	750
2006 - 2007	1800	2000	750 - 1000

[1)] 1 l oil ~ 2,5 kg wood (dry matter), 100 € dry ton, small quantities

1 Euro = 1.35 US$

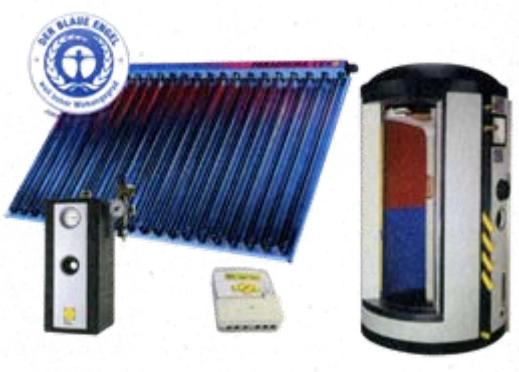
Heat generation with wood pellets, 1,5 MW

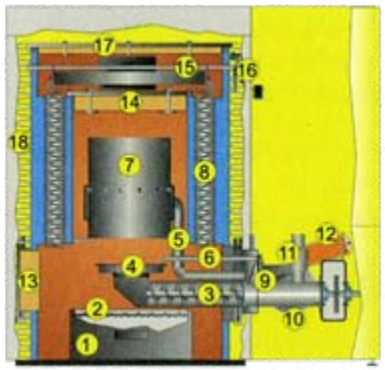
- environmental friendly
- easy maintenance
- low investment

Pellets – one Way to Combat Fossil Fuel Prices

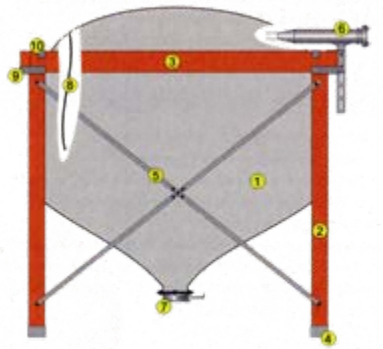
Sawdust or small particles ⟶ Pellets 6-10 mm diameter, density 0,8-1,0 g/cm³

Solar Heating System + **Pellet Heating System**





Silo 10-15 m³ (5-8 t)



Source: Paradigma

70% of required energy

Solar panel

Hot water storage
- Heating
- Hot water

30% of required energy

energy demand
heating + hot water 50 Kwh/m²
150 m² home → 4,0 t Pellets/y
(for new houses)

Pellets - the Rising Star – an Economic Evalutation

Single Family home 150 m² living area		
Pellet firing system 15 kW		12.000 €
Pellet storage + transp. System		2.000 €
Hot water storage system 500 l		2.000 €
Solar panel system 5 m²		5.000 €
others		2.000 €
	Investments	**23.000 €**
costs per year:		
depreciation 20 years		1.150 €/y
maintenance		500 €/y
pellets 4 t/y		900 €/y
	total	**2.550 €/y**
Alternative:		
gas-oil system 8.000 € Invest		160 €/y (no solar)
maintenance		300 €/y
oil/gas (3.000 l oil /y)		1.950 €/y
	total	**2.410 €/y**

