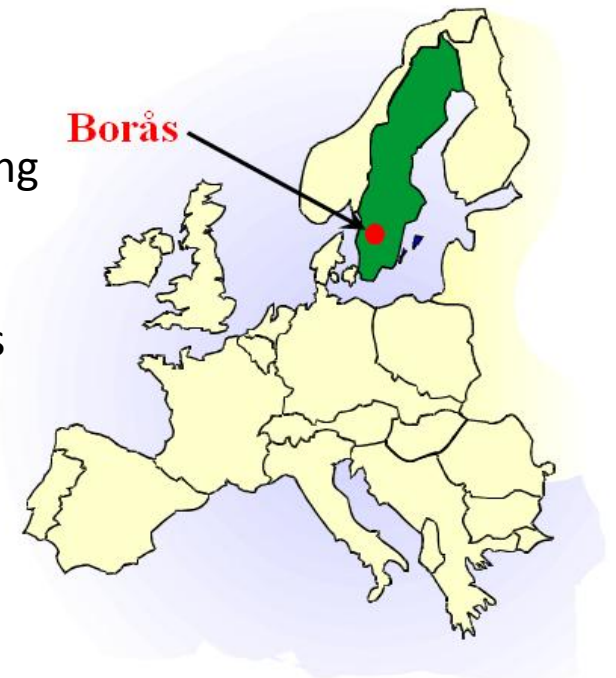


Wastes to Energy & Materials

Education, research, planning, implementations & international collaborations

Olle Engström
Member or City Council of Borås
&
Mohammad Taherzadeh
Prof., Bioprocesses
University of Borås
Sweden

Hans Björk
Dean, School of Engineering
&
Tobias Richards
Prof., Thermal processes
University of Borås
Sweden



www.wasterecovery.se,
www.resourcerecovery.se



List of contents

- Olle Engström:
 - Facts about Sweden and Borås,
 - Visions, goals and facts on waste management in Borås
- Hans Björk:
 - Facts about University of Borås
 - International collaboration
- Mohammad Taherzadeh:
 - Waste recycling and separation
 - Biological treatment of wastes, today and future
- Tobias Richards:
 - Thermal treatment of wastes, today and futur



Sweden



- 9 miljon people
- 450 000 km²
- Forest 53%
- Lakes & rivers 9%
- European Union
- Nordic weather
- Swedish Language
- 30 Universities

www.wasterecovery.se,
www.resourcerecovery.se



... and more on Sweden ...

- Technology
(Volvo, SKF, IKEA, ABB, SCANIA
H&M, Ericsson, Electrolux)



- Free education
- Mentality
- Gender equality



Borås

105,000 inhabitants



BORÅS STAD



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www.resourcerecovery.se





UNIVERSITY OF BORÅS

SCIENCE FOR THE PROFESSIONS



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www.resourcerecovery.se



Technical Research Institute of Sweden (SP)



- No. of employees: 950
- Turnover USD 100 million
- Owned by the Swedish state
- Website: www.sp.se

● Universities and institutes of technology
● SP



Turnover, by geographical areas:

□	outside Sweden	19 %
■	northern Sweden	9 %
■	western Sweden	27 %
■	eastern Sweden	27 %
■	southern Sweden	18 %

www.wasterecovery.se,
www.resourcerecovery.se



Waste to Energy and Material by: Borås Energi och Miljö



- Owned by Borås City
- Founded 1891
- City of Borås
- Turnover 80 million dollar
- 150 employees
- Website: www.borasenergimiljo.se



www.wasterecovery.se,
www.resourcerecovery.se



Sweden in 30 years ago!

One day my son all this vill become yours



www.wasterecovery.se,
www.resourcerecovery.se



Environmental policy

- The Municipality of Borås shall strive to be a **green community** by means of proactive environmental measures with a **good balance between ecological, economic and social values**.
- In their actions, municipal employees and elected representatives shall show **great consideration for ecological impact** so as to avoid the accumulation of unsolved environmental problems for future generations.



VISION

In the long term sustainable waste management

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www.resourcerecovery.se

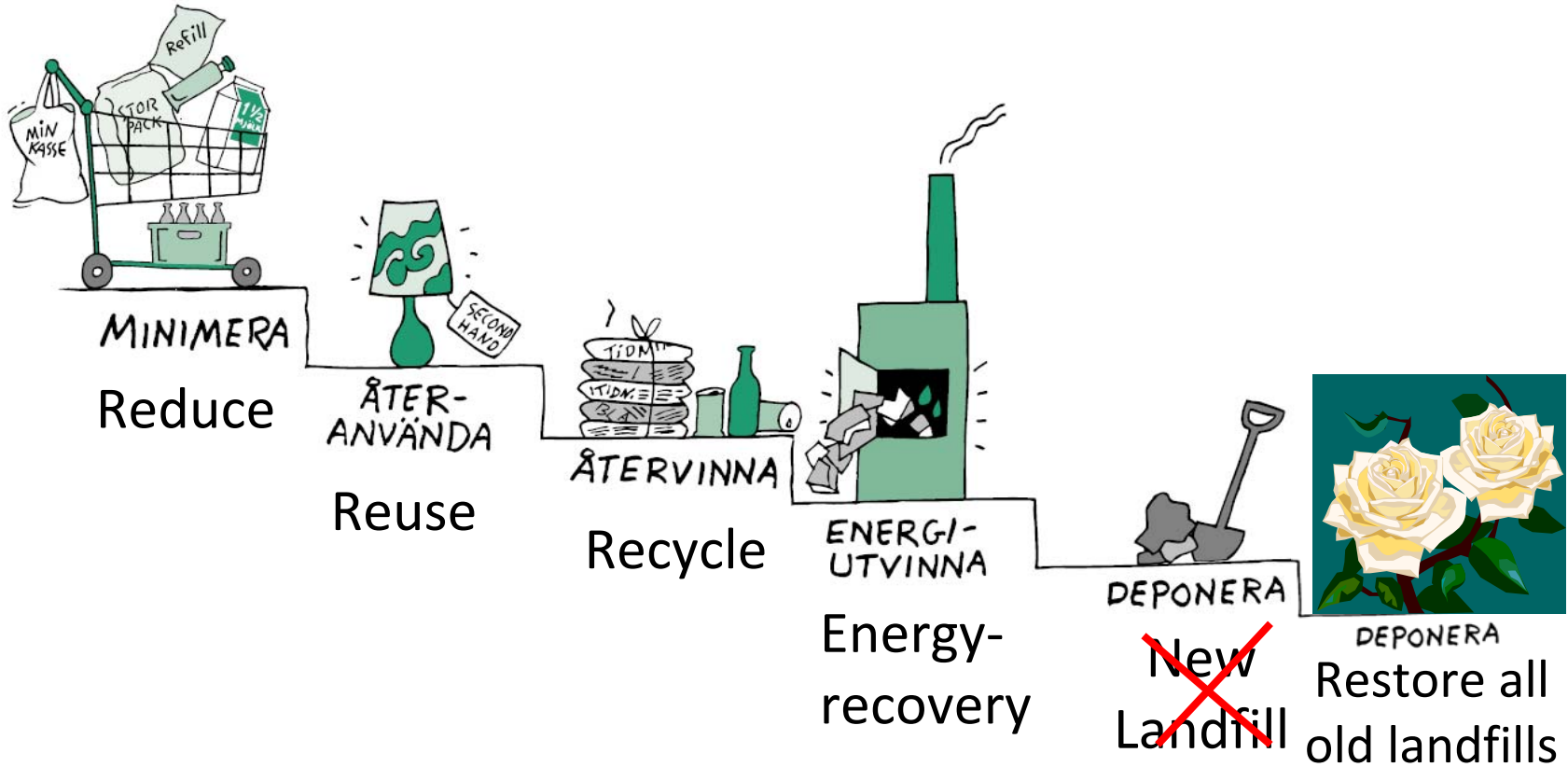


Overall goals

- Protect the environment for the coming generations
- Resource savings
- Resource recovery



How to do?



