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Increasing energy efficiency of pulp mills

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Current situation

- Pulp and paper industry has in the recent past significantly reduced energy use and increased share of primary energy – example Finland
- As one of the largest industrial sectors continuing progress is essential
- New opportunities for electricity generation can lead to changes in processes for boilers
- New opportunities for biofuel utilization can lead to extraction of organics

Share of bioenergy in Finnish forestindustry is high

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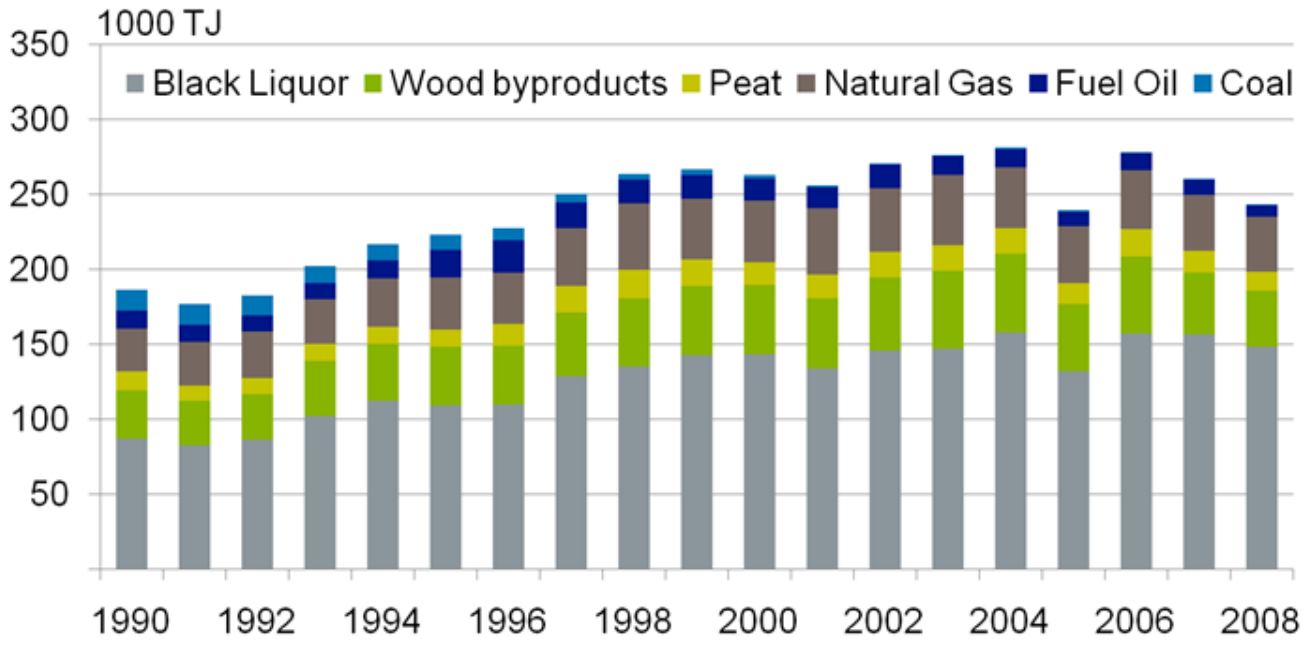
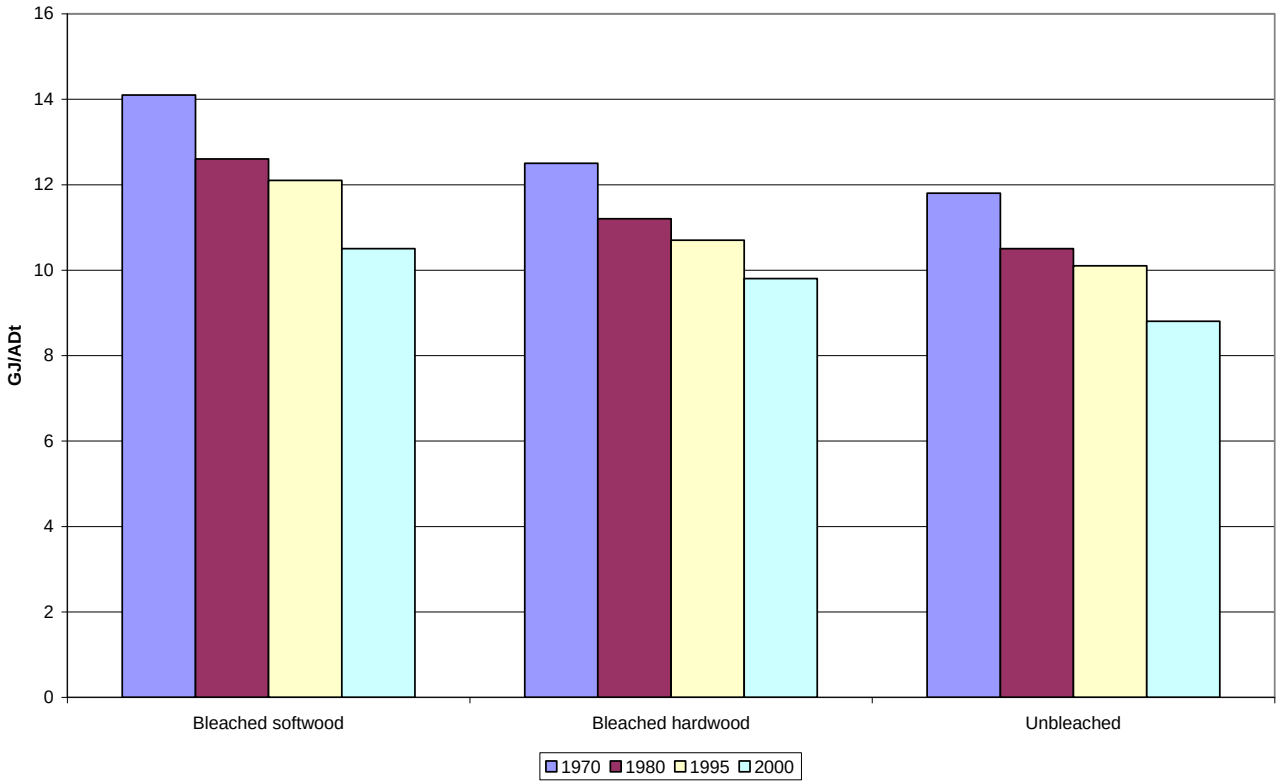