1 Euro = 1.35 US$

CHP-Plant of medium size

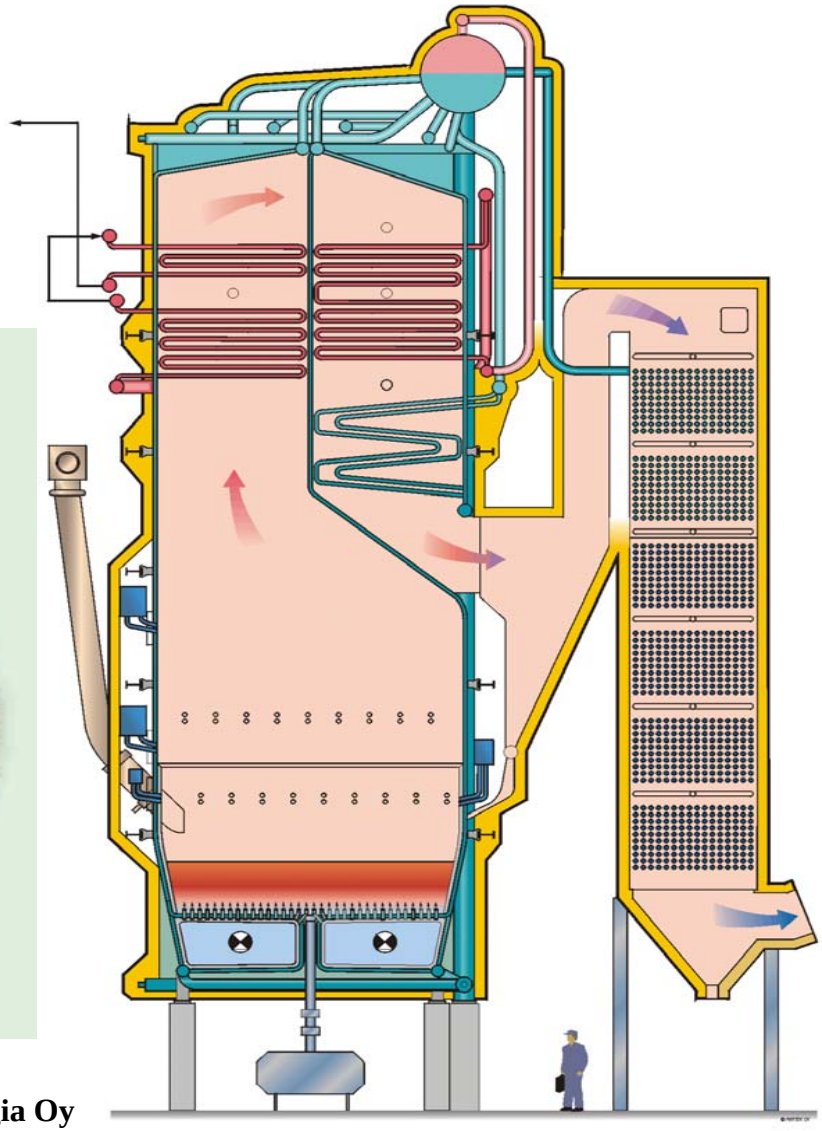
FOSTER WHEELER

Forssan Energia Oy, Finland

Bubbling fluidizes bed boiler

22.8 kg/s, 62 bar, 510°C 66 MW_{th}

fuels: recycled wood, forest residues



With permission of Forssan Energia Oy and Foster Wheeler Energia Oy

FORSSAN ENERGIA OY
FORSSA, FINLAND

Lunds Energi AB
wood fired
district heating plant
Lund/Lomma, Sweden

Lunds Energi AB
heating plant

Lunds Energi AB
silo for chips

Lunds Energi AB
waste wood storage

Economic Aspects

CHP-Plant 4,5MWth/1,1 MWel
Investment 4.455.000 EURO (2006)
fuel: green chips (non forest)

Sales Revenues	**€/y**	