Waste planning is like doing a puzzle

Waste planing is like doing a jig-saw



Development of waste treatment in Borås (1986-2010)

- | | |
|--|-------------|
| 1. Investigation and planning | 1986 |
| 2. Start of source sorting in 3,000 households | 1988 |
| 3. 10-years planning 1989-2000 | 1989 |
| 4. Full scale sorting with optical sorting system | 1991 |
| 5. Anaerobic digestion and composting | 1995 |
| 6. Interim storage of hazardous waste | 1998 |
| 7. First collecting vehicle run with gas | 2002 |
| 8. Waste plan 2001 - 2010 | 2003 |
| 9. Public gas station opened | 2003 |
| 10. New digester ready | 2003 |
| 11. New incineration plant ready | 2004 |
| 12. First bus ran on biogas | 2004 |
| 13. All 39 buses inside the city run on biogas | 2008 |
| 14. A new gas station for private cars | 2009 |
| 15. All 59 Biogas buses run in the city | 2009 |
| 16. Planning for a new energy complex | 2010 |



Treatment of household waste in Borås Today

Landfilling	~0 %
Recycling	27 %
Biological treatment	30 %
Incineration	43 %



OUR DREAM

A CITY FREE FROM FOSSIL FUELS





UNIVERSITY OF BORÅS

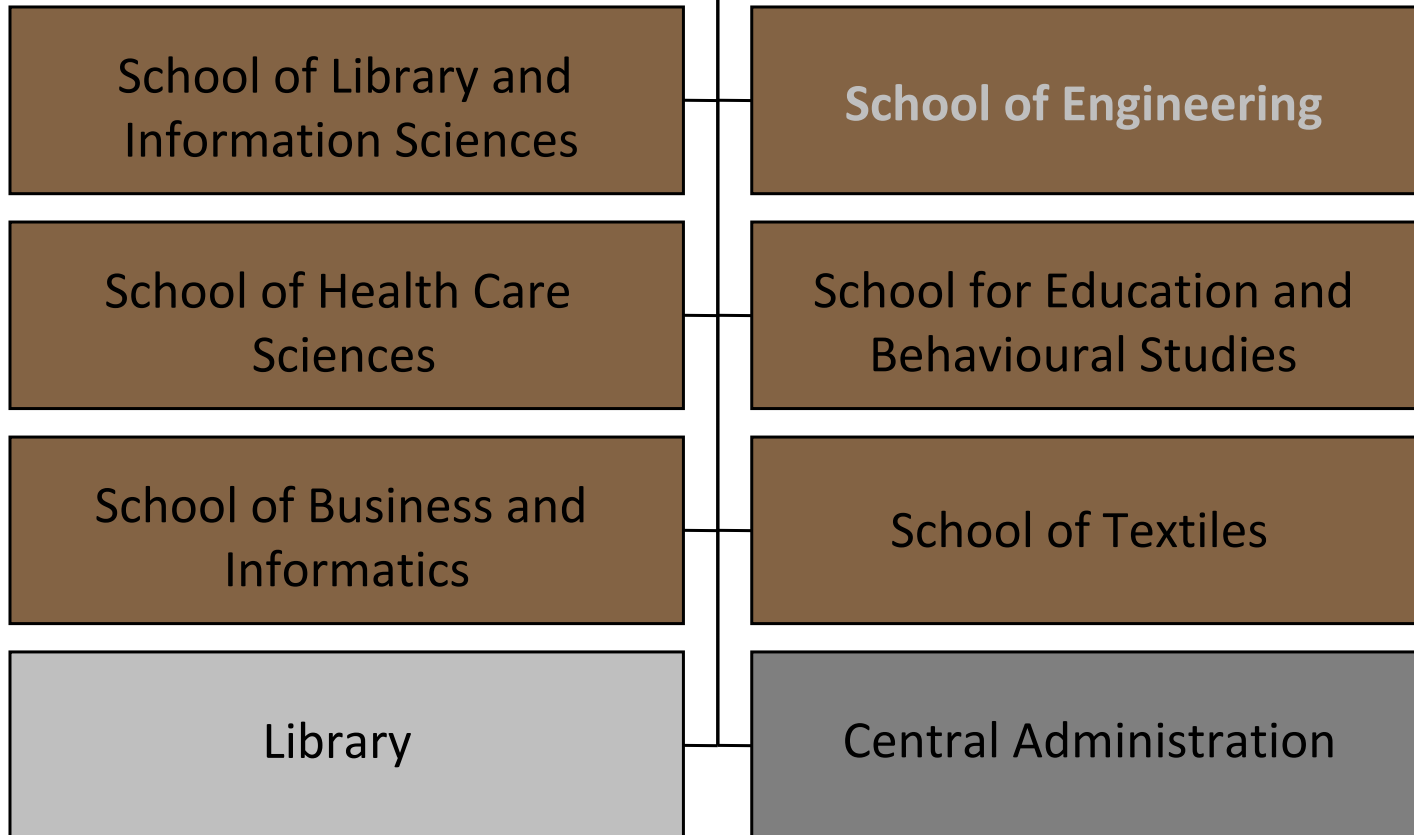
SCIENCE FOR THE PROFESSIONS

- Budget: 545 million SEK
- (~ 70 million USD)
- Staff: 650
- Students: 14791
- Full Professors: 52
- PhD Students: 124
- Rector: Prof. Lena Nordholm
- Website: www.hb.se





UNIVERSITY OF BORÅS
SCIENCE FOR THE PROFESSIONS



School of Engineering

Fourth largest educator of
bachelors of engineering in Sweden

- 1900 students
(1100 full time)
- 70 teaching staff
- 11 full professors
- 25 PhD students



School of Engineering

Research and PhD-studies in 3 research areas

Everything is done in English

4 Master programs (1-2 years)

All given in English

9 Bachelor programs (3 year)

1 given in English, the rest in Swedish

4 Diploma programs (2 year)

All given in Swedish



Resource Recovery

two international master programs

Industrial Biotechnology (Two-year master)

