Raw Material Availability to Synfuels Production and remarks on RTD Goals

Results of the BioFuture project

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Synbios 18-19.5.2005 Stockholm

1. Drivers in Europe:
   - EU White Paper 6 --> 12 % Renewables
   - Bioenergy up to 130 Mtoe/a -> from where ?
   - Directives on RES-electricity, CHP and biofuels
   - Landfill directive: urban and industrial waste

2. Biofuels for transport in Finland – recommendation of a VTT report

3. Forest based bioenergy is dominating today, visions for 2010+ ?

4. Biomass resource availability for forest industry platforms ?

5. How much biofuels or electricity could be produced, Emission trading ?

6. Priority for policies, new concepts and technologies

7. Conclusions and input to road maps for the future

Results of a VTT Biofuel Report for Finland:

- in 2010 max. 3 % level could be reached without massive import of biofuels

- priority on: 1) synthetic diesel fuel 0.5 – 1 %
  2) EtOH & MeOH - > ETBE & MTBE 1 – 1.5
  3) biogas boosted natural gas vehicles 0.5 - 1
  4) limits set by biomass availability and price !

- Neste Oil new investment on syndiesel, 170 ktoe/a
  - presentation by Raimo Linnaila in Synbios

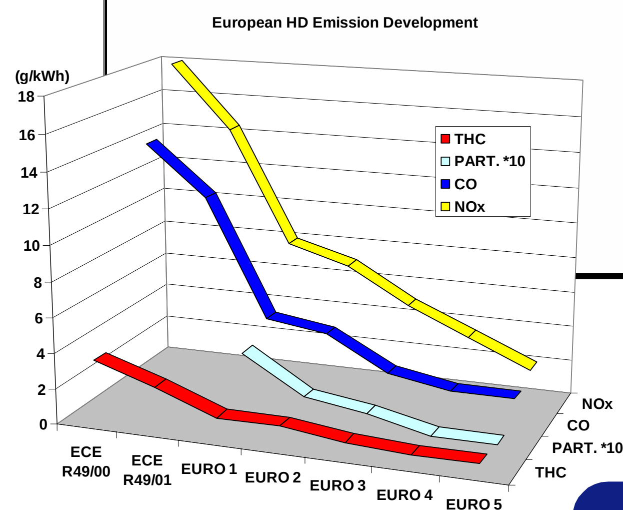
- Extensive RTDD needed, priority on:
  1) new syngas production technology
     - presentation by Esa Kurkela in Synbios
  2) new ethanol concepts, waste fractions
  3) new integrated concepts – Biorefinery reduction of production cost
  4) balance of electricity and biofuels production, – price on CO_2 avoided,
     - priorities in the national climate policy ?

ESPOO 2005 VTT TIEDOTTEITA 2288

Tuula Mäkinen, Kai Sipilä & Nils-Olof Nylund

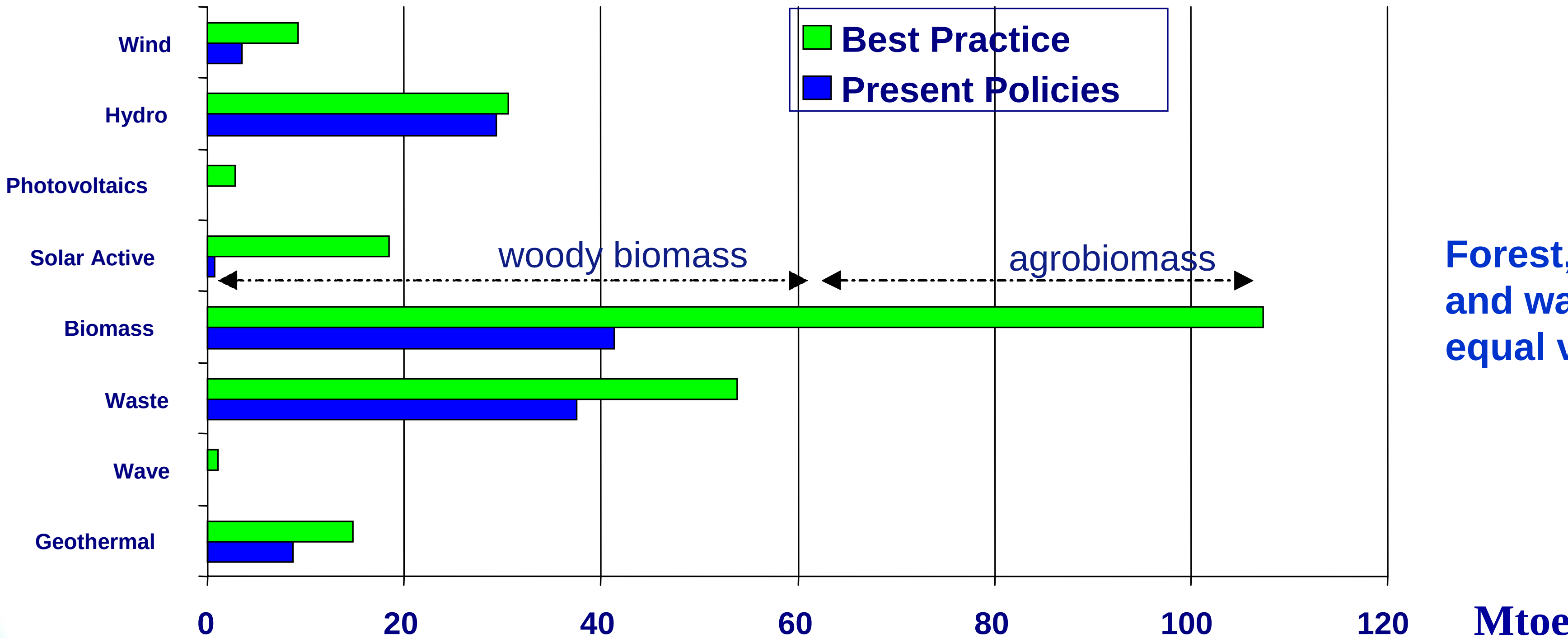
Liikenteen biopolttoaineiden tuotanto- ja käyttömahdollisuudet Suomessa

Taustaselvitys



RENEWABLE ENERGY PENETRATION EU15 IN 2010

Source : TERES II



Forest, agro and waste offer equal volumes !

Bioenergy in 1995

Bioenergy target for 2010 in EU ---------------->

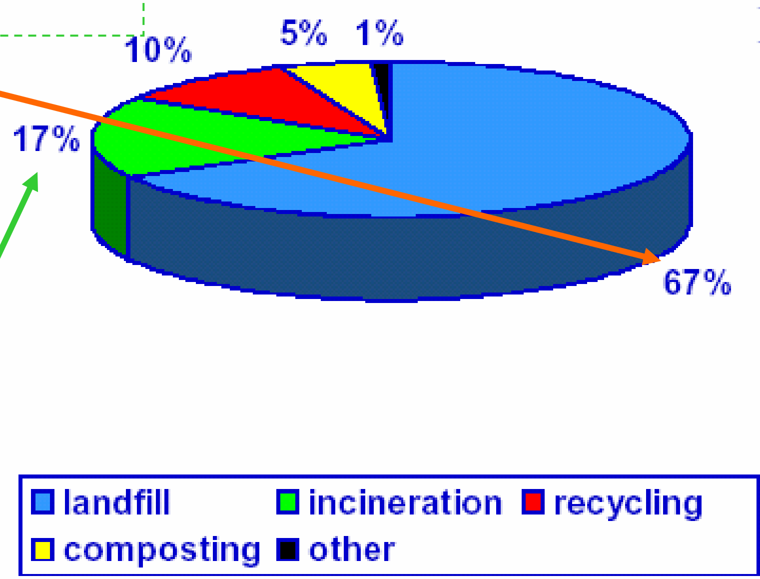
RES-E | 2020 2010 | Biofuels for transport 6/8 %

18 / 36 Mtoe ?

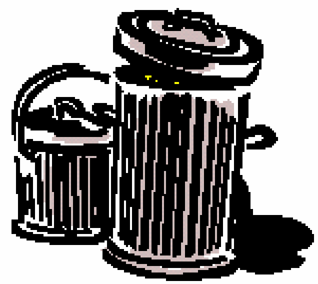
Forest industry wood demand | in 2010

MSW disposal in 2000

EU Landfill Directive:
In 2016 max. 35 %
can be landfilled



Where the 200 million tonnes of MSW went in 2000?

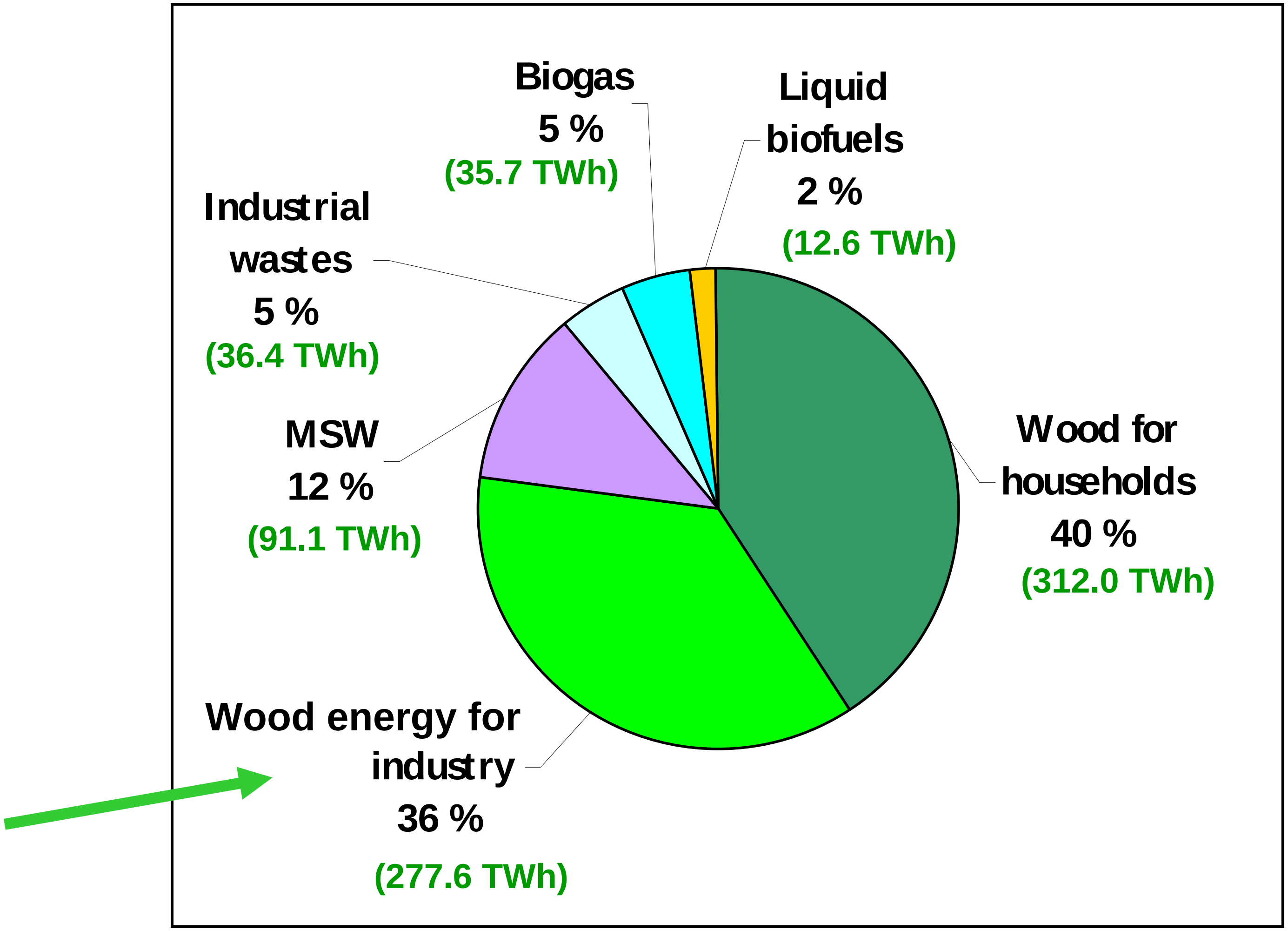


(about 40 to 50% of MSW is biowaste - excluding paper)