Power 8000 h/y x 1,09 MWh = 8546 MWh x 119 €/MWh	= 1.016.000	
Heat 8000 h/y x 2,39 MWh = 19000 MWh x 4 €/MWh	= 76.000	
Total	**= 1.092.000**	
Cost Structure		
chips: 43.152 m³ (vol) x 3 € /m³	= 129.000	**9 €/m³**
electricity: 8000 h/y x 264 KW = 2112 MWh/y x 55 €/MWh	= 116.000	
ash: 532 t/y x 40 €/t	= 21.000	
personal: 1 person x 35.000 €/y	= 35.000	
maintainance: 1,3 % o f investments	= 58.000	
insurance:	= 8.000	
others:	= 30.000	
sub-total	**= 390.000**	**648.000**

Source: Seeger Engineering 2007

1 Euro = 1.35 US$

Economic Aspects

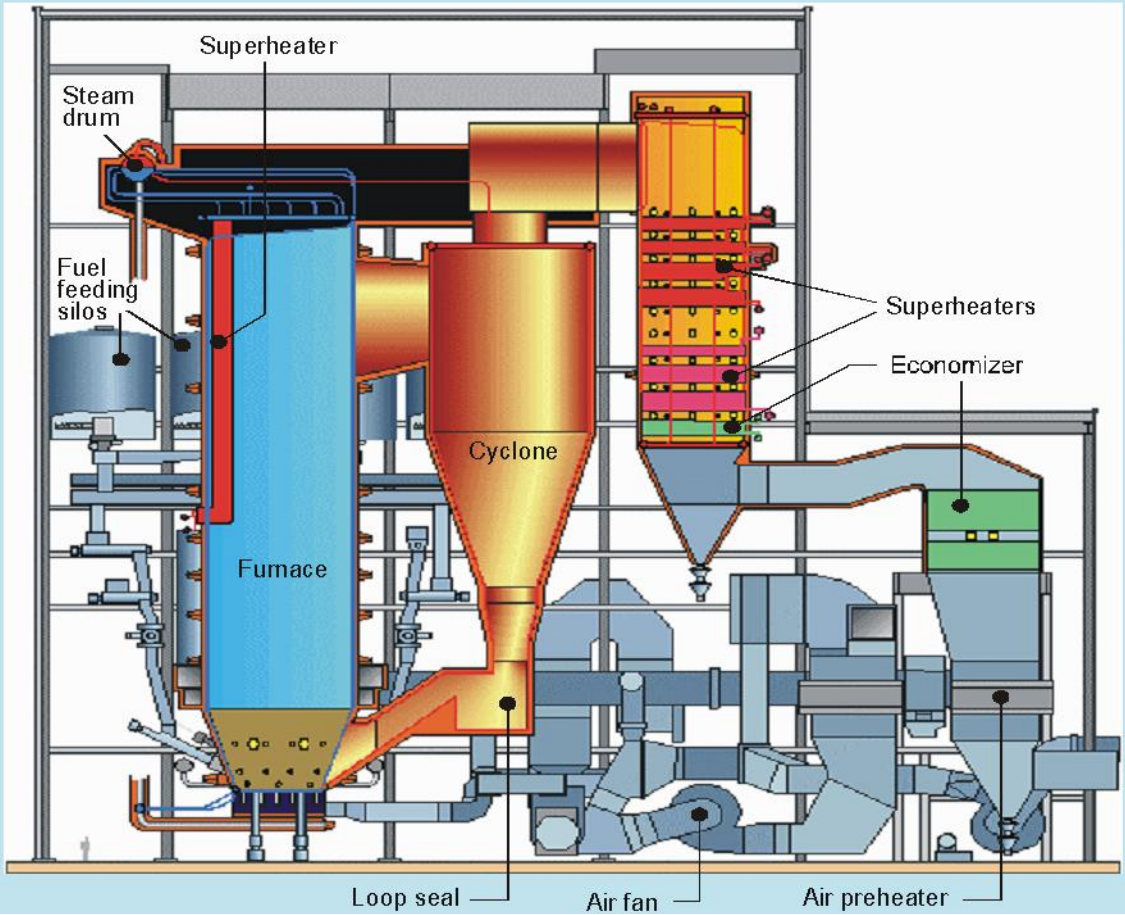
CHP-Plant 4,5MWth/1,1 MWel
Investment 4.455.000 EURO (2006)
fuel: green chips (non forest)

