

MUNICIPAL AND COMMERCIAL SOLID WASTE FOR PYROLYSIS (OILS) AND GASIFICATION MARKETS

Kai Sipilä, VTT Processes, Finland

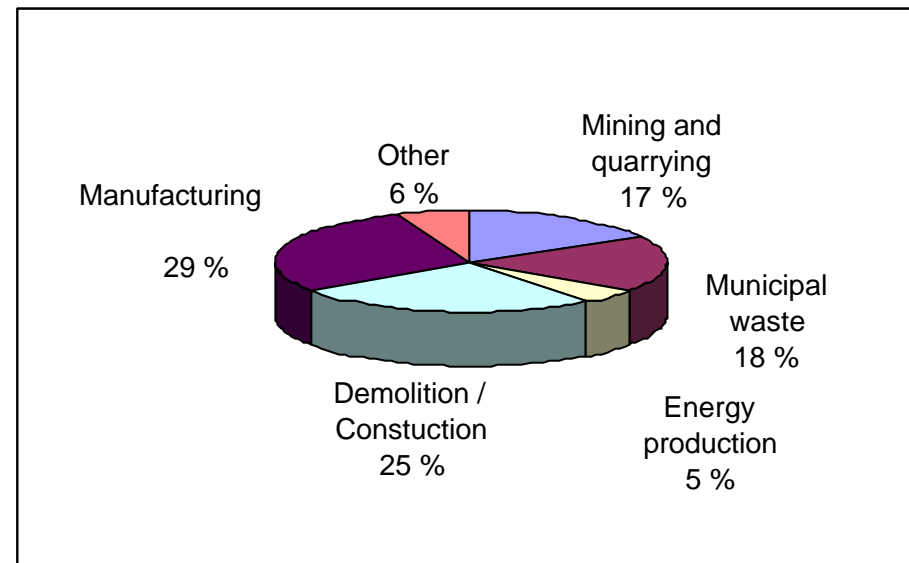
PGBW - Expert meeting in Strasbourg, 30.9.2002



- 1. EU Directives:** Landfill directive
Waste incineration directive
RES - E directive
packaging directive, ESR etc. for material recycling
- 2. Waste fuels:** Mixed solid waste, municipal solid waste (MSW)
Solid recovered fuel (SRF)
Mono streams based on source separation
- 3. Advanced waste to energy, key role in future waste management**
Mixed waste massincineration
Cofiring and co-gasification
Integrated material and energy recovery
- 4. Technologies, emission control and costs**
- 5. Conclusions**

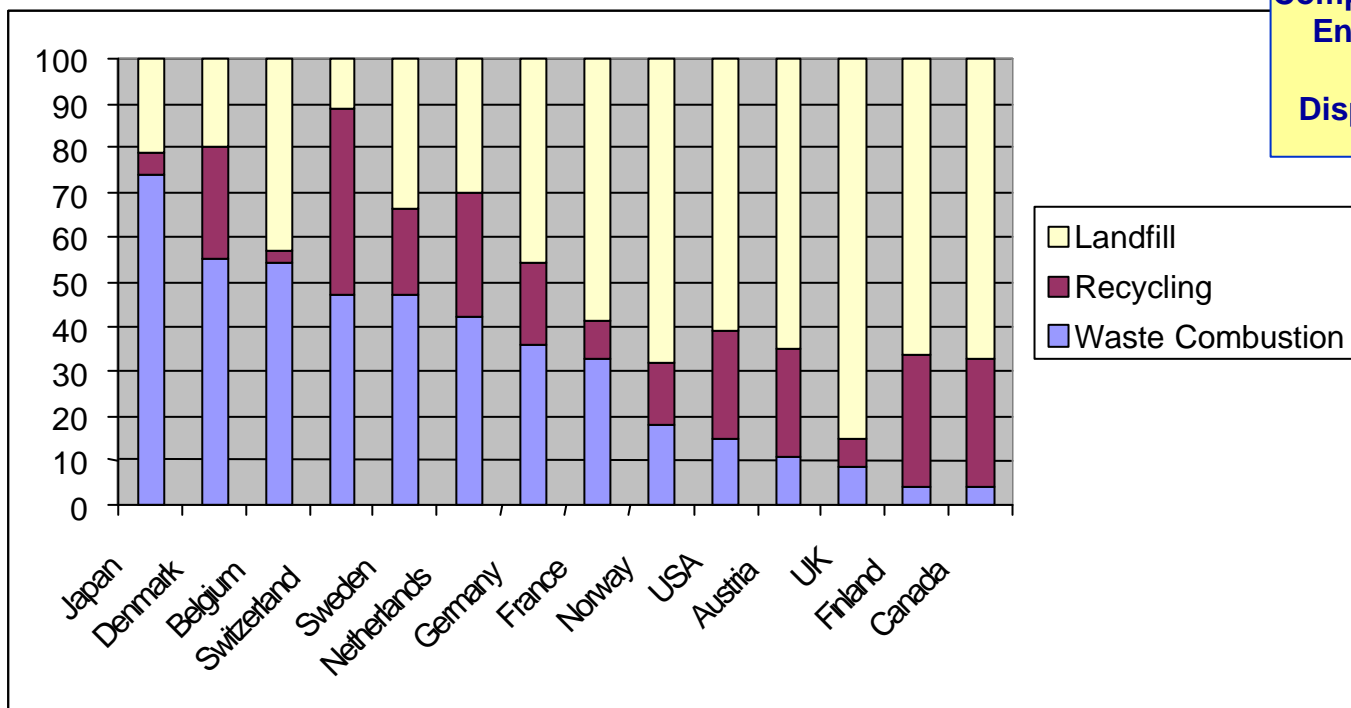
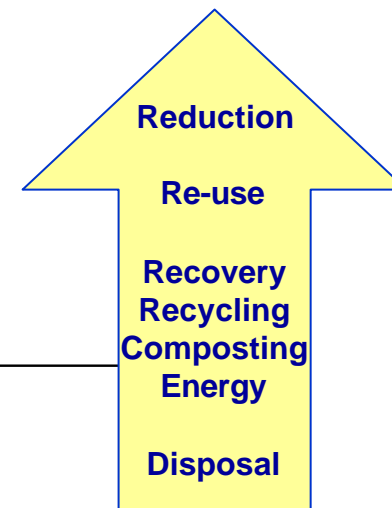
Waste management market in Western Europe

- **Waste generation in the EU 1400 Mt/a and 3,5 t/a per capita excluding agricultural wastes**
- **Increased by 15% between 1995 and 1998**
- **Manufacturing and demolition / construction dominant by mass**
- **MSW dominant by market value**



Source: P.Väisänen, Electrowatt-Ekono

MSW management methods

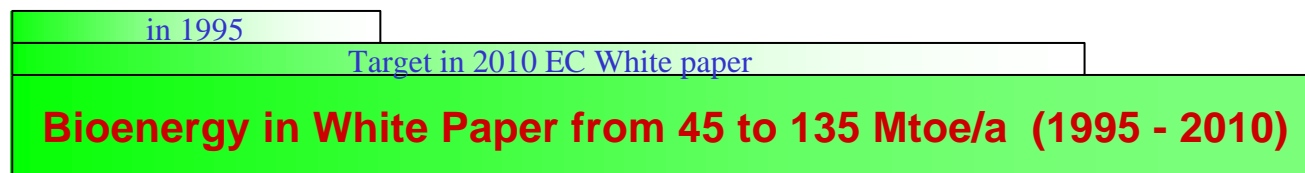
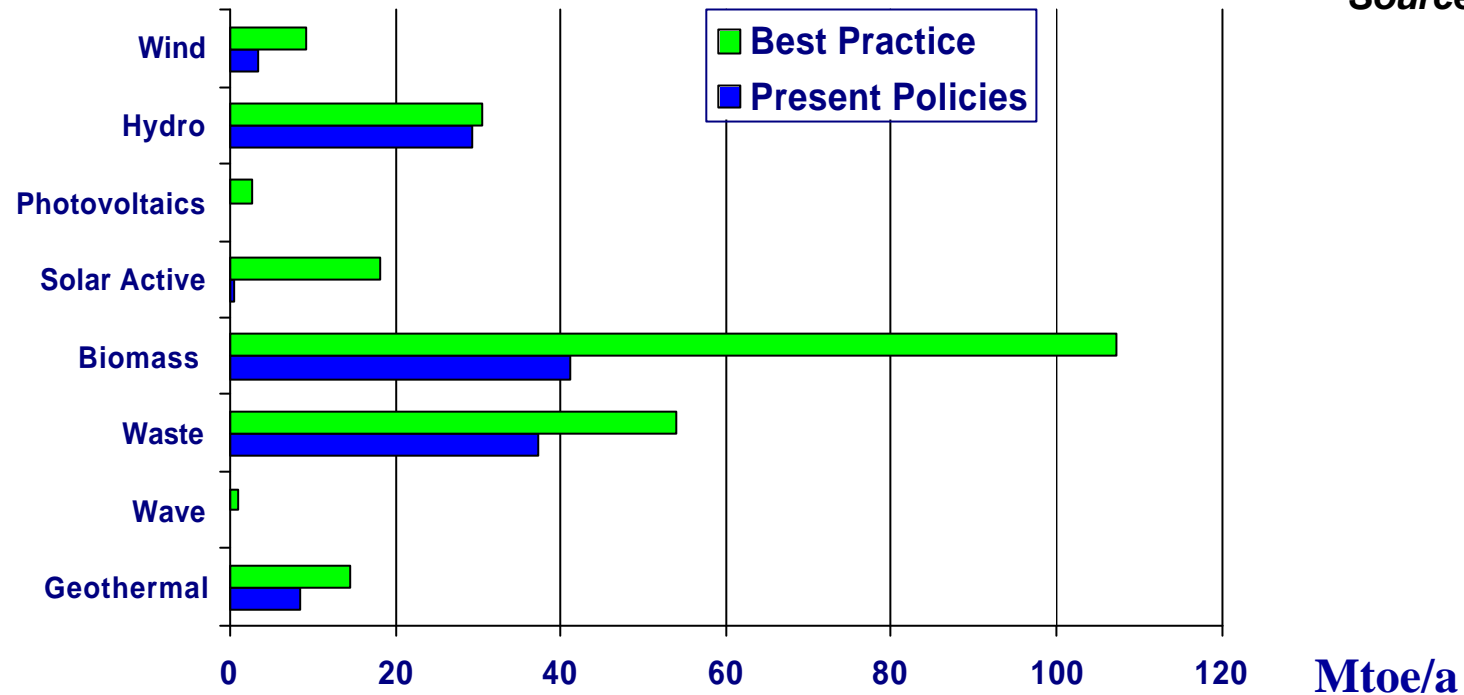