Luca Marmo - European Commission - DG ENV.G.4

340 units in operation in 2002, processing 50 Mt/a, in 2010 about 165 new units needed

Bioenergy and Waste in EU-25 in 2002

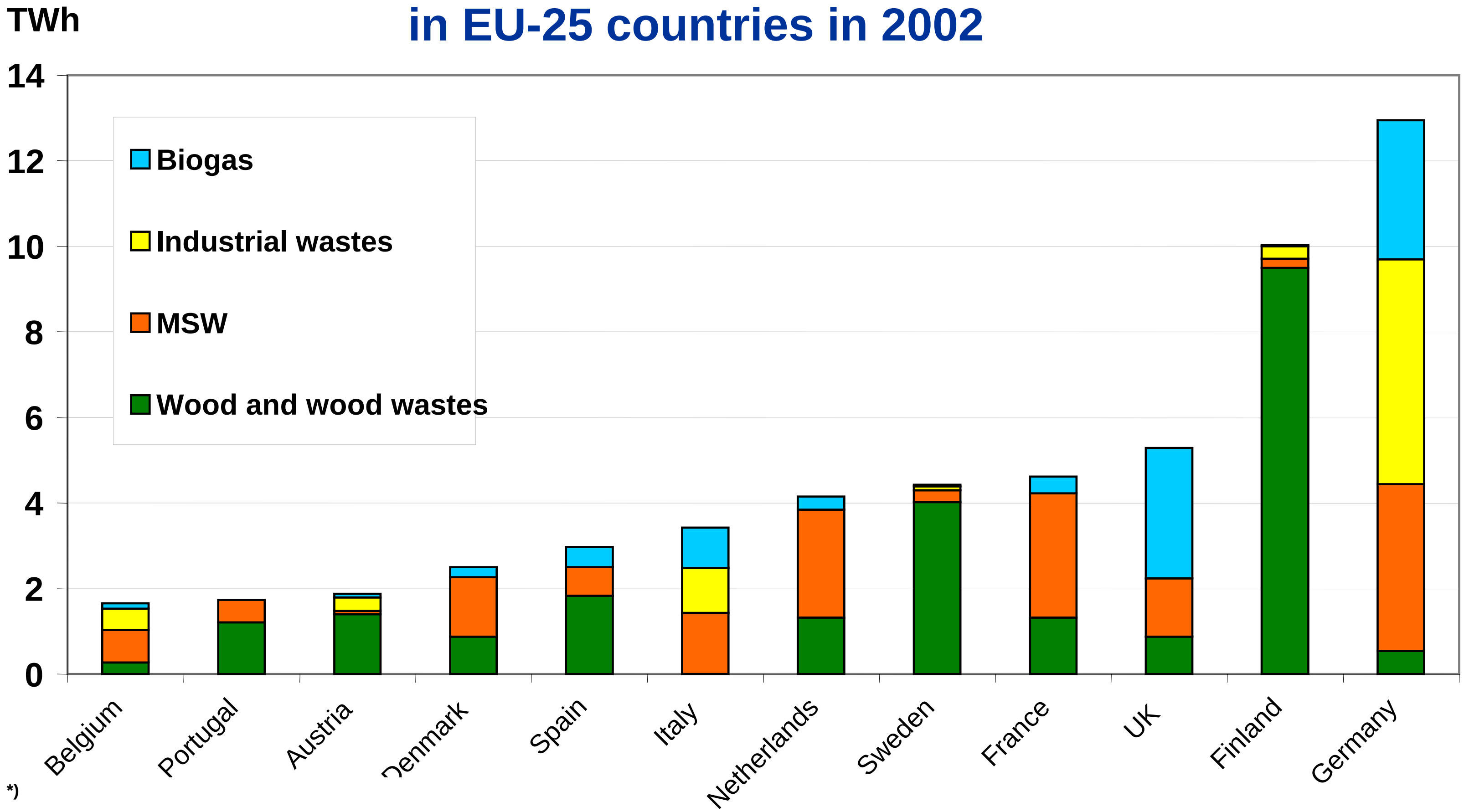


Total use of biomass & waste in EU-25 was 68 Mtoe ~ 2 755 PJ ~ 765 TWh

1 PJ = 0.278 TWh = 0.027 Mtoe

Source: Eurostat

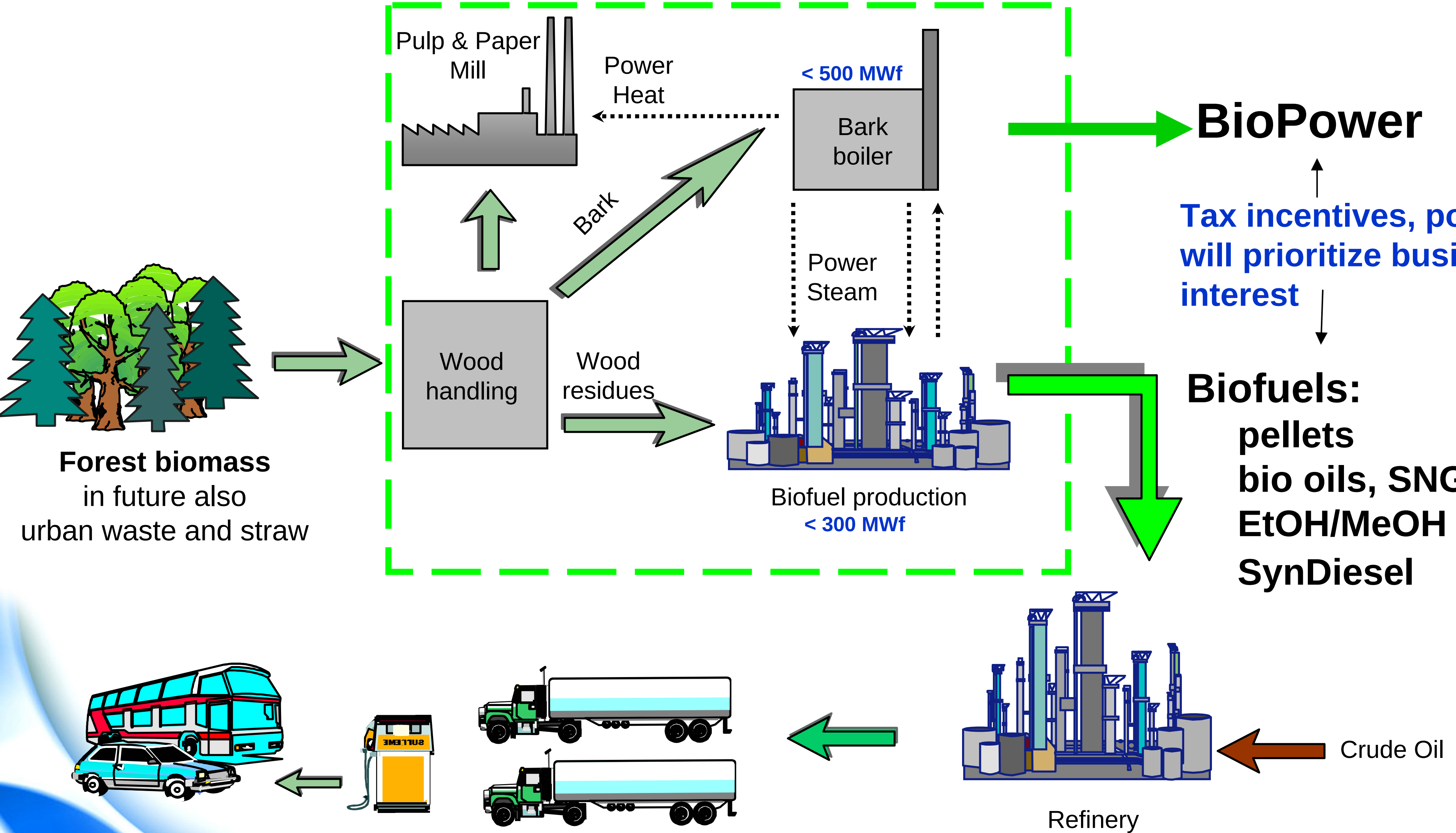
Gross electricity production from biomass and waste in EU-25 countries in 2002



Source: Eurostat New Cronos Database

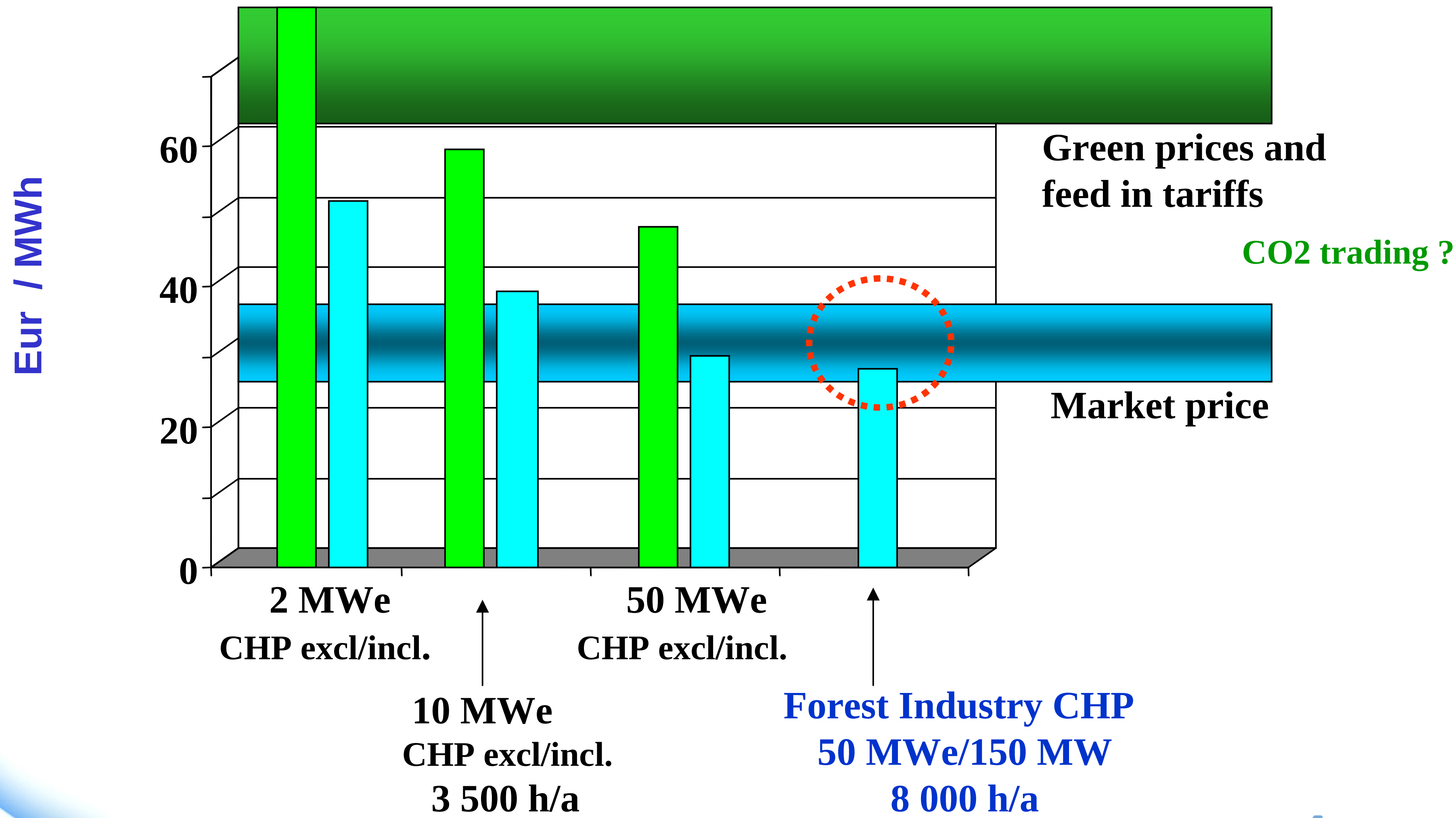
OPTIONS FOR FOREST INDUSTRY ?