Maintaining high energy efficiency and intelligent use of resources is essential

Specific use of heat can be improved



Finnish pulp mill heat usage per ton of production (Nieminen, 2007)

Specific use of heat can be improved

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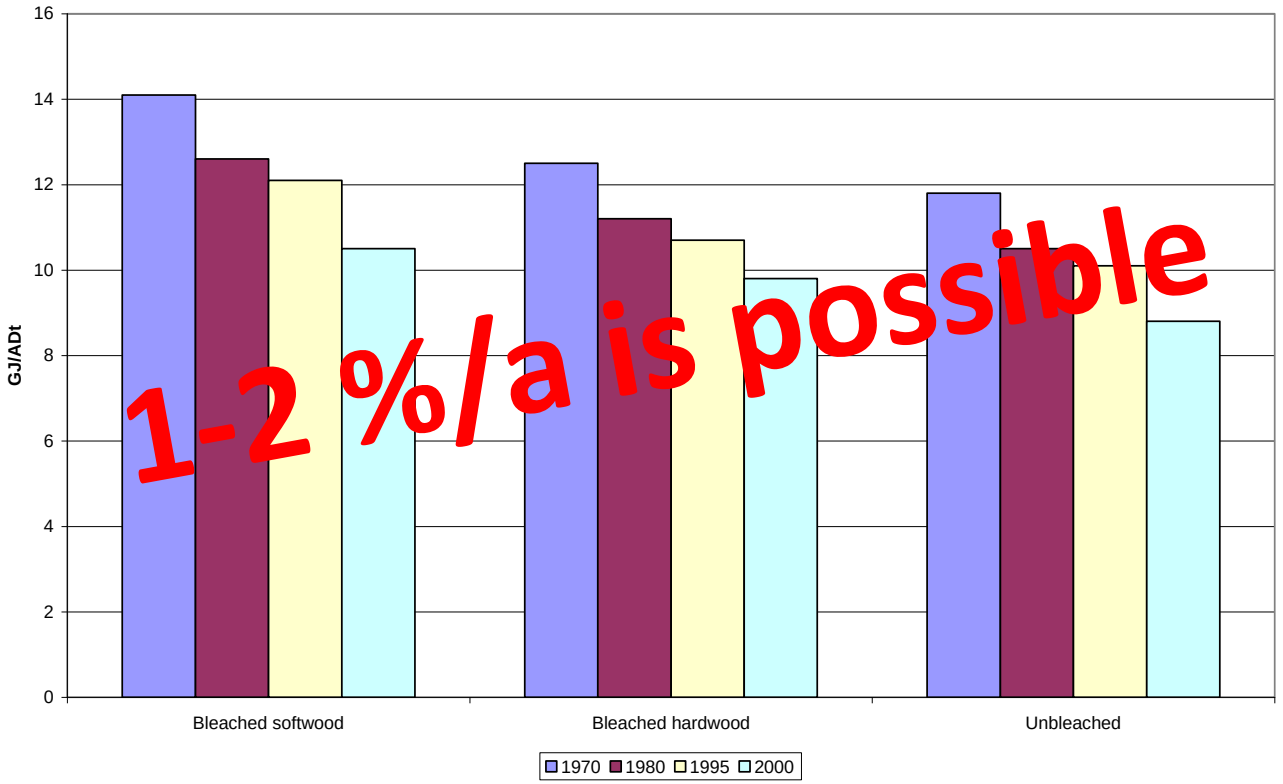

Finnish pulp mill heat usage per ton of production (Nieminen, 2007)