Sales	1.092.000		
Direct Costs	390.000		
Gross Profit	702.000	→ 16 % of Investment pay back 6,7 years	**648.000** **10 % of Investment** **pay back 10 years**
Depreciation 8 %/12,5 years	376.000		
Net Profit	326.000	→ 7,3 % interest on capital	

Source: Seeger Engineering 2007

1 Euro = 1.35 US$

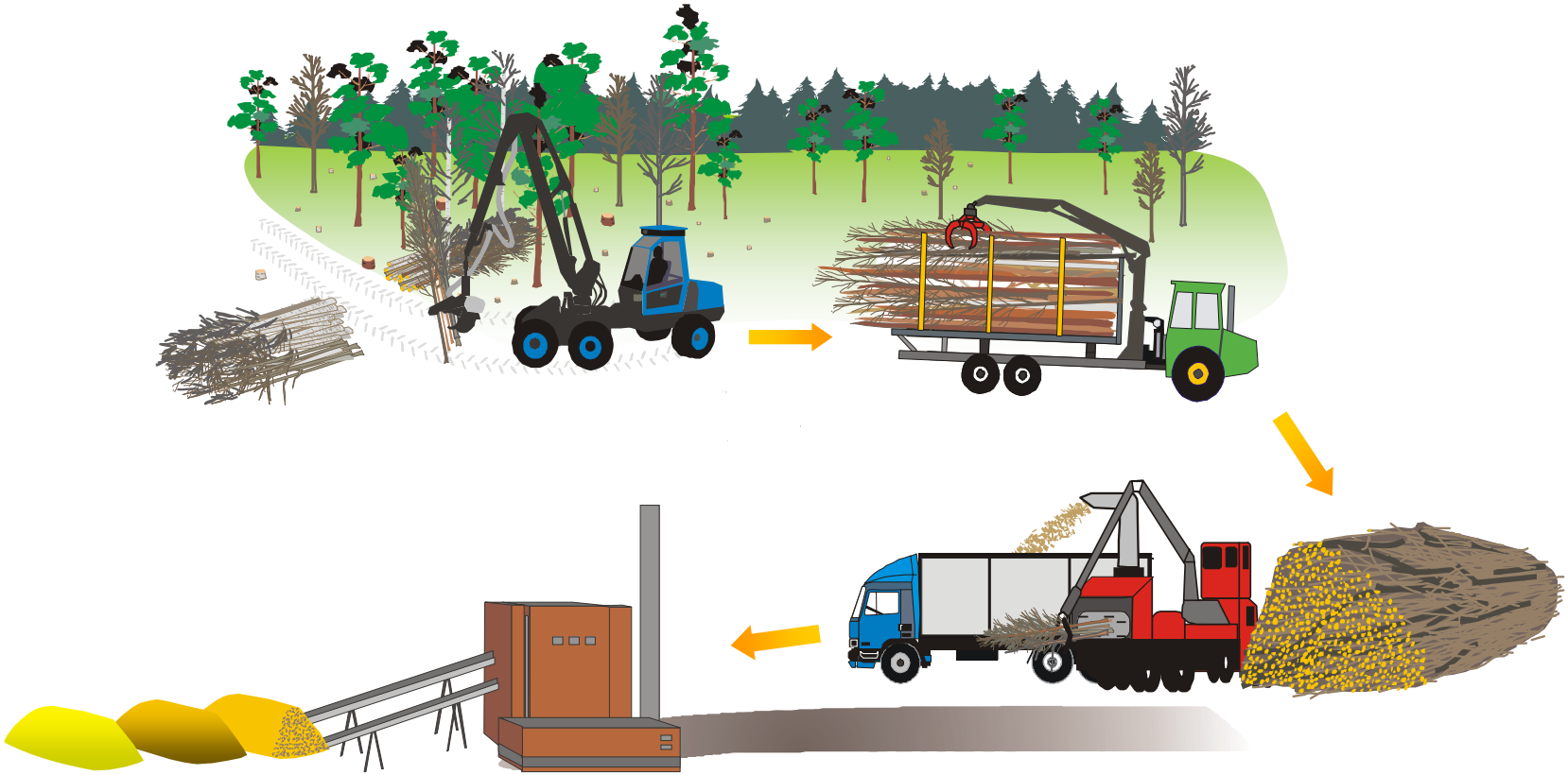
The world largest biomass heated CHP-Plant (550 MWel)