- benefit of raw material, polygeneration, large scale -



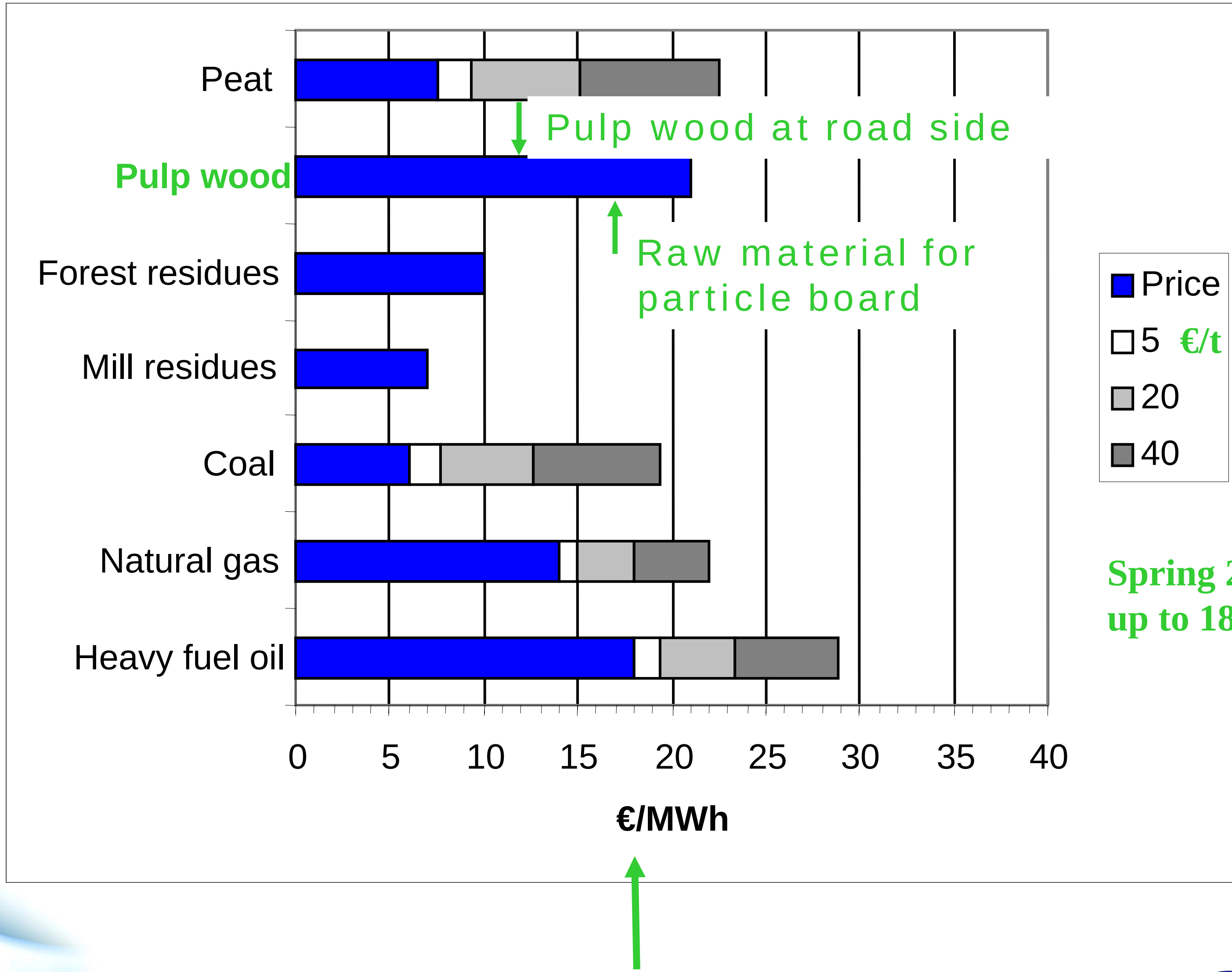
TYPICAL POWER PRODUCTION COSTS

- effect of scale, Combined Heat and Power CHP and annual peak load time



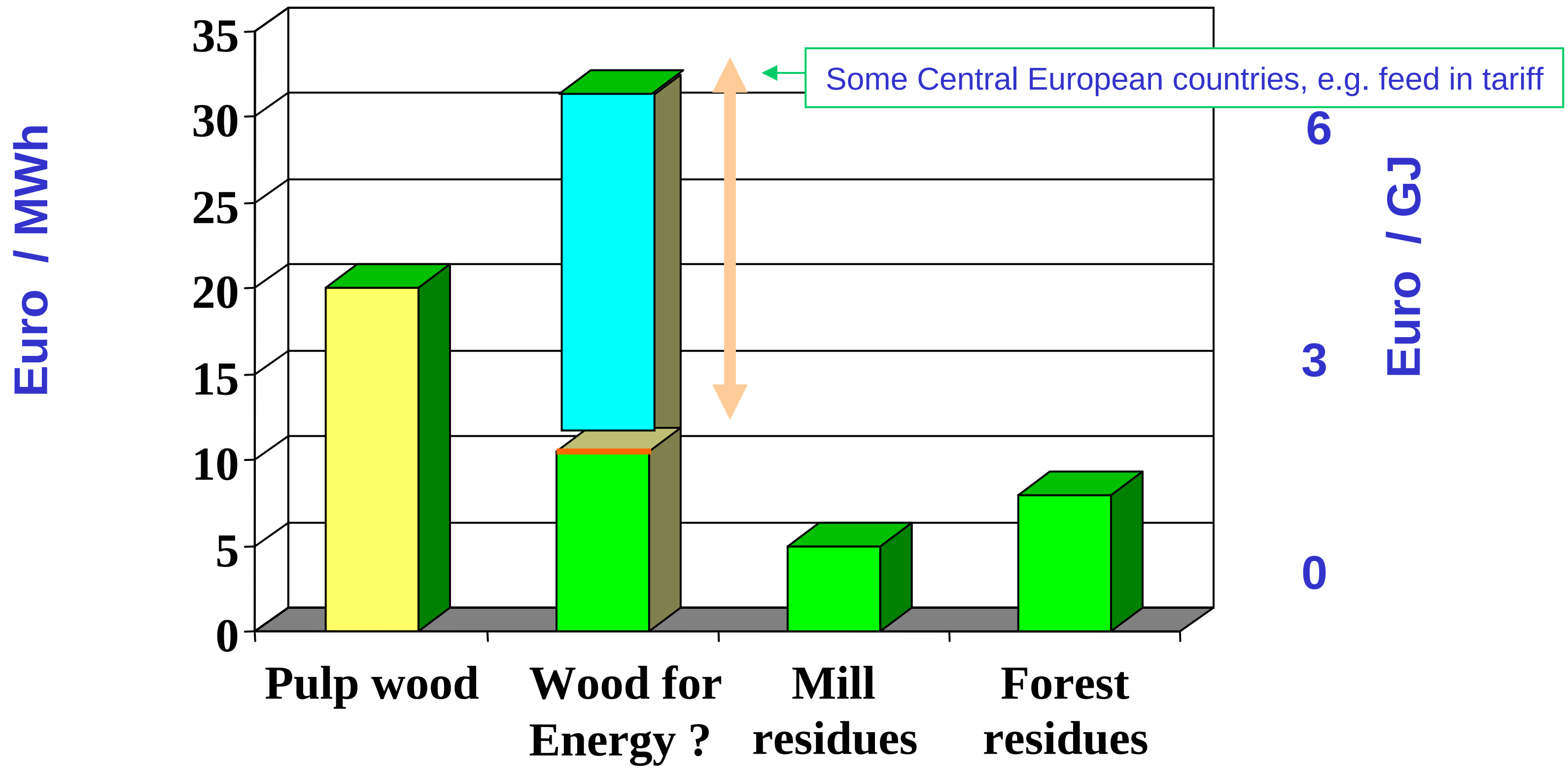
Price of solid bio fuel ~ 8 – 10 €/MWh

Fuel Prices in Finland without Tax – Effect of Emission Trading - with high CO_2 prices Pulp Wood to energy production ?



Spring 2005:
up to 18 €/t CO_2

WOOD FOR PULPING OR GREEN ENERGY ?
- typical prices in Nordic countries

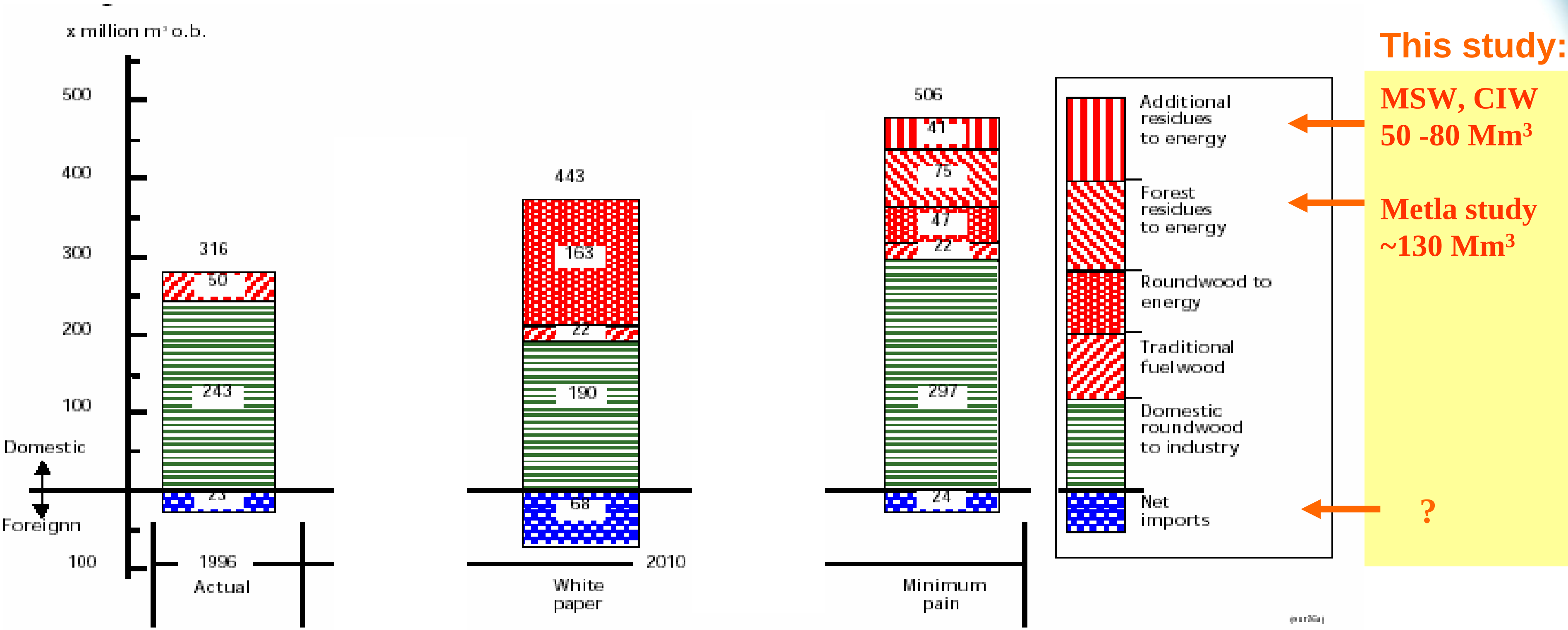


“ In White Paper scenario the wood price will increase 39 - 75 % from current prices to 2010 “

Source: CEPI - EU Energy Policy Impacts on the Forest Based Industry,2000”

Forest industry wood demand - Bioenergy in the EU White Paper ?