Wood species will affect the energy consumption

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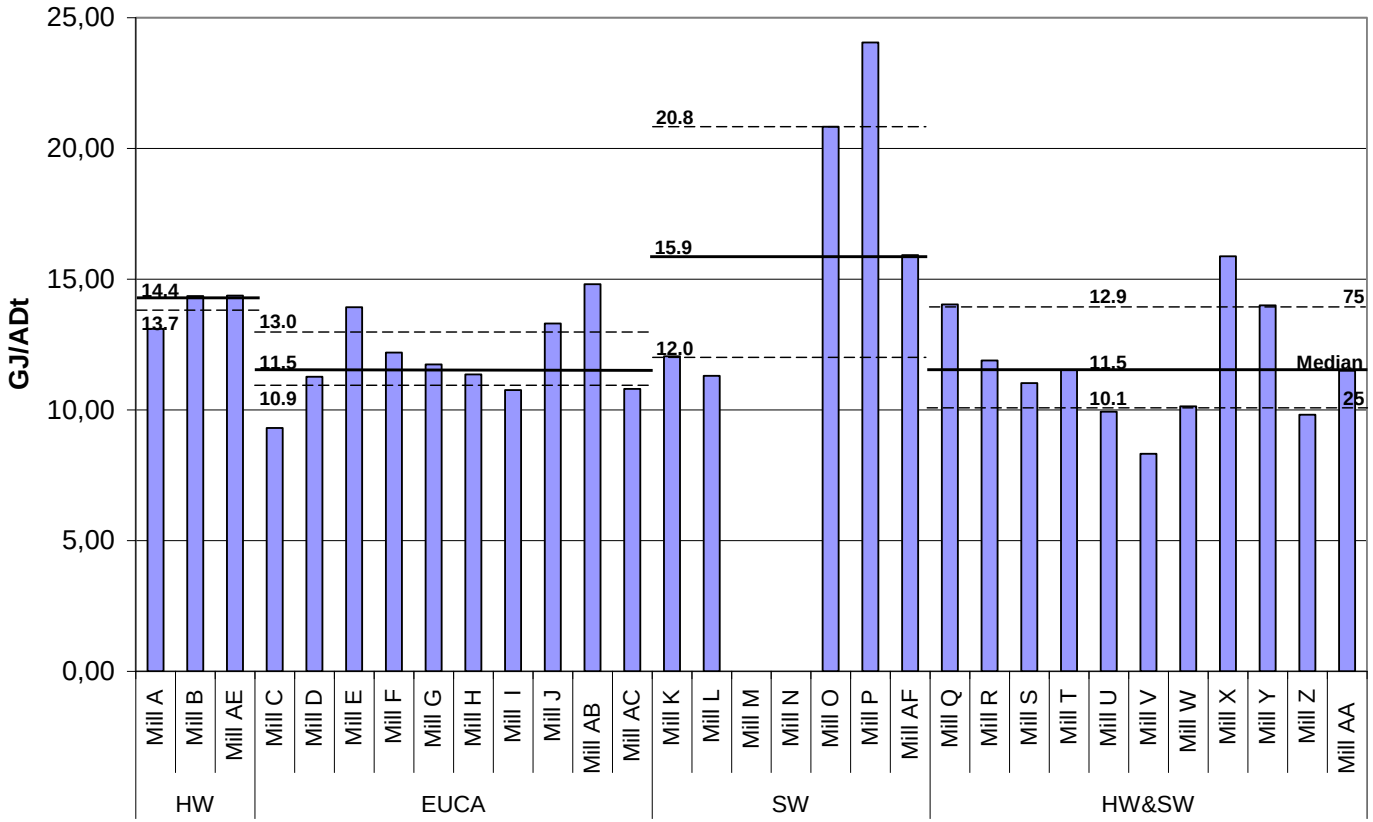

Pulp mill heat consumption vs. species from selected modern mills (Nieminen 2007)

New mills use less energy

Department	IPPC BAT		Mill median		Modern mill		AMT	
	Heat GJ/Adt	Power kWh/Adt	Heat GJ/Adt	Power kWh/Adt	Heat GJ/Adt	Power kWh/Adt	Heat GJ/Adt	Power kWh/Adt
Woodhandling	0.15	55	0.23	30	0.1-0.3	20-40	0.3-0.5	30-50
Cooking	2.05	65	2.33	52	1.5-2.2	30-70	1.7-2.4	35-70
Washing, Screening		55		85		65-100		90-130
Oxygen delignification	0.40	45	0.38	34	0.2-0.5	25-40	0.4-0.5	40-50
Bleaching	0.50	83	1.16	114	0.7-1.4	75-140	0.4-0.6	80-120
Bleach chemicals preparation	0.07	6	0.28	24				
Bleached stock screening		40						25-85
Pulp drying	2.85	105	3.11	126	2.4-3.1	100-130	2.0-2.7	80-130
Evaporation	4.10	30	3.99	29	3.4-4.2	25-30	3.2-4.5	20-30
Recovery boiler	0.61	60	1.17	79	0.8-1.6	60-85		35-70
Power boiler(s)		30	0.15	39		20-70		20-25
Recausticizing		20	0.07	20		20-25	0.02	8-22
Lime kiln		10		10		10-15	0.02	8-13
Mill water				27		20-40		12-23
Effluent treatment		20		30		25-40		25-40
Other	2.17	136	0.92	37				30-45
Total	12.9	760	13.8	736	12.1	680	11.5	690

Comparison of kraft pulp mill heat use (Nieminen 2007)