Prereq: BSc in Chemical Engineering or Chemistry

Features: Industrial application of biotechnology
for a sustainable development

Sustainable Technology (Two-year master)

Prereq: BSc Engineering or Chemistry
(Chemical, Mechanical, Industrial, Electrical or Civil)
course in Thermodynamics

Features: Resource management and
recovery of energy and material resources



University of Borås

Focus Areas of Research

- **Resource Recovery**
- **Business and IT**
- **Textiles and fashion**
- **Library and information science**
- **Teacher education and education work**
- **Integrated nursing science**



Our Map on wastes to energy and materials

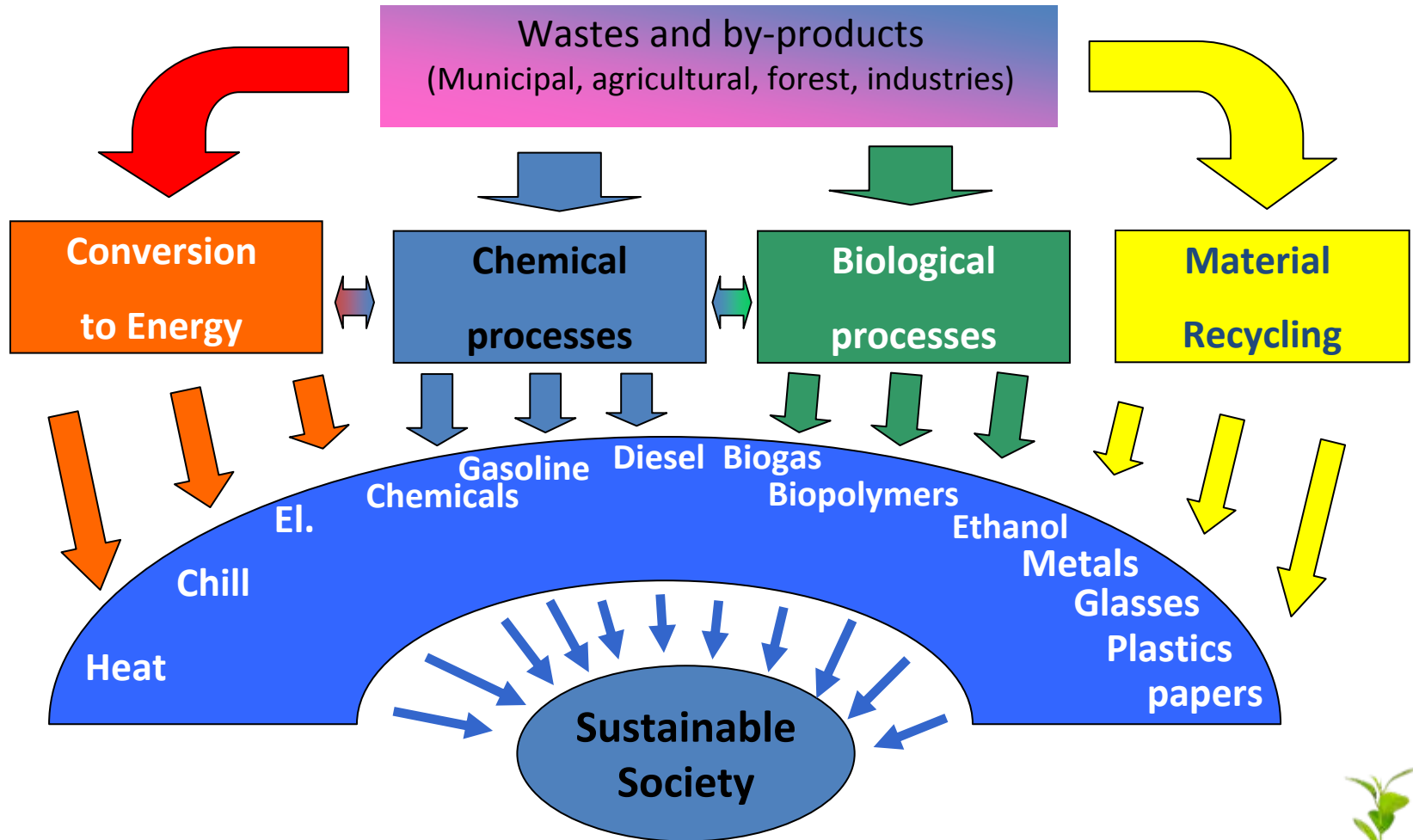
Collaborative R&D:
Universities/
Companies
[Waste Refinery]
www.wasterefinery.se

Research/Education
at the university
[Resource Recovery]
www.resourcerecovery.se

International partnership
[Waste Recovery]
www.wasterecovery.se



University Research Profile Resource Recovery!



Research Collaborative partners in:

Waste Refinery (Sweden)

- | **3 Universities**
- | **3 Research institutes**
- | **20 companies**
- | **City of Borås**
- | **Swedish National energy agency**
- | **Regional authorities**
- | **Represent Sweden in IEA task waste to energy**



