Business from technology

Bioenergy carriers - Integrated pyrolysis and torrefaction concepts

‘Thermal pre-treatment of biomass for large-scale applications’

IEA Bioenergy ExCo 66, York,UK 12.10.2010

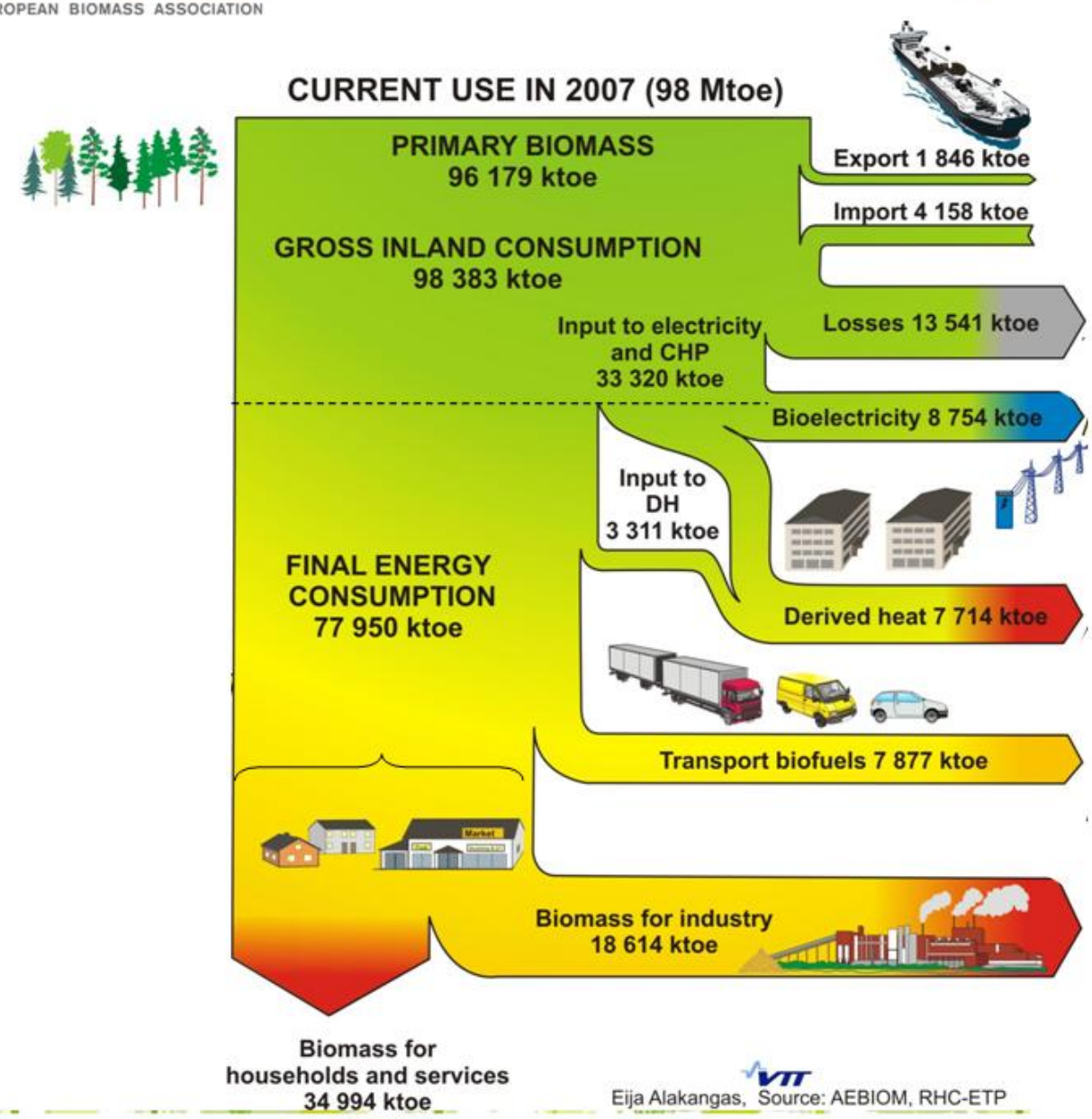
Kai Sipilä, Yrjö Solantausta, Carl Wilén
VTT Technical Research Centre of Finland

Esa Sipilä
Pöyry Management Consulting

Content

- EU policies and the 2020 targets will increase the market for renewable energy sources, especially for bioenergy. Currently ~ 65 % of RES demand, 2 x current volumes ?
- Ambitious target for 10 % biofuels in transport and large scale green electricity production. Huge fuel demand.
- Lack of low price raw material sources, key focus to overall chain integration and efficiencies. Biomass trade.
- EIBI European Industrial Bioenergy Initiative call for new solutions in 7 value chains – bioenergy carrier is one.
- Pyrolysis and torrefaction integration to current forest biomass operation. Parallel to utility and refinery actions.
- Conclusions and recommendations

Is biomass availability sufficient ?

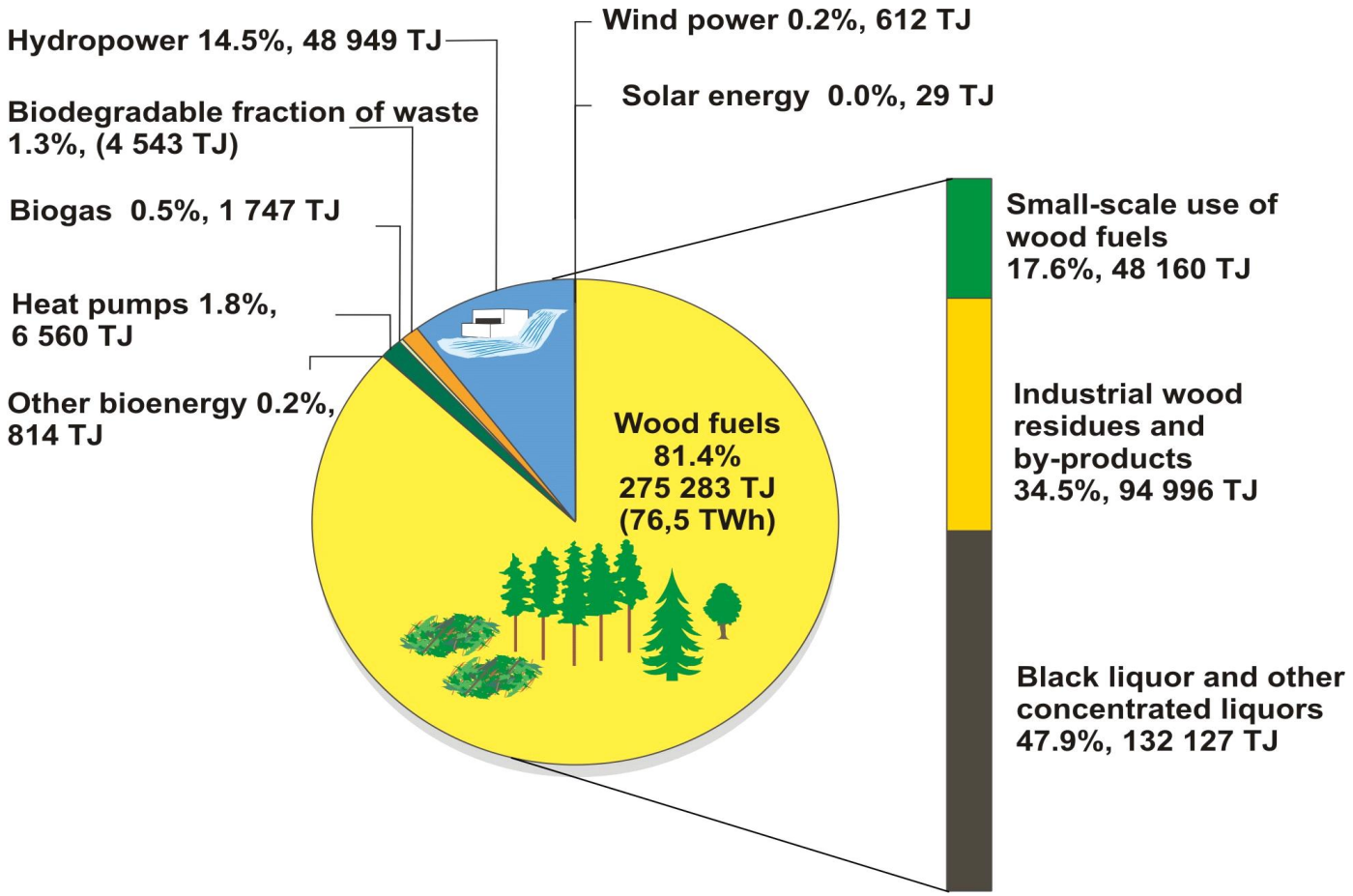


Gross inland consumption

Final energy consumption

Source: Jean Marc Jossart, Aebiom
" Evaluation of the
National Renewable Energy Action Plans"
Forest Bioenergy Conf, Tampere 2010