Partial load increases specific energy consumption

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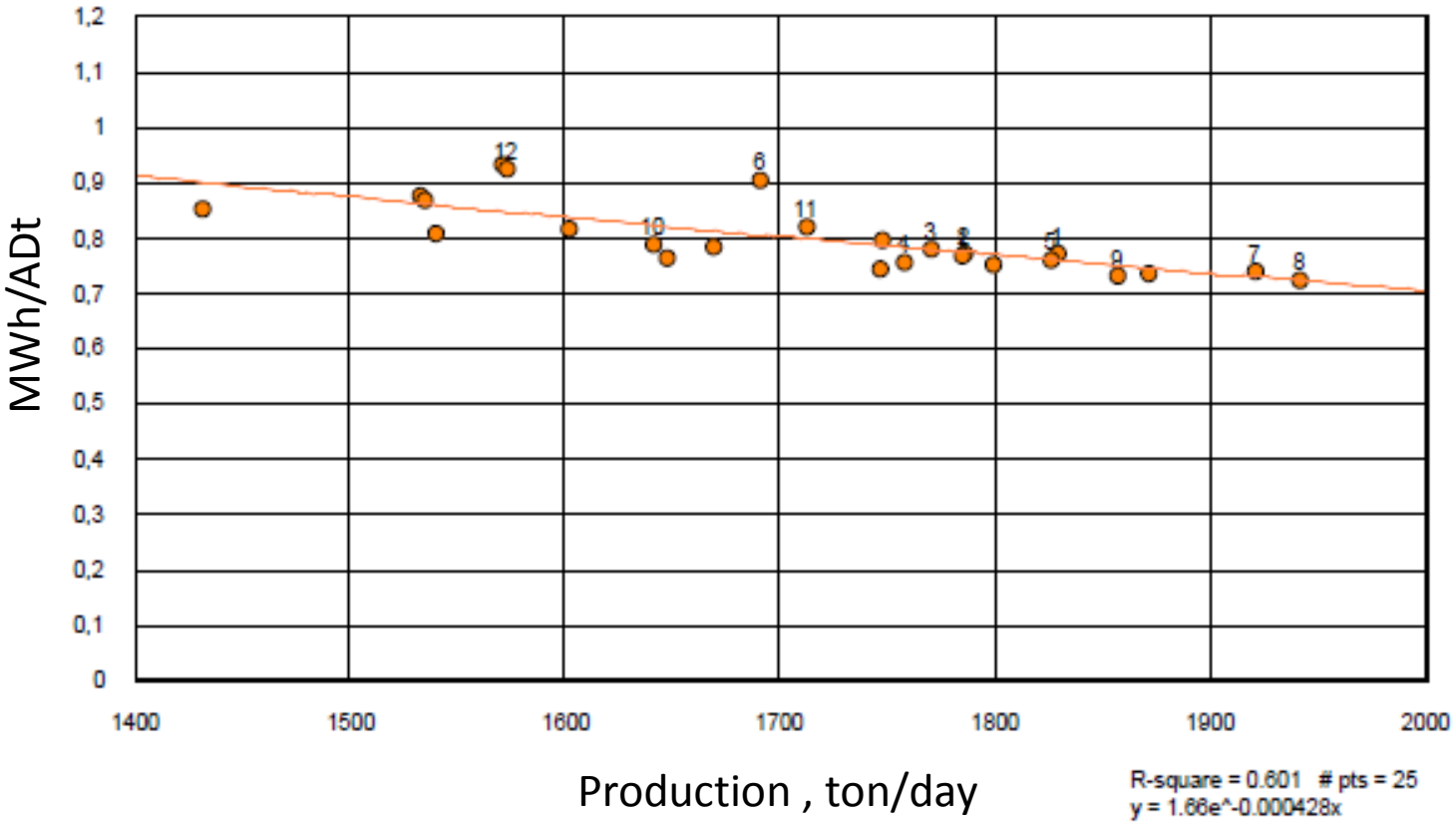


Example of mill electricity usage per ton of production (Svinhufvud, 2010)

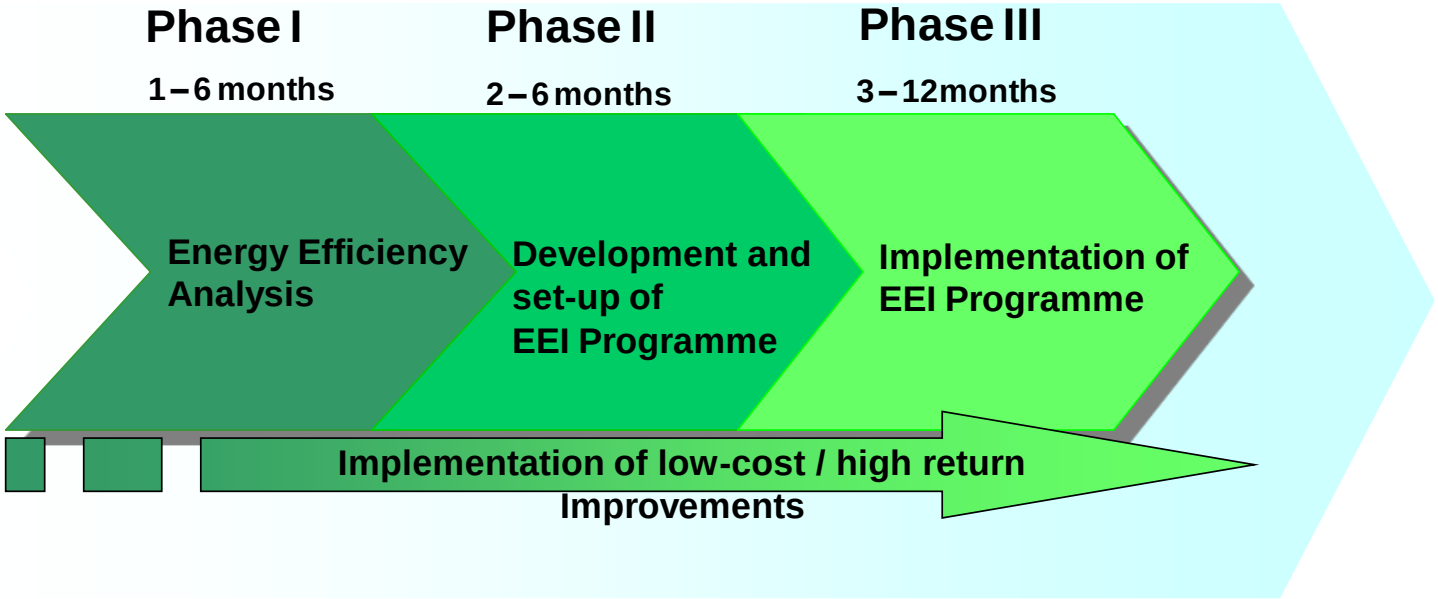
Improving energy efficiency

- New modes of operation
- Improvement of skills and motivation of personnel
- Energy audits
  - Enhanced process integration of existing processes and industrial plants
  - Collecting of reliable process information (monitoring and control)
  - Modern financing mechanisms of energy conservation projects (ESCOs)
- New technology
  - Introduction of more energy-efficient technologies
  - Electrical devices with low energy consumption