Status of waste to energy in Europe:

- in 2000 there were 304 units in operation
- total capacity of the units were 50.2 Mt/a of MSW and related waste
- energy recovery was 49.6 TWh/a, of which 70 % for heat and 30 % for electricity generation
- average size 225 000 t/a input, power output 400 GWh/a
- new capacity demand in 2010 up to 100 Mt/a (= 250 TWh = 25 Mtoe)

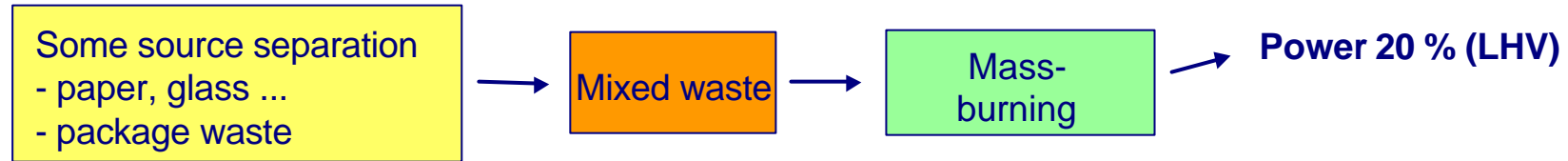
Renewable Energy Penetration EU 15 in 2010

Source : TERES II
EU DG TREN

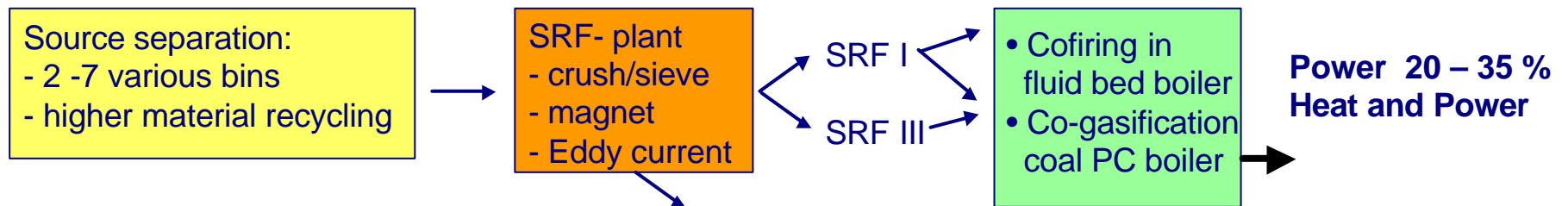


WASTE TO ENERGY PRINCIPLES

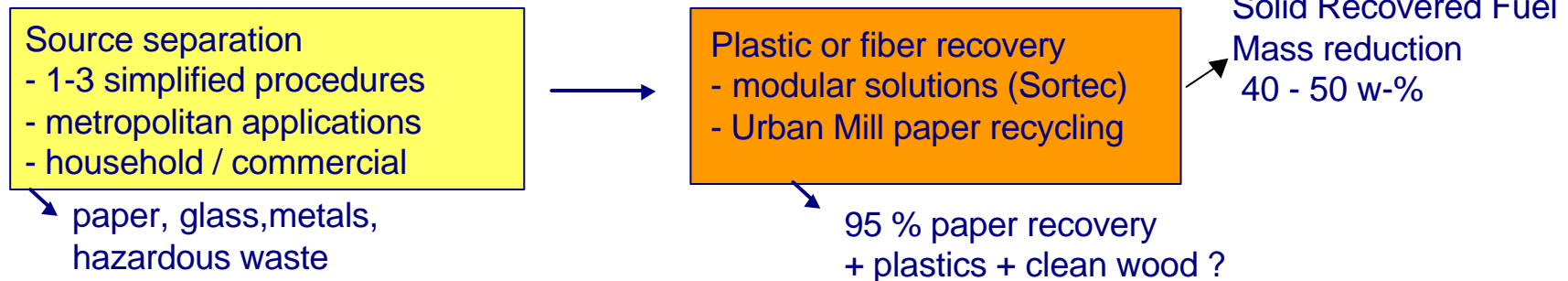
A. Mixed waste massburning



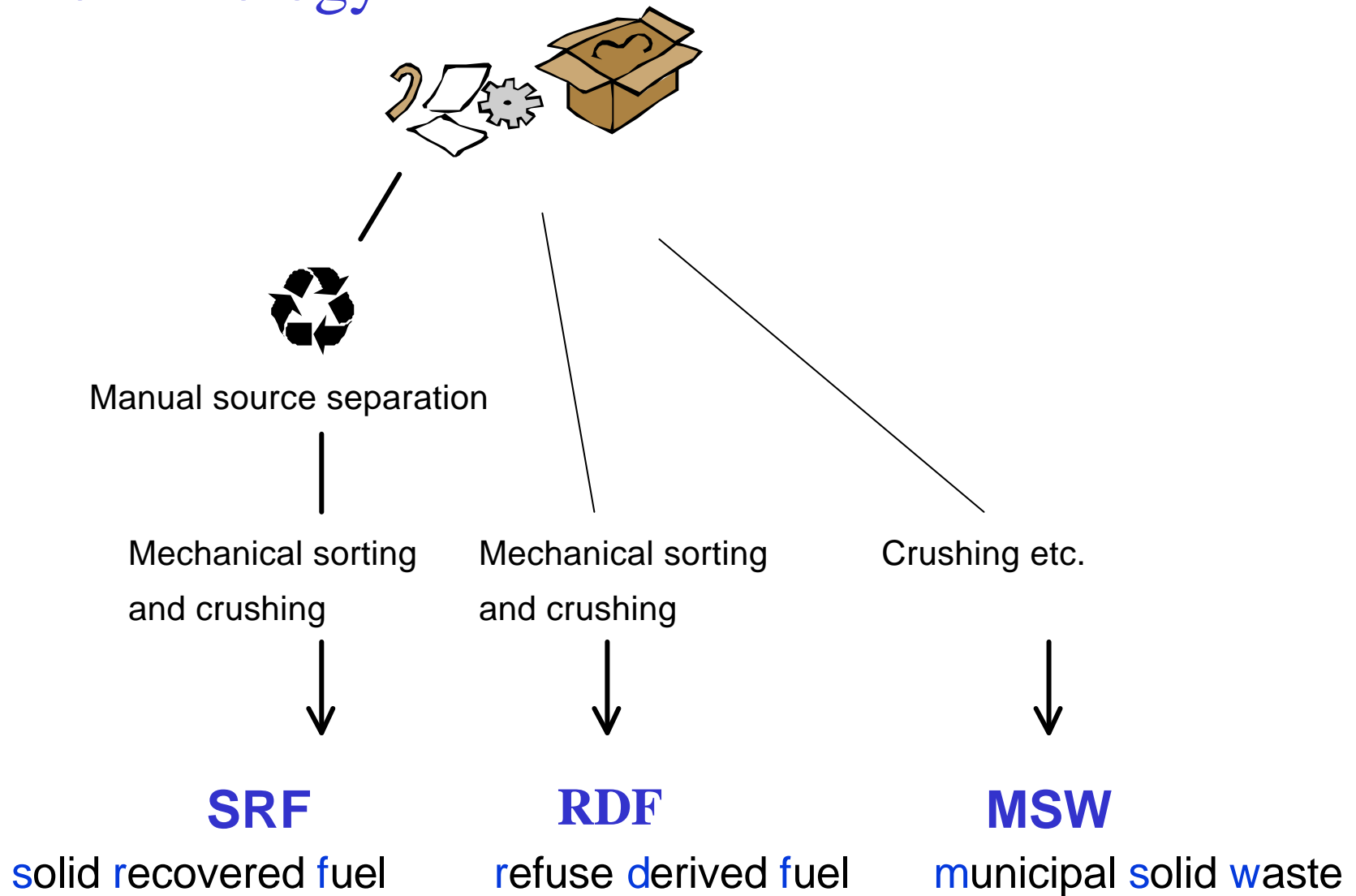
B. Solid Recovered Fuel Production and Co-firing