Source: EU Energy Policy Impacts on the Forest Based Industries, 2000, CEPI



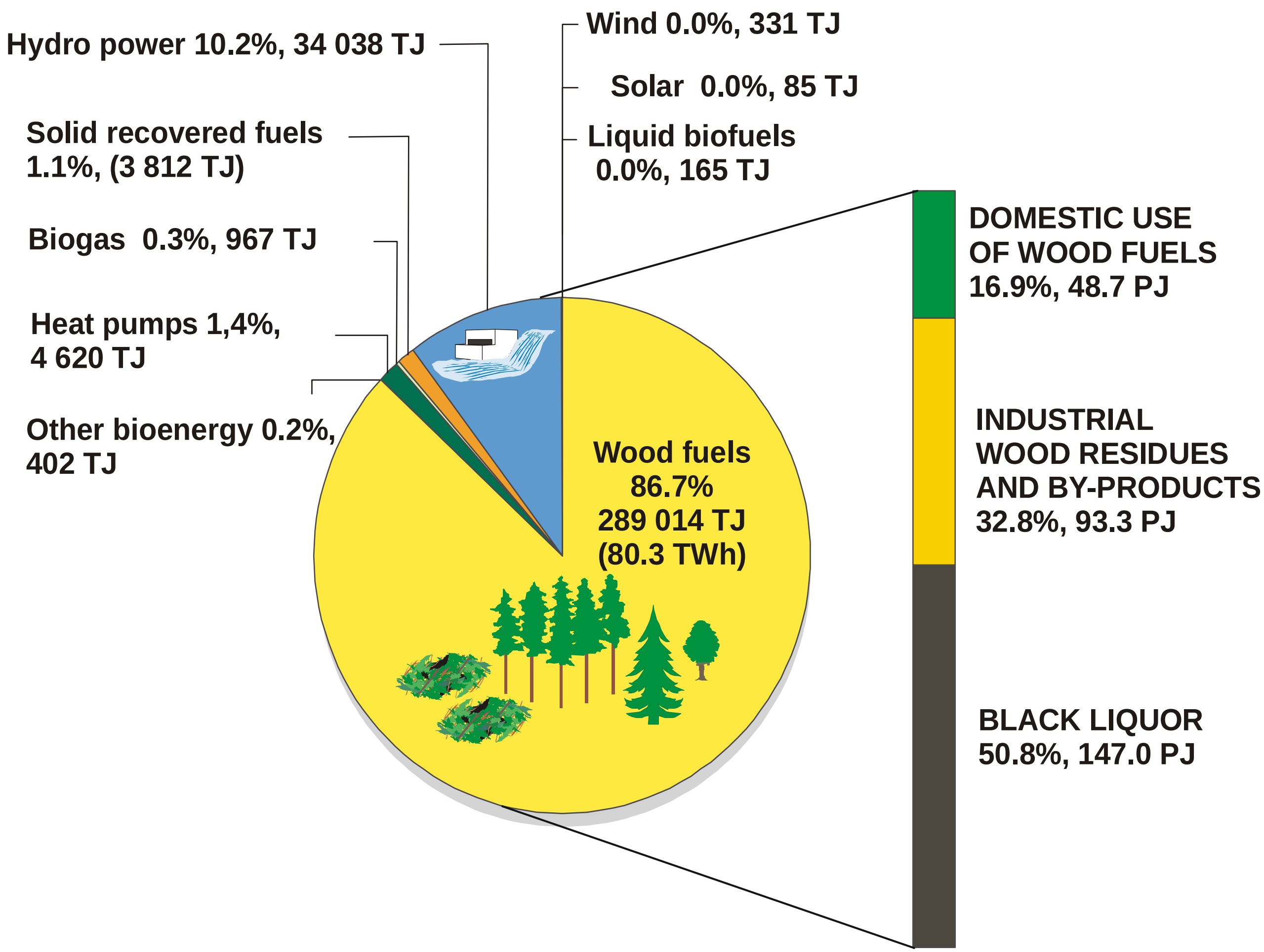
- Roundwood to industry in 1996 was 266 Mm³/a = equal to 44 Mtoe/a

- Total wood demand in 2010 in White Paper scenario 443 Mm³ = 73.5 Mtoe/a, additional use of roundwood to energy 163 Mm³/a = 27 Mtoe/a

1 Mm³ = 0.166 Mtoe

VTT

Renewable energy sources in Finland, 2003

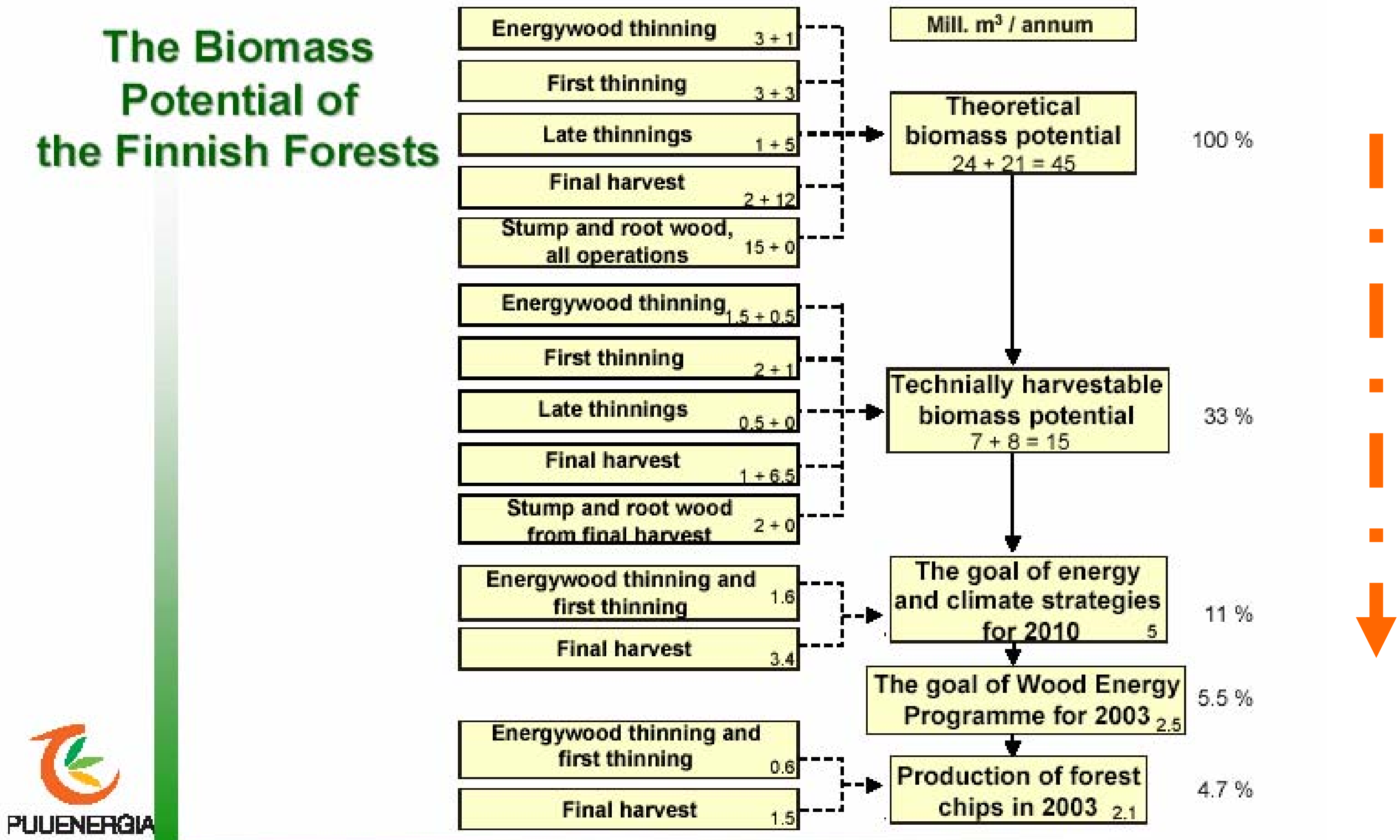


What could be the potential in 2010 - 15 ?

Total use of renewable energy sources was 333.4 PJ (9 Mtoe ~ 92.6 TWh), which is 22.4% of total primary energy consumption in Finland