Agreement on energy conservation and energy audits

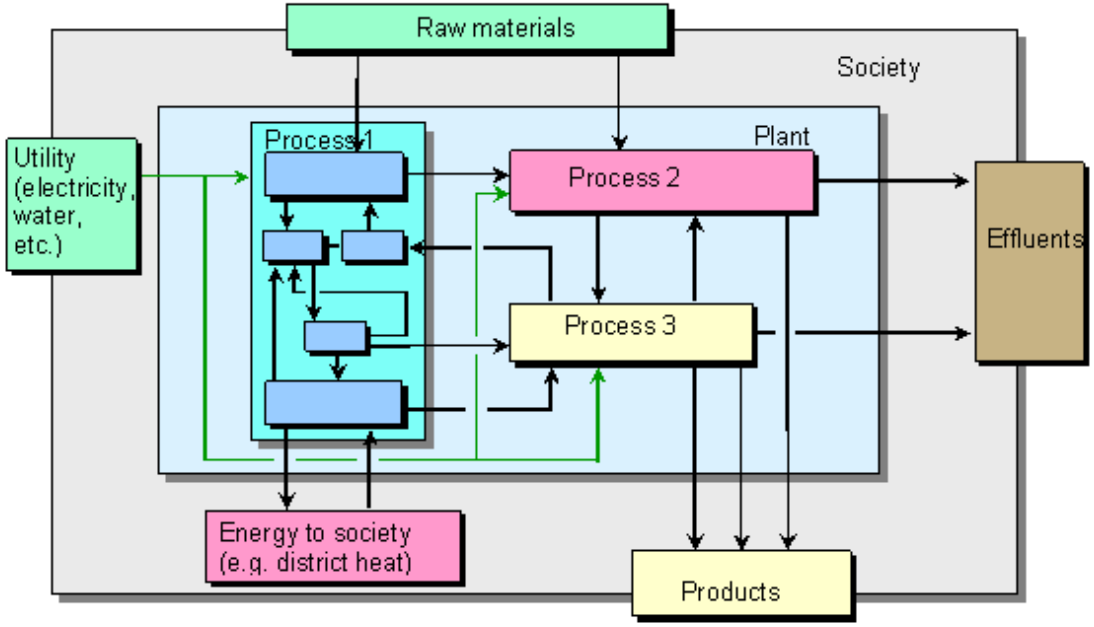
- Energy audits provide valuable information on the possibilities that exist to improve energy efficiency.
- Obtain adequate knowledge of current energy consumption profile
- Identify factors that have an effect on energy consumption
- Identify and scale cost-effective energy-saving opportunities
- In 1997, the Ministry of Trade and Industry and the Federation of Finnish Industry and Employers signed a voluntary Agreement on Energy Conservation in Industry.
- For a high energy-intensity process industry such as the pulp and paper industry a three-step audit model is often applied (Kuisma, Kari et al., 2004).

Three step energy efficiency program



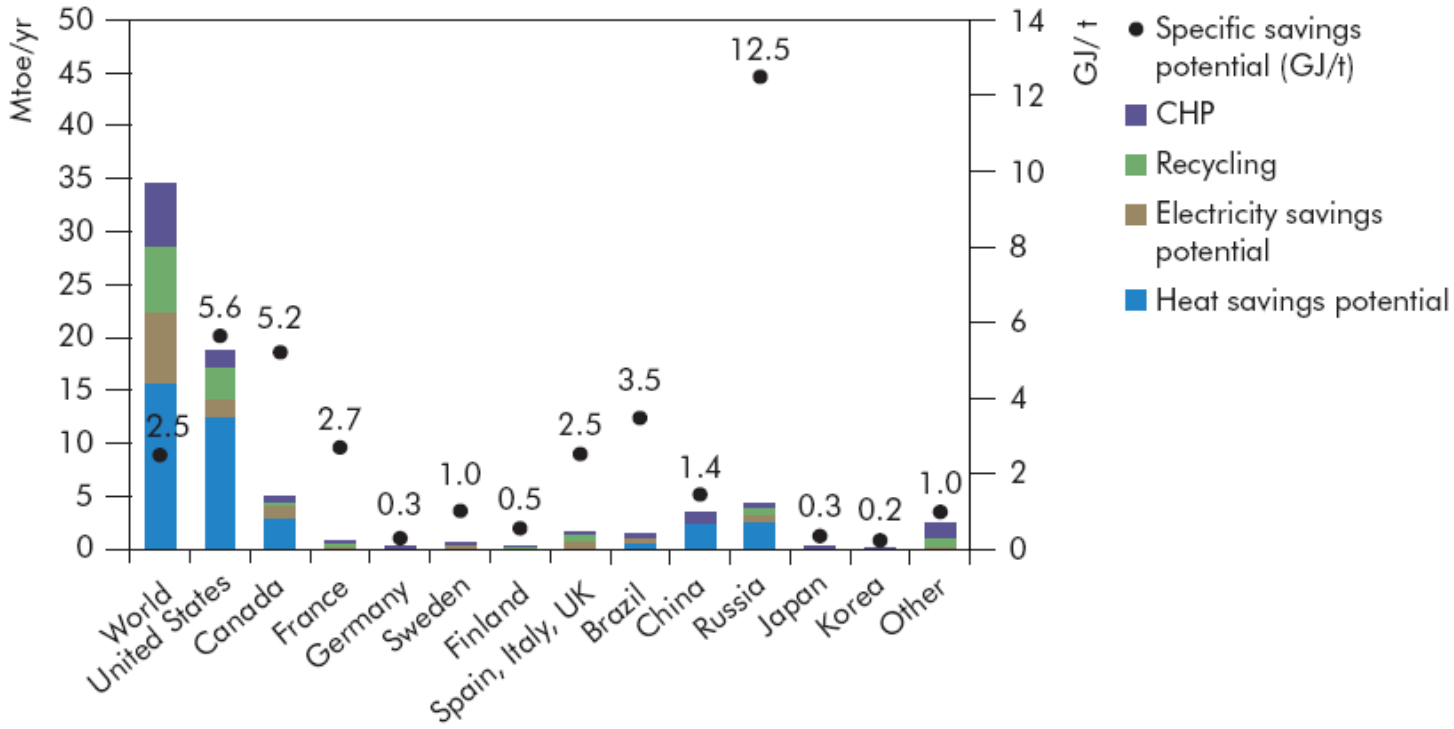
For high energy intensity process industry (pulp and paper) a three-step audit Shows great promise (Kuisma et al., 2004)