C. Integrated Concepts for Material and Energy recovery ?



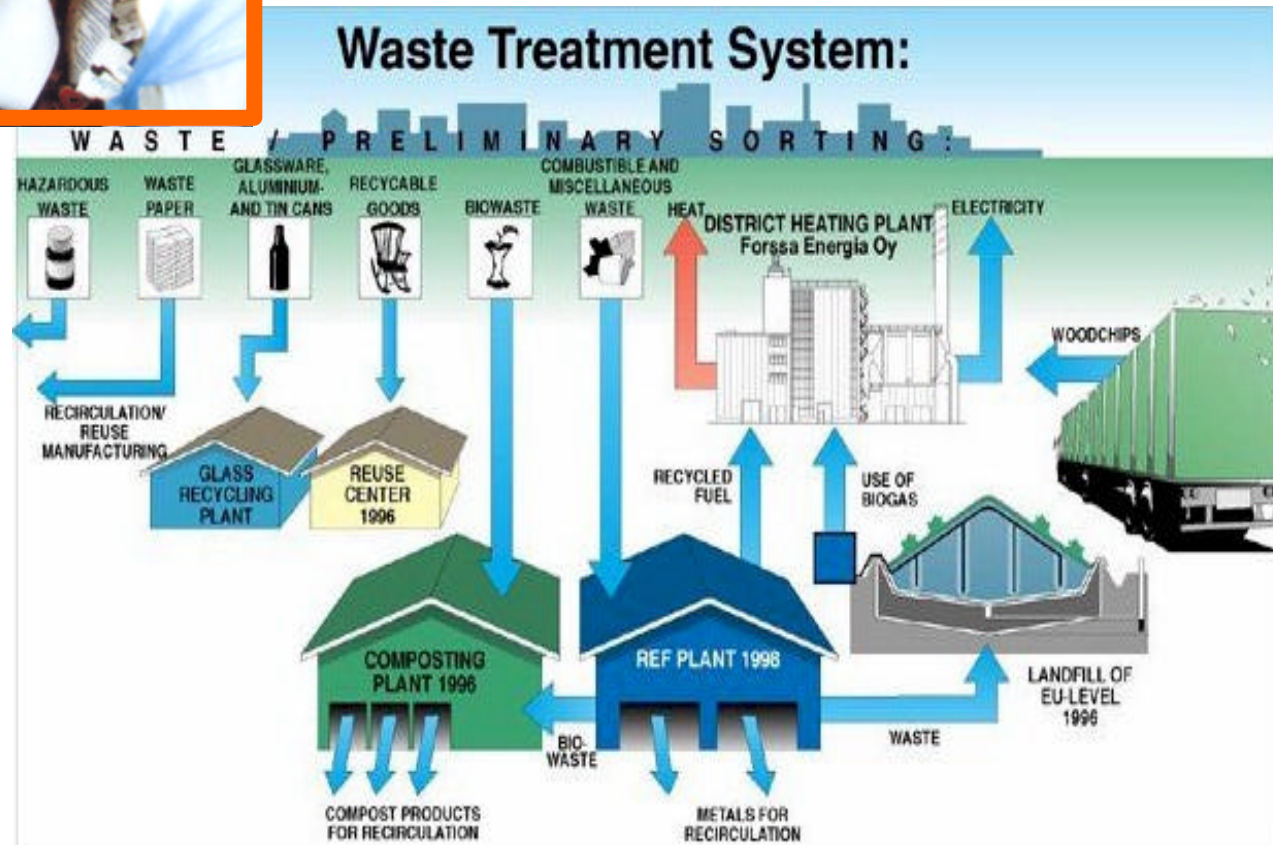
Terminology



- yield from unsorted waste and fuel properties ! -

Source separation and SRF production

- Loimi-Hämeen Jätehuolto, Forssa, Finland -



PROPERTIES OF VARIOUS SRF - FRACTIONS

Helsinki, Finland



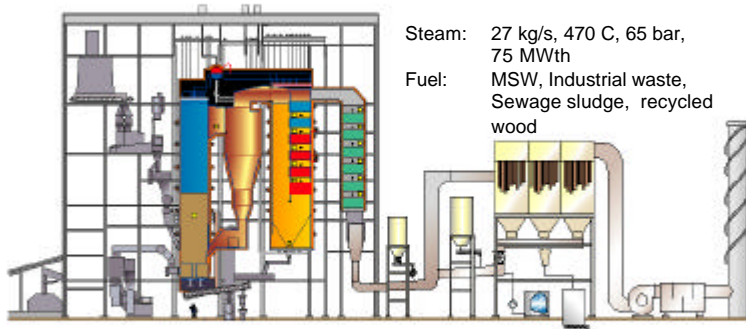
		Commercial waste	Construction waste	Household waste
Combustible waste volume	t/a	115 000	80 000	85 000
Lower heating value as received	MJ/kg	16 - 20	14 - 15	13 - 16
	MWh/t	4.4 - 5.6	3.8 - 4.2	3.6 - 4.4
Annual energy content	GWh/a	530	285 - 315	360 - 440
Moisture	w -%	10 - 20	15 - 25	25 - 35
Ash	w -%	5 - 7	1 - 5	5 - 10
Sulphur	w -%	<0.1	<0.1	0.1 - 0.2
Chlorine	w -%	< 0.1 - 0.3	<0.2	0.3 - 1.0
Storage properties		good	good	Good in pellets or baled

Source: Mäkinen et.al. YTV Report, 2000



Norrköping Miljö och Energi

Steam: 27 kg/s, 470 C, 65 bar,
75 MWth
Fuel: MSW, Industrial waste,
Sewage sludge, recycled
wood

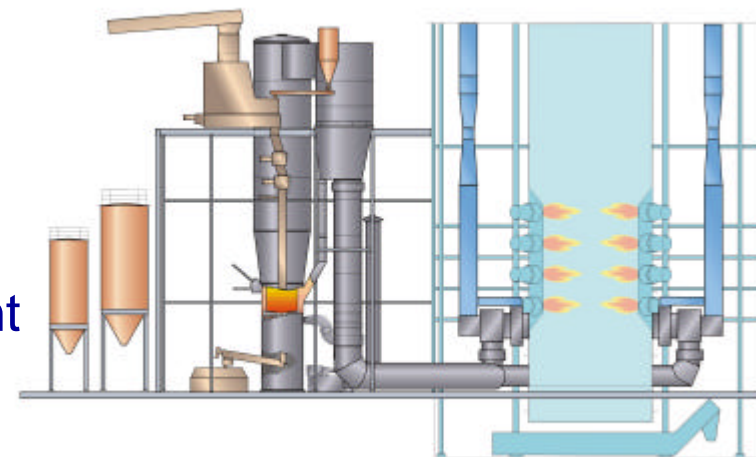


Fluid Bed Combustion 20 - 300 MW_f

- multi fuel BFB and CFB technology
- co-firing biomass and coal, lignite
- high efficiency, low emissions
- proven technology
- typical investment ca. 2-3000 €/kWe

Fluid Bed Gasification 15 - 120 MW_f

- multi fuel BFB and CFB technology
- co-firing the clean gas in coal boiler
- high efficiency, low investment
- typical investment ca. 6-800 €/kWe
in co-firing large coal/oil/gas power plant



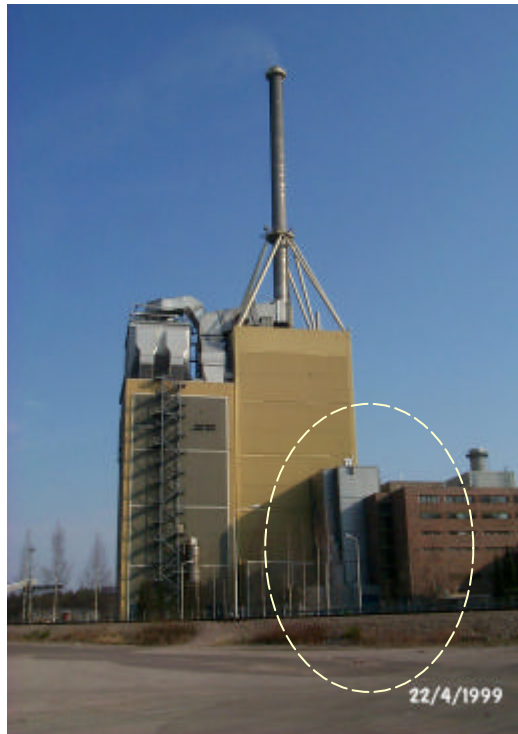
Flue Gas Emission Limit Values - EU Waste Incineration Directive, 1.1.2002

Emission	Waste incineration (mg/Nm ³) red.11% O ₂	Solid fuel (mg/Nm ³ red. 6 % O ₂)		Coal fired boiler+ 30 % REF from the flue gas (mg/Nm ³ red 6 % O ₂)	Biomass (mg/Nm ³ red. 6 % O ₂) 100-300 MW	Biomass boiler+30 % REF from the flue gas (mg/Nm ³ red. 6 % O ₂)
		100-300 MW	>300 MW	200 MW	200 MW	200 MW
SO_x		850-200	200	390	200	162
NO_x	400(< 6 t/h) 200 (> 6 t/h)	300	200	300	300	300
Dust	10	30	30	25.5	30	25.5
CO	50			*		*
NH₃				*		*
TOC	10			*		*
HCl	10			*		*
HF	1			*		*
Hg	0.05			0.05		0.05
Cd+Tl	0.05			0.05		0.05
As+Pb+Mn+ Ni+Cr+Cu+ Co+V+Sb	0.5			0.5		0.5
PCDD/F, I- TEQ	0.1 ng/Nm ³			0.1 ng/Nm ³		0.1 ng/Nm ³

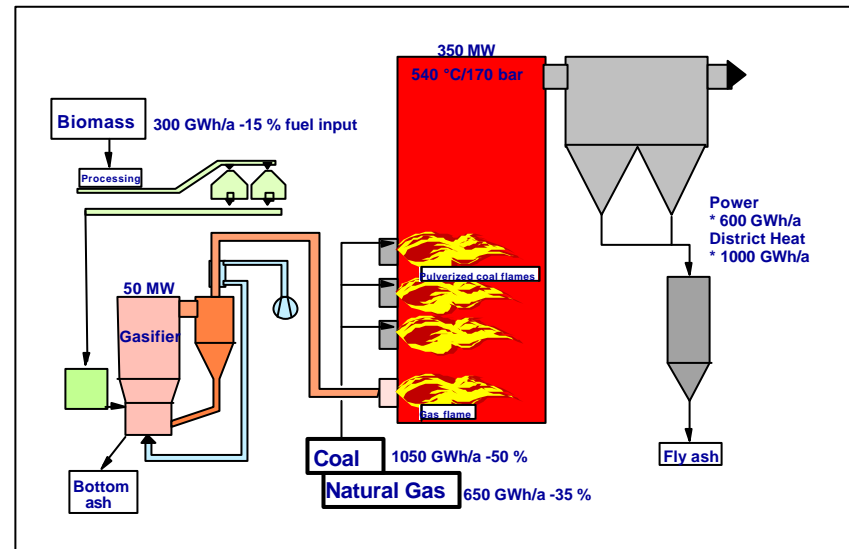
- open questions: definition of clean wood, amount of biodegradable fractions etc...