Renewable energy sources in Finland

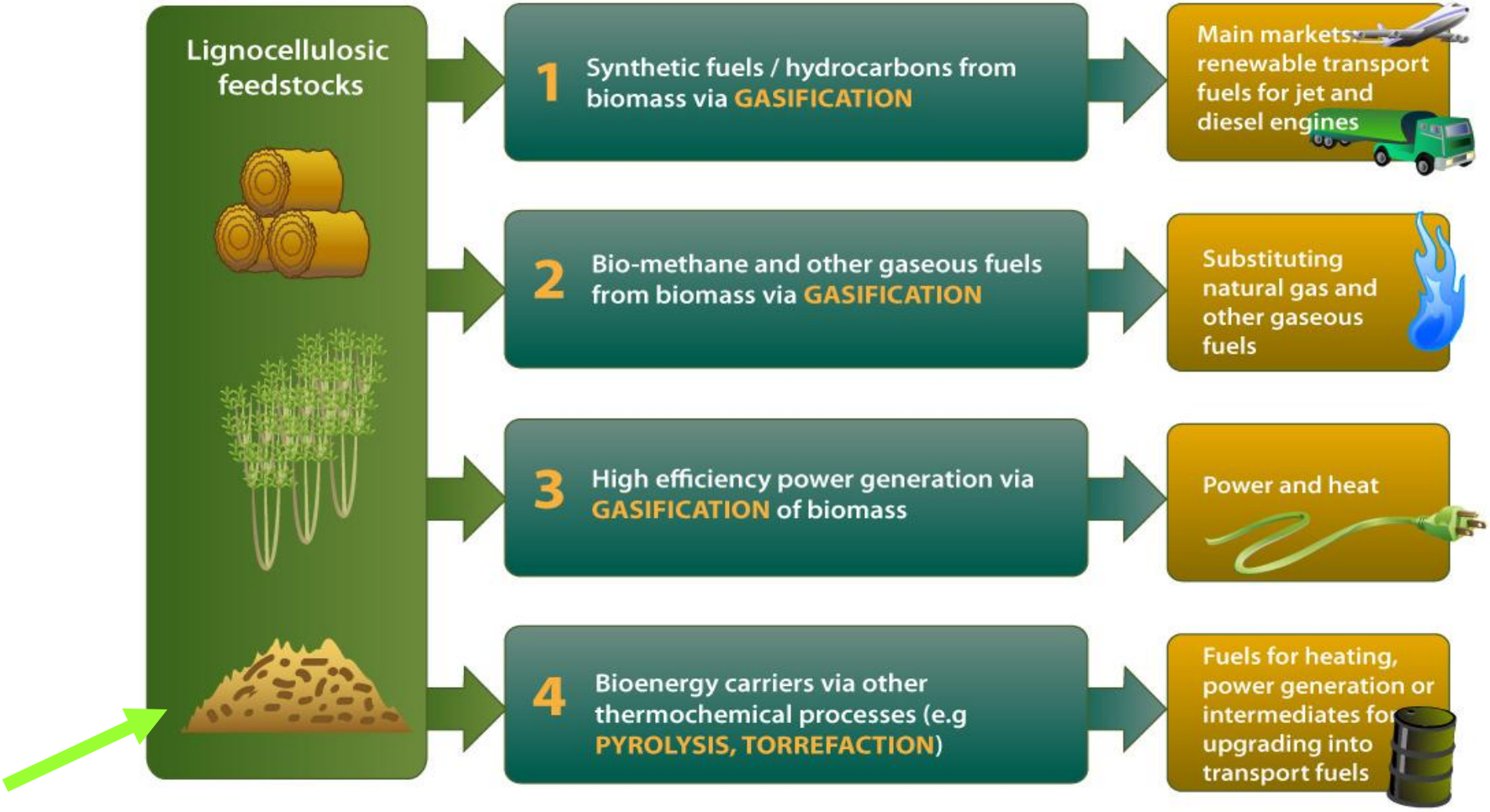


Renewable energy sources 338 537 TJ (8.1 Mtoe), 25% of total energy consumption

EIBI European Industrial Bioenergy Initiative-

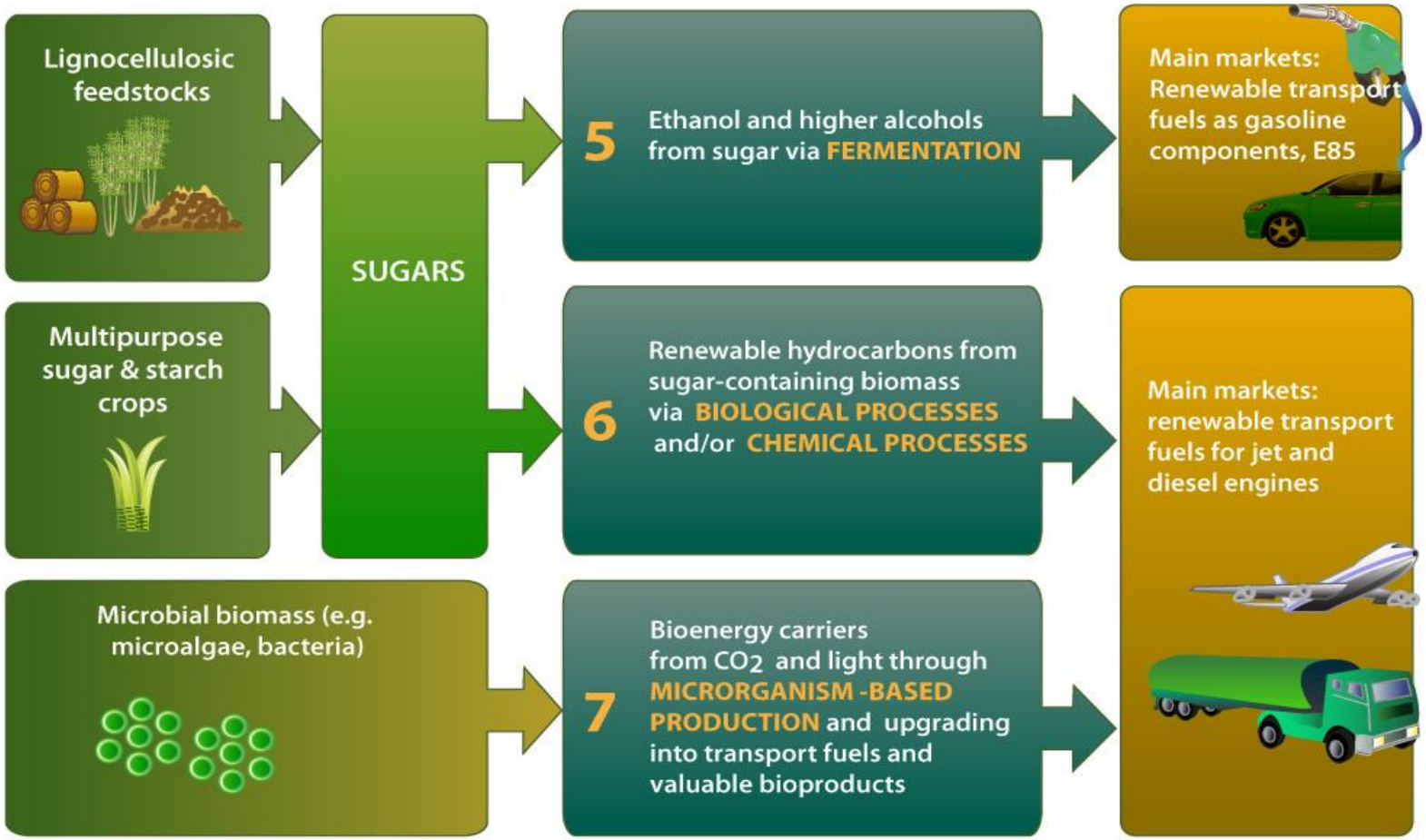
Selected large scale bioenergy value chains 1(2)

Advanced conversion paths based on thermochemical processes



Selected large scale bioenergy value chains 2(2)

Advanced conversion paths based on biological and chemical processes



European Biofuels TECHNOLOGY PLATFORM

EBTP proposal for EIBI

Budget, timing & funding

7 "generic" value chains		Estimated # of demo / reference needed	Total estimated budget M€	Public funding M€	Comments Ratio Public Grant /RSFF*
1	Synthetic fuels / hydrocarbons from biomass via gasification	1 D 2 R	1300-1700	650-850	50%/50%
2	Bio-methane and other gaseous fuels from biomass via gasification	1 D,2 R	500 - 800	250-400	50%/50%
3	High efficiency power generation via gasification of biomass	2 R	600 - 900	300-450	50%/50%
4	Bioenergy carriers from biomass via other thermochemical processes like pyrolysis, torrefaction etc.	2 R	300 - 400	150-200	50%/50%
5	Ethanol and higher alcohols from carbohydrates containing biomass[1]	1D 2 R	900 - 1200	450-600	50%/50%
6	Renewable hydrocarbons from carbohydrates containing biomass via biological and/or chemical process	2 D 1 R	400 - 500	200-250	50%/50%
7	Production of bioenergy carriers from CO2 & sunlight through micro-organism based production (algae, bacteria etc.) and further upgrading into transportation fuels and valuable bio-products	2-3 D 1 R	1200 - 1500	600-750	50%/50%
Additional activities					
B	- Contribution to production and harvesting of biomass - Reserve for still unidentified value chains		800 -1000	400-500	50%/50%
	TOTAL		6000 - 8000	3 000-4000	

Overview on estimated Budget per value chain

*RSFF = Risk Sharing Finance Facility

Bioenergy Market Potential in European Forest Industry to 2G Biofuels and CHP by 2020

Kai Sipilä & Satu Helynen,
VTT

Esa Sipilä & Jaakko Jokinen,
Pöyry Forest Industry Consulting

17th European Biomass Conference

Hamburg 30.6.2009

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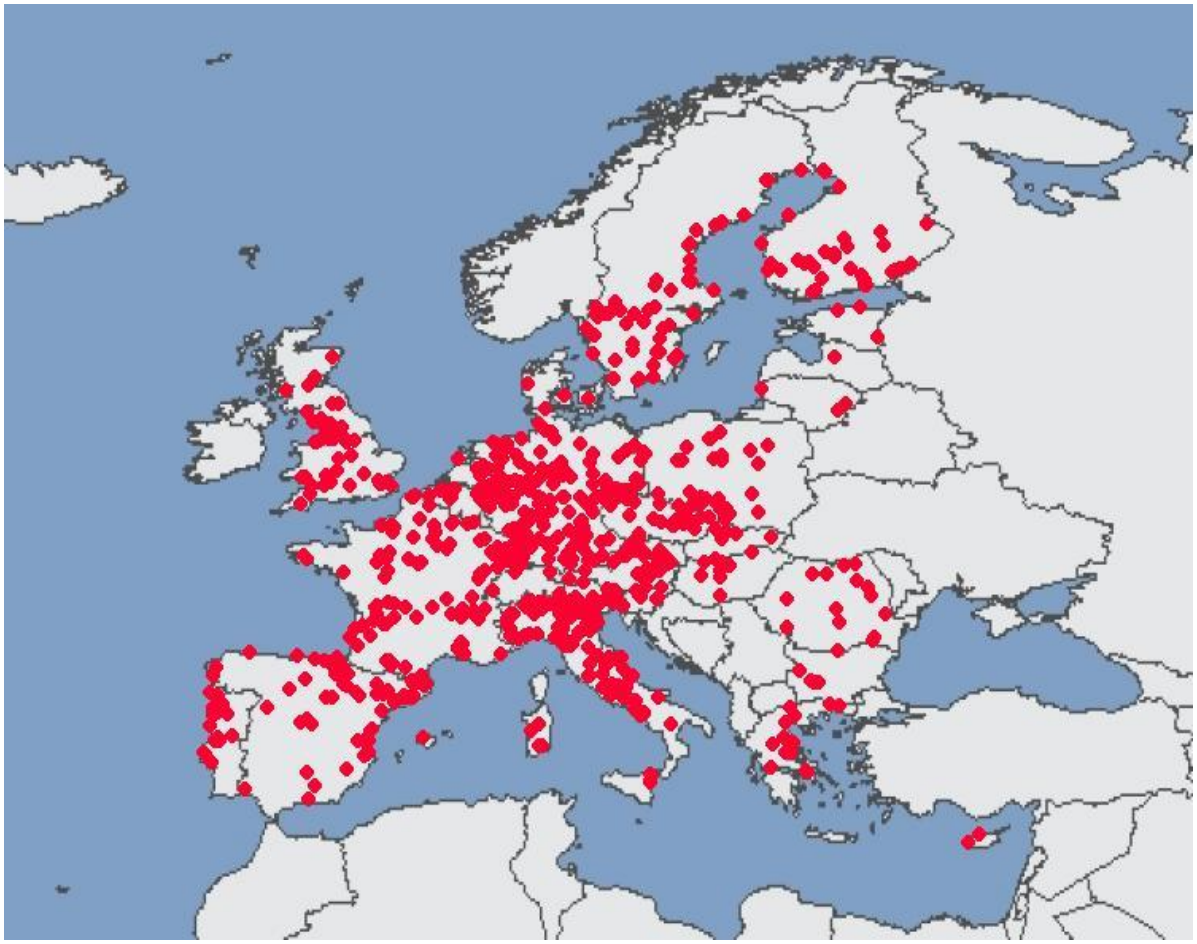
There Are More Than 950 Pulp and Paper Mills in Europe – how large market potential by 2020, raw material demand ?