Process integration



Process integration is an efficient tool for the optimisation of energy use. Improvements in process steam use usually reduce the consumption of purchased fossil fuels and CO2 emissions. Avoid heating with primary energy at temperatures below the hottest available secondary energy. (Kilponen, 2000)

Pulp and Paper energy savings potential, IEA



Finnish pulp and paper has potential of 0.5 GJ/t production. Brazil has 3.5 GJ/t, Total savings potential is about 150 PJ per year.

Highly efficient production is possible

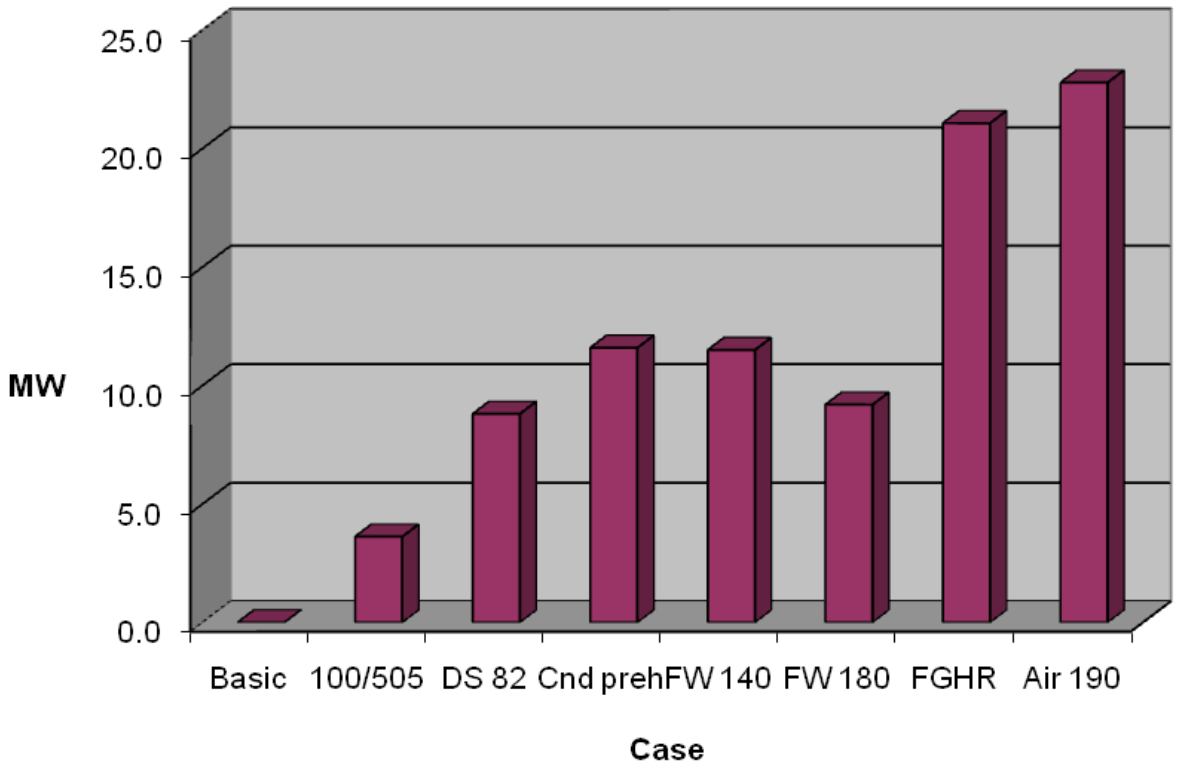
Mill type	Units	Non-integrated and bark sold	Non-integrated and bark fired	Fully integrated and bark fired
Heat generation				
Black liquor	GJ/adt	18.0	18.0	18.0
Bark and wood waste	GJ/adt	-	4.2	4.2
Heat consumption				
Pulp mill process	GJ/adt	11.0	11.0	8.5
Paper mill process	GJ/t paper	-	-	6.0
Back pressure power	GJ/adt	3.0	3.0	4.0
Condensing power	GJ/adt	4.0	8.2	3.5
Power generation				
Back pressure power	kWh/adt	820	820	1150
Condensing power	kWh/adt	390	800	340
Total	kWh/adt	1210	1620	1490
Power consumption				
Pulp mill process	kWh/adt	660	700	550
Paper process	kWh/t paper	-	-	650
Power to grid	kWh/adt	550	920	290

Heat and power balance for a BKSW 1 000 000 Adt/d mill (Kankkonen et al., 2010).