Plant	Oy Alholmens Kraft Ab	
Supplier	Kvaerner Pulping Oy	
Commissioning	2001	
Fuels (annual share)	Peat	45%
	Wood fuels	45%
	Coal and oil	10%
Thermal power	550 MW	
Live steam	194 kg/s, 165 bar, 545 °C	
Boiler efficiency	92%	
Plant output	Electricity	240 MW
	Process heat	100 MW
	District heat	60 MW
Emission limits	SO_2	70 mg/MJ
	NO_x	50 mg/MJ
	Particles	30 mg/m^{3}n

Whole tree chips for energy

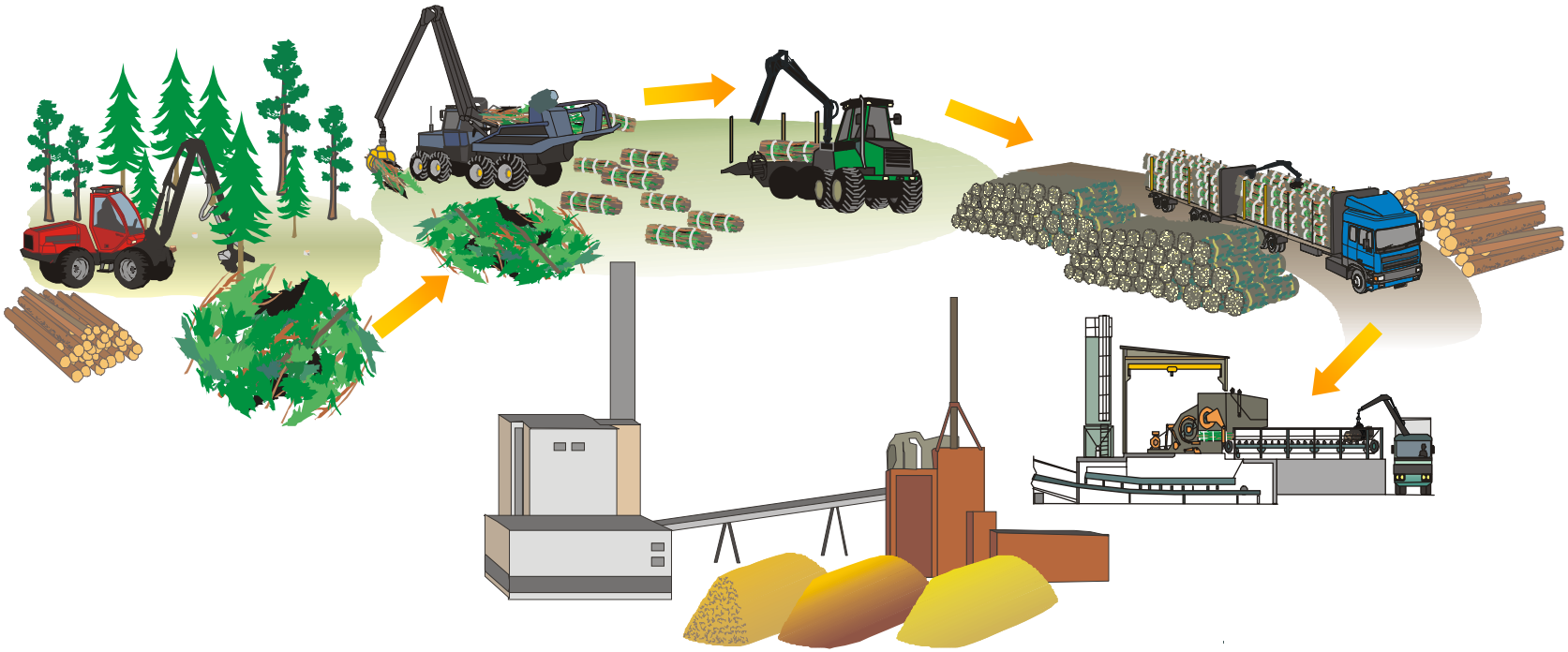
Whole trees, chipping at landing, transport with truck to plant