Source: Energy Statistics 2003

The Biomass Potential of the Finnish Forests

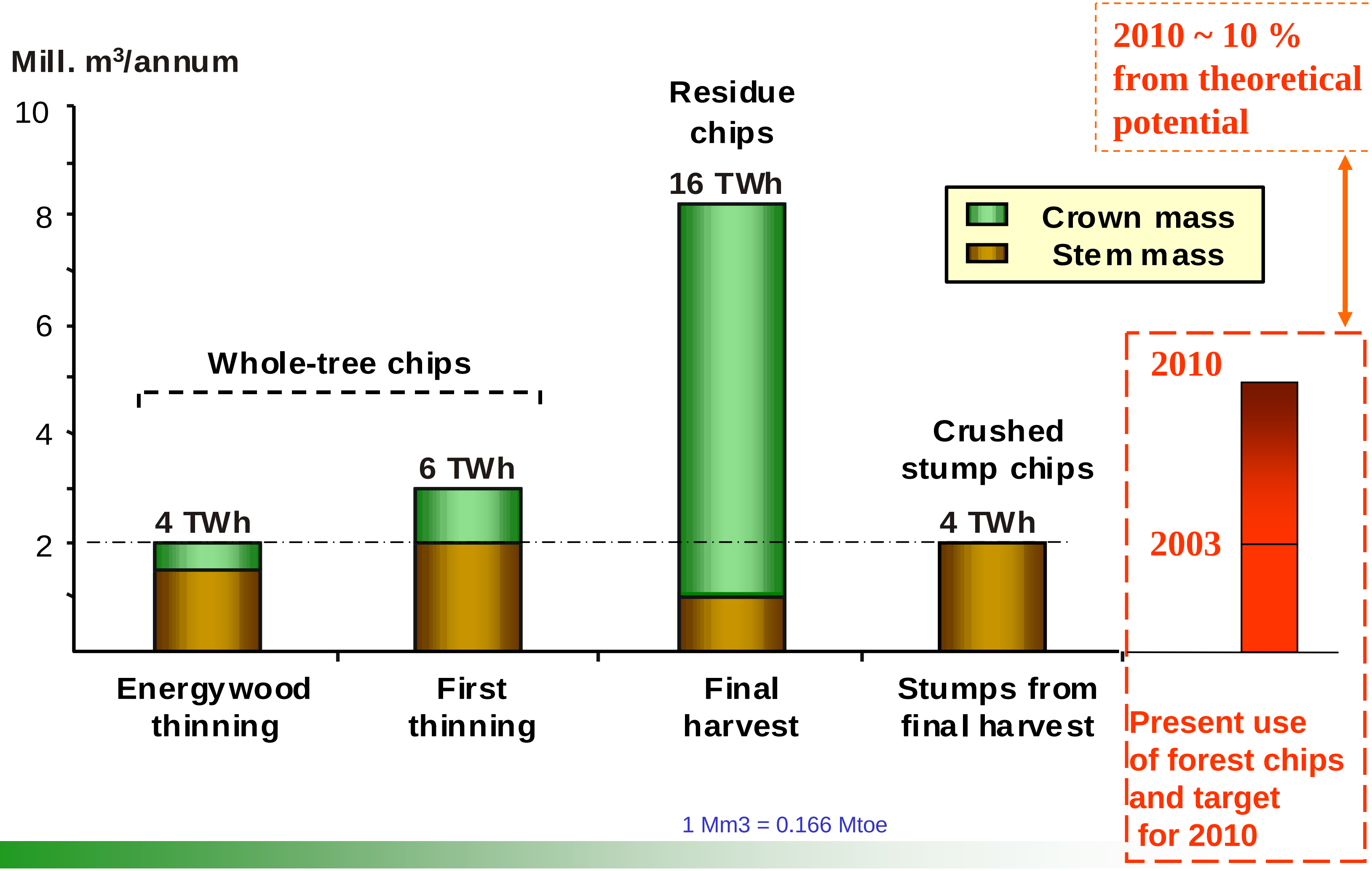


PUUENERGIAN TEKNOLOGIAOHJELMA ● WOOD ENERGY TECHNOLOGY PROGRAMME

1 Mm3 = 0.166 Mtoe

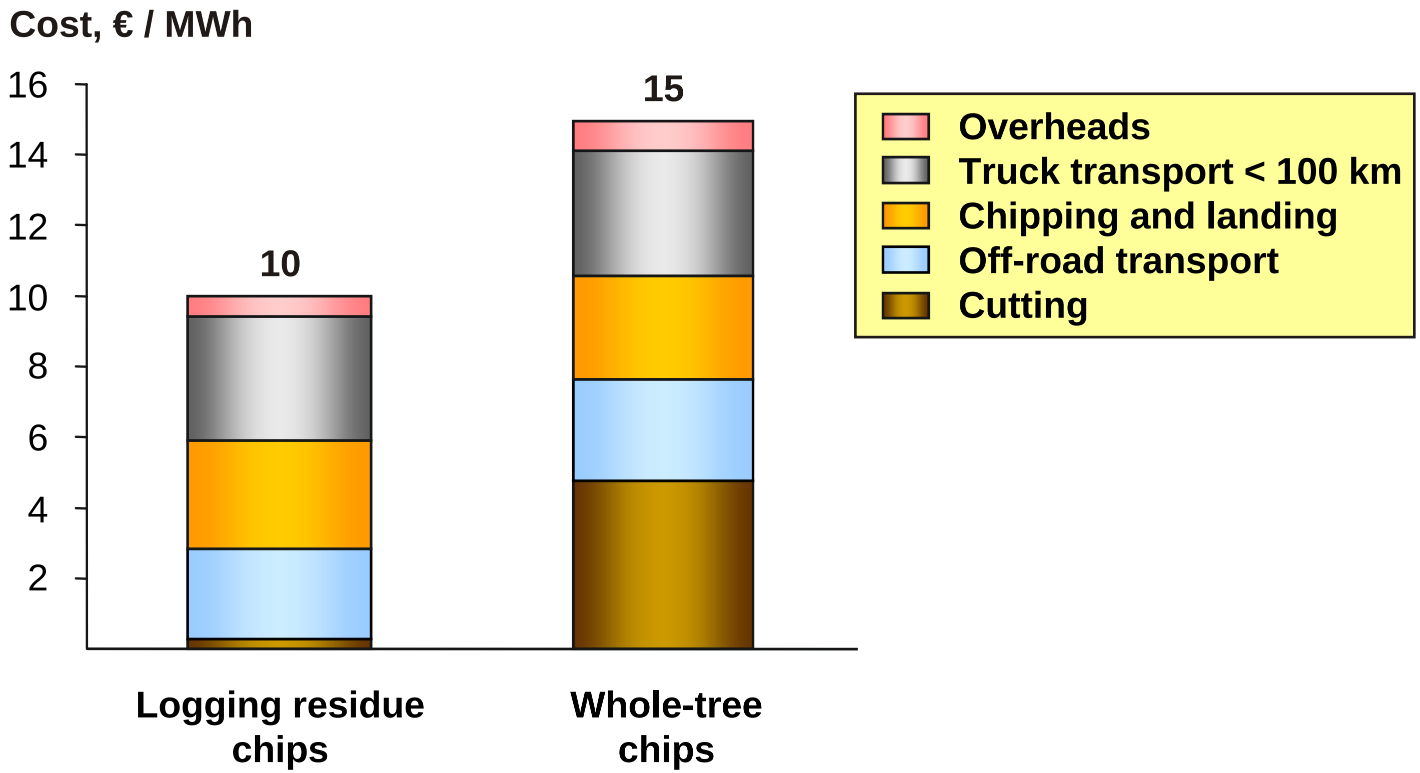
Technically Harvestable Biomass Potential

- totally 15 mill.m³/a - 30 TWh/a, 33 % of the theoretical potential



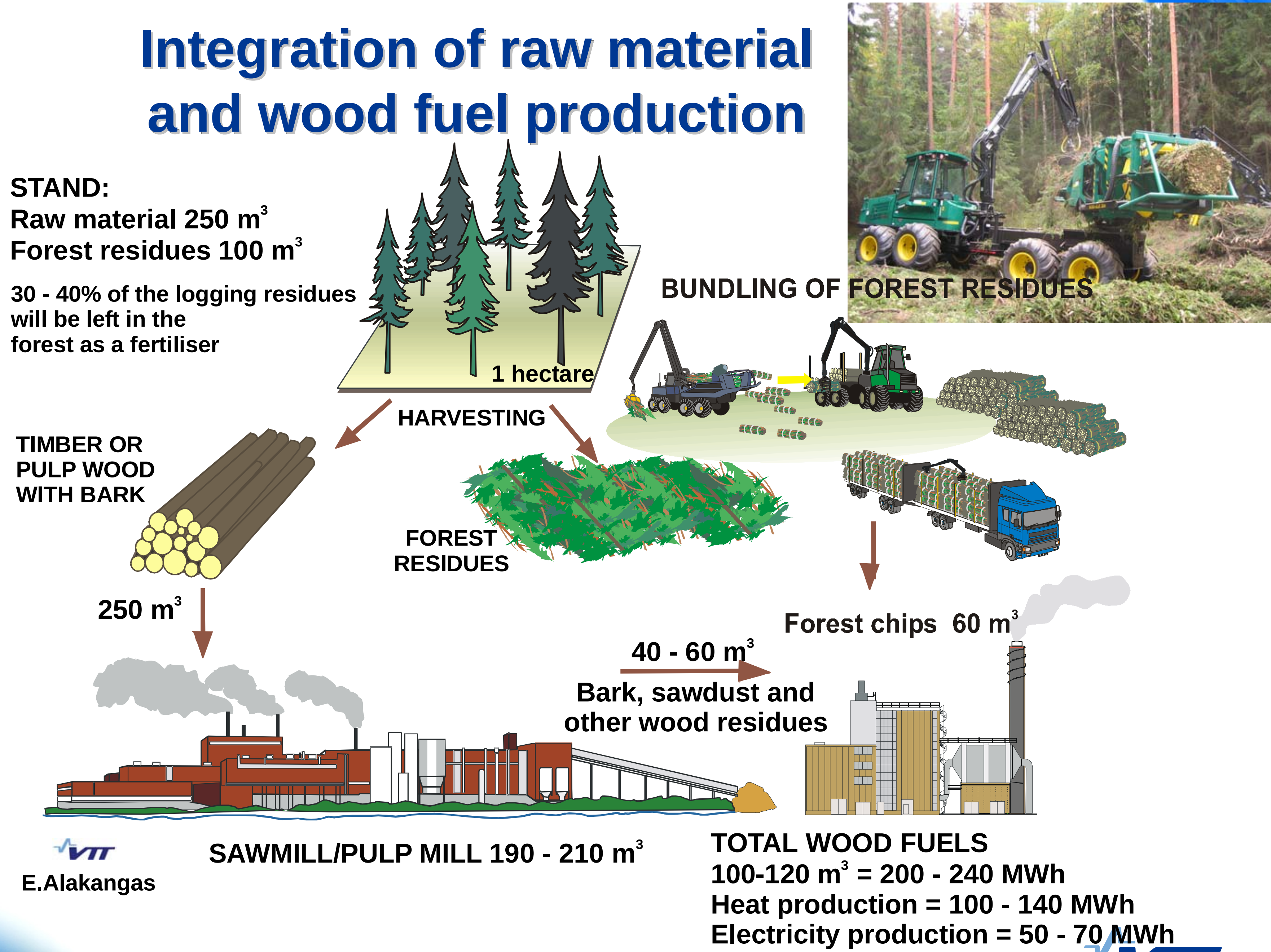
PUUENERGIA

Cost Structure of Forest Chips



Source: Hakkila, Wood Energy Technology Programme, 2004

Integration of raw material and wood fuel production



$1\ m^3 \sim 2\ MWh \sim 0.2$ toe

ESTIMATION OF ENERGY WOOD POTENTIAL IN EUROPE

Research to VTT BioFuture project:

”Reliable, up to date and accurate information about the forest resource base that could be used for energy purposes is essential to any analysis on energy wood potential in Europe”

Prof. Timo Karjalainen

Prof. Antti Asikainen

Dr. Jan Ilavsky

Ms. Kaisa-Elina Hotari (part I)

M.Sc. Raffaela Zamboni (part II)

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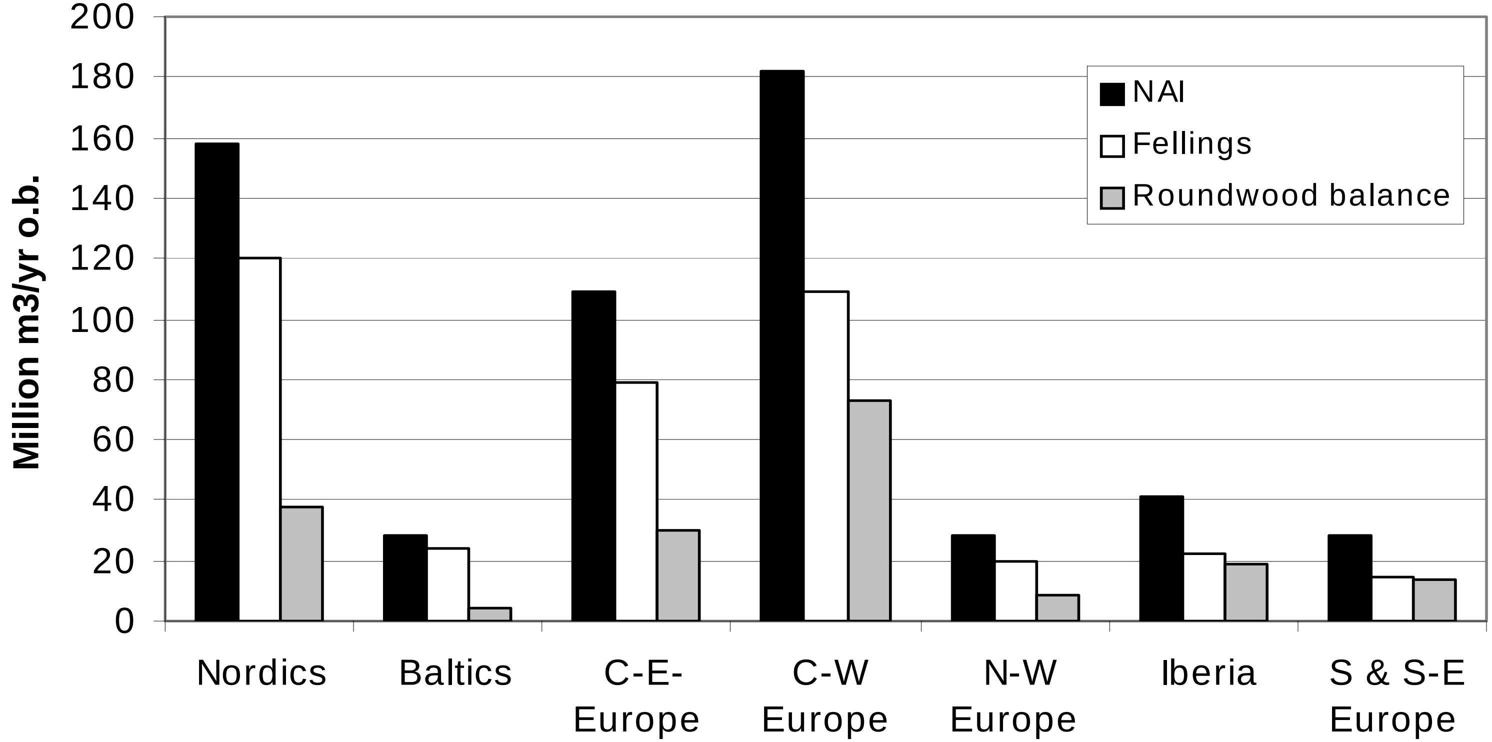
Assignment