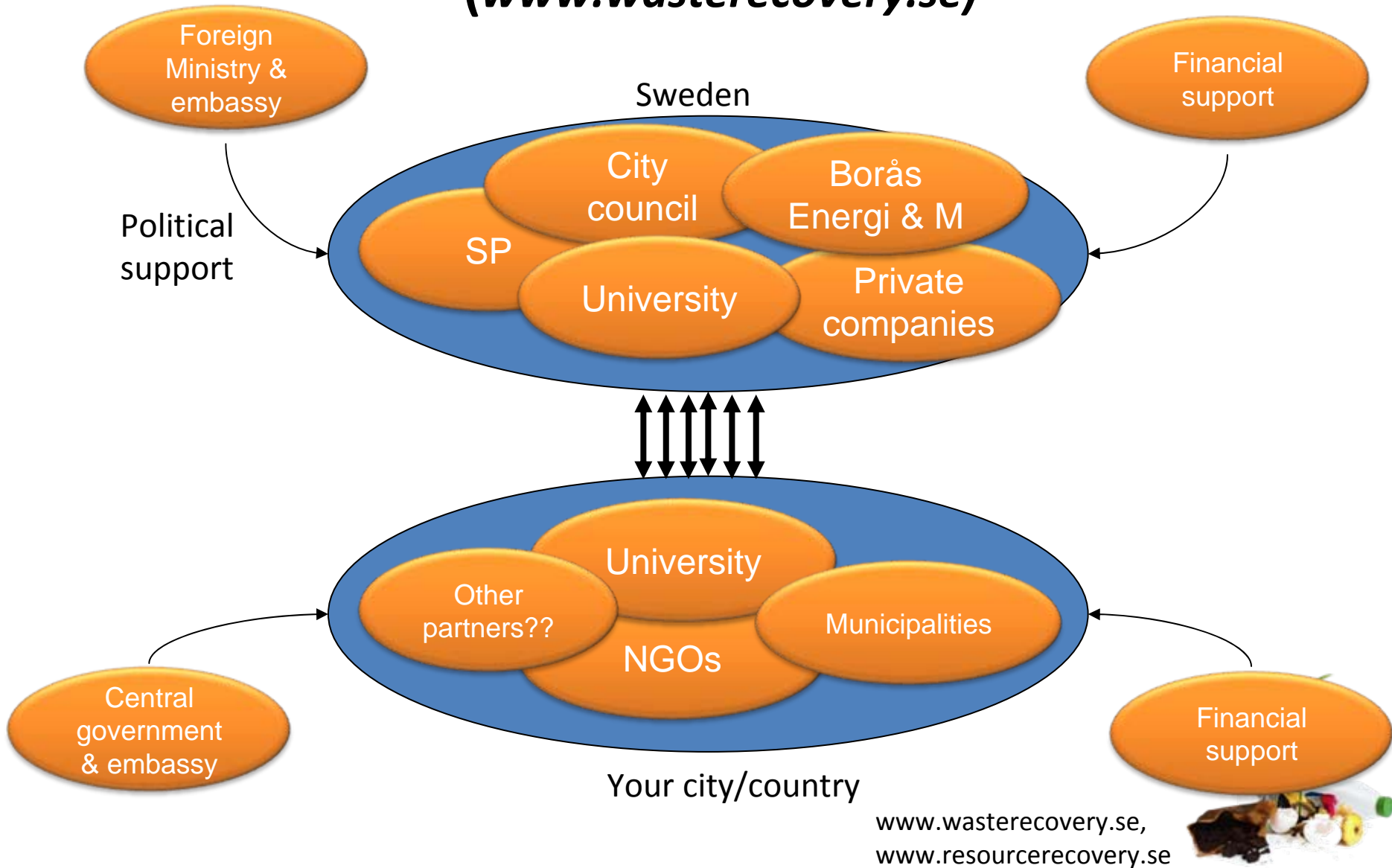
Waste Refinery

www.wasterefinery.se

www.wasterecovery.se,
www.resourcerecovery.se



Waste Recovery organization (www.wasterecovery.se)

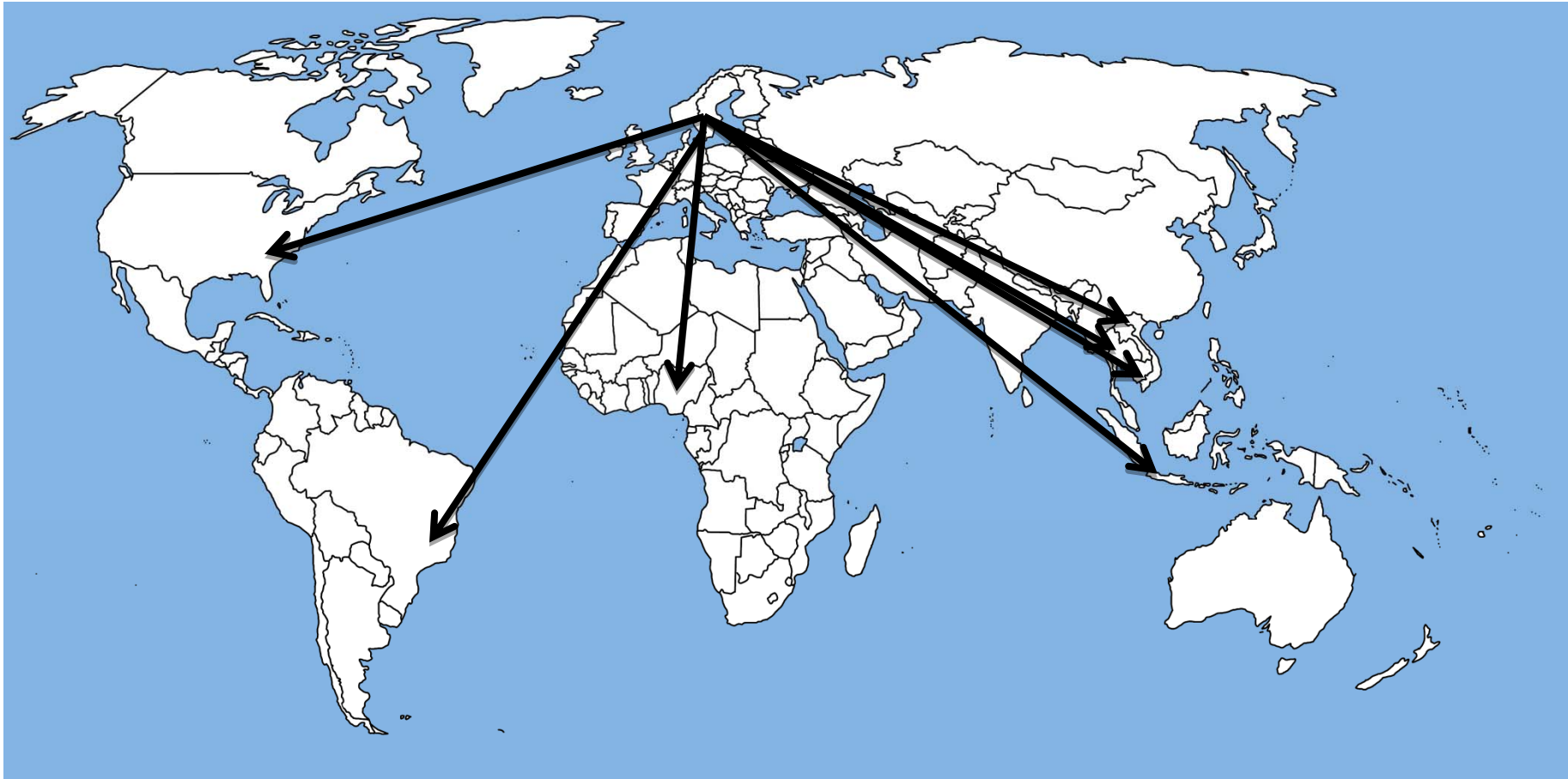


What to do together in Waste Recovery?

- Political platform for bilateral collaboration
- Educate on the problem and solutions (Sweden and here):
 - Students, children, public awareness
- Joint research (e.g. sandwich PhD students)
- Give visions to decision-makers (meetings and visit to Sweden)
- Environmental review:
 - Study current situation
 - Put realistic goals and milestones,
- Implement the individual projects:
 - Start with the pilots and small scales to make good example
 - Finding financing
 - Finding companies to execute the project (local and international, e.g. Sweden)