Increasing electricity generation

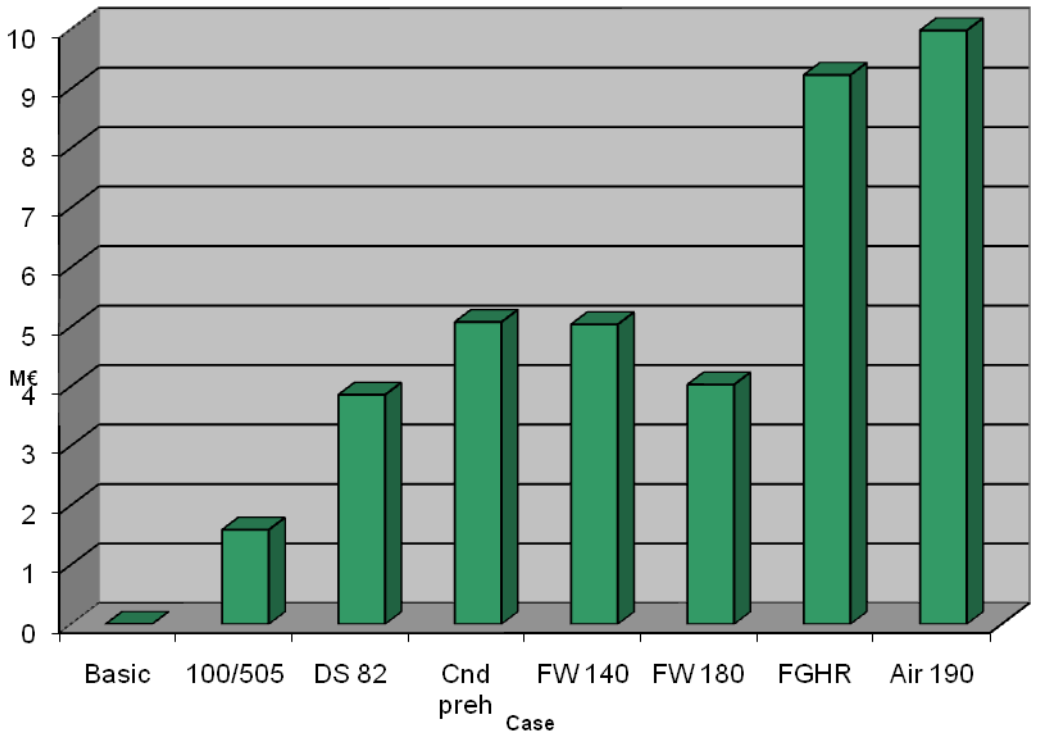
- High steam values
- High firing liquor dry solids
- Increased feed water temperature
- Back-pressure turbines with controlled extraction
- Improvement of sootblowing
- Flue gas heat recovery
- Preheating of combustion air with steam

Increasing electricity production



Each step has unique increase (Kankkonen et al., 2010).

Investment needed

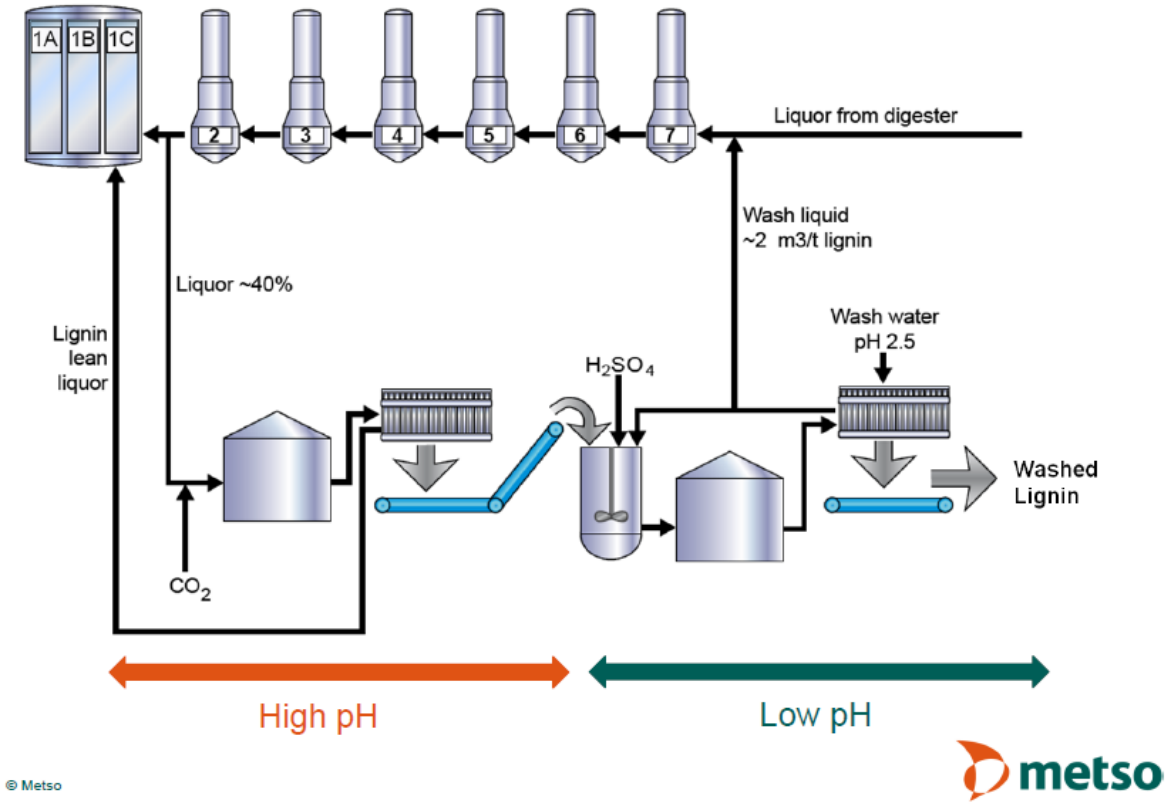


Each step has unique profitability (Kankkonen et al., 2010).