Fluid bed gasification - Lahti co-gasification plant

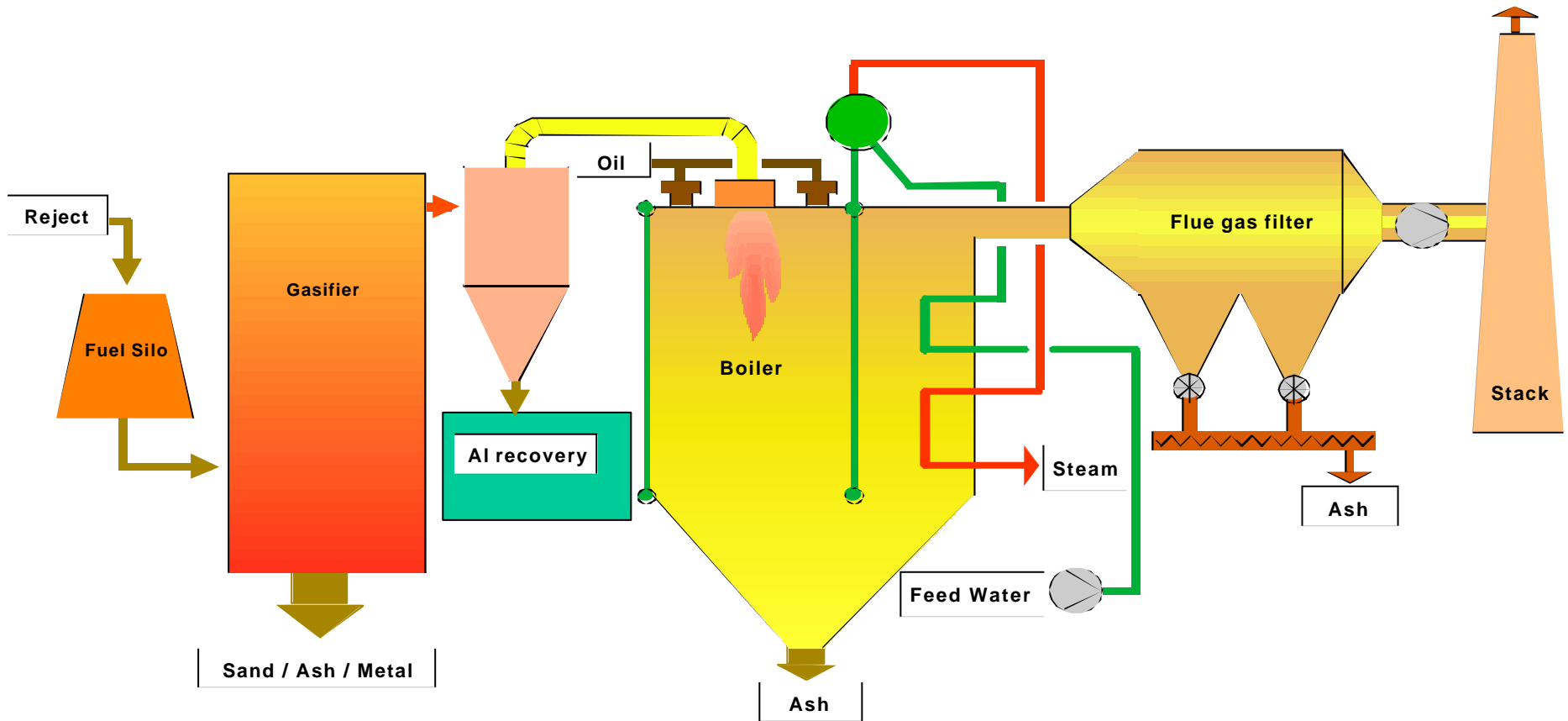
- Multi fuel operation since 1998
- Relative simple technology, low cost
- Additional gas cleaning optional



BIOMASS GASIFICATION - COAL BOILER - LAHTI PROJECT



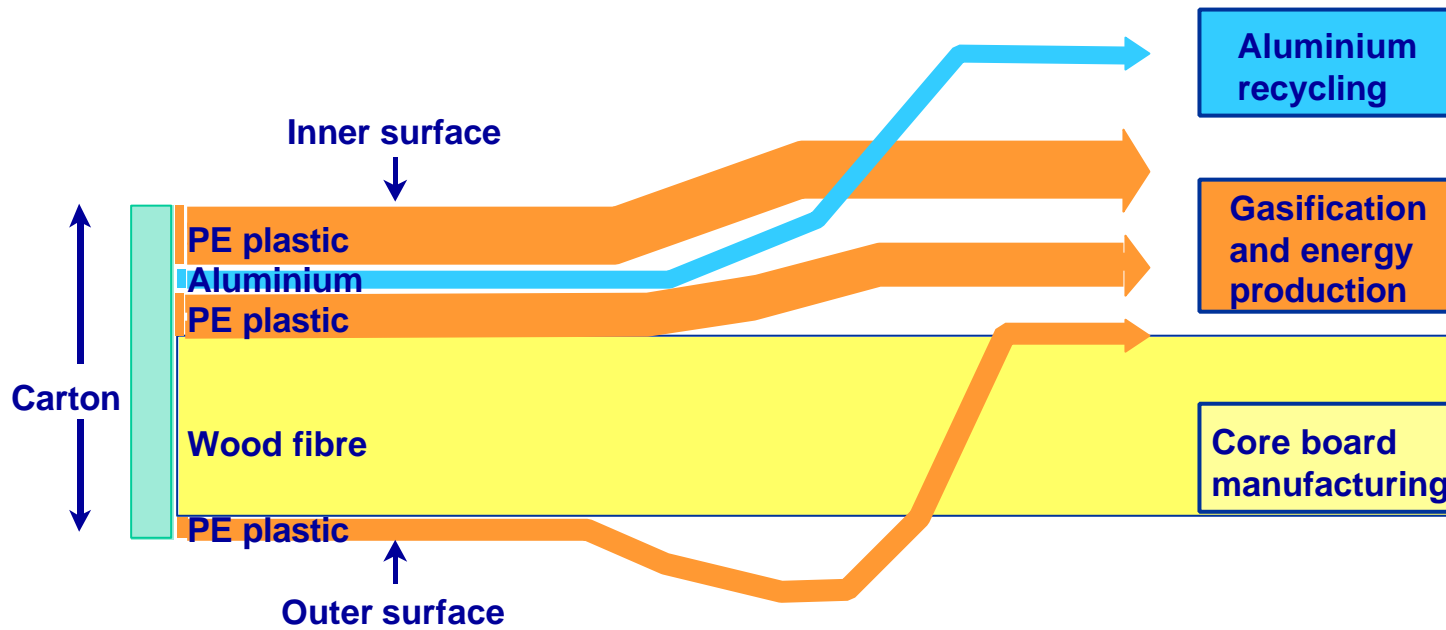
Corenso Gasifier 40 MW, Varkaus, Finland