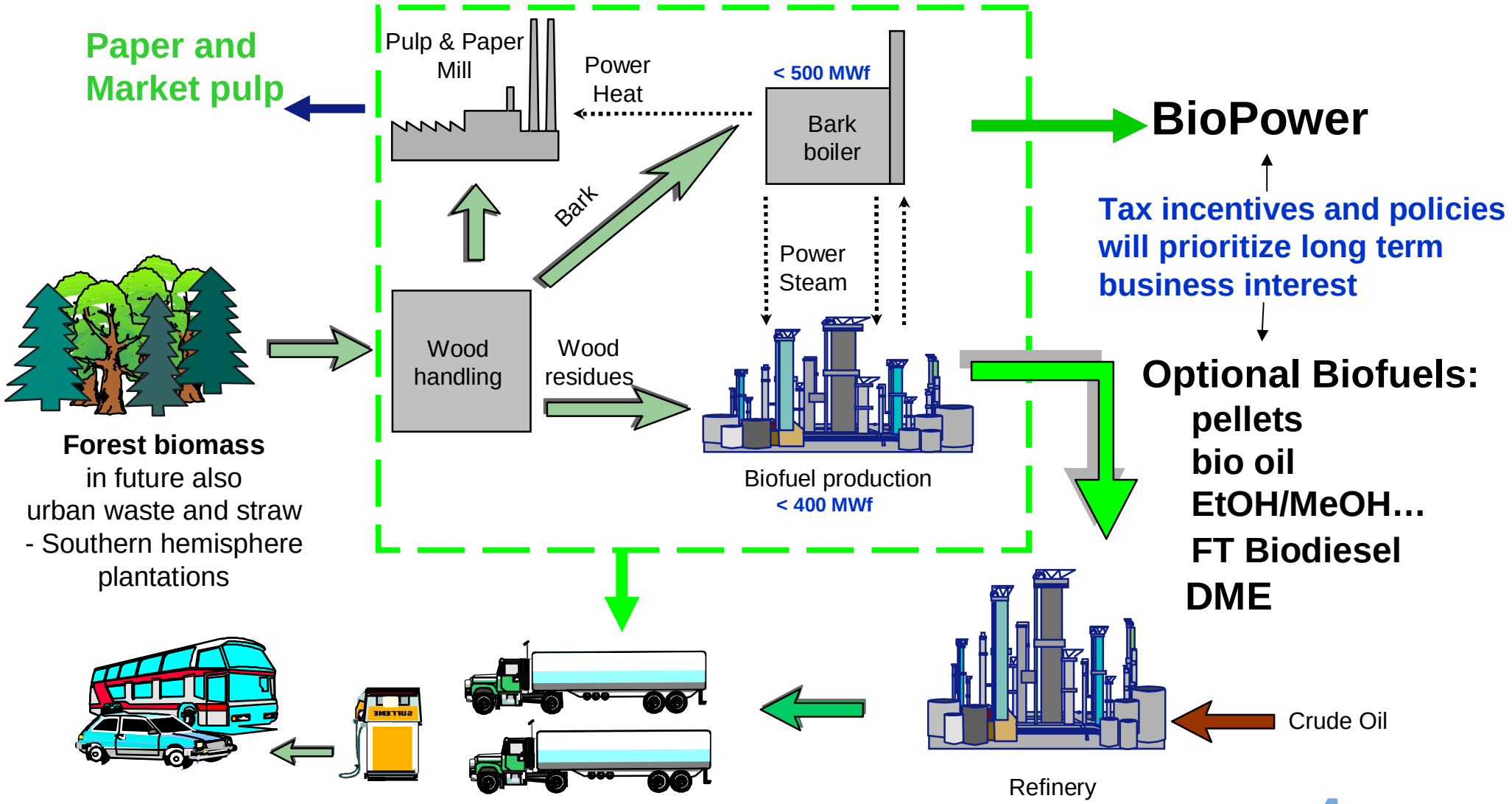


PÖYRY

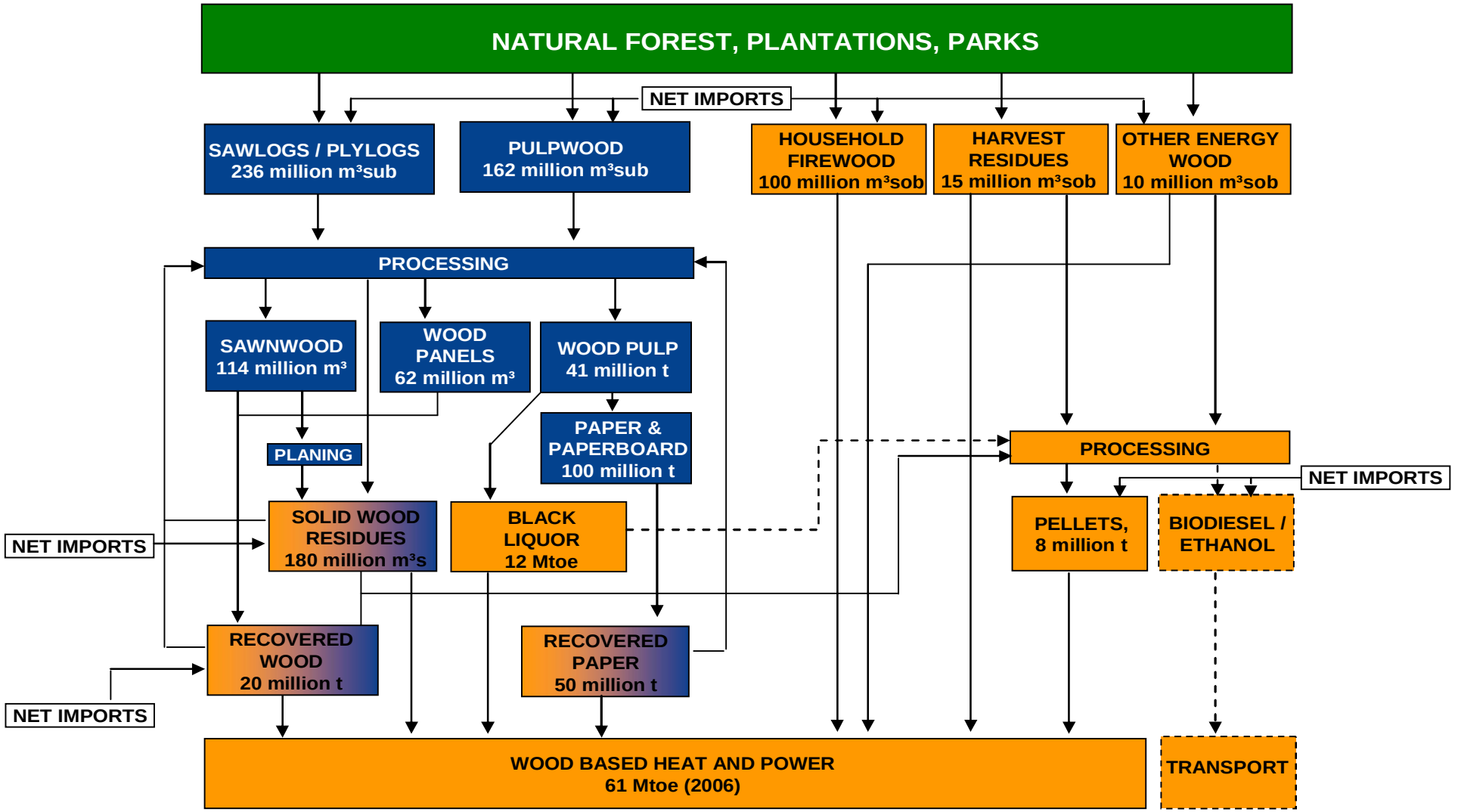
VTT

BIOFUELS FROM FOREST INDUSTRY

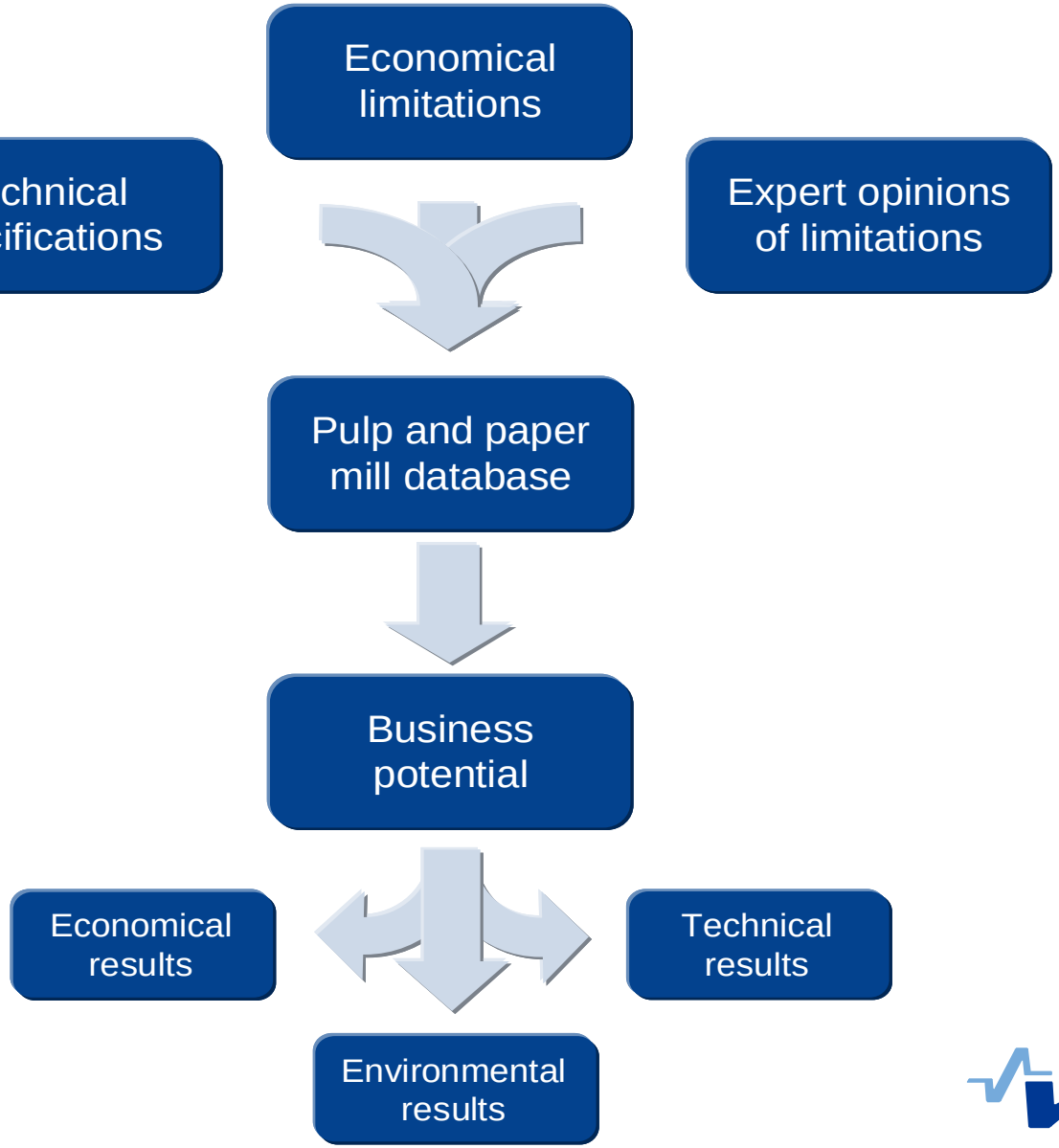
- wood logistics and process integration benefit -