- estimation of roundwood balance on forest available for wood supply, i.e. estimation of unutilised roundwood potential that could be used for energy purposes, but also for manufacturing conventional products in the forest based industries or not harvested
- Study limited to forests available for wood supply
  - include forests where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood, and thus use of wood for energy purposes is not restricted either
  - This is a practical limitation, as forests with above mentioned restrictions are likely to have very small supply of wood, and therefore also very limited source of energy wood

Assignment

- Roundwood balance calculated as a difference between net annual increment and fellings
- roundwood and fuelwood production data collected and estimated

Round Wood Balance



- In relative terms, Round Wood Balance smallest in the Baltics (15%), largest in South & South-Eastern Europe (48%).
- Altogether 39% of the round wood balance is in two countries, in Germany and France (72.5 mill. m3)

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Estimation of technically harvestable forest fuel potential

REDUCTION FACTORS:

1. On **75%** of **clearcut** sites and on **45%** of **thinning** sites, residues can be harvested

   - **65%** of residues from **mechanized** cutting are recoverable
   - **50%** of residues from **manual** cutting are recoverable

2. **20%** of volume of **roots from clearcuts** are harvestable

3. **25%** of volume of **balance** is harvestable
   (roots volume of balance is not taken under consideration)

Volume of technically available forest fuels in EU25:

71.6 mill. m3 from felling residues
+ 67.3 mill m3 from balance = 138.9 mill. m3

- **approximately 25% of the theoretical potential !**

TOTAL FELLING RESIDUES (mill. m^3 /y)	AVAILABLE RESIDUES OF FELLING (mill. m^3 /y)	AVAILABLE SHARE OF BALANCE (mill. m^3 /y)	VOLUME OF ROOTS AVAILABLE FROM FELLINGS (mill. m^3 /y)	VOLUME OF ROOTS AVAILABLE FROM BALANCE (mill. m^3 /y)
173,2	62,6	63,5	9,0	3,8
above ground	36% of residues	25% of above ground balance	14% on top of above ground available felling residues	6% on top of above ground available balance

Totally about 130 mill.m^3/y - 21 Mtoe/y
(in the Cepi report 75 mill.m^3/y)

1 Mm3 ~ 0.166 Mtoe

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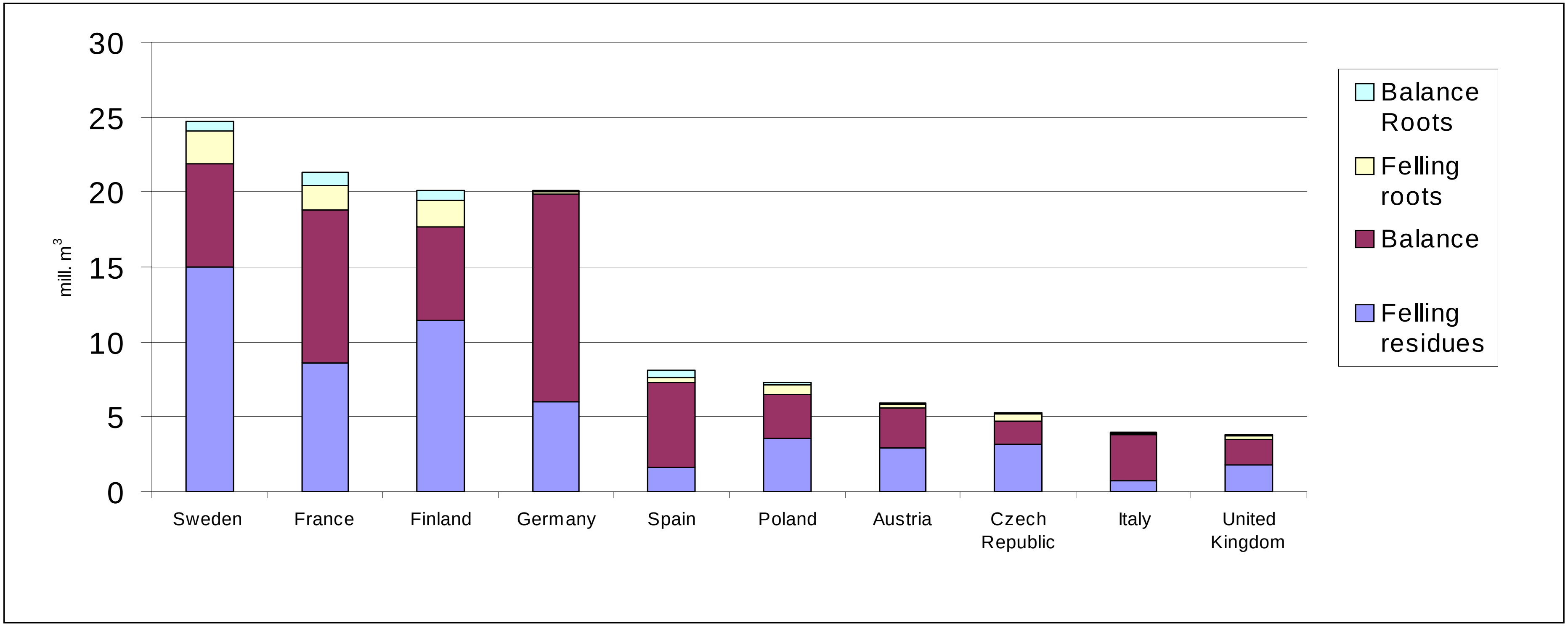
Volume of available forest fuels by country in Europe

COUNTRY	Share of timber from clearcuts %	Share of mechanization in cutting %	Total felling residues (mill. m^3 /y)	AVAILABLE RESIDUES OF FELLING (mill. m^3 /y)	AVAILABLE RESIDUES OF BALANCE (mill. m^3 /y)	FELLING RESIDUES VOLUME OF ROOTS AVAILABLE (mill. m^3 /y)	BALANCE VOLUME OF ROOTS AVAILABLE (mill. m^3 /y)
Austria	18 %	30 %	10,1	2,9	2,7	0,2	0,1
Belgium	(70% by default)	80 %	2,6	1,1	0,3	0,1	0,0
Cyprus							
Czech Republic	83 %	10 %	8,9	3,2	1,5	0,5	0,1
Denmark	70 %	50 %	1,2	0,4	0,4	0,0	0,0
Estonia	73 %	55 %	1,6	0,6	0,0	0,1	
Finland	79 %	97 %	26,7	11,4	6,3	1,8	0,6
France	76 %	40 %	22,6	8,6	10,2	1,6	0,9
Germany	5 %	35 %	23,4	6,0	13,9	0,1	0,1
Greece	6 %	0 %					
Hungary	72 %	15% A.A. estimation	2,0	0,7	1,2	0,1	0,1
Ireland	82 %	95 %	1,3	0,6	0,4	0,1	0,0
Italy	20 %	2 %	2,9	0,7	3,1	0,1	0,1
Latvia	76 %	5 %	2,9	1,0	1,5	0,2	0,2
Lithuania	50 %	0 %	2,2	0,7	1,1	0,1	0,1
Luxembourg							
Malta							
The Netherlands	80 %	25 %	0,6	0,2	0,3	0,0	0,0
Poland	44 %	2,0%	12,5	3,6	2,9	0,6	0,2
Portugal	(70% by default)	(40% by default)	3,6	1,3	0,5	0,3	0,0
Slovakia	40,2%	0,7%	3,0	0,9	1,7	0,1	0,1
Slovenia	0 %	0,7%	1,1	0,3	1,3	0,0	0,0
Spain	(70% by default)	(40% by default)	4,4	1,6	5,7	0,3	0,5
Sweden	70 %	98 %	35,2	15,0	6,9	2,2	0,6
United Kingdom	(70% by default)	90 %	4,4	1,8	1,7	0,2	0,1
TOTAL			**173,2**	**62,6**	**63,5**	**9,0**	**3,8**

Volume of technically available forest fuels, top 10

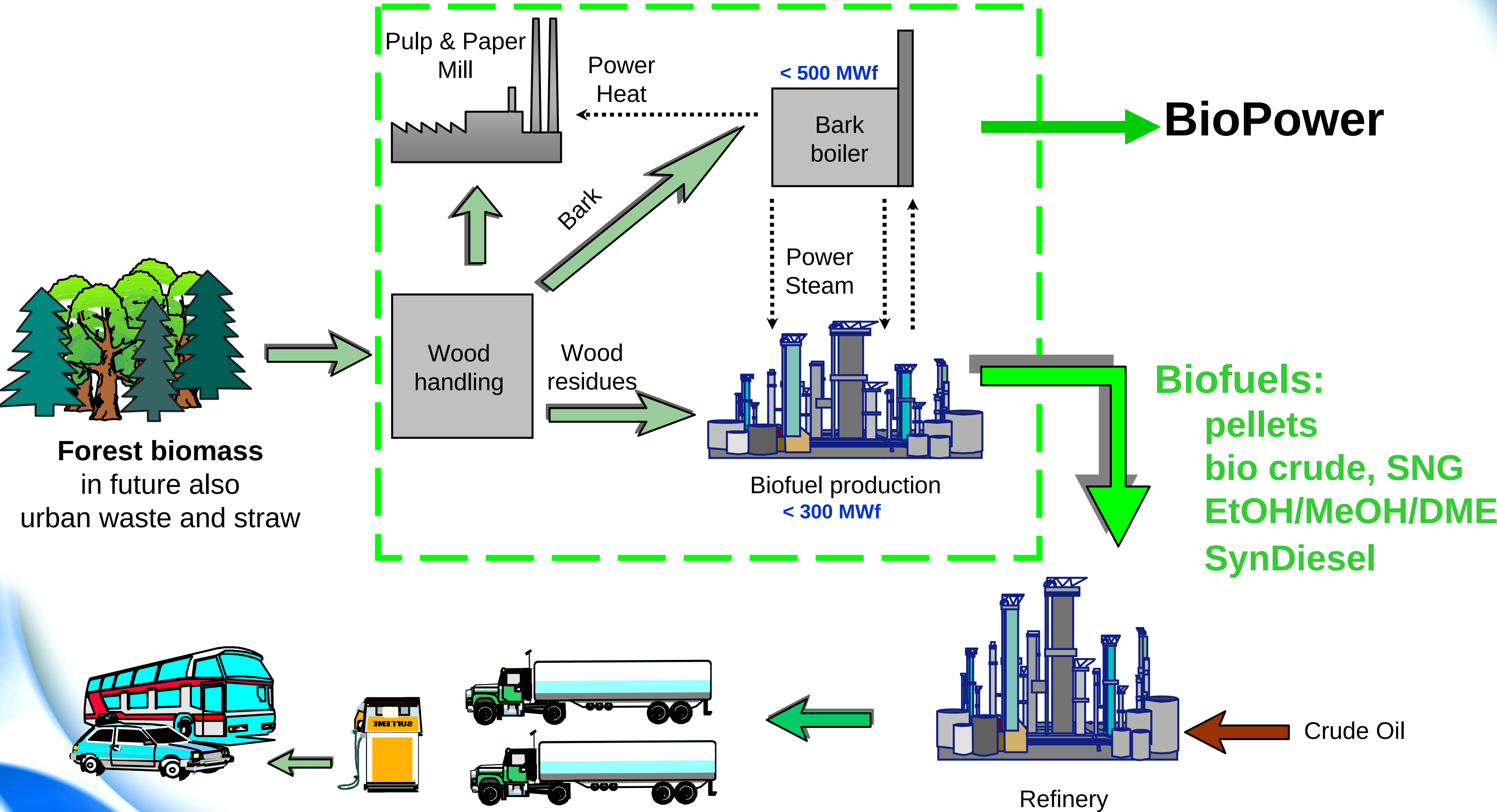


- Industrially available, < 20 €/MWh,
  20 – 50 % of the technically available volumes ?