LIQUID PACKAGING RECYCLING - THE PRINCIPLE

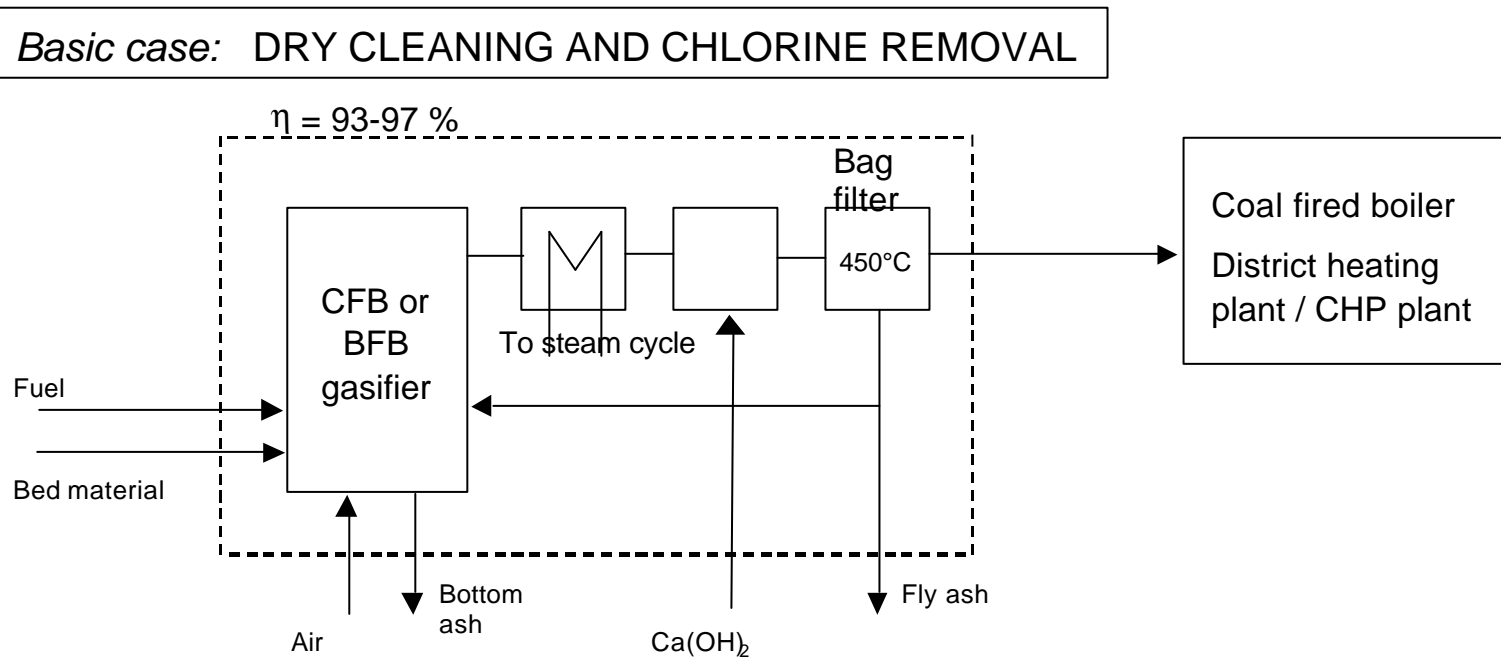
Corenso Oy - Varkaus

The construction of a tetra bric milk carton



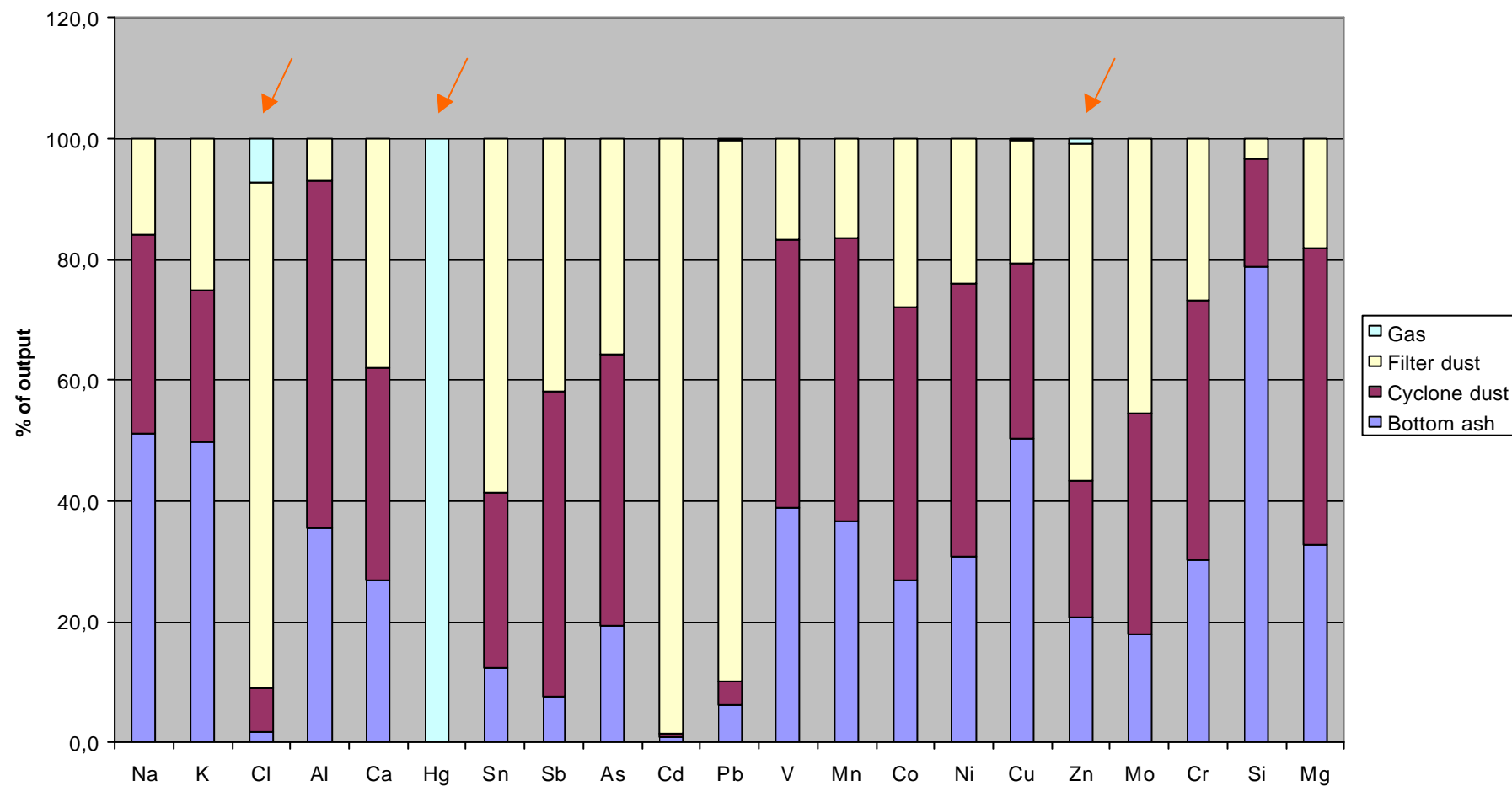
Co-firing future concept based on CFB/BFB Gasification, Martinlaakso case, Finland

- suitable size range: 20 - 100 MW_{fuel}, SRF feed 20 - 100 000 t/a



Source: E.Kurkela, VTT

Distribution of trace metals and chlorine in CFB-gasification and hot filtration tests (70 % SRF pellets + 30 % wood)



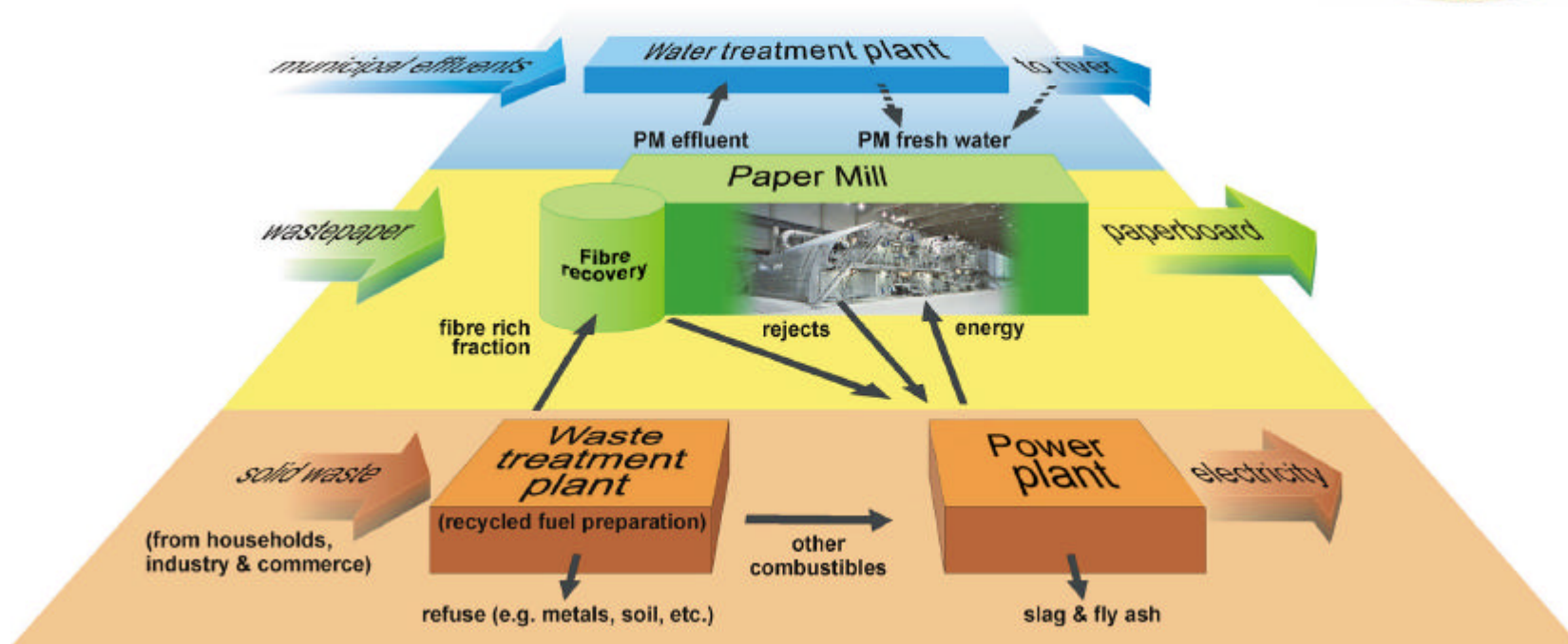
Source: Kurkela and Nieminen, VTT Processes