Source: VTT

Chipping at power plant

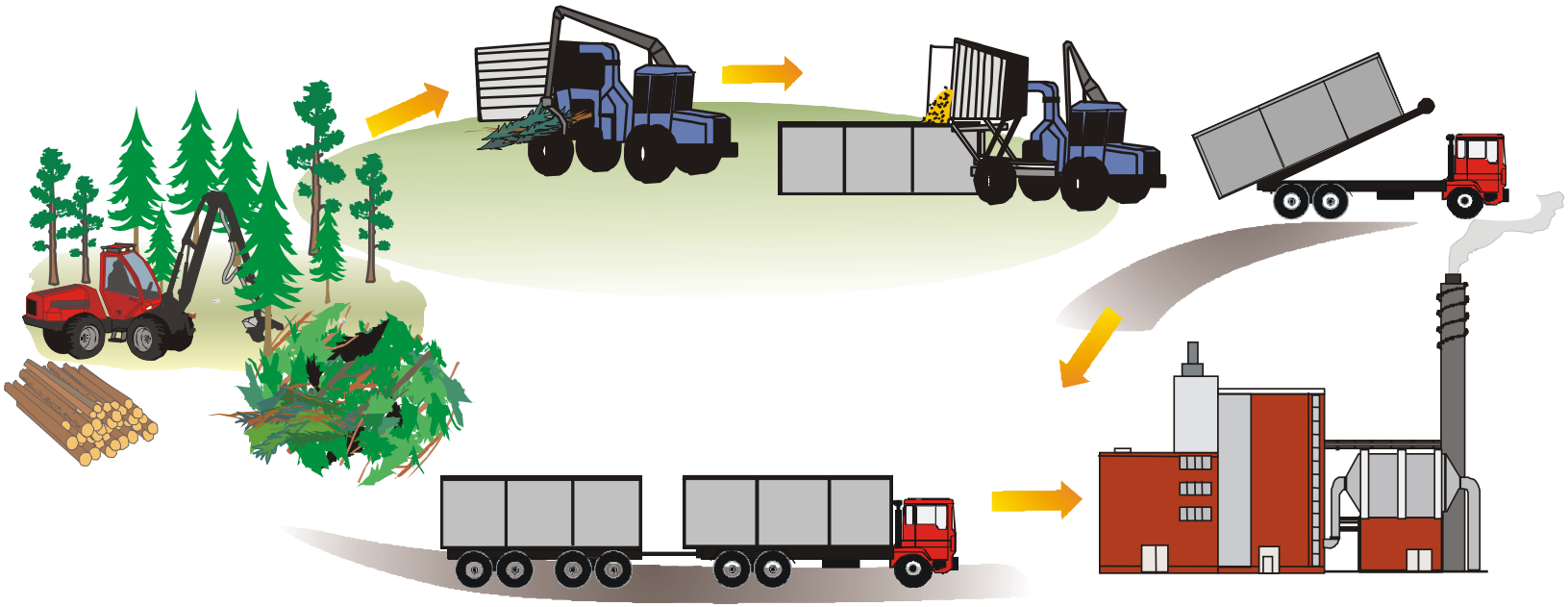
Logging residues, bundling at logging site, forwarder to street, transport with truck to plant