1 Mm3 = 0.166 Mtoe

OPTIONS FOR FOREST INDUSTRY ?

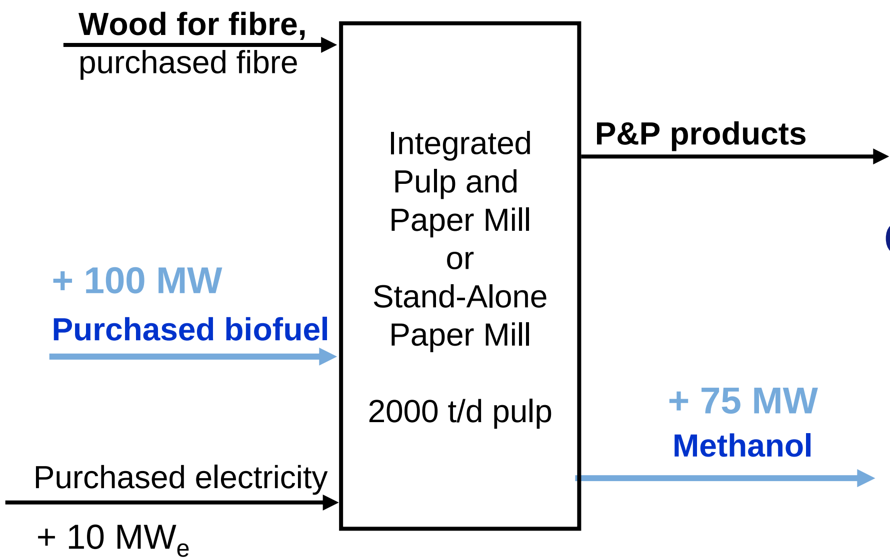
- benefit of raw material, polygeneration, large scale -



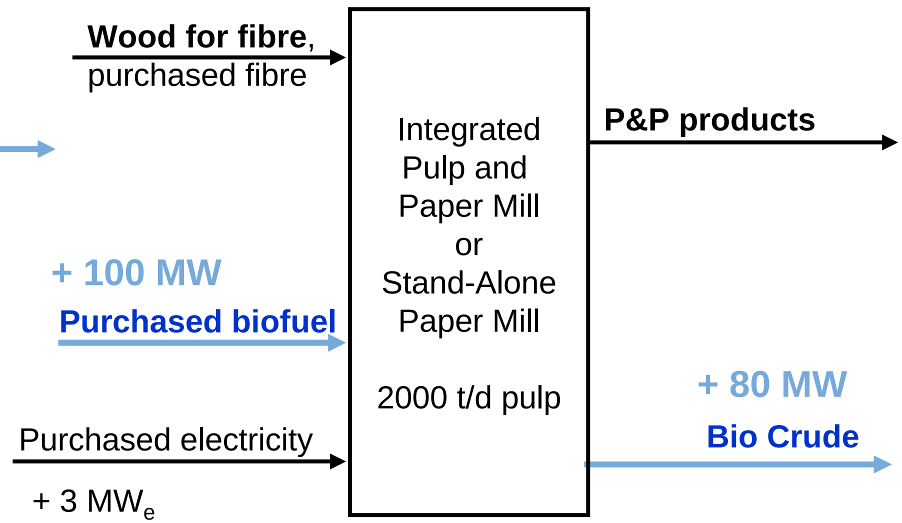
Energy Balances for Upgraded Biofuels at Pulp & Paper Mills

Fuel input of 100 MW_{fuel} - Incremental energy flows (LHV basis)

Case A: methanol from solid biofuel



Case B: pyrolysis oil from solid biofuel



Investment of the order of:

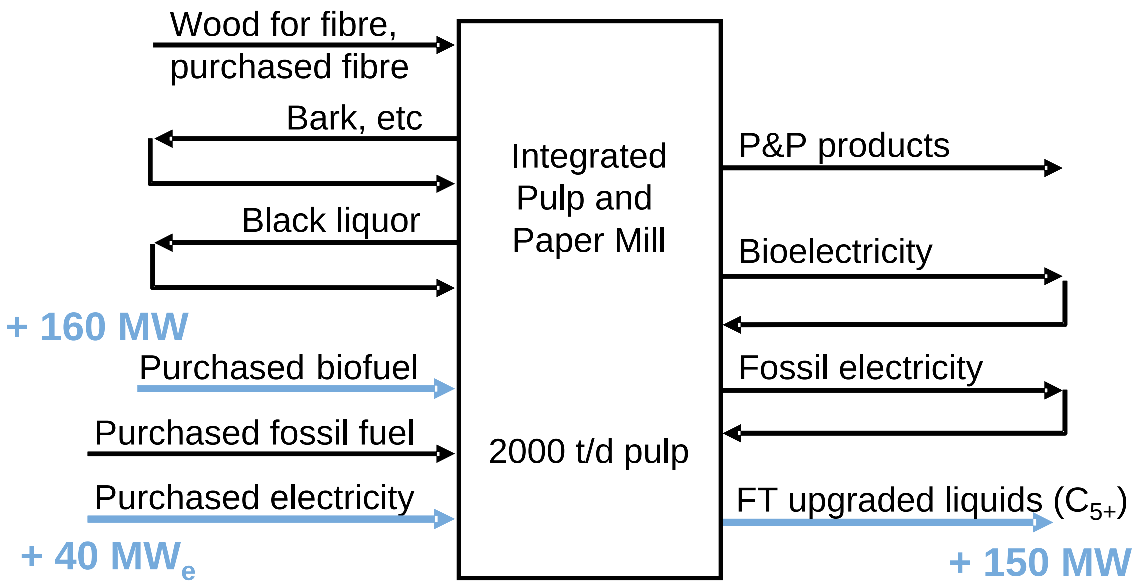
100 - 130 M€

15 - 20 M€

Co-Production of Syngas Derivatives

Incremental energy flows (LHV basis)

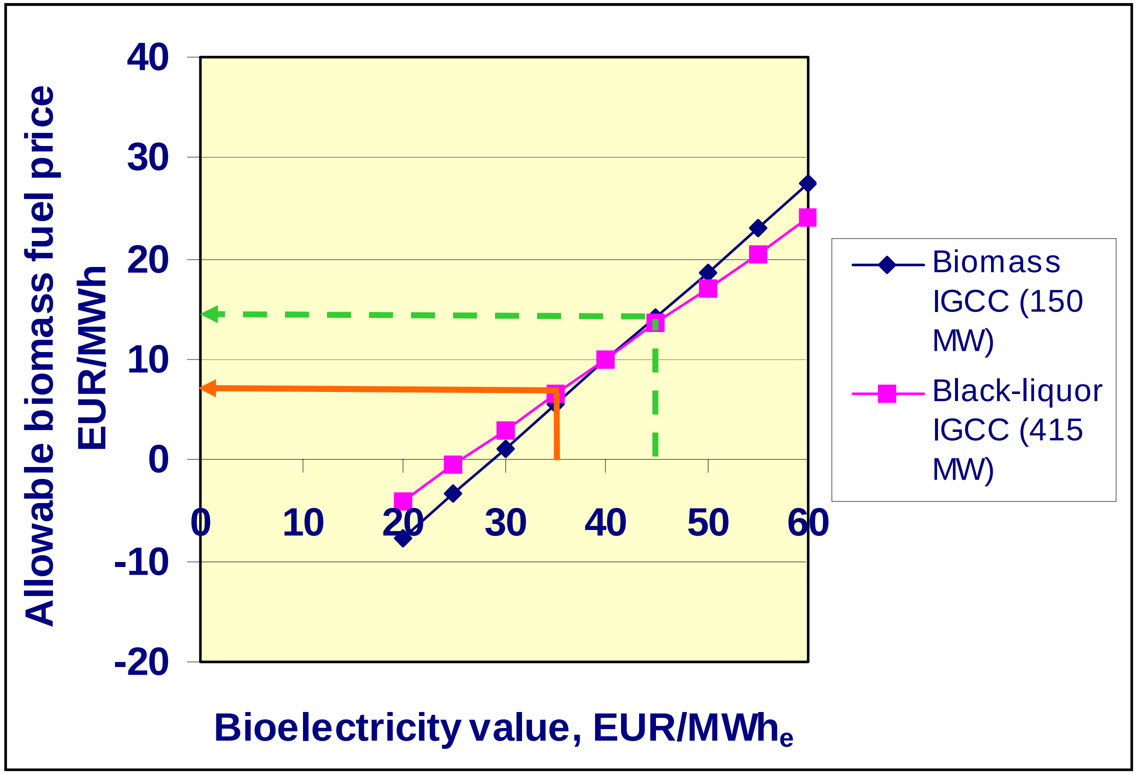
Case C: FT-liquids production from solid biomass residues (300 MW_{fuel})



Increased Electricity Production

IGCC fired by solid biomass residues vs. IGCC fired by black liquor

Feed-Cost-Product-Cost-Lines for incremental power; heat 13 €/MWh, interest 10 %



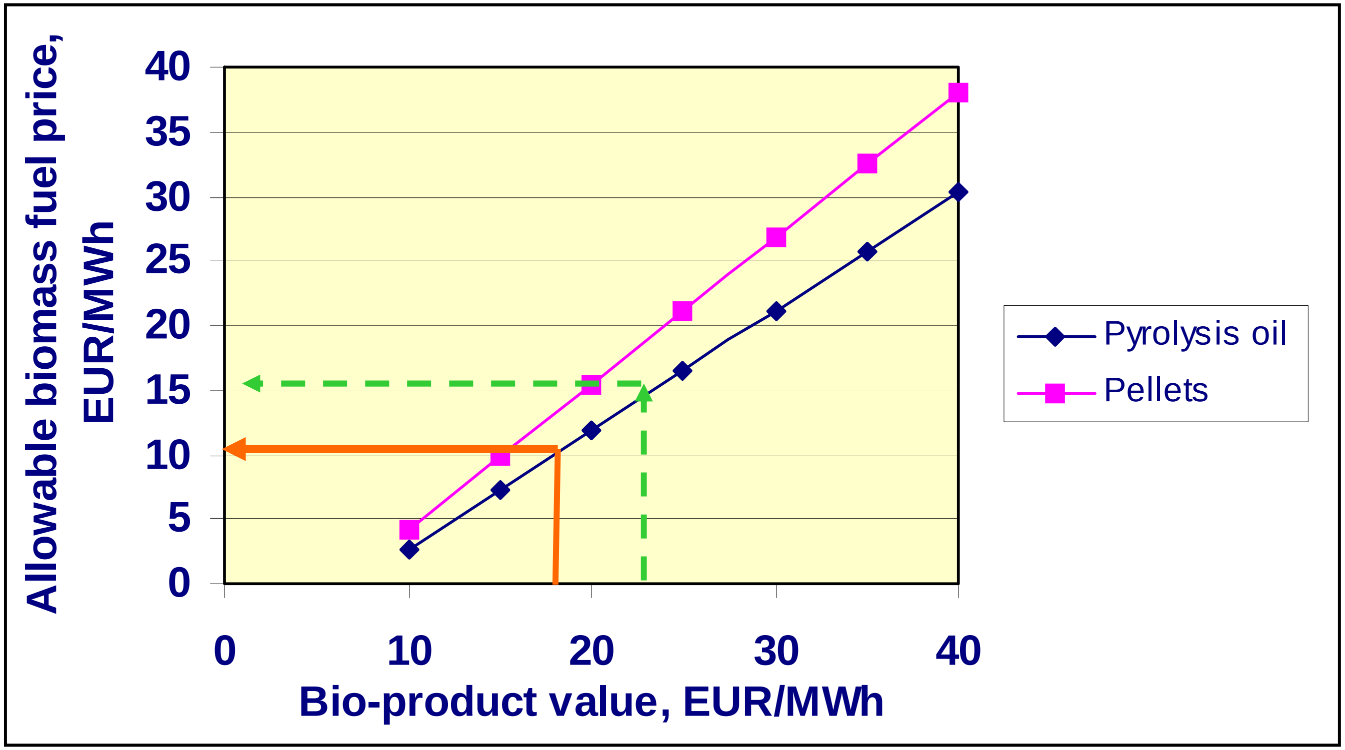
Notes: (1) incremental power costs are independent of the price of process heat