Urban Mill - Novel Concept for Waste-to-Energy and Recycled Paper Making

Europe 70 Mt/a



**Material Recovery
with Economy !**

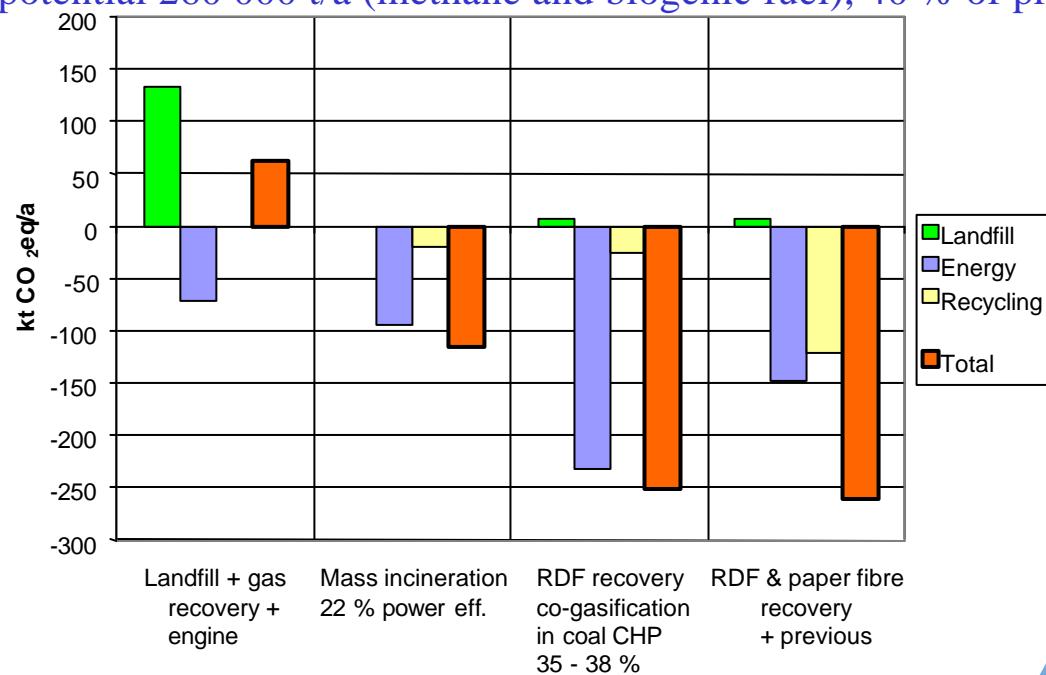
Source: Petri Ristola, Metso



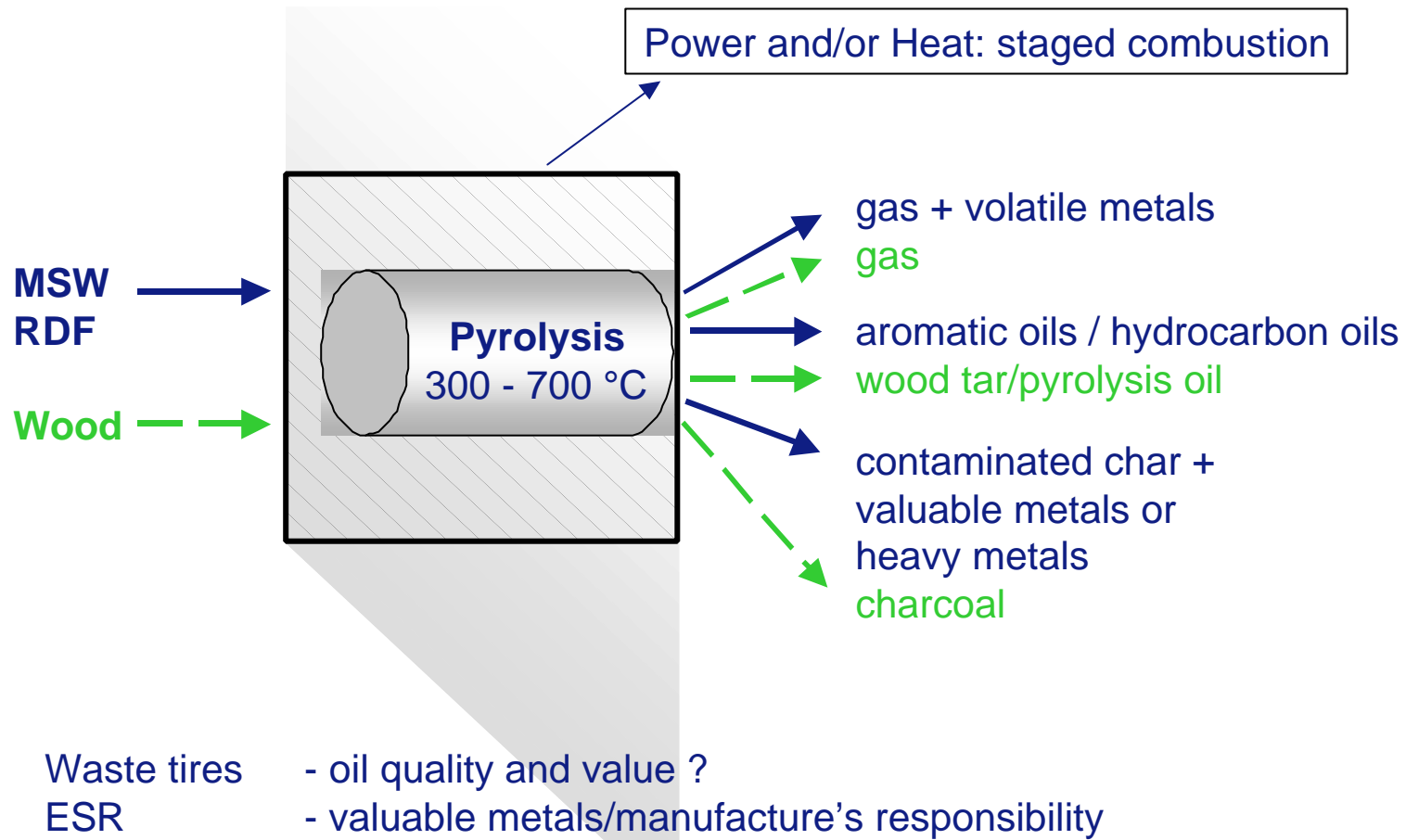
Green house gas emissions and waste management - Case Helsinki metropolitan area -

In Helsinki area 780 000 t/a MSW is generated:

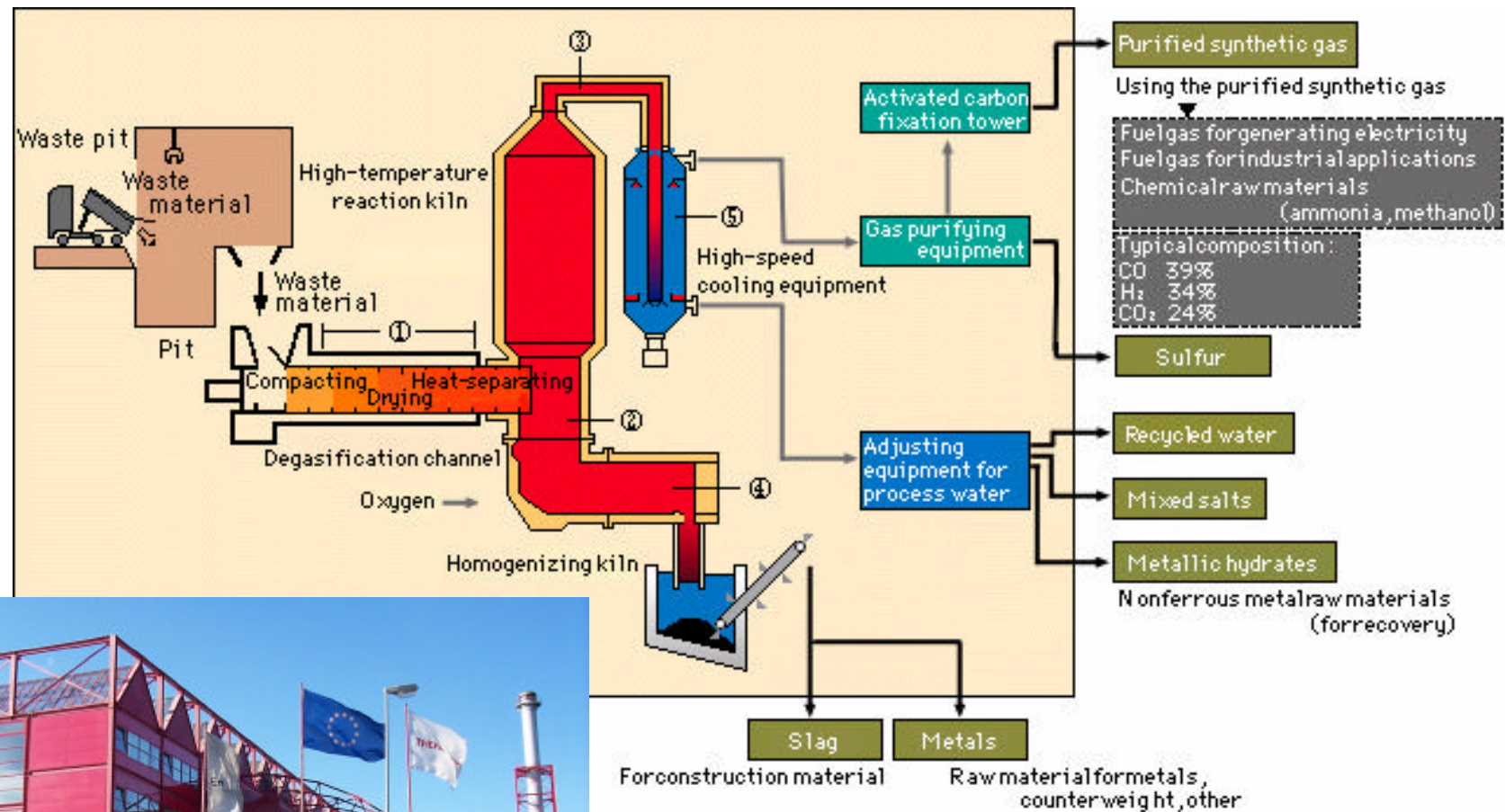
- 300 000 t/a source separated and recovered as material recycling (paper etc.)
- 480 000 t/a still landfilled, including 280 000 t/a combustible material
- what are the future scenarios for total recovery of combustible material, when biogenic fraction of SRF is replacing coal based CHP production ?
- GHG reduction potential 260 000 t/a (methane and biogenic fuel), 40 % of present coal emissions