Waste Recovery collaborations



www.wasterecovery.se,
www.resourcerecovery.se



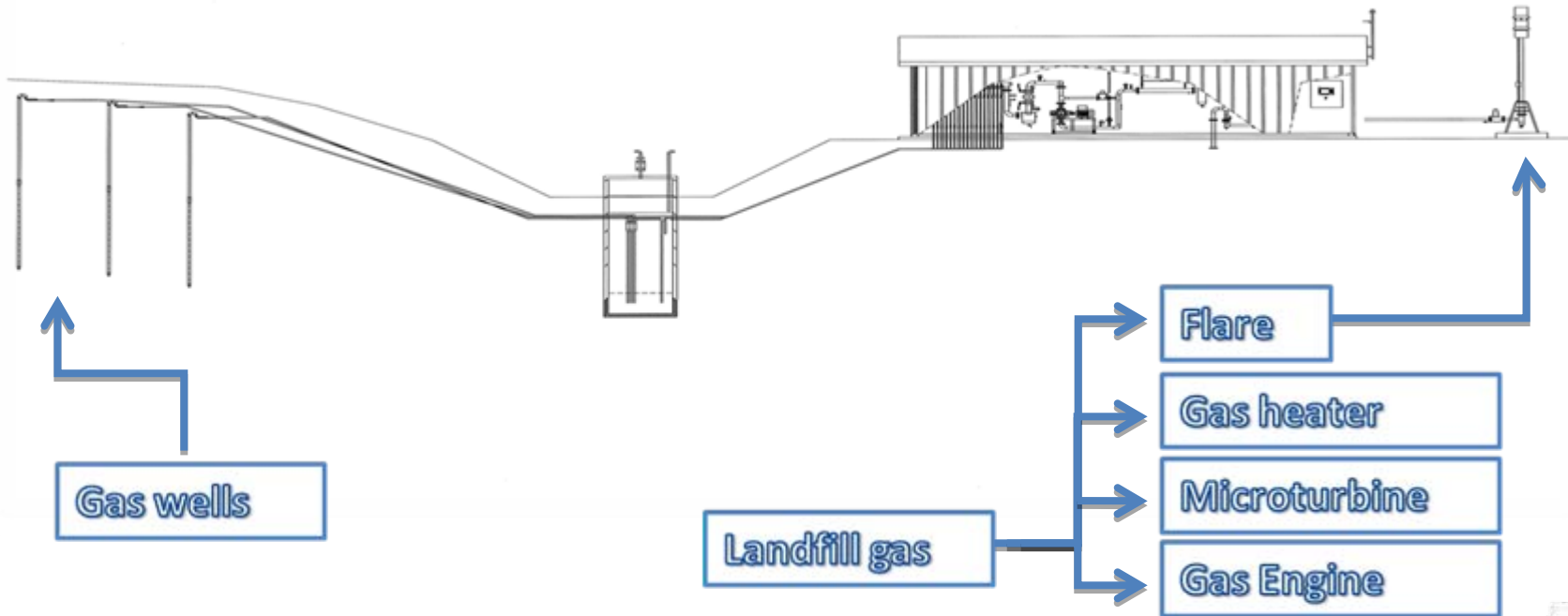
Waste to Resources in Borås & Sweden

www.wasterecovery.se,
www.resourcerecovery.se



First step:

Using landfill gas



www.wasterecovery.se,
www.resourcerecovery.se



A typical operating landfill:

- A city of 100,000 inhabitants
 - Landfill gas: 500 m³/hour (45% methane)
 - Power (heat): 2250 kW
 - Power (electricity): 750-800 kW
- These numbers can varied based on the amount and composition of the wastes



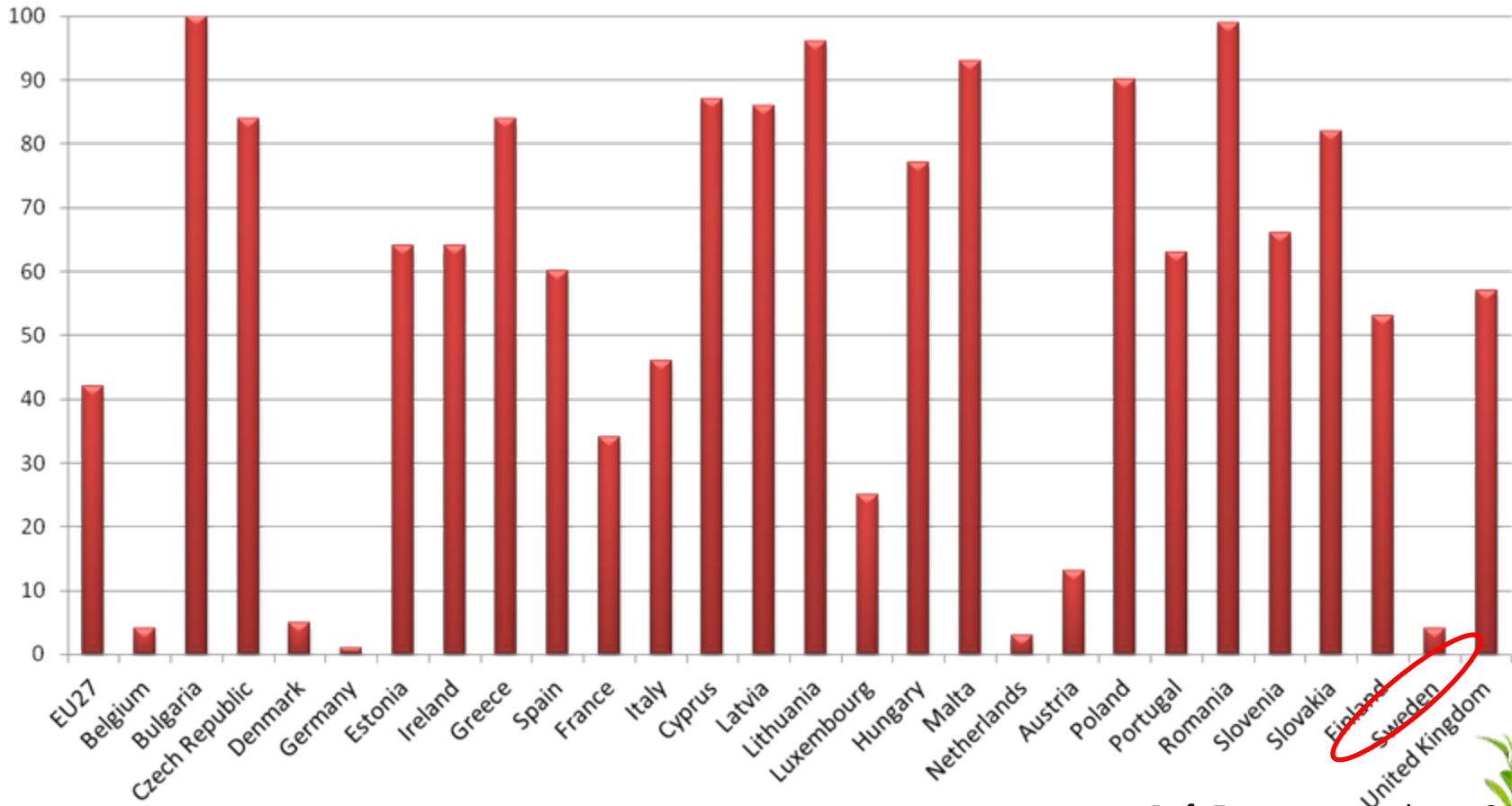
Legal Drivers to stop landfills

- 1991** Municipal waste treatment plan
- 1994** Producer responsibility
- 1998** The local investment program (LIP)
- 2000** Landfilling tax (~ 27 EUR/tonne)
- 2002** Landfill ban on combustible waste
- 2005** Landfill ban extended to include all organic waste
- 2006** Landfill tax increased for the 3rd time (~ 47 EUR/tonne)
- 2006** Incineration tax (~ 8 - 47 EUR/tonne)
- 2009** New legislation on landfill (SFS 2001:512)