Wood Flows by End Uses in EU-27



Methods for VTT-Pöyry Bioenergy Market Potential Analysis

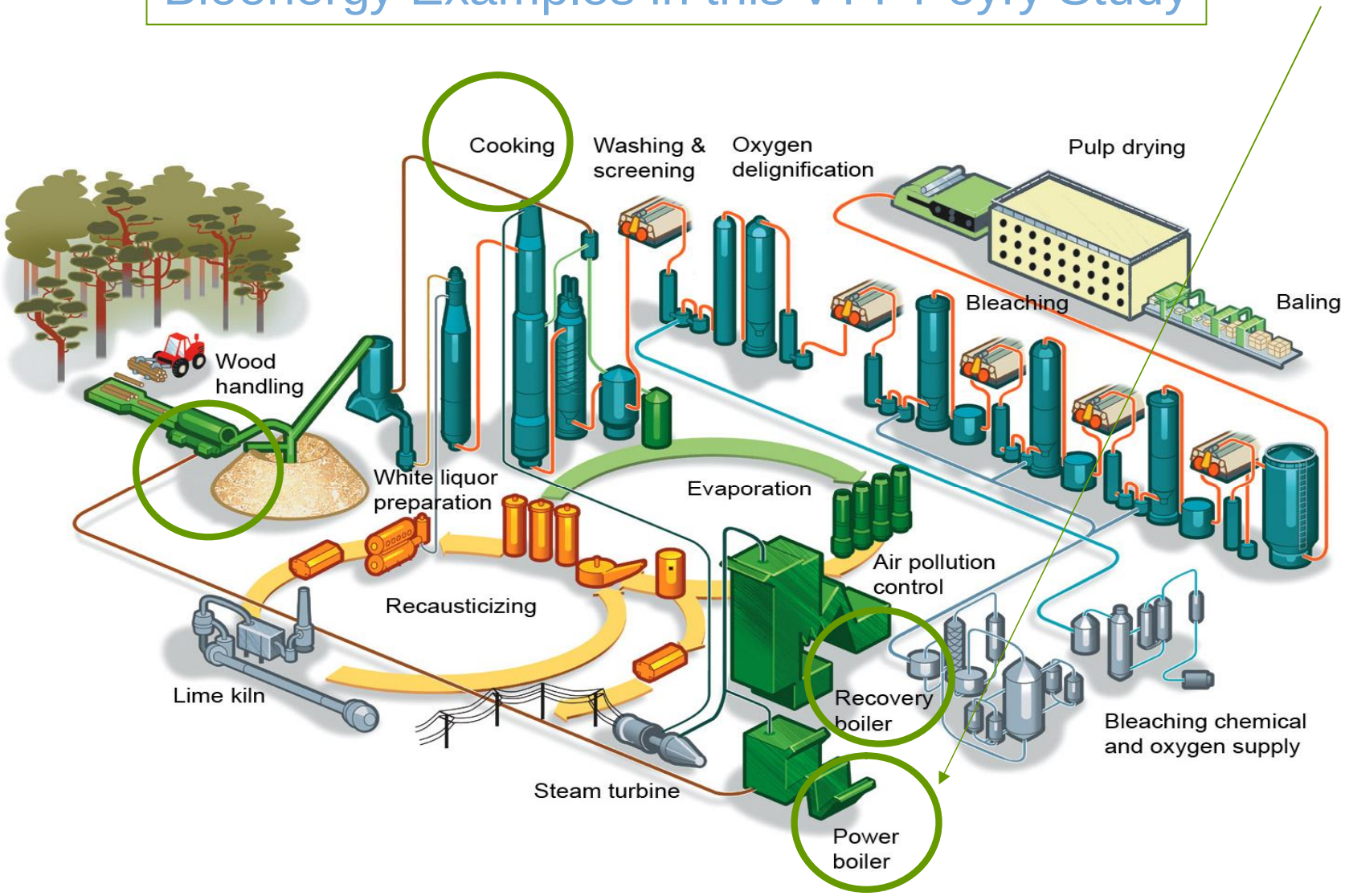


Analysed technologies in EU forest industry

- **Wood fuel oil**
- **Green electricity**
- **FT-biodiesel from wood**
- **EtOH from waste fibre**
- **DME**
- **TOP torrefaction**

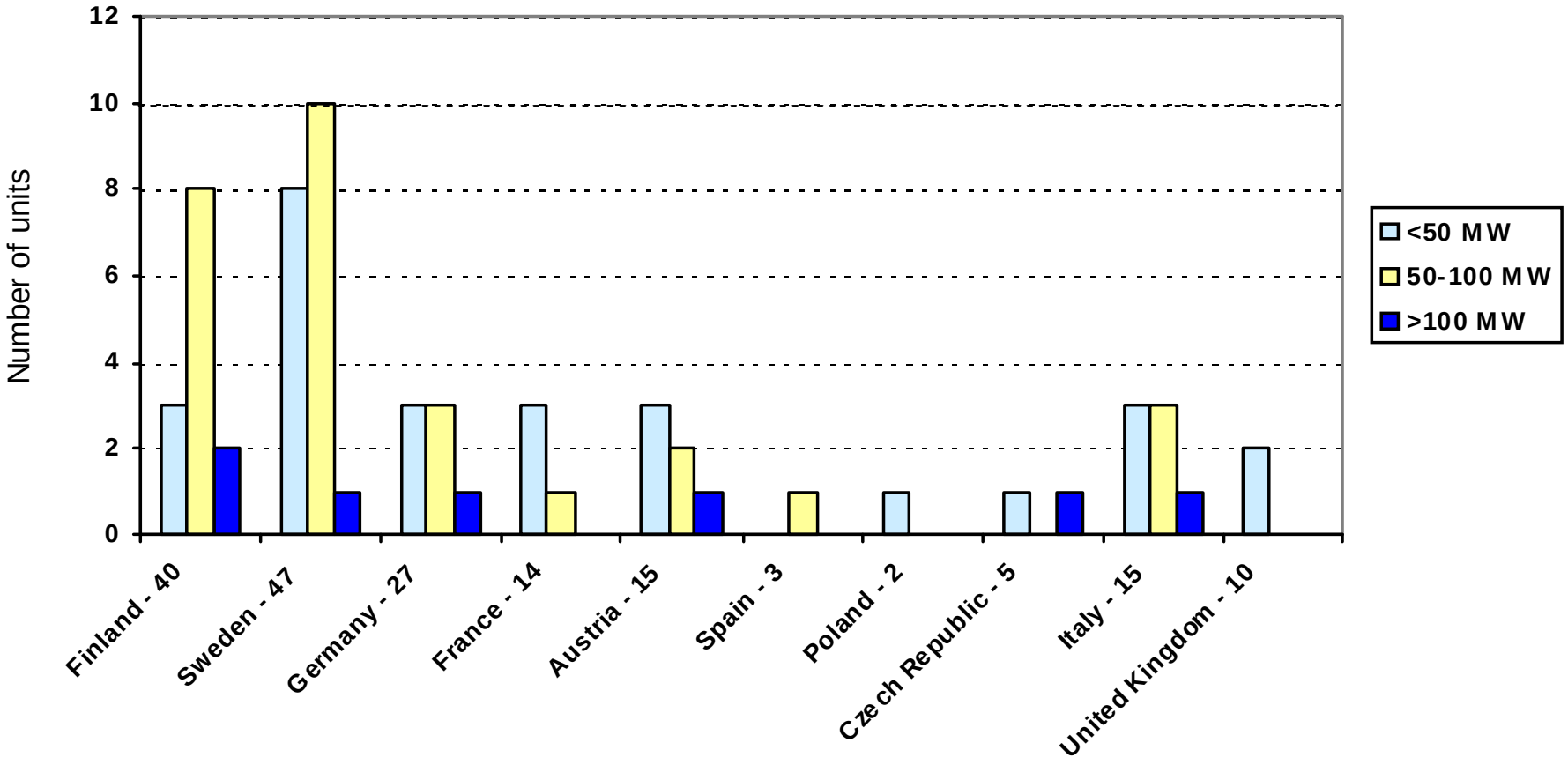
- **Process steam demand is limiting the industrial CHP+Fuel capacity.**

Bioenergy Examples in this VTT-Pöyry Study



Replacement potential of ~ 60 Solid Fuel Boilers in European Pulp and Paper industry by 2020

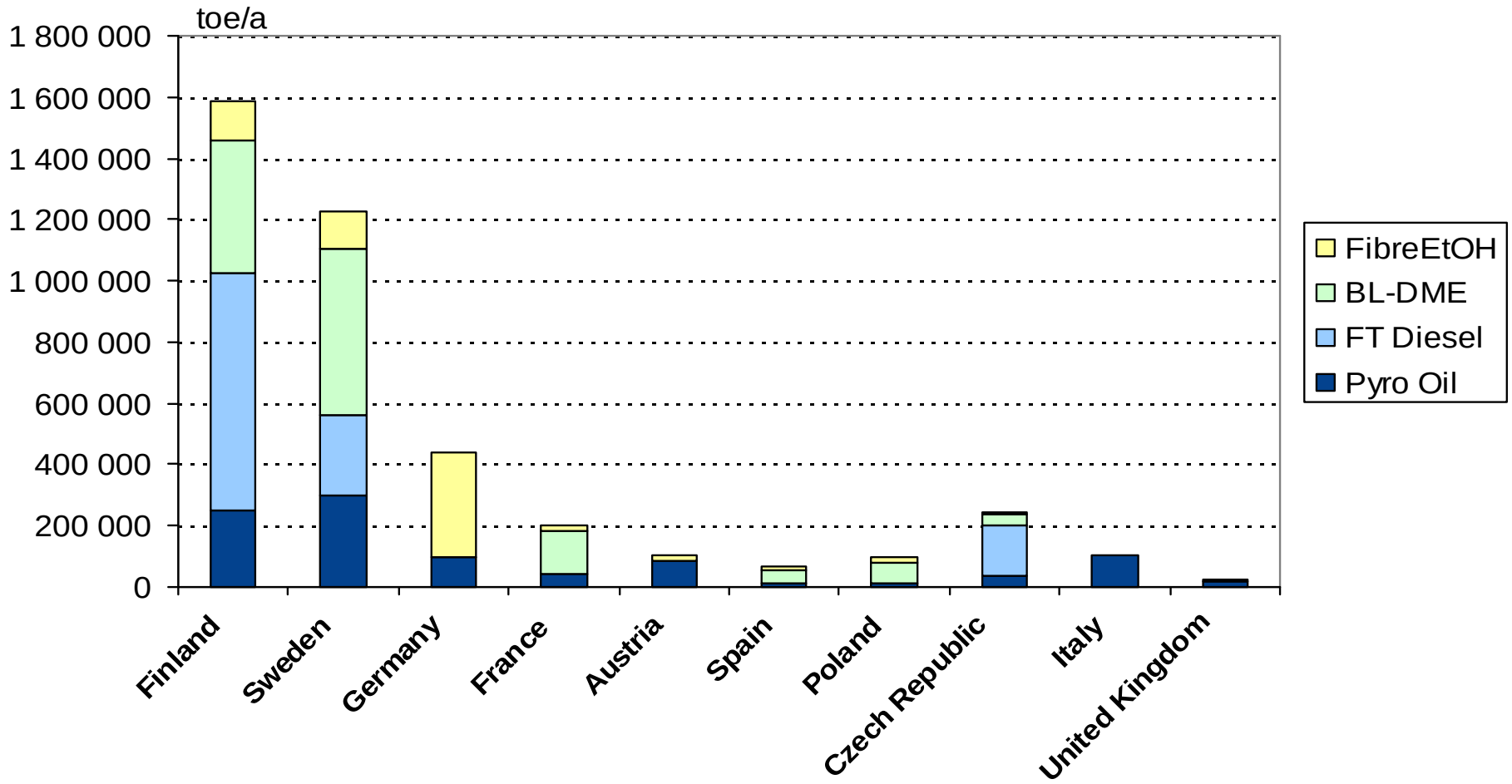
The basis for this market potential analysis is the replacement potential of old solid fuel boilers - 50% replacement for over 25 years old boilers and 25% for boiler over 15 years old.