Source: VTT

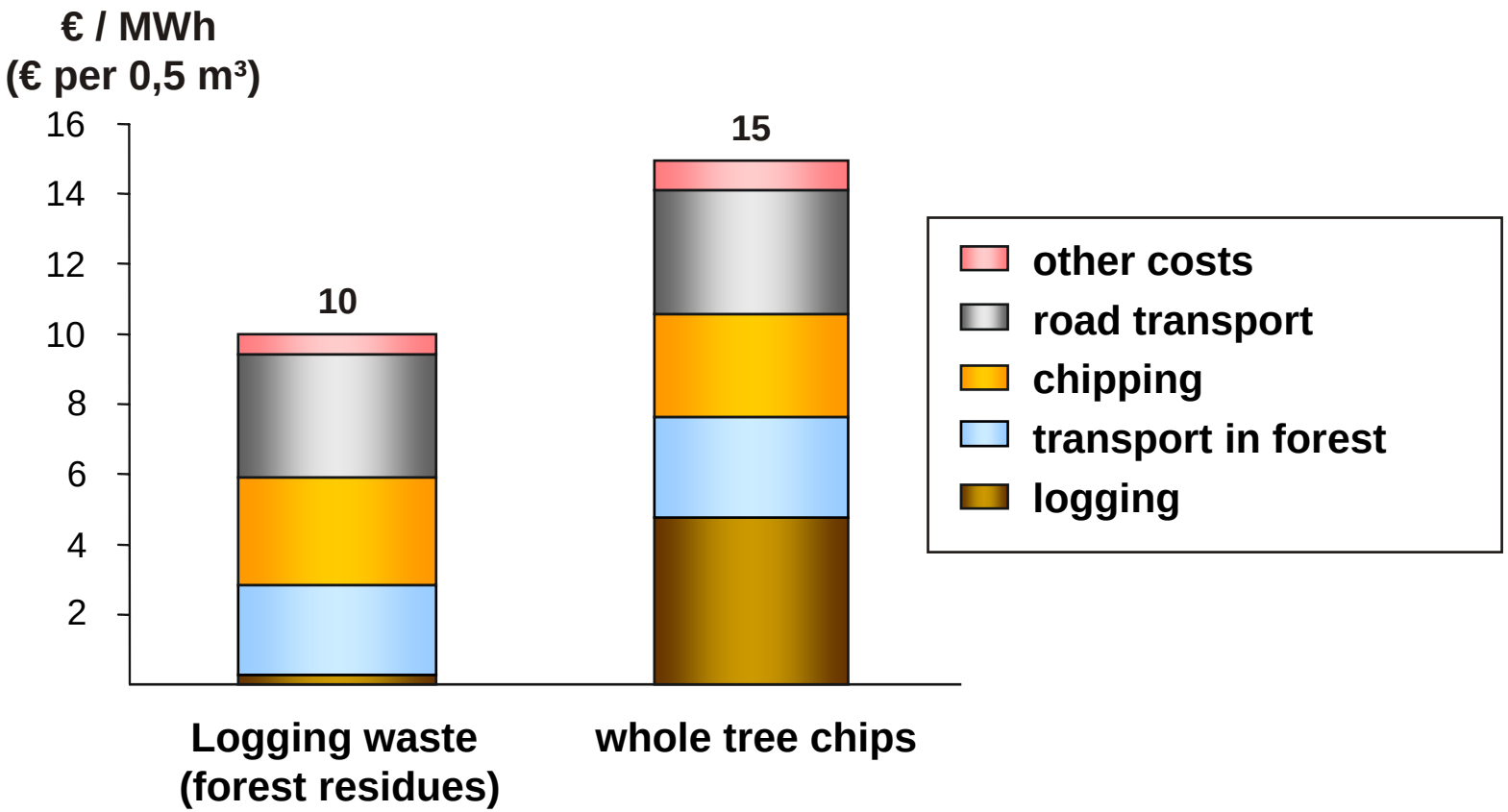
Chipping at logging sites

Logging residues, off road chipper, transport in separat containers



Source: VTT

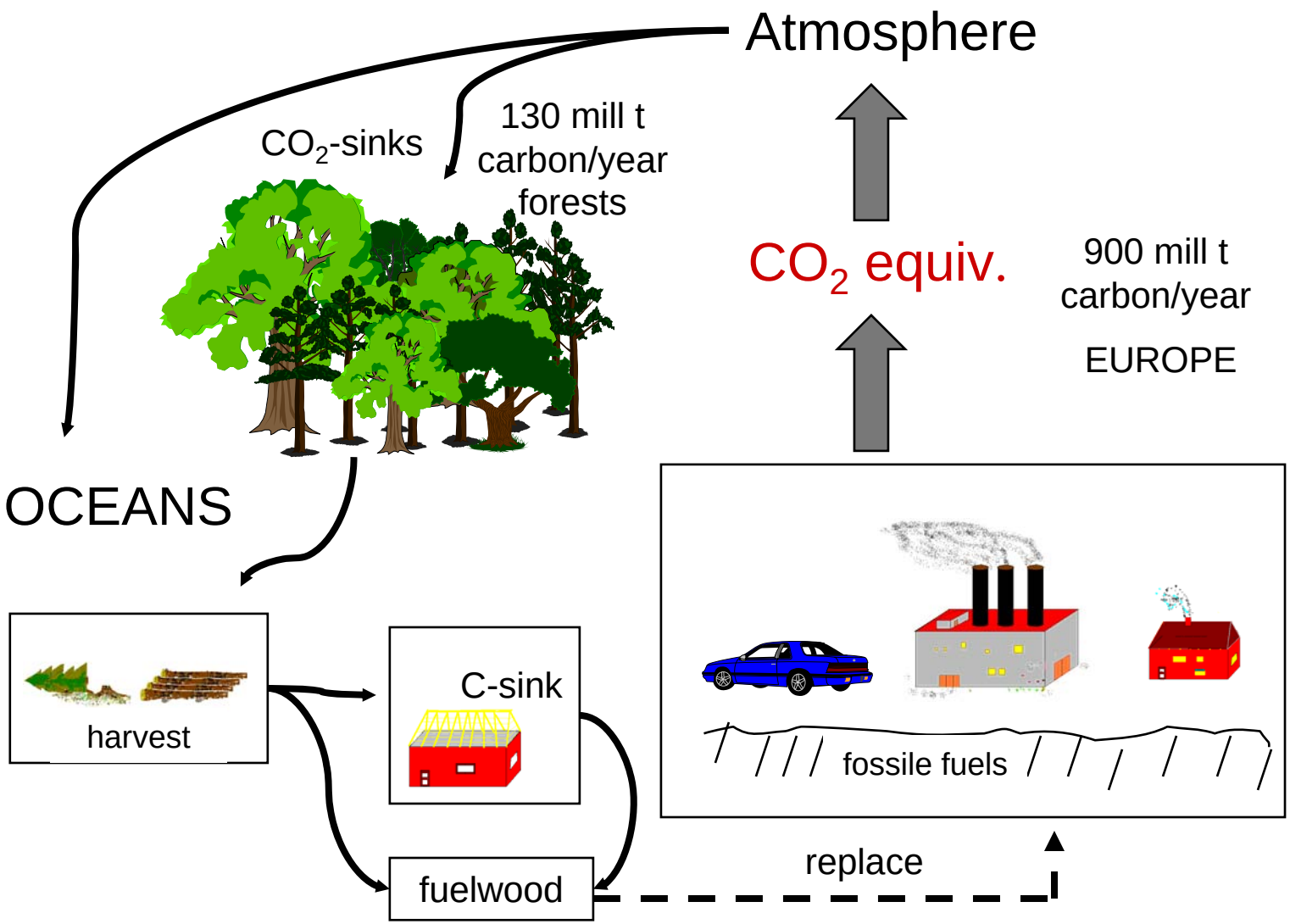
Cost structure for forest residues for energy