Municipal waste landfilled in EU (2007)

%Municipal waste landfilled



Ref: Eustat newsrelease 31/2009

www.wasterecovery.se,
www.resourcerecovery.se

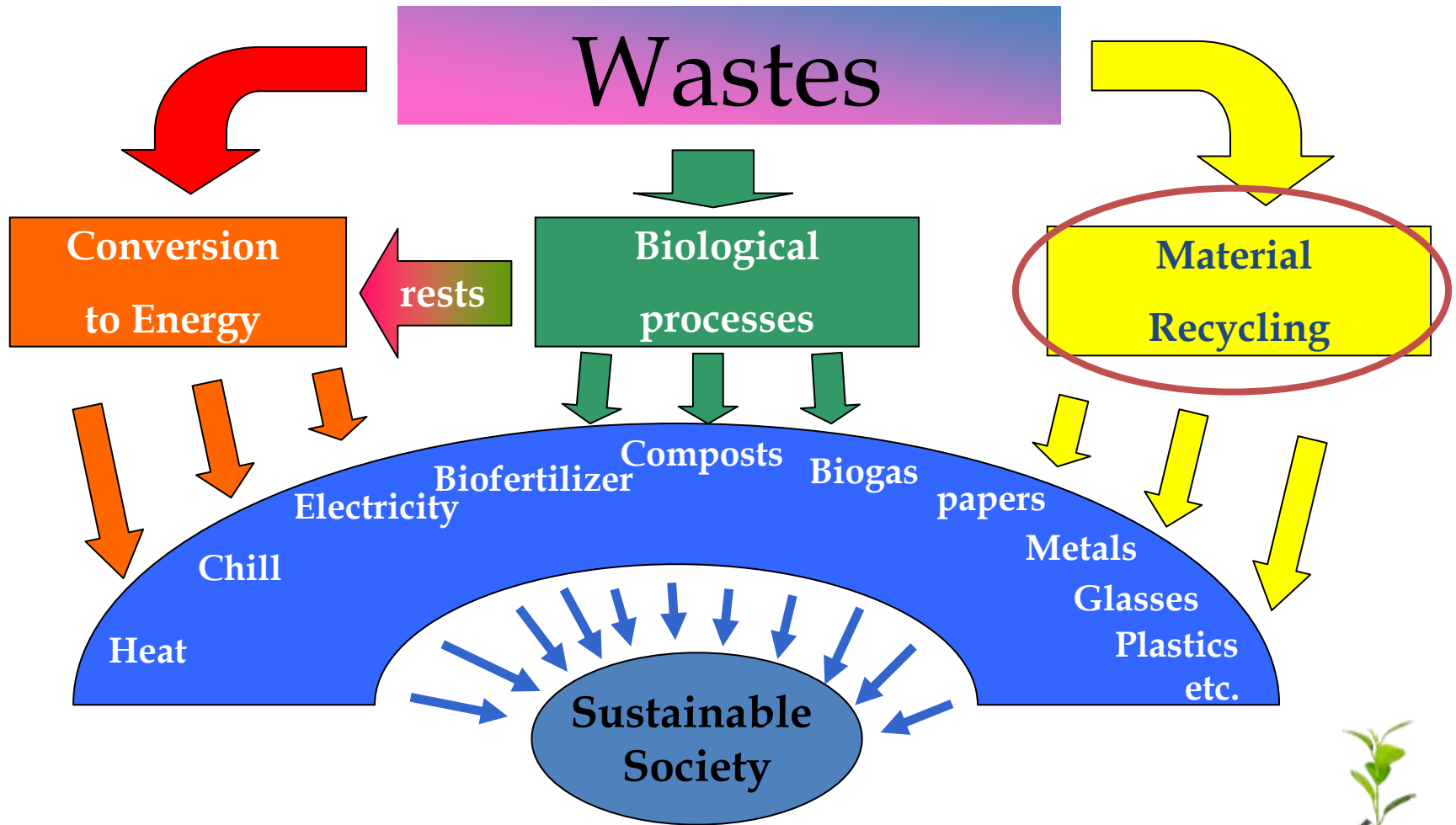


No landfill, so what to do?

www.wasterecovery.se,
www.resourcerecovery.se



Waste to Energy and Materials



Deposits for recycling PET & Aluminium



www.wasterecovery.se,
www.resourcerecovery.se



Recycling with zero payment!

Collection of packages and papers

- Paper packages
- Newspaper
- Metal packages
- Hard plastic packages
- Batteries
- Glass (no colour)
- Glass (coloured)



... and other wastes (odd and big size)!



www.wasterecovery.se,
www.resourcerecovery.se



Disassembling of Equipments



www.wasterecovery.se,
www.resourcerecovery.se



Fragmentation of metal scrap



Input material:

1/3 cars

1/3 domestic scrap

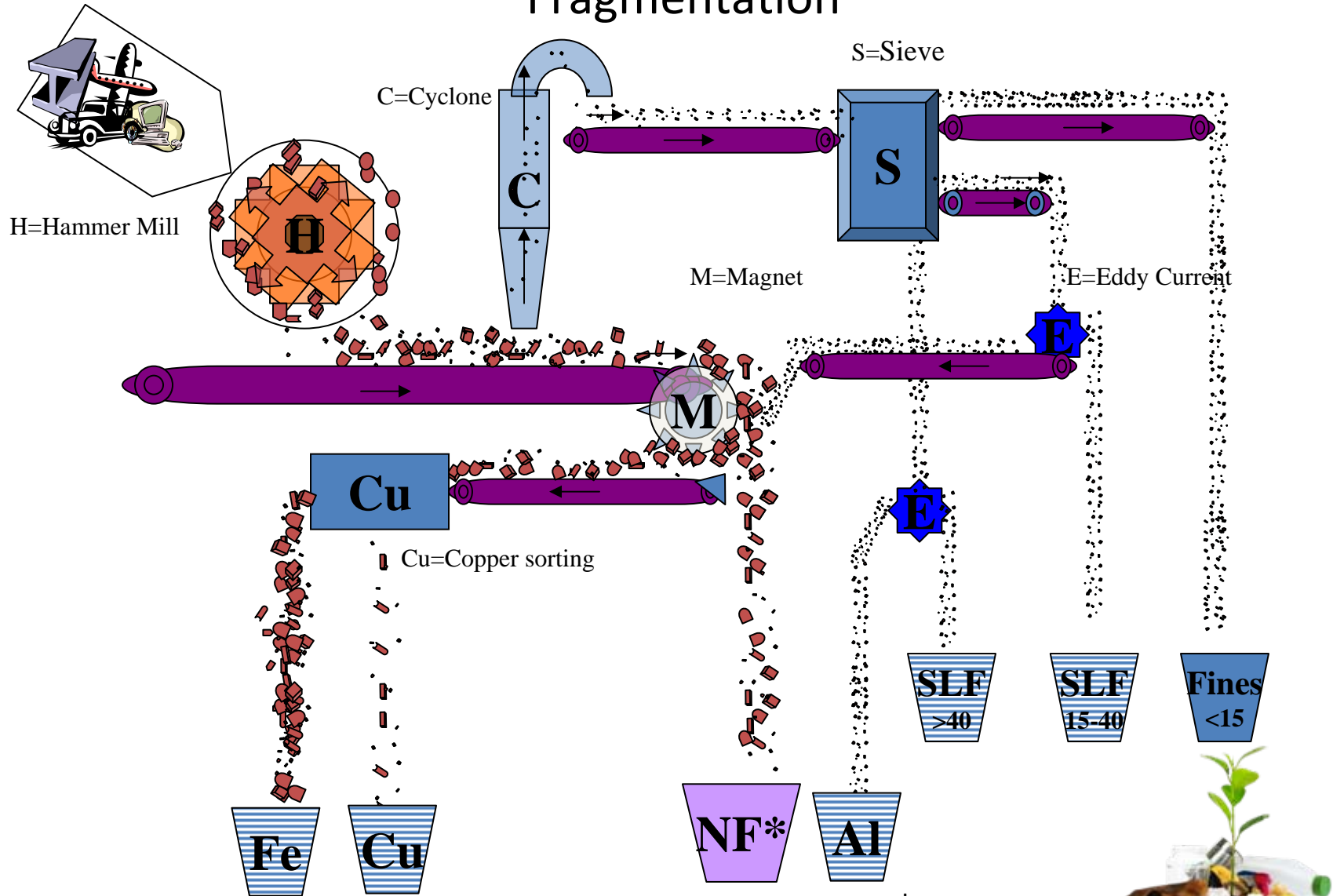
1/3 scrap from industry



www.wasterecovery.se,
www.resourcerecovery.se



Fragmentation



What about the rest?