Note: Number following the country's name is the total number of solid fuel boiler in pulp and paper industry

Scenario of the Biofuels Business Potential Analysis – 4 Mtoe

The total business potential of liquid biofuels in European pulp and paper industry with selected bioenergy technologies has a revenue potential of 2 500 - 5 000 MEUR/a and a investment potential 11 000 - 16 000 MEUR by year 2020.



Wood Bio-oil (Pyrolysis Oil) Market Potential

Business potential is calculated with the following predictions:

• Over 25 years old solid fuel boilers in European P&P industry will be replaced with new fluidised bed boilers and pyrolyzers with 50 % penetration before year 2020

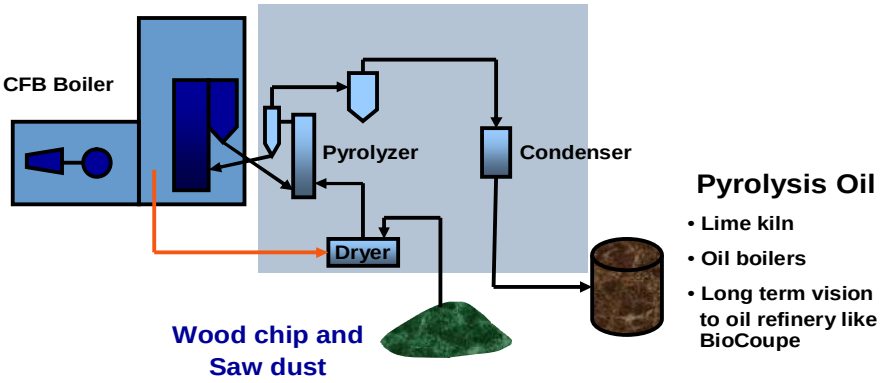
• 25 % penetration of fluidised bed boilers with pyrolysis for 15-25 years old boilers

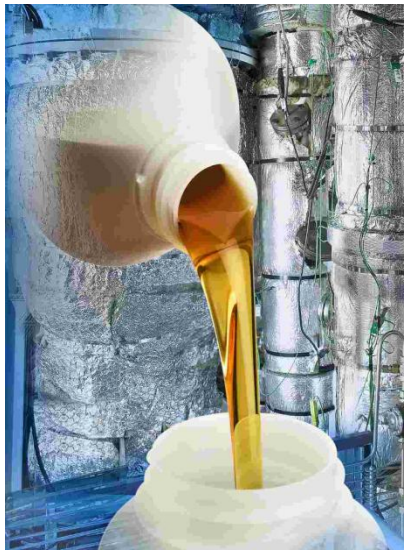
• Fuel input of the pyrolyzer was selected to be 25 MW in <50 MW boilers, 40 MW in 50-100 MW boilers and 80 MW in >100 MW boilers. Integration to main FB-boiler.

• Numbers of boilers in each country is based only on the boiler data with size and age known in the Pöyry's database.

• Pyrolysis oil can be processed to transportation fuels in existing oil refineries in Europe (e.q. Biocoupe project)

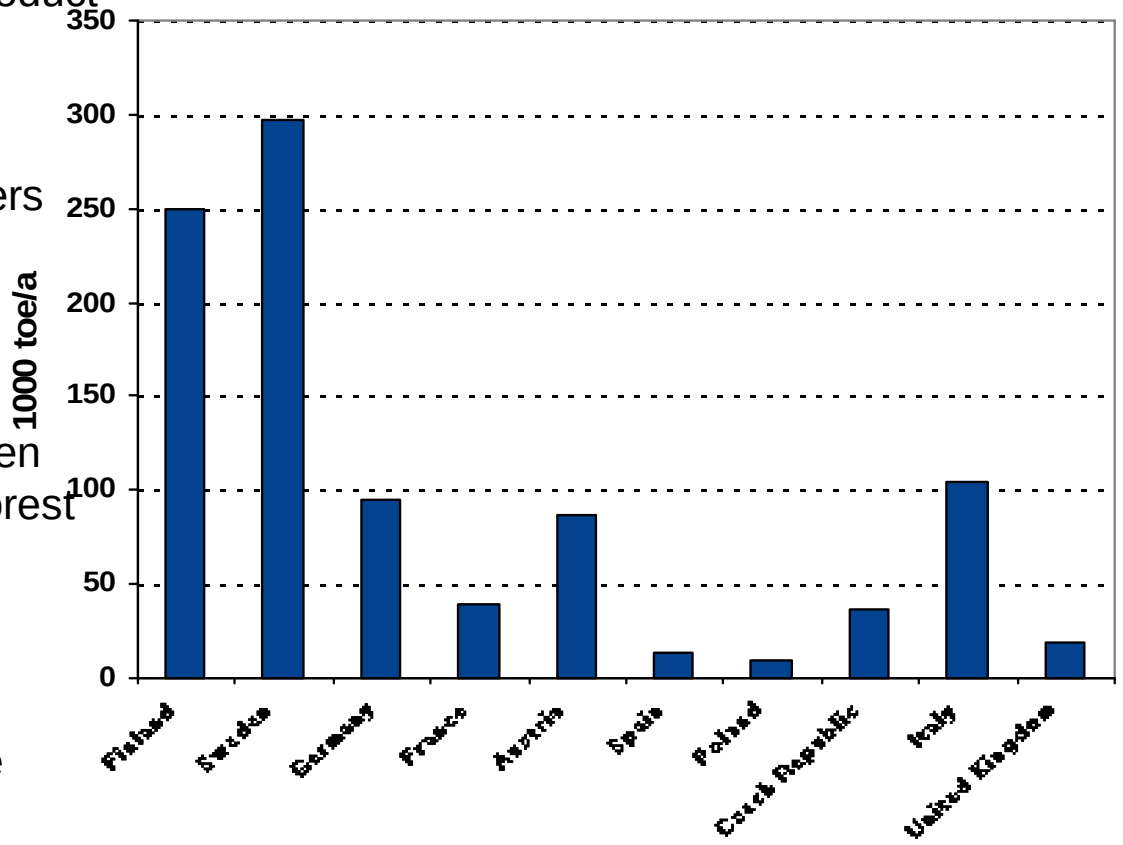
ITP-Pyrolysis unit - VTT ™





Wood Oil Market Potential – 11 TWh/a

- Pyrolysis oil production potential is 11 000 GWh/a, ~ 0,95 Mtoe in 58 units, with the product value of 330 M€/a in selected countries.
- This pyrolysis oil production potential covers 130 % of fossil fuels used in European lime kilns!
- Solid wood fuel demand for pyrolysis is then 17 TWh/a which is 14 % of the European forest residue potential
- Main results were presented in details in the 15th European Bioenergy Conference



DECREASE IN ASH AND HARMFULL ELEMENTS IN PYROLYSIS

Potassium (K), Chlorine (Cl), and Sulphur (S)

	Forest residue		Wheat straw	
	Feedstock	Oil	Feedstock	Oil
K, ppm	1500 - 1800	40 - 110	9000	900
Cl, ppm	100 - 300	20 - 40	2900	1100
S, ppm	400 - 800	90	1200	850