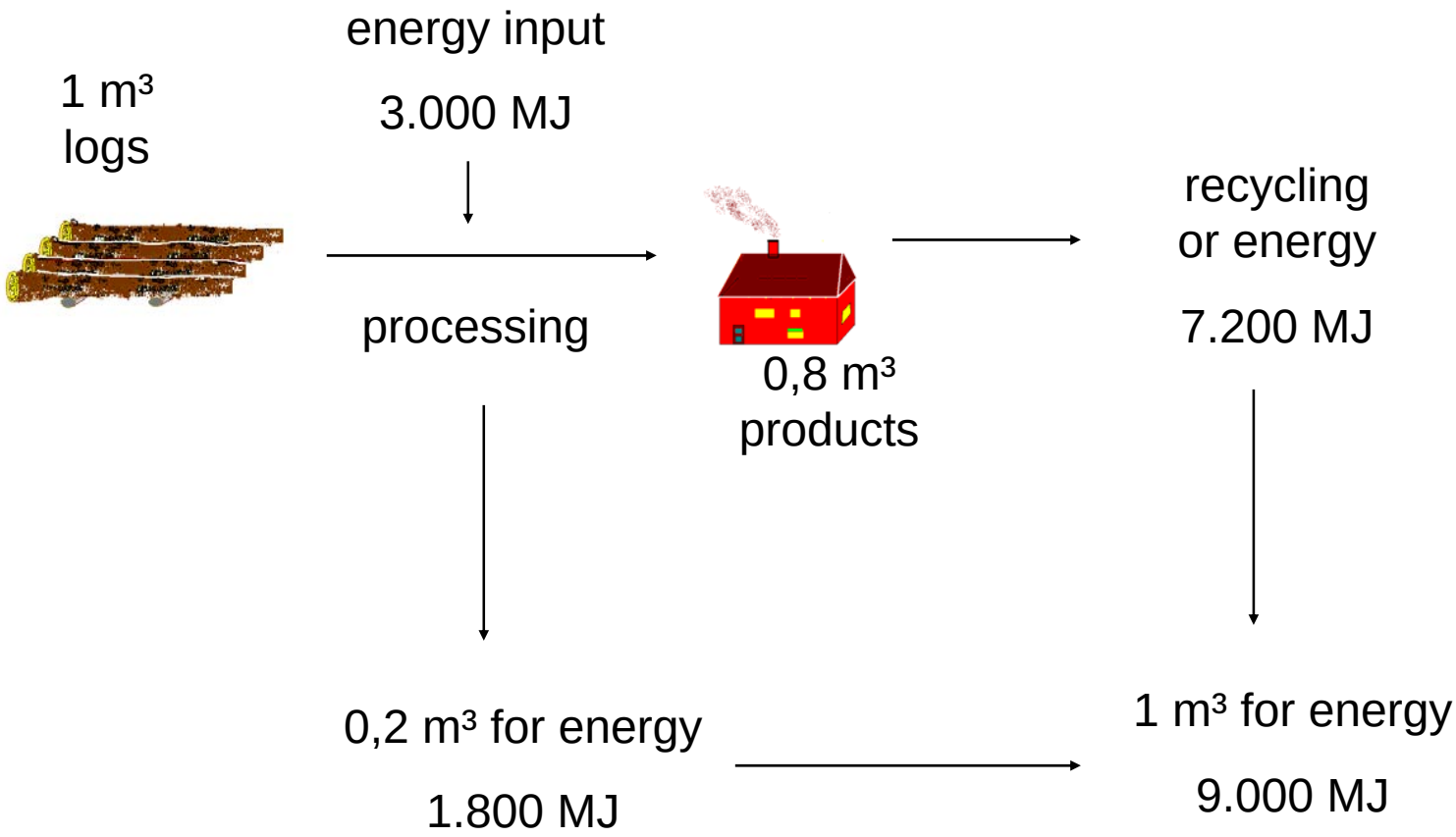
Source: VTT

1 Euro = 1.35 US$

Closed carbon cycle

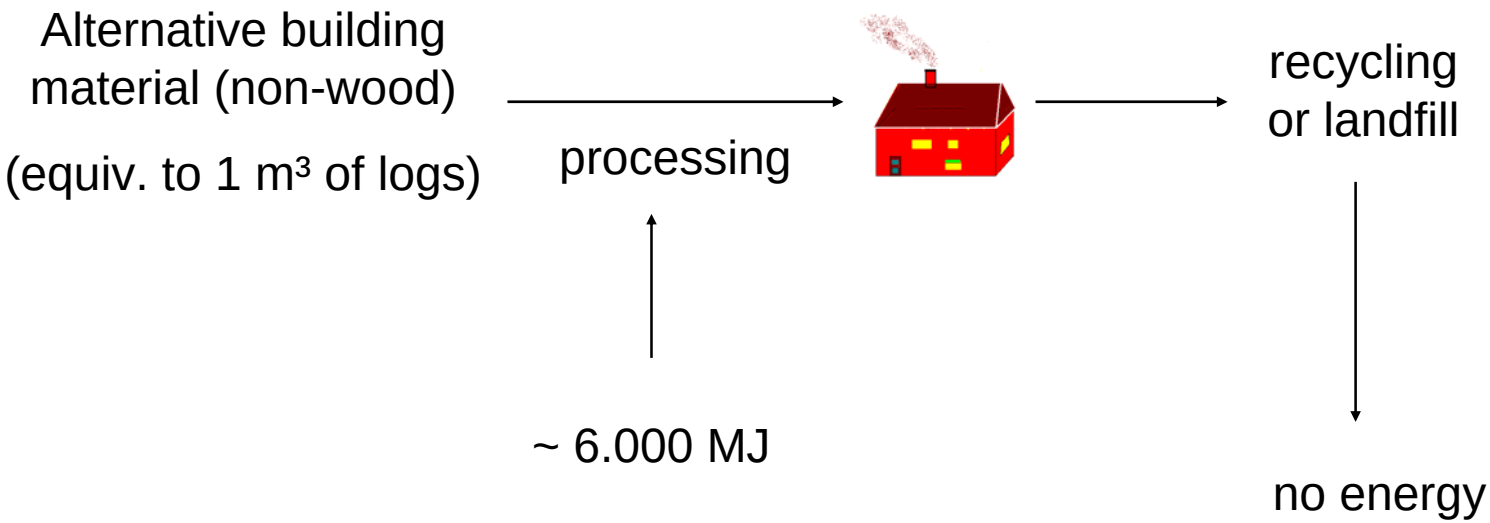


Energy aspects of wooden products



Δ = 6.000 MJ/m³ energy surplus

Energy aspects of non-wooden products



Δ = 6.000 MJ/m³ energy consumption

Summary comparison wood - non wood system

a) from wood system — 6.000 MJ/m³ logs surplus energy (to replace fossil energy)

b) from non wood systems — 6.000 MJ/m³ logs equivalent input (fossil energy)

Wood system replaces 12.000 MJ/m³ logs fossil energy

=> equivalent to 1,10 t CO_2 or 0,30 t C emitted into atmosphere

Compared to storage in the forest

1 m³ is equivalent to ~ 0,25 t C or 0,90 t CO_2

The consequences: **Use more wood**

- **first to produce products**
- **second to produce energy**

Summary

1. More wood is available from traditional forestry – in Europe as in many other countries – but: forest owners often not interested to sell wood
2. Higher wood removals cause higher costs and higher market prices
3. Wood-fuel prices are generally competitive
4. Technologies for wood-energy generation exist in all capacities, from 3 KW up to 200 (500) MW
5. Small (20 KW) and mid-size installations are competitive to other (fossil!) fuels
6. Policy can establish measures to promote renewable energy (biomass)
7. Wood-energy is environ mentally friendly but competes with the use of wood for products

Thank you for listening

Tack för Uppmärksamheten

Merci beaucoup pour votre attention

Vi ringrazio per la cortese attenzione

Muchas gracias por su atención

Vielen Dank für Ihre Aufmerksamkeit