www.wasterecovery.se,
www.resourcerecovery.se



***In Borås:
Source-separation in black and white bags***

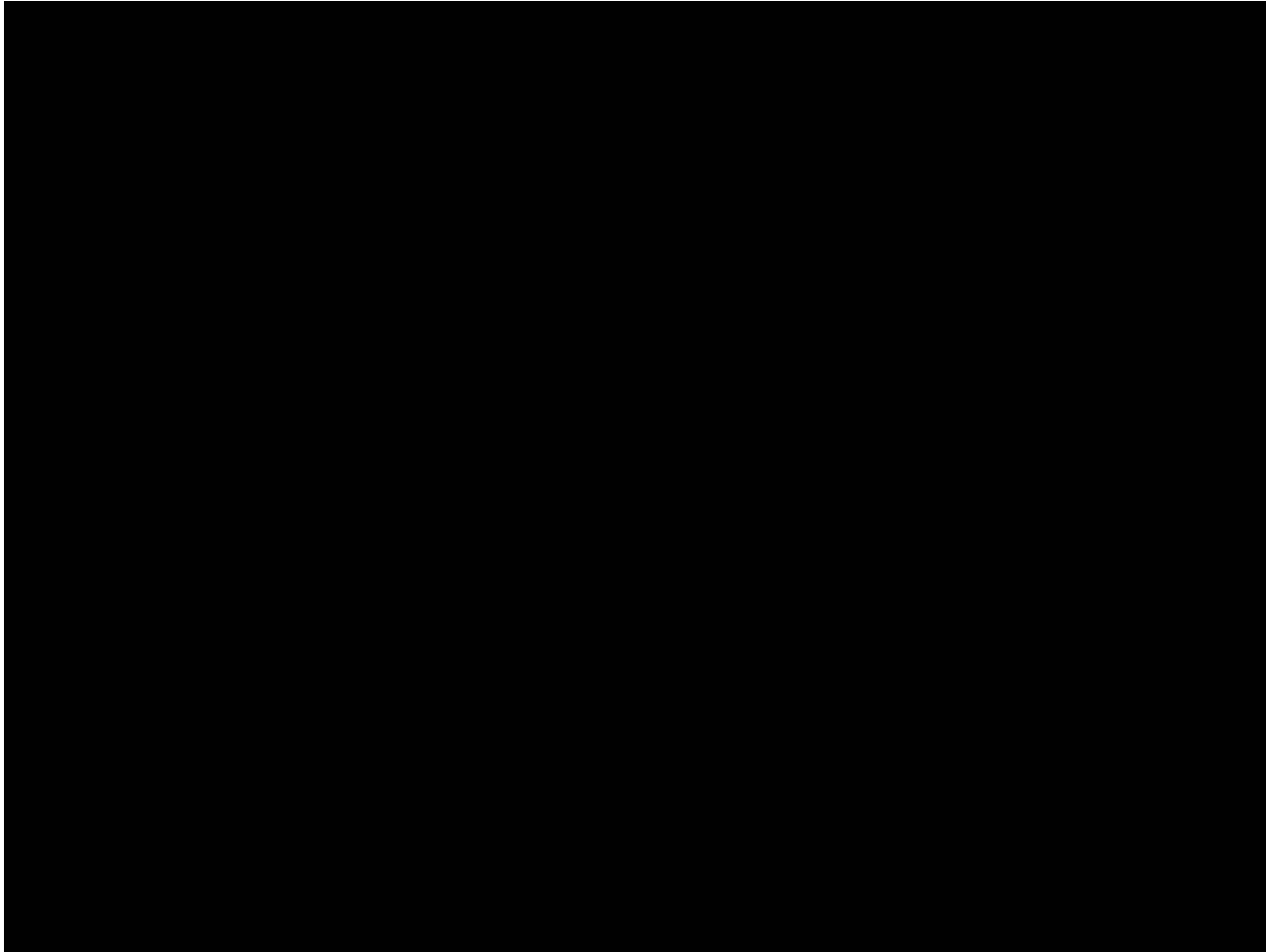
Toward Heat
for households ←



Toward Biogas
For cars and buses ←



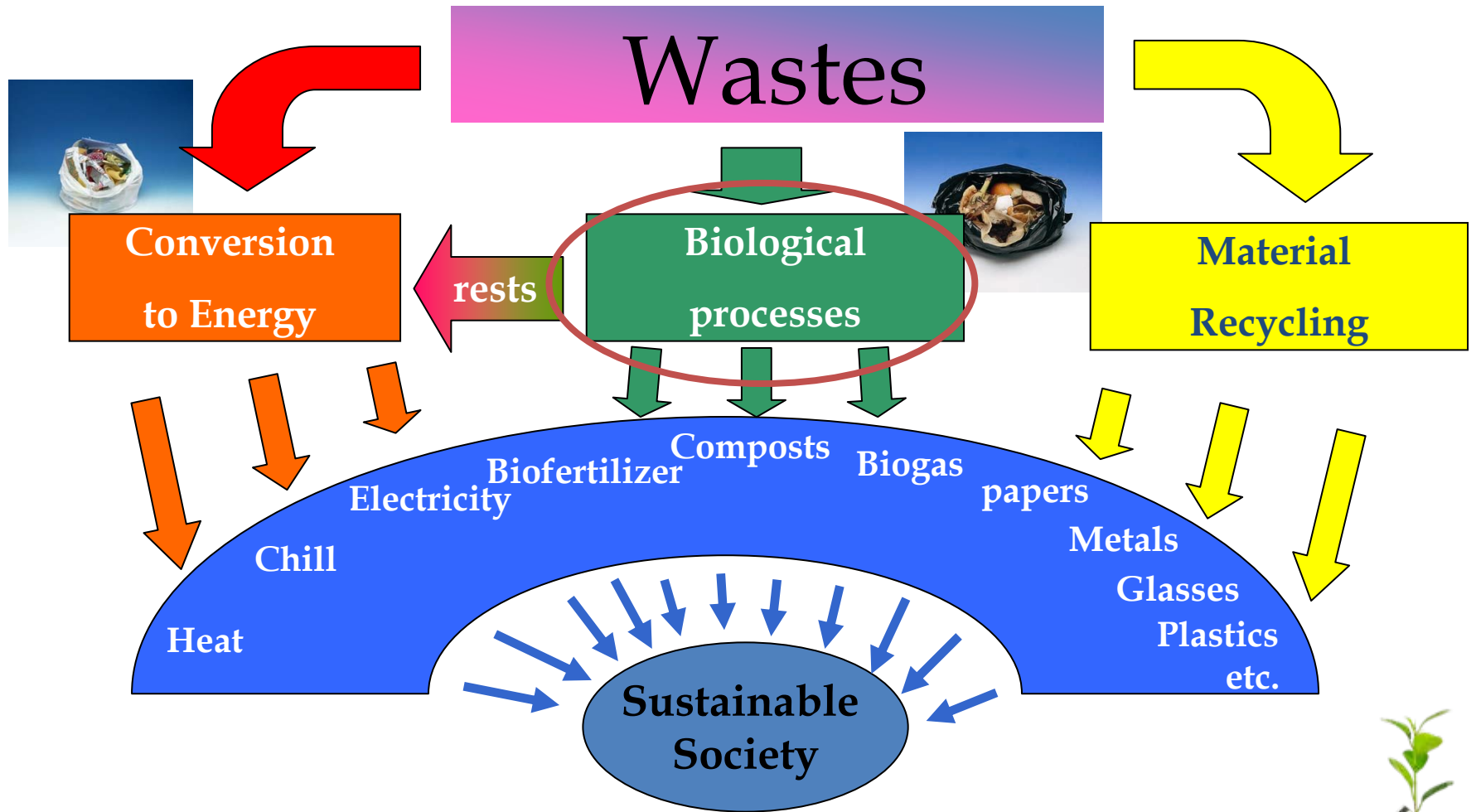
Movie: waste sorting



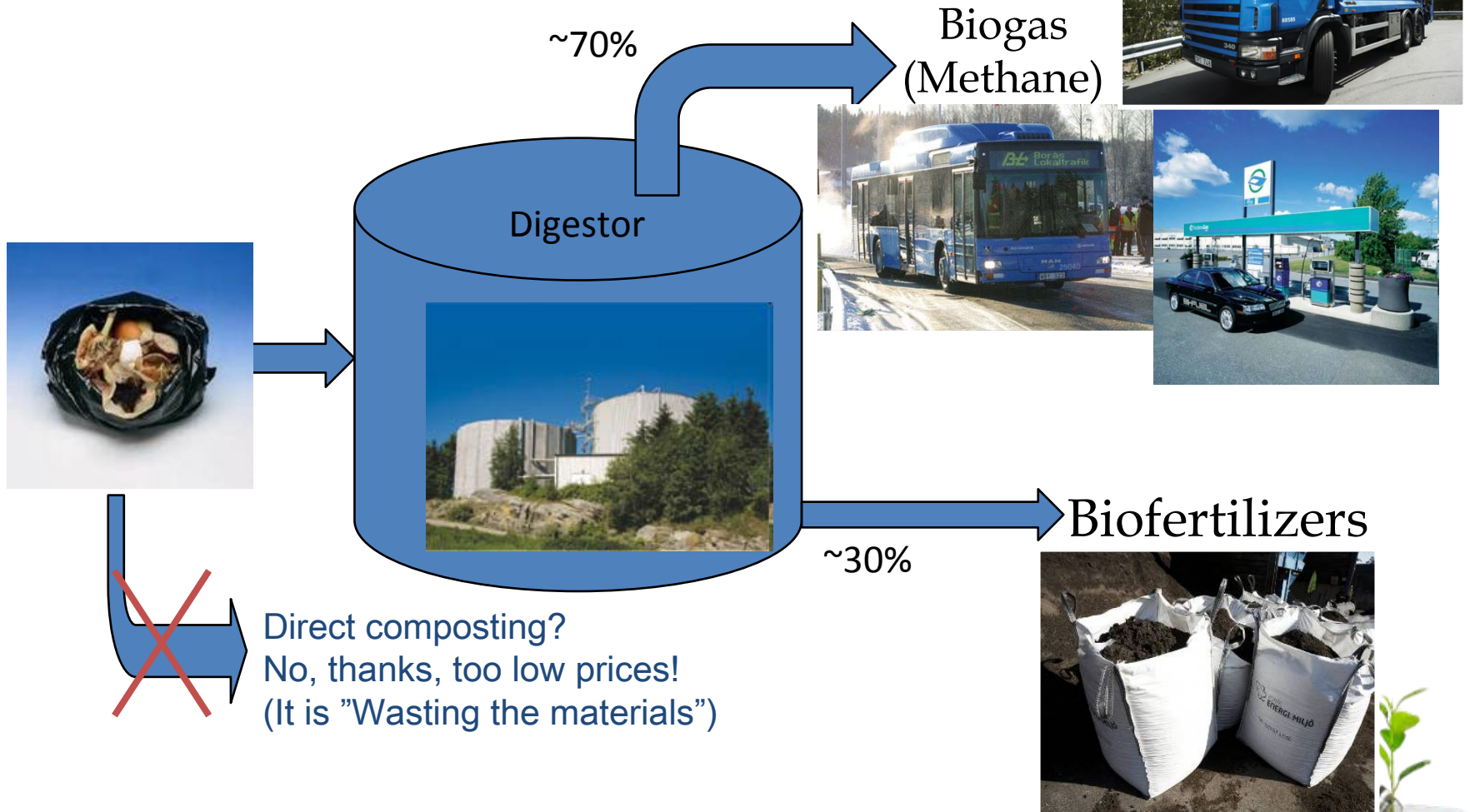
www.wasterecovery.se,
www.resourcerecovery.se