VTT results: solid content in the product < 0.5 m-%

→ ***More than 90% of total ash removed in pyrolysis***

- Up to 95% decrease in K

- Up to 90% decrease in Cl

- Up to 80% decrease in S

→ ***Less ash sintering and melting***

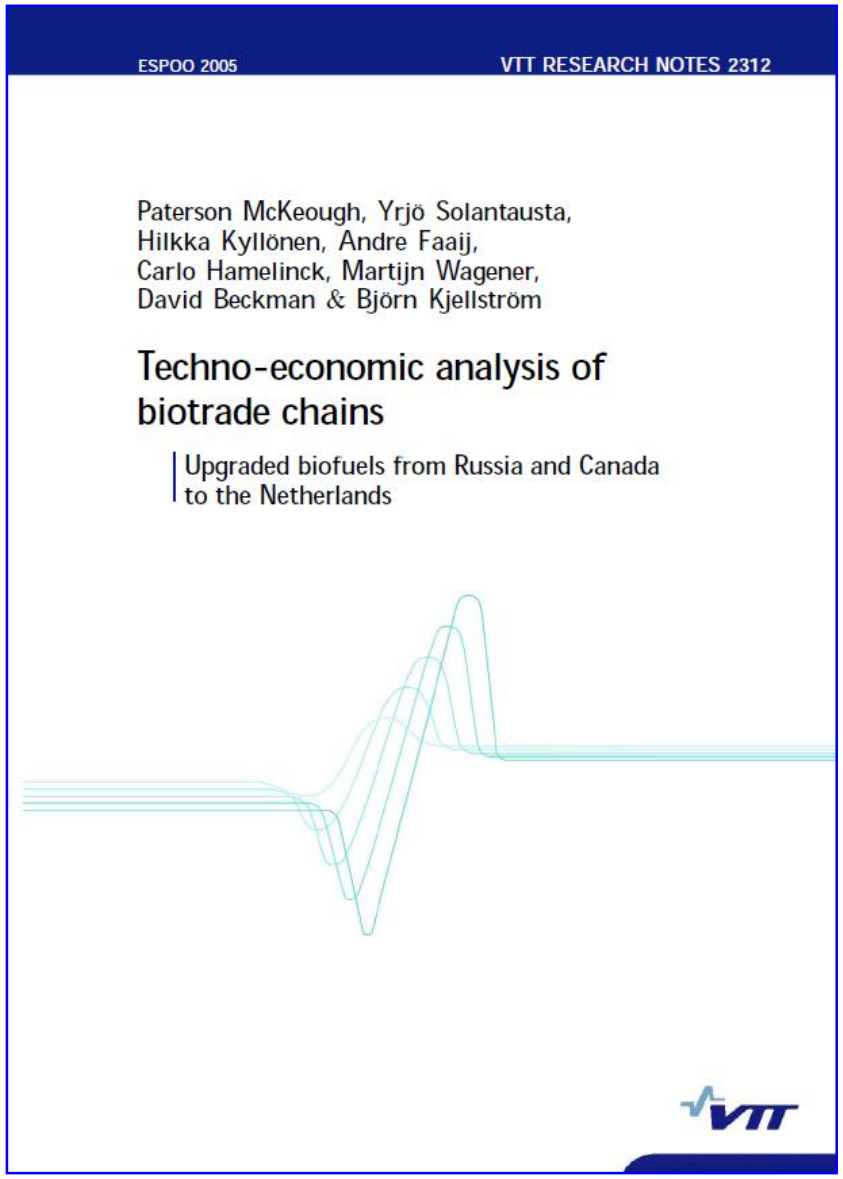
→ ***Less corrosion and fouling***

Source: Anja Oasmaa, VTT

METSO - UPM – Fortum - VTT

Source: Jani Lehto, MetsoPower

- Metso, UPM, Fortum and VTT have developed an integrated biomass-based bio-oil production concept to provide an alternative to fossil fuel oil
- A 2 MW_{th} fuel fast pyrolysis unit has been integrated with Metso's 4 MW_{th} circulating fluidized bed boiler, located at Metso's R&D Center in Tampere
- **Proof-of-concept has been done:**
  - More than 70 tons of bio-oil have been produced from sawdust and forest residues
  - High availability, reliable process
- **Bio-oil utilization has been proven:**
  - More than 20 tons of bio-oil has been used to replace heavy fuel oil at district heating boiler in Masala, Finland
  - More than 50 MWh of district heating has been done by utilizing bio-oil
- **Demonstration plant is being planned**



www.vtt.fi/publications

Table 1. Summary of evaluated biotrade chains.

Export region	Feedstock	Traded commodity	Importing country	End-use
North-Western Russia	Forestry residues	Pyrolysis oil	The Netherlands	Co-firing in coal-fired power station
North-Western Russia	Forestry residues	Pellets	The Netherlands	Co-firing in coal-fired power station
Eastern Canada	Sawmilling residues	Pyrolysis oil	The Netherlands	Co-firing in coal-fired power station
Eastern Canada	Sawmilling residues	Pellets	The Netherlands	Co-firing in coal-fired power station

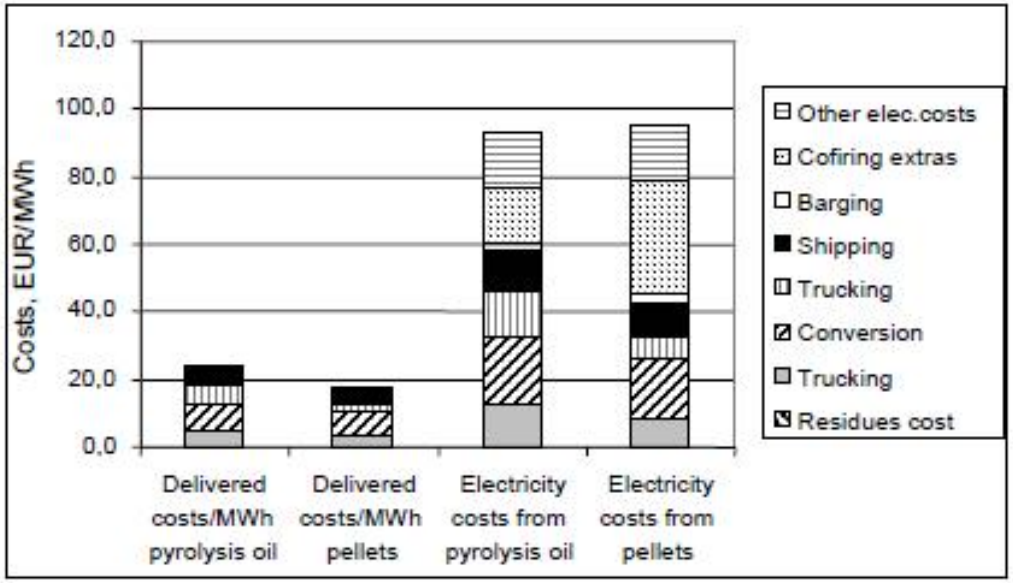


Figure 14. Estimated delivered costs of biofuel and bioelectricity-generation costs for the Canada-Netherlands chains; zero cost for sawmill residues; large custom-built tanker used for shipping pyrolysis oil.

Table 8. Estimated performances and costs of producing pyrolysis oil from stemwood-derived wastes.

Case:	8	9	10	11	12
Configuration	Stand-alone	Integrated with industrial CHP, >100 MW heat	Integ with heat >10 h		
Dryer type	Flue-gas	Flue-gas	Flue		
Operating time, h/a	7800	7800	50		
Plant performance:					
Feedstock input, MW (LHV)	46.8	40.1	4		
Electricity requirement, MW	1.5	1.5	1		
Oil produced					
– top phase, MW (LHV)					
– bottom phase, MW (LHV)	37.1	37.1	3		
LHV-efficiency **, %	79.3	92.5	9		
Total investment, MEUR	11.6	10.2	1		
Production costs, MEUR/a:					
Feedstock	2.99	2.57	1		
Electricity	0.42	0.42	0		
Labour & overhead	0.83	0.21	0		
Maintenance, taxes, etc.	0.46	0.41	0		
Capital costs	1.36	1.19	1.19	1.19	1.28
Total, MEUR/a	6.07	4.79	3.72	3.92	3.99
Production costs, EUR/MWh oil product	21.0	16.6	20.1	21.1	21.5

** Defined as: 100*(LHV-energy output of oil products)/(LHV-energy input of feedstock).

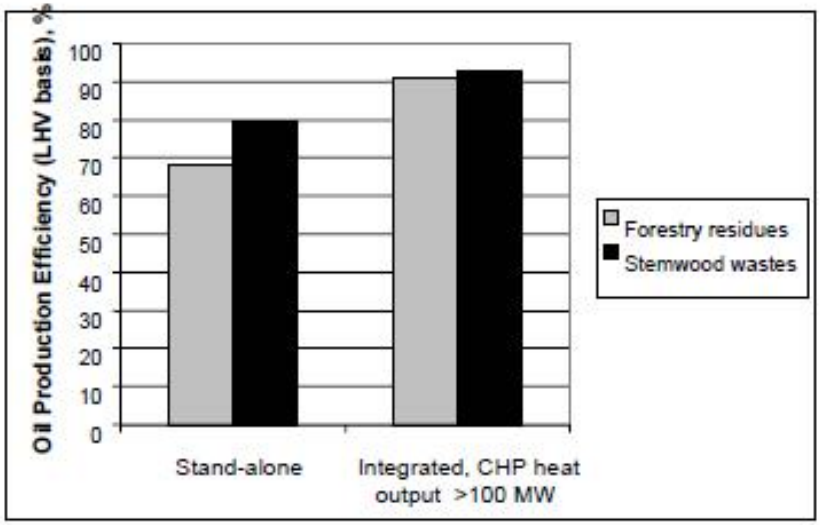


Figure 3. Comparison of estimated LHV-efficiencies of pyrolysis-oil production from forestry residues to those of pyrolysis-oil production from wastes derived from stemwood; feed-rate to pyrolyser same in both cases; oil production rates: 30 MW from forestry residues, 37.1 MW from stemwood-derived wastes; flue-gas drying.

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Wood Torrefaction Products and European Forest Industry by 2020 – opportunities and constraints

Kai Sipilä & Carl Wilén, VTT

Esa Sipilä & Jaakko Jokinen,
Pöyry Forest Industry Consulting

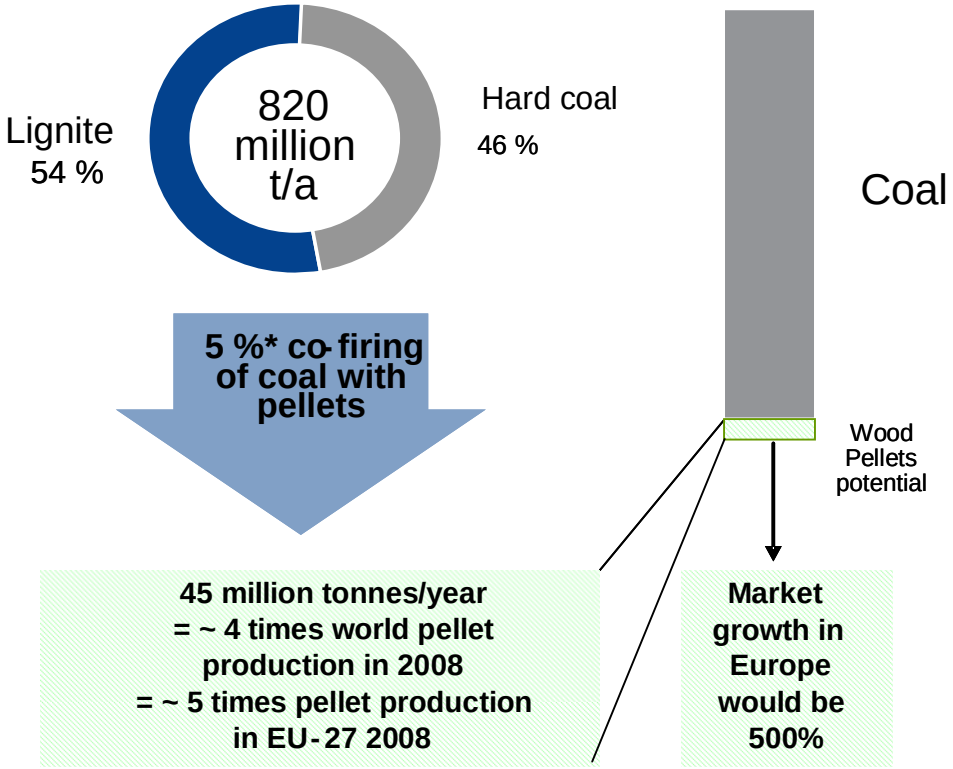
Jaap Kiel, ECN

18th European Biomass Conference, Lyon May 3-7,2010, France

Pellet co-firing potential in existing coal fired power plants in Europe

The demand for wood pellets from the European coal based industry has grown steadily as co-firing is viewed as a necessity to reach CO_2 targets. In the US, the Renewable Portfolio Standard (RPS) programme requires electricity utilities to produce a minimum portion of their supply from renewable sources, including biomass.