(2) black-liquor case includes larger power boiler

Co-Production of Fuel-Oil Substitutes

Pyrolysis oil vs. pellets from solid biomass residues (44 MW_{fuel})

Results: Feed-Cost-Product-Cost-Lines; interest 10 %



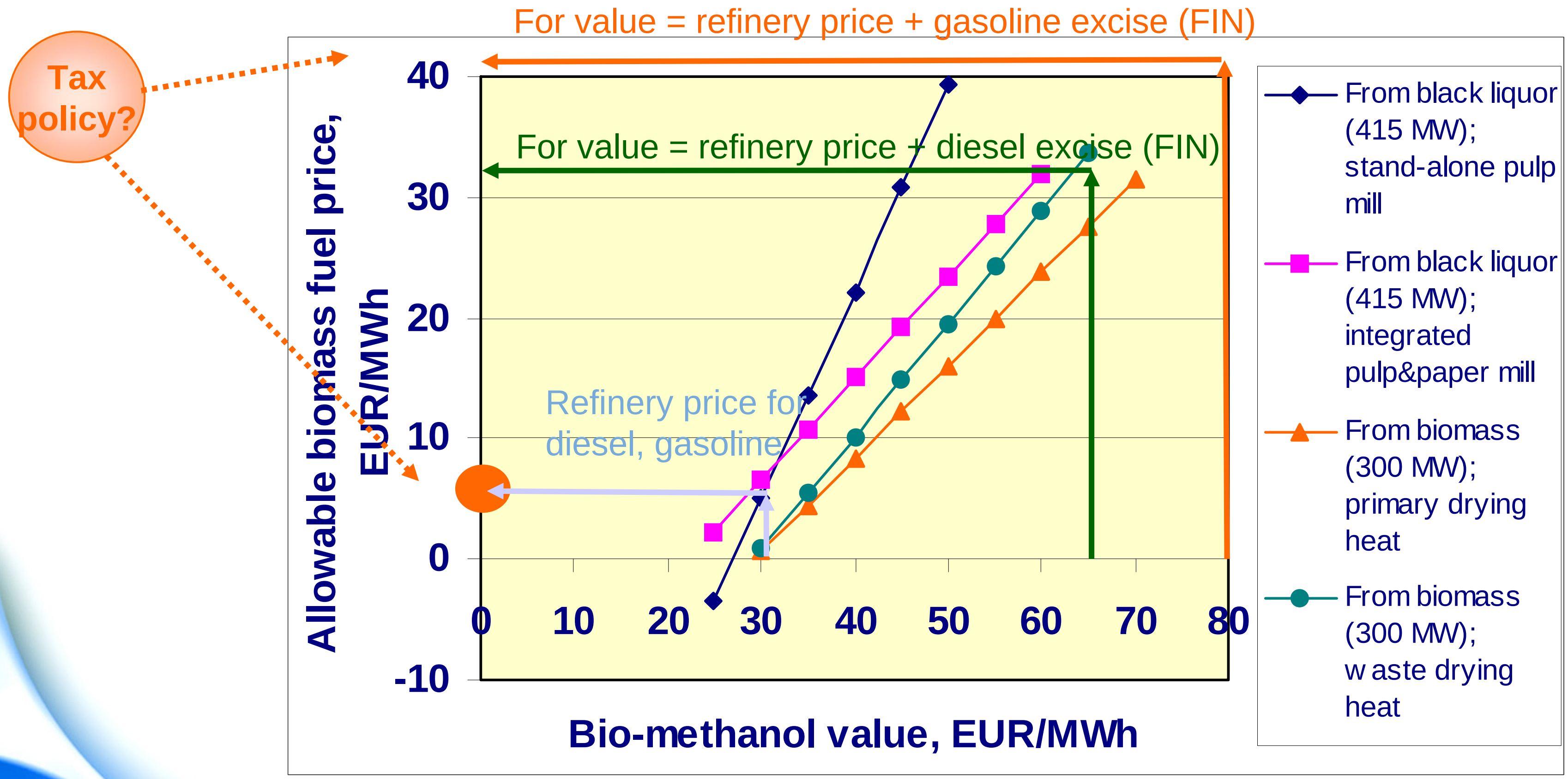
Note: results have only a minor dependence on interest rate over range 5 – 10 %

Incremental investment requirements: 10 - 11 MEUR

Co-Production of Syngas Derivatives

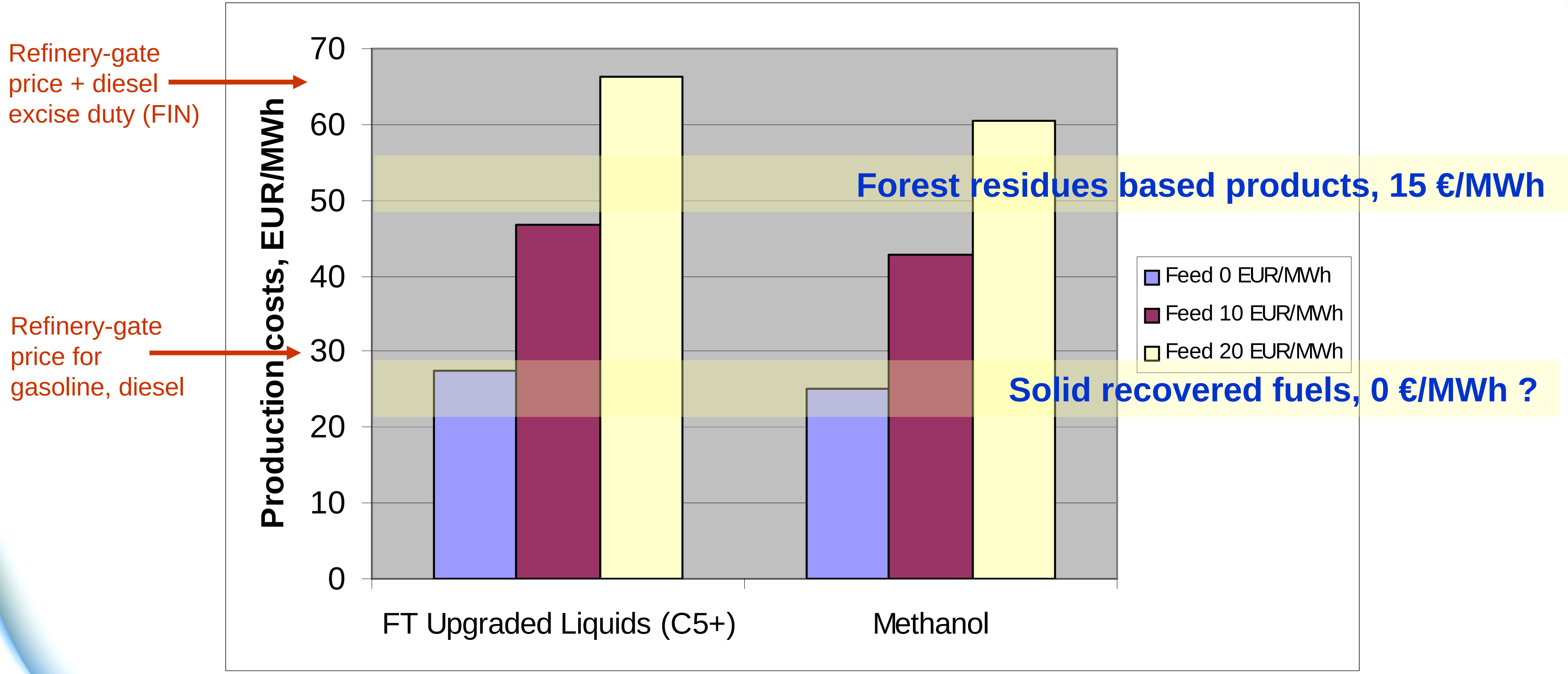
Methanol production from solid biomass residues vs. from black liquor

Results: Feed-Cost-Product-Cost-Lines; interest 10 %



Co-Production of Syngas Derivatives

Results: Raw material price - case: 300 MW_{fuel}, interest 10 %



FT process: FT reforming loop included; FT reactor with reasonably high once-through performance

Theoretical Potential in European Forest Industry Platforms - 100 sites out of 1300 mills -

- for IGCC plants: 4 000 MW_e ~ **33 TWh_e/a** of additional electricity from 4500 MW (37 TWh/a) ~ 3 Mtoe/a of solid biomass residues

- for methanol plants: 16 500 MW (135 TWh/a ~ **12 Mtoe/a**) of methanol from 25000 MW (205 TWh/a) ~ 18 Mtoe/a of solid biomass residues

- for FT-liquids plants: 14 500 MW (120 TWh/a ~ **11 Mtoe/a**) of FT liquids from 18 000 MW (150 TWh/a) ~ 14 Mtoe/a of solid biomass residues

- Forest residues would be available, < 20 €/MWh price, up to 6 – 10 Mtoe/a. Solid recovered fuels (SRF) and straw/annual crops should be supplementary fuels

- The forest industry platform offers up to 20 – 30 % lower production cost than in stand alone option.

- The EU biofuel demand in 2010 is **18 Mtoe/a** according to the Biofuel Directive

Conclusions

- **Forest residues from integrated wood harvesting offer low price raw material for synfuels. Commercial wastes and Solid recovered fuels additional option in some countries.**
- **Production of IGCC power is profitable when bio-electricity value of 35 - 40 EUR/MWh$_e$. The corresponding costs of CO_2 emissions abatement are low: 5 - 20 €/t of CO_2.**
- **Co-production of pyrolysis oil and pellets is competitive at the current price of fuel oil**
- **Co-production of syngas-derived transportation fuels is estimated to be competitive provided that the liquid biofuels are granted exemption from excise duty. CO_2 abatement costs are fairly high > 50-100 €/t of CO_2, however much lower than for traditional RME and grain EtOH. Second generation syngas production technology needed !**
- **Synfuels could be co-produced from black liquor or from solid biomass residues. Solid biomass-fired technologies have greater market volume potential, represent a smaller availability risk for the pulp mill and have considerably less technical uncertainty associated with them.**
- **For the European forest-products industry, co-production of bioenergy is an attractive opportunity. Low production cost alternative. The capacity would be limited, not by the availability of forest-products industry platforms, but by the availability of competitively-priced solid biomass fuel. Long term policies and tax incentives needed.**
- **Biofuels production for transport has changed the role of bioenergy from regional to European and global challenge. International RTD co-operation is essential for the future.**

Thank you !