PYROLYSIS TECHNOLOGY

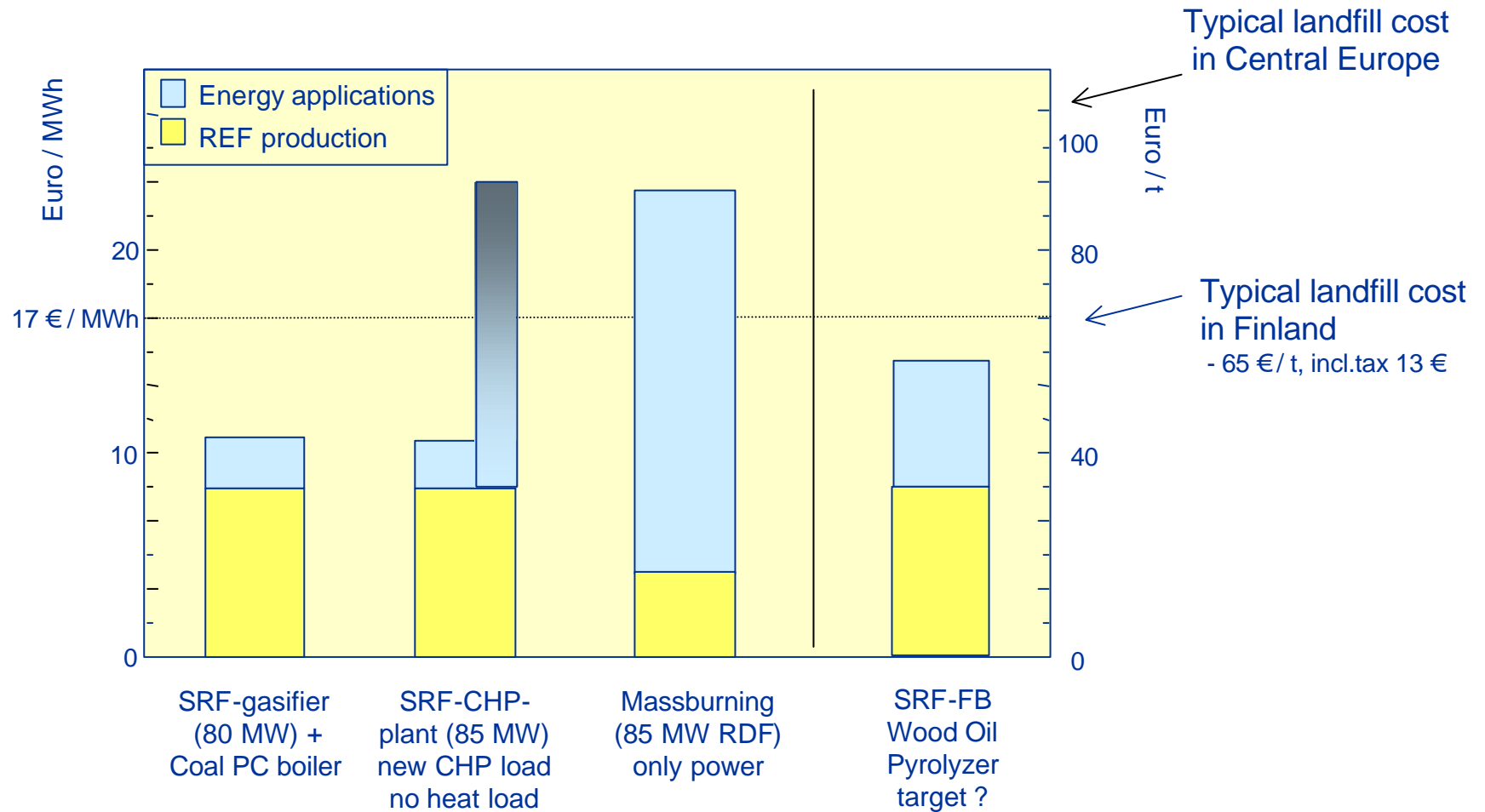


Termoselect, Karlsruhe, Germany



SRF/ RDF / MSW TREATMENT COST

- gate fee estimations -



Source: Mäkinen et.al. YTV Report, 2000

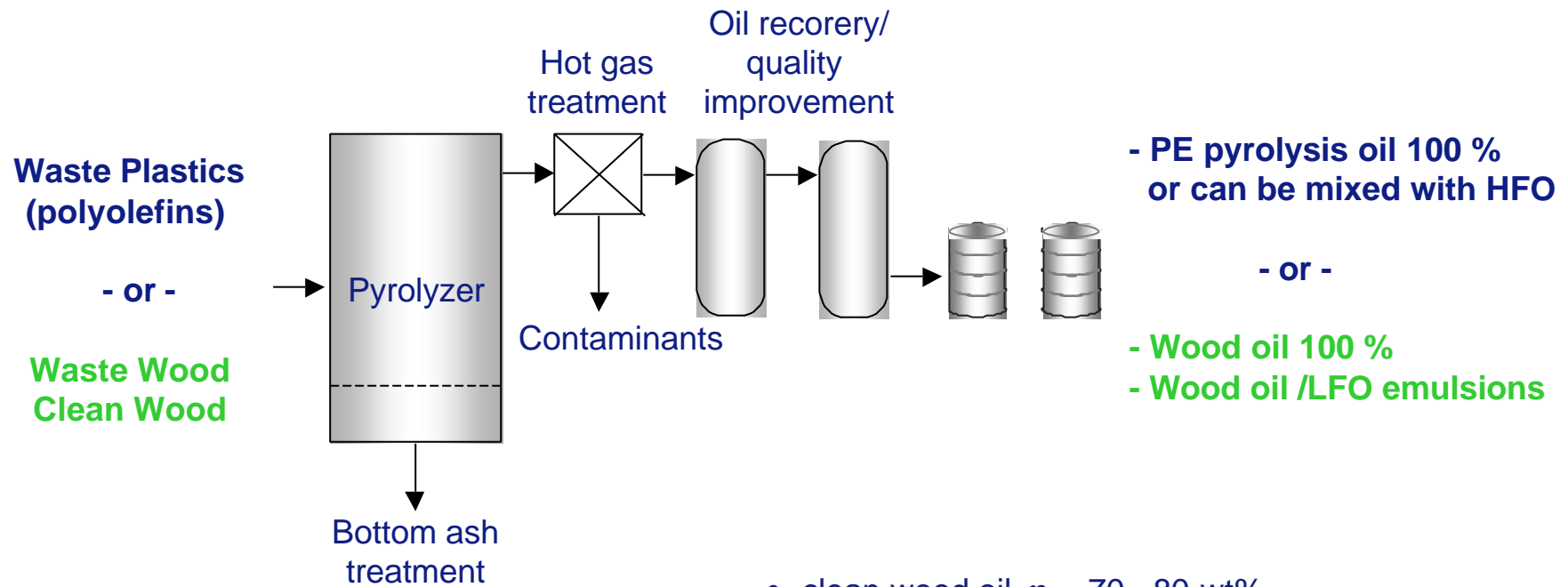
Power 2.4 €/kWh
District heating 13 €/Mwh



Conclusions:

- pyrolysis option is attractive for waste R&D:
 - for valuable metals recovery
 - fast pyrolysis for clean hydrocarbon oil production
 - mainly for polyolefines, presorting needed
 - for treated wood, if heavy metals and halogenated hydrocarbons can be removed and clean wood/green oil produced
- gasification is commercial and R,D&D options are:
 - SRF co-gasification like the Lahti concept
 - demonstration of hot gas cleaning important
 - valuable metal recovery option instead of oxides in combustion
 - Vargas aluminium concept, ESR and ASR treatment
- fast growing market for simultaneous material and energy recovery
- source separation and solid recovered fuel production/ stable quality are basis for commercial gasification and pyrolysis investments.

Fast Pyrolysis



- PE pyrolysis oil 100 %
or can be mixed with HFO

- or -

- Wood oil 100 %
- Wood oil /LFO emulsions

- clean wood oil $\eta = 70 - 80 \text{ wt\%}$
- clean hydrocarbon oil $\eta = 85 \text{ wt\%}$

Market drivers and trends (1)

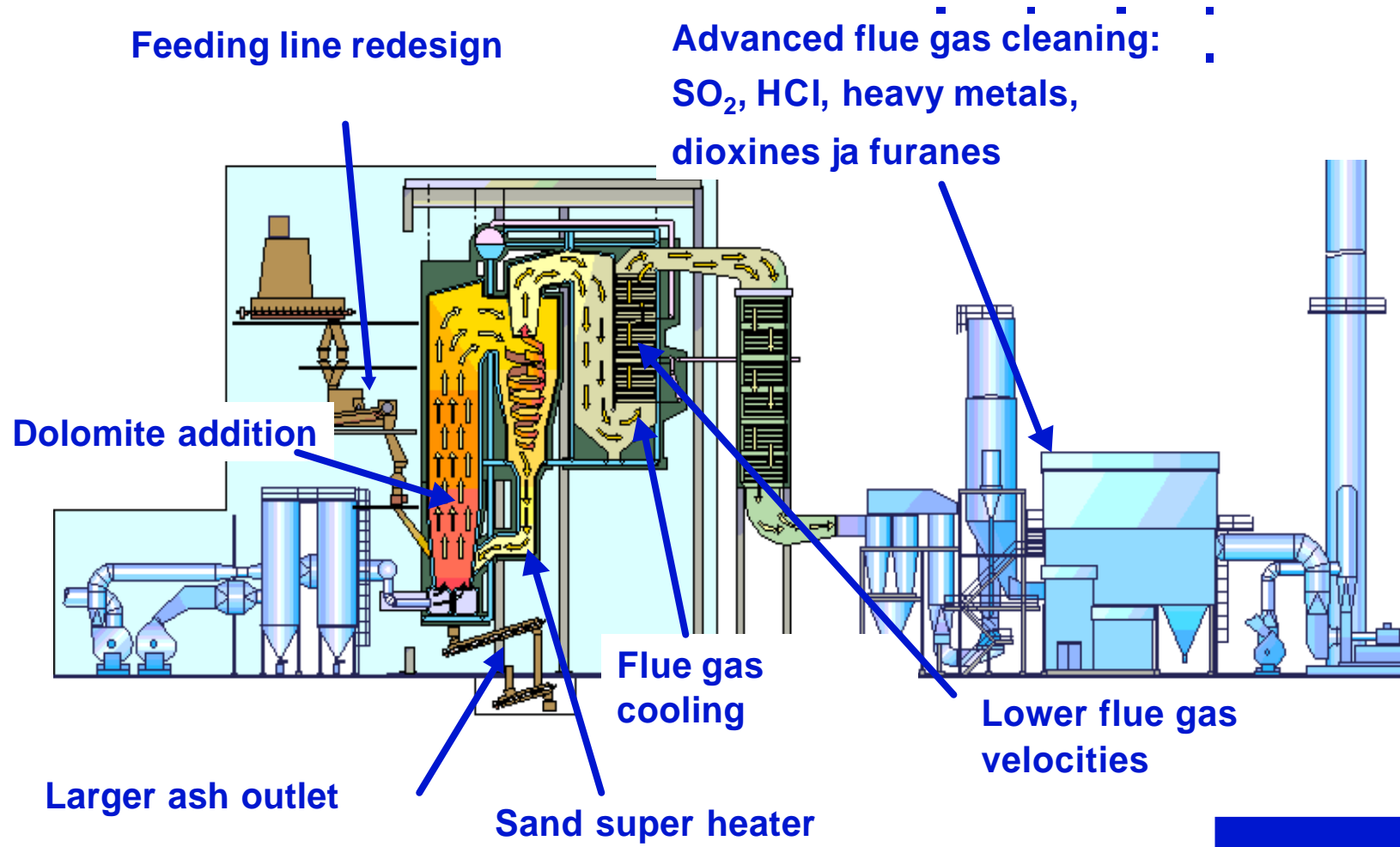
- Increasing legislative backing and economical incentives
- Rising waste volumes in general
- From small scale to large scale operations
- From mixed waste to dedicated fractions
- From integrated waste management to sustainable resource management
- Transition from low cost landfill disposal to mechanical / biological and WtE

Market drivers and trends (2)

- Privatisation of the waste management
- Deregulation and privatisation of the energy market
- Consolidation of operators and WtE contractors
- Promotion of RES and CHP