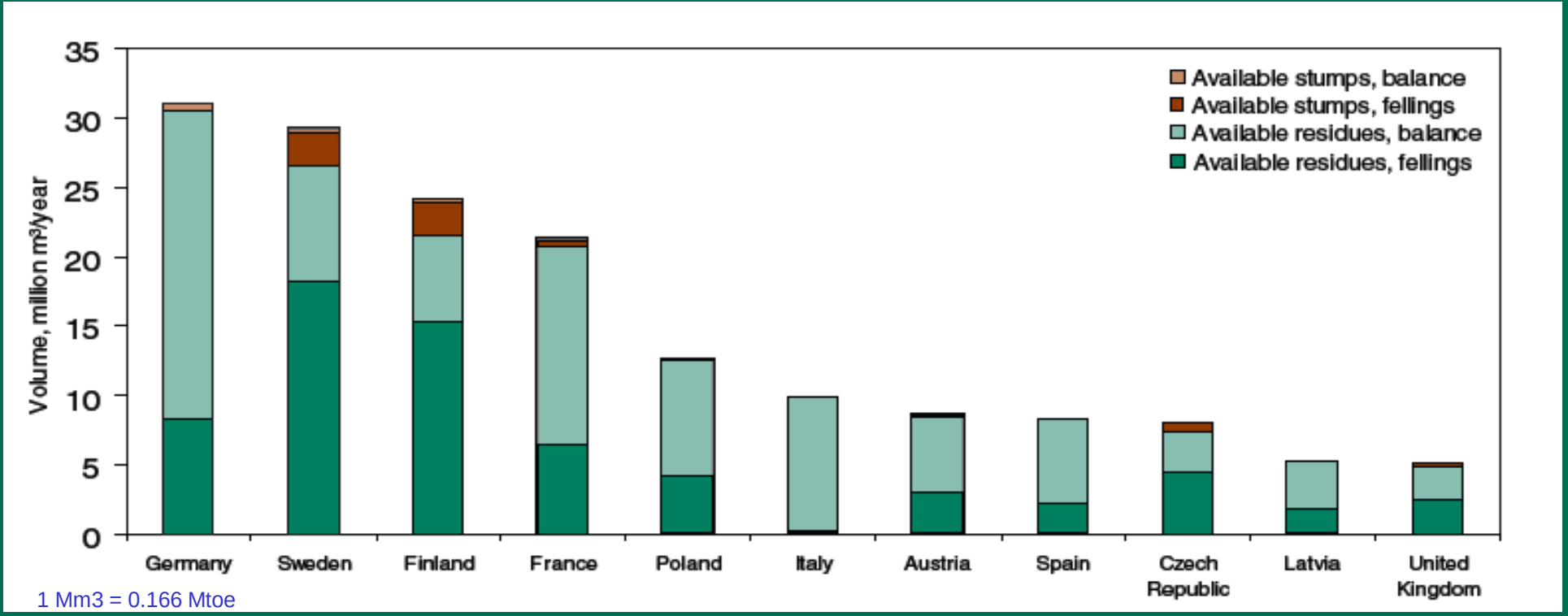
European coal consumption by coal type, 2007



- Torrefied wood products to:
  - cofiring in coal boilers due to good grinding properties in coal mills
  - no high cost investments at power plants
  - cofiring in cement kilns
  - entrained flow gasifiers for transportation fuels or high efficiency power IGCC
- Benefit in large volumes and long transportation distances
- Ash content and properties ?

Forest energy resources of the EU27

- Largest forest energy resources can be found in Germany, Sweden, Finland and France
  - Finland & Sweden: logging residues from current fellings
  - Germany and France: biomass from balance



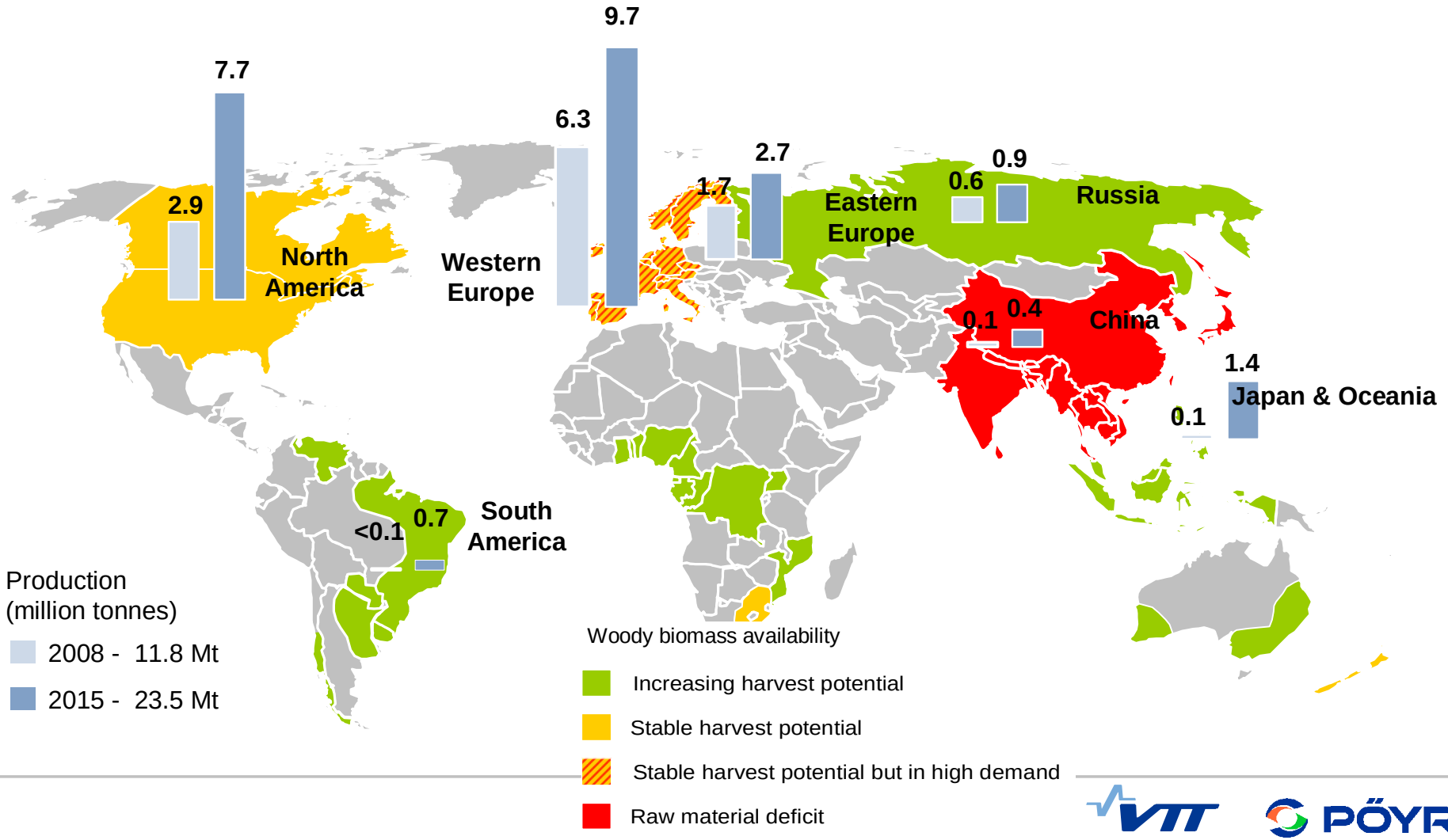
1 Mm3 = 0.166 Mtoe

Source: Prof. Antti Asikainen

METLA

Global raw material availability and pellet production, 2008-2015

- **European forest resources will be utilised for forest industry and its bionenergy production**
- **There are available woody biomass resources for import purposes connected to local forest industry operations in Russia, North and South America.**



Woody biomass availability – outside Europe ?

Availability and accessibility of raw materials suitable for torrefied pellet production is connected to existing wood chains

Russia

- Russian forest law determines that all wood residues have to be removed from the forest
- Sawmills utilise only the logs and waste wood is often unutilised
- Torrefied pellets production could be integrated to sawmills wood chains and processes

North America

- Wood use differs in North America by region but especially in West coast the wood flows go through sawmills
- Economic problems in pulp and paper industry can leave large amounts of wood unutilised
- Sawmills could be feasible sites to integrate torrefied pellets production by means of logistics and energy
- Pine beetle affected area require more harvesting than demand is for wood products and pulp&paper markets (thermal treatment required for pine beetle affected wood by torrefaction or pyrolysis)

→ At s*awmill torrefied pellets and bio-oil production seems to be the most attractive option to import bioenergy carriers to European markets*