Biofuel instead of electricity

- Electricity generation and selling is existing technology and can be done at low risk
- Recently extraction of hydrocarbons and or lignin and further processing have come to light
- Use of extracted lignin to replace oil in lime kiln is studied
- Alternative is to gasify wood

Lignin removal



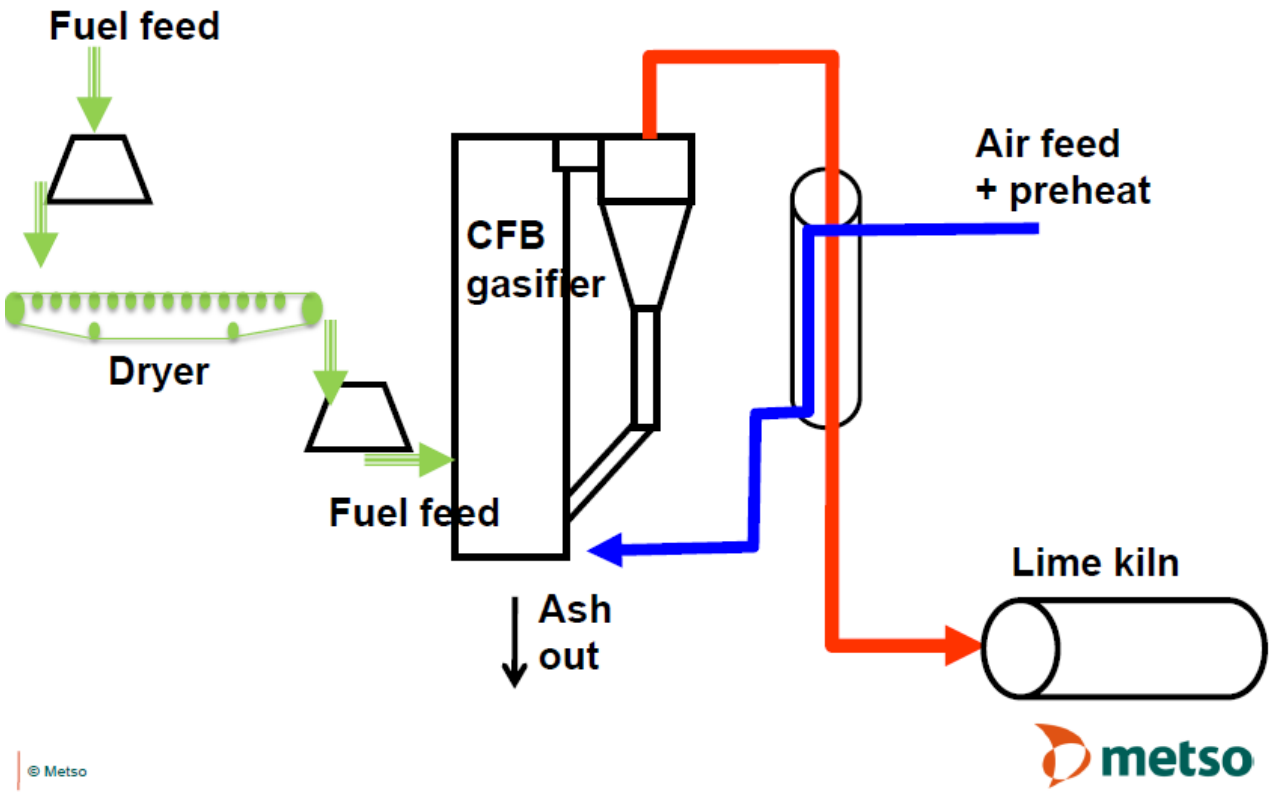
Can be applied to existing mills to debottleneck recovery boiler.

Lignin removal

Variable		Percentage of lignin removal			
	Unit	0%	10 %	20 %	30 %
Dry solids in BL after lignin removal	kg/Adt	1353.2	1307.2	1261.1	1215.1
White liquor density	kg/m^3	1144	1143.9	1143.8	1143.7
White liquor flow	m^3/h	547.9	547.9	547.9	547.9
Total inorganics to black liquor	kg/Adt	437.2	437.3	437.3	437.3
Total organics to black liquor	kg/Adt	915.9	869.9	823.8	777.7
Lignin in black liquor	kg/Adt	460.7	414.6	368.5	322.5
Black liquor HHV	MJ/kg	14.3	13.94	13.55	13.14
Heat into recovery boiler	MW	892.3	840.3	788.2	736.2
Weak black liquor flow	m^3/h	1483.2	1483.2	1483.2	1483.2
Black liquor flow to furnace	tDS/d	5991	5787.5	5583.6	5379.7
Smelt flow	kg/kgDS	0.425	0.436	0.447	0.46
Evaporation load	tH_2O/h	1310.6	1322.6	1334.7	1346.8
- Steam consumption	t/h	218.5	222.1	223.7	225.2
- Cooling water flow	m^3/h	13834	13961	14088	14216
Power generation	MW	198.5	180.3	162.2	143.7
Dry solids in BL after lignin removal	kg/Adt	1353.2	1307.2	1261.1	1215.1

Affects mainly recovery boiler, minor effects elsewhere.

Biomass gasification for lime kiln



Has been applied to several mills now multiple projects in Scandinavia.

Conclusions

- By introducing new modes of operation or tools such as energy audits and process integration, significant energy efficiency improvement is possible.
- The heat and fuel consumption of the forest industry have been successfully reduced by the closing of the water circuits and the efficient utilization of secondary energy.
- The forest industry's own electricity production can be increased by the following measures:
  A. Increasing the proportion of CHP production by introducing processes with a higher power-to-heat ratio
  B. Improving the energy use of black liquor (increasing the temperature and pressure of live steam in the Kraft recovery boiler and adding the preheating of feed water)
  C. Integration between industry and society (increasing CHP production by increasing the heat load)
- Replacing oil use in lime kiln is possible

Acknowledgements

– We especially want to extend our gratitude to the mill personnel who helped to gather this data

Thank you