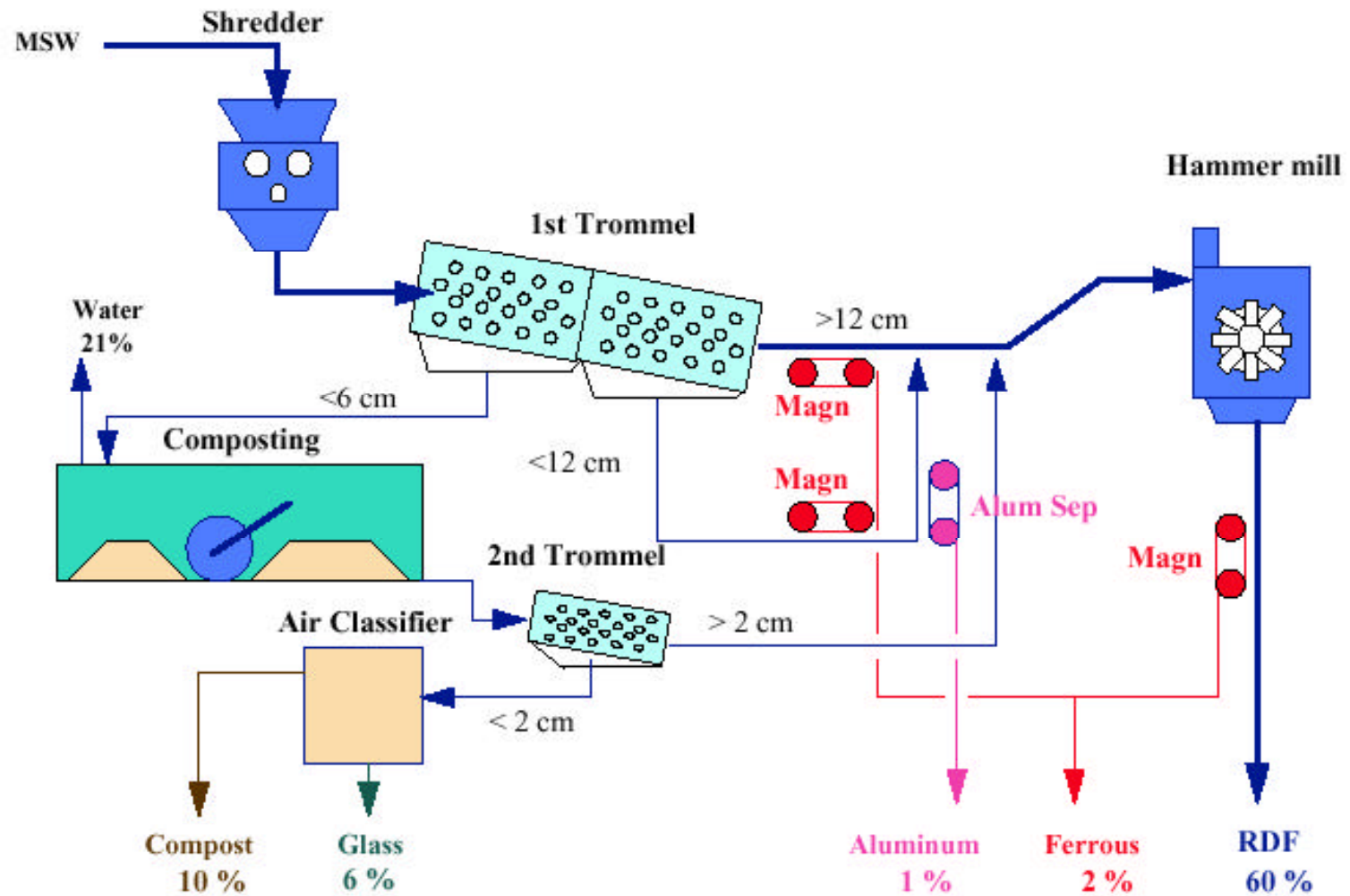


Power plant modifications for SRF



Foster Wheeler CFB in Lomellina, Italy

Waste Handling



Foster Wheeler CFB in Lomellina, Italy

Fuels

- **RDF**

- **Analysis**

Cl (af)	%	0.6
S (af)	%	0.1
Ash (af)	%	13.5
Moisture	%	20-35

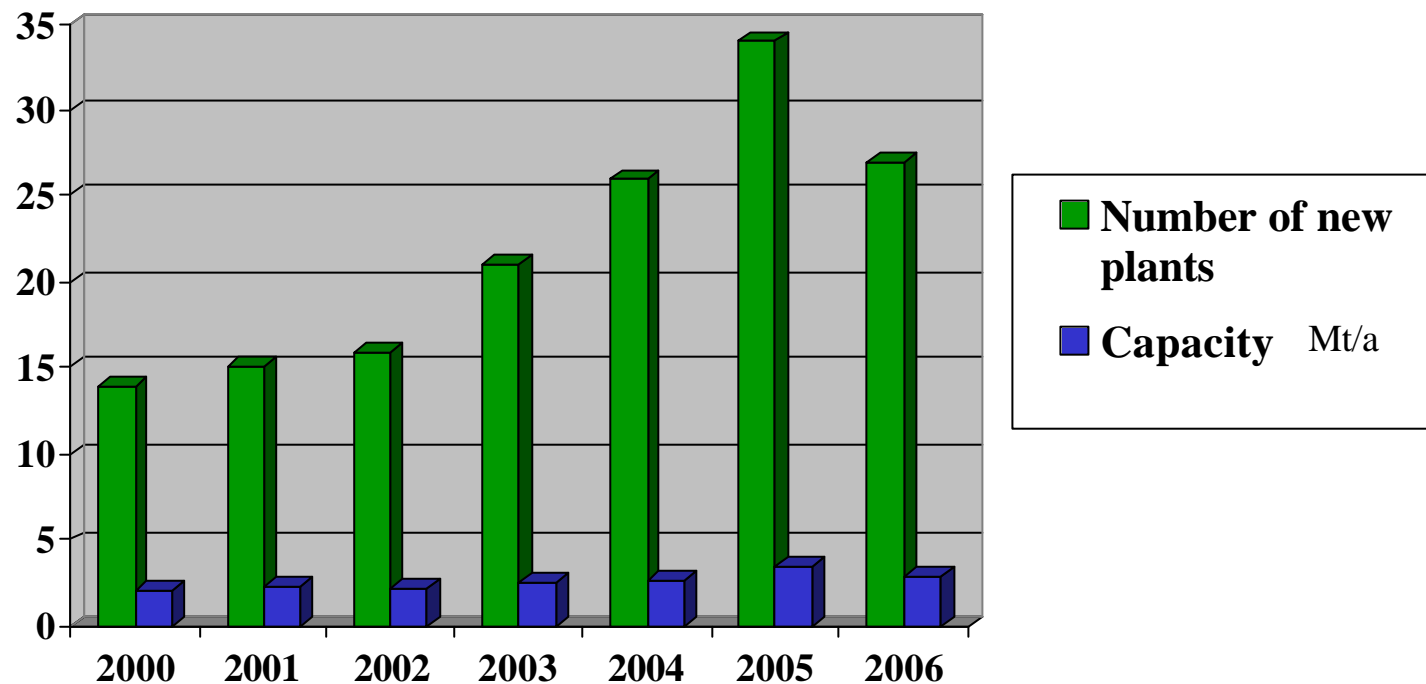
- **RDF makes about 60 % of the total incoming MSW**
 - **To compost goes about 30% of MSW, the rest is glass, inerts, aluminium and ferrous material**

- **MSW**

- **Characteristics**

Food waste	%	20.0
Paper and cardboard	%	27.5
Plastic	%	13.5
Textiles	%	3.5
Metals	%	3.5
Wood	%	3.5
Yard waste	%	7.5
Glass	%	8.0
Screenings	%	5.0
Napkins	%	2.0
Bulky waste	%	4.0
Others	%	2.0
TOTAL	%	100.0

Waste to Energy market in Europe



New technologies (CFB, BFB, Gasification & pyrolysis) 30 % market share ?

Source: Frost & Sullivan 1999



MSW statistics - Europe

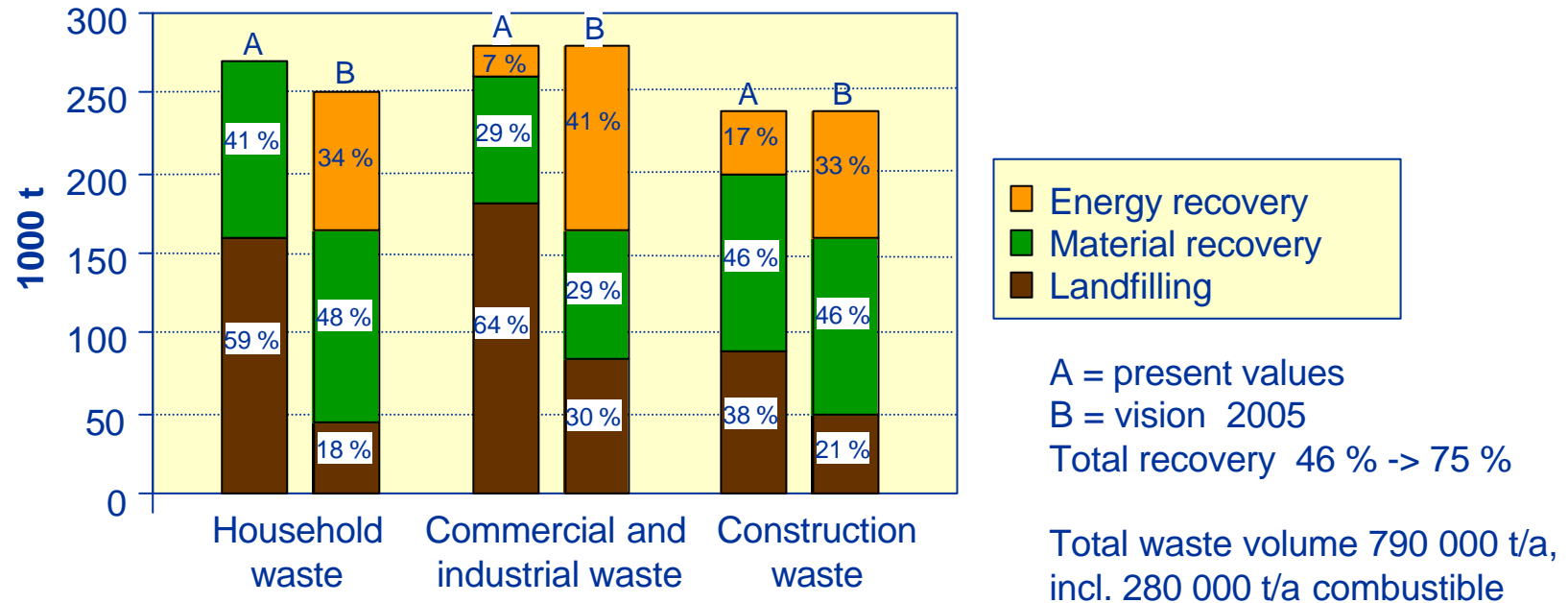
	MSW total 1000 t	Household 1000 t	per capita kg/capita	per capita kg/capita
Austria	4,100	2,775	510	340
Belgium	4,852 -		480	
Denmark	2,951	2,776	560	530
Finland	2,100	870	410	170
France	28,800	20,800	480	350
Germany	36,976	35,402	460	440
Greece	3,900 -		370	
Ireland	2,032	1,325	560	370
Italy	26,605 -		460	
Luxembourg	193	100	460	250
Netherlands	8,716	7,471	560	480
Portugal	3,800 -		380	
Spain	15,307 -		390	
Sweden	3,200 -		360	
UK	28,000	26,000	480	440
Czech Rep.	3,200	2,600	310	250
Hungary	5,000	3,350	500	330
Poland	12,183	8,169	320	210
Slovak	1,800	1,100	340	200

Source: OECD 1999, or latest available year

Source: P.Väisänen, Electrowatt-Ekono



WASTE RECYCLING VOLUMES IN HELSINKI - present values and vision to 2005



Waste fractions excluded:

- municipal sludges, 25 000 t dm/a
- contaminated soil
- hazardous waste

Source: Mäkinen et.al. YTV Report, 2000