New Sawmill Bioenergy Concepts – Bio-oil and Torrefied Pellets

Pöyry-VTT Sawmill case 30 – 80 MW and 0.2 – 0.5 TWh/a

Bio-oil Production Potential in North American Forest Industry by 2020

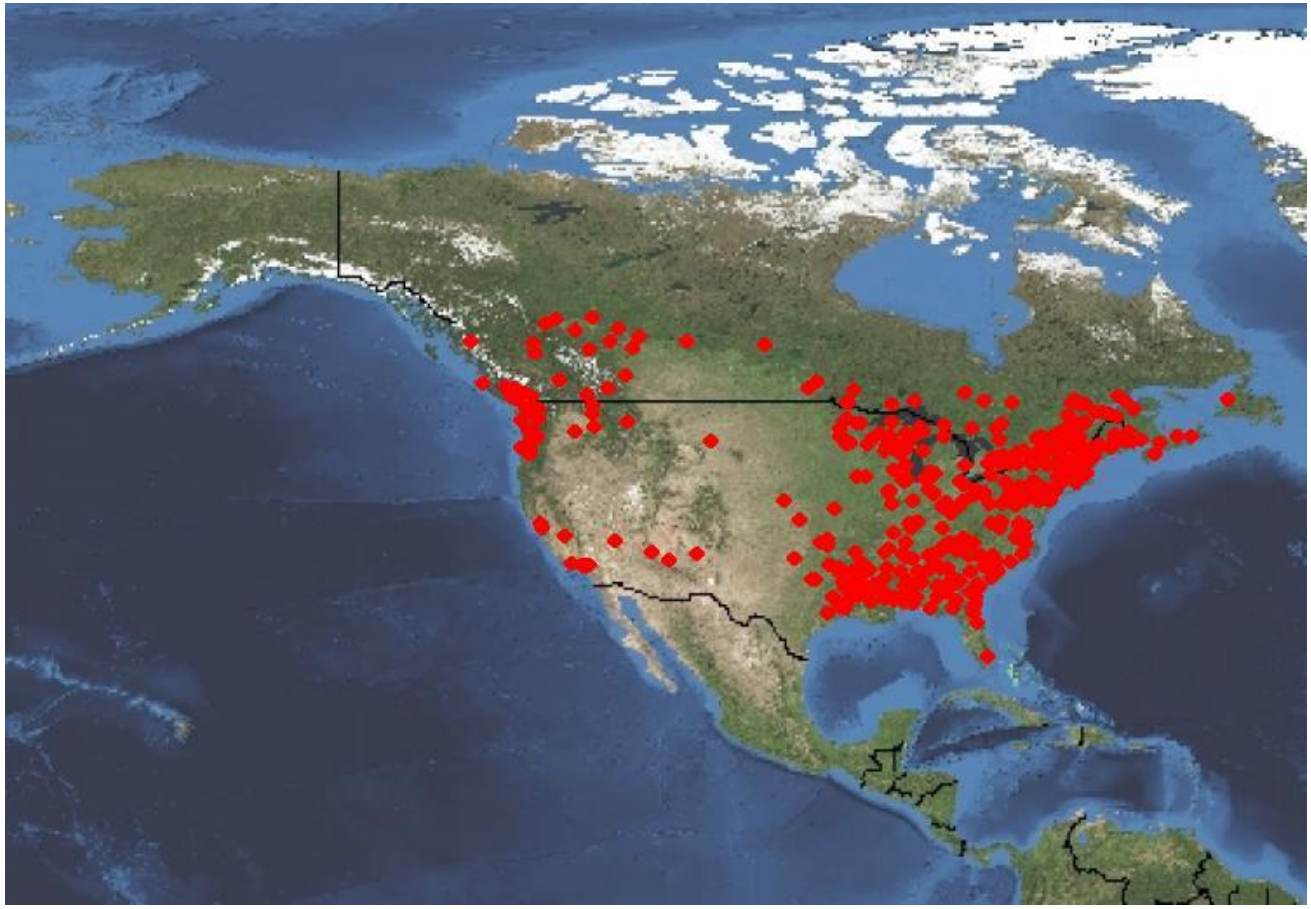
August 30, 2010
Draft Report

Esa Sipilä & Jaakko Jokinen
Pöyry Management Consulting

Pulp and Paper Industry in North America - Options for New Bioenergy

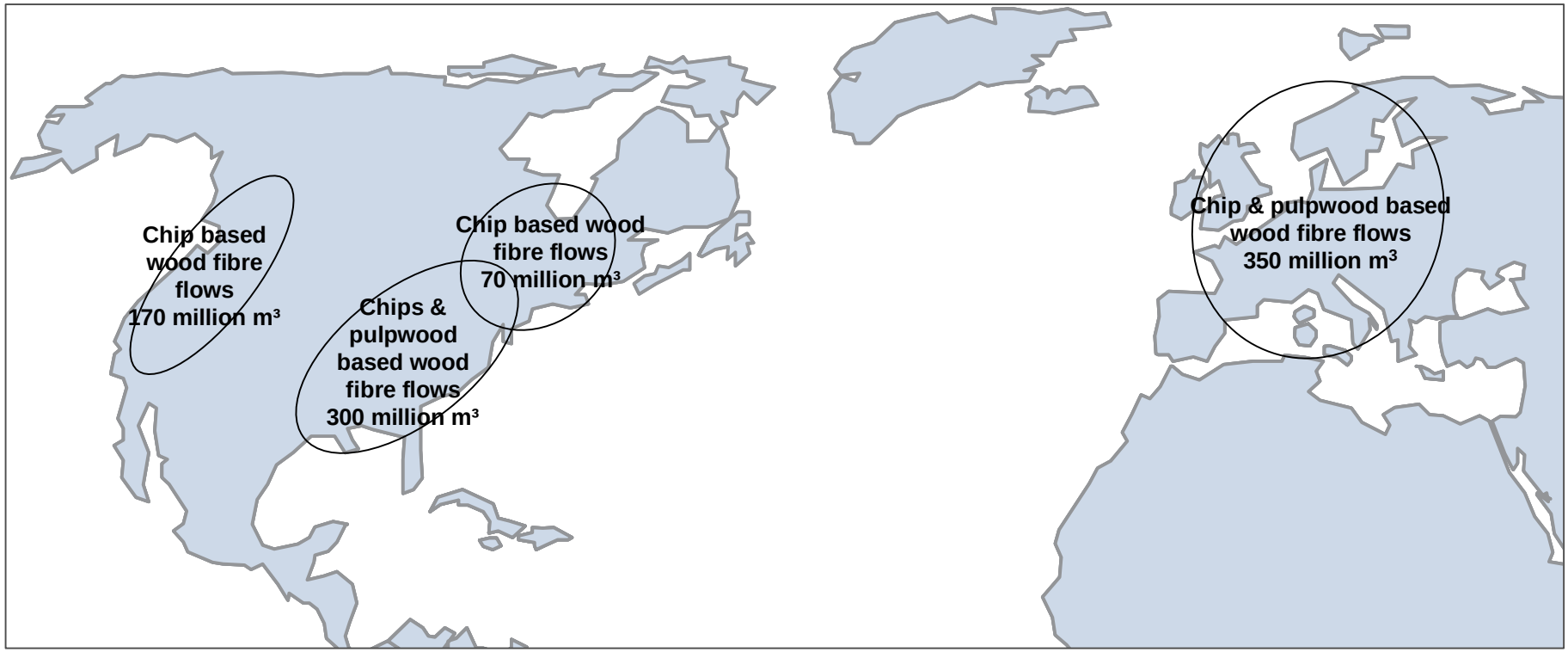
There are 515 pulp and paper mills in North America

Total paper capacity of 98 million tons and pulp capacity 87 million tons annually



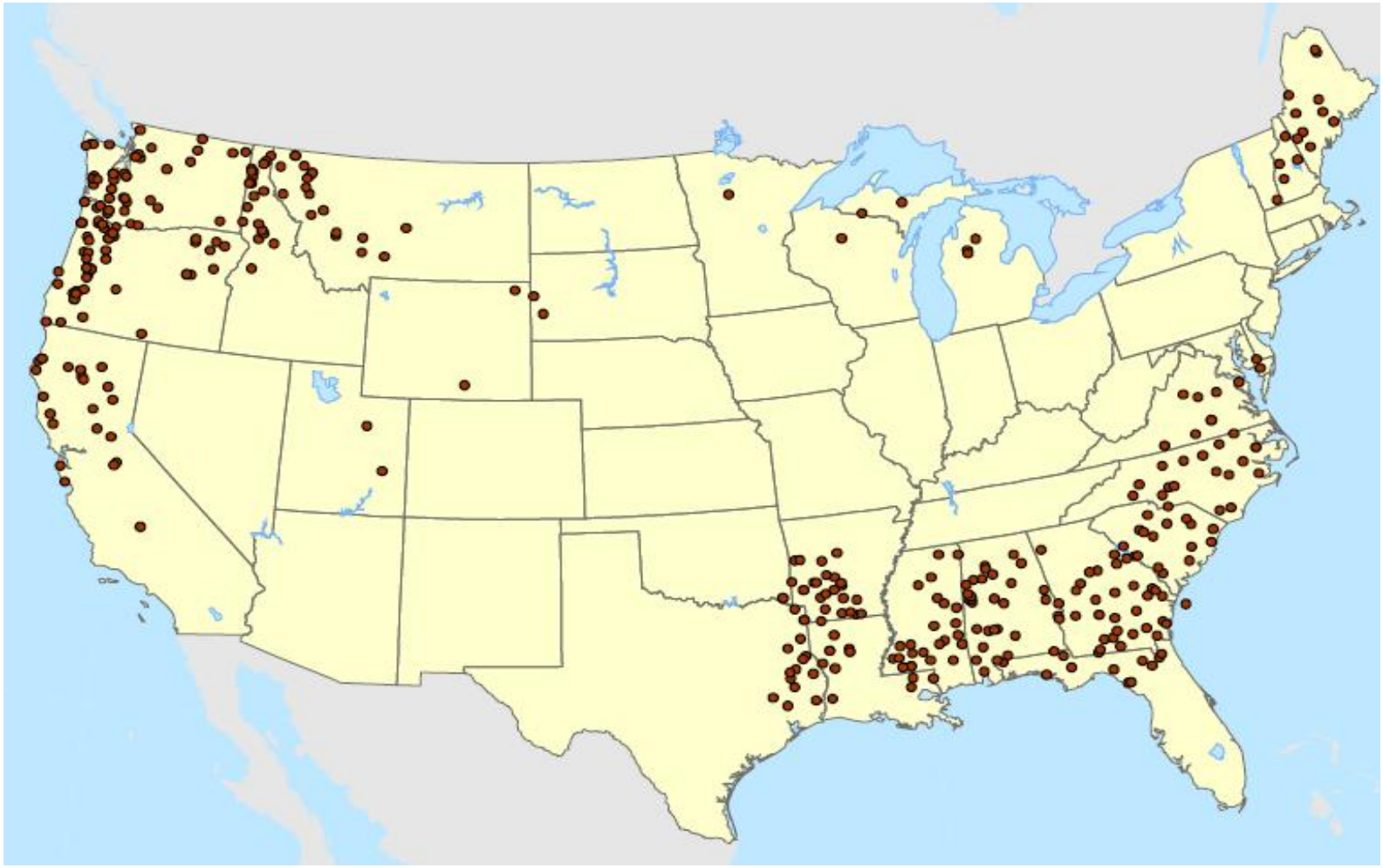
Typical Wood Fibre Flows

In Europe, both sawmill chips and round pulpwood are utilized in industrial processing. In western part of North America, sawmill chips is a typical raw material for industrial processing, where as in eastern / southern parts of North America also round pulpwood is utilized in industrial processing. There are regional differences in the utilization rate of wood residues.



USA – Softwood Sawmills with Annual Capacity over 50 000m³

Sawnwood production in 2008 73 million m³



Canada – Softwood Sawmills with Annual Capacity over 50 000m³

Sawnwood production in 2008 42 million m³

Methodology of Mechanical Wood Industry Potential

The potential analysis is based on current capacities of sawmills from Pöyry's databanks

The sawmills are divided into 3 different classes that are based on size (> 200 000 m3/a)

– Size categories: under 400 000 m^3, 400 – 600 000 m^3 and over 600 000 m^3

The bio-oil or torrefaction investment potential by 2020 is estimated to be

– 15 % for sawmills under 400 000 m^3

– 25 % for sawmills between 400 – 600 000 m^3

– 30 % for sawmills larger than 600 000 m^3

The bio-oil production is estimated to utilise sawmill chips, bark and sawdust from the sawmilling as feedstock for bio-oil and process heat production

Bio-oil Potential in Mechanical Wood Industry in this study

Bio-oil potential in North American mechanical wood industry is 69 units in this study. They have a production potential of 3.9 Mtoe annually

The potential is almost equal in US and Canada

Bio-oil potential in Canada is larger in mechanical wood industry than in pulp and paper industry

	Number of units	Capacity, MW	Production, GWh/a	Prodution, Mtoe/a	Raw material demand, GWh/a	Raw material demand, 1000 m3sub/a
Canada	30	3 290	21 640	1,9	33 300	16 700
USA	39	3 650	23 970	2,1	36 870	18 400
Total NA	*69*	*6 940*	*45 610*	*3,9*	*70 170*	*35 100*

- **The bio-oil potential in North American forest industry is 10 million tons of oil equivalent that has a value of USD 5 billion/a**

Conclusions

- Forest industry platforms offers significant benefits for future bioenergy carrier investments: logistics of wood and forest residues, multifuel operations, process integration and industrial CHP
- Current wood to energy 60 Mtoe/a in EU – additional raw material demand in this study 45 Mm3 ~ 9 Mtoe forest residues and 7 Mtoe ~ 20 Mt/a solid recovered fuels from MSW and CIW
- New green electricity and biofuels will have lowest production cost when integrated to global forest industry operations at saw, pulp and paper mills
- New technologies will increase the profit and market volume
- EU SET-Plan and European Industrial Bioenergy Initiative will accelerate the development the bioenergy market and market introduction of new technologies
- Collaboration within the IEA Bionergy member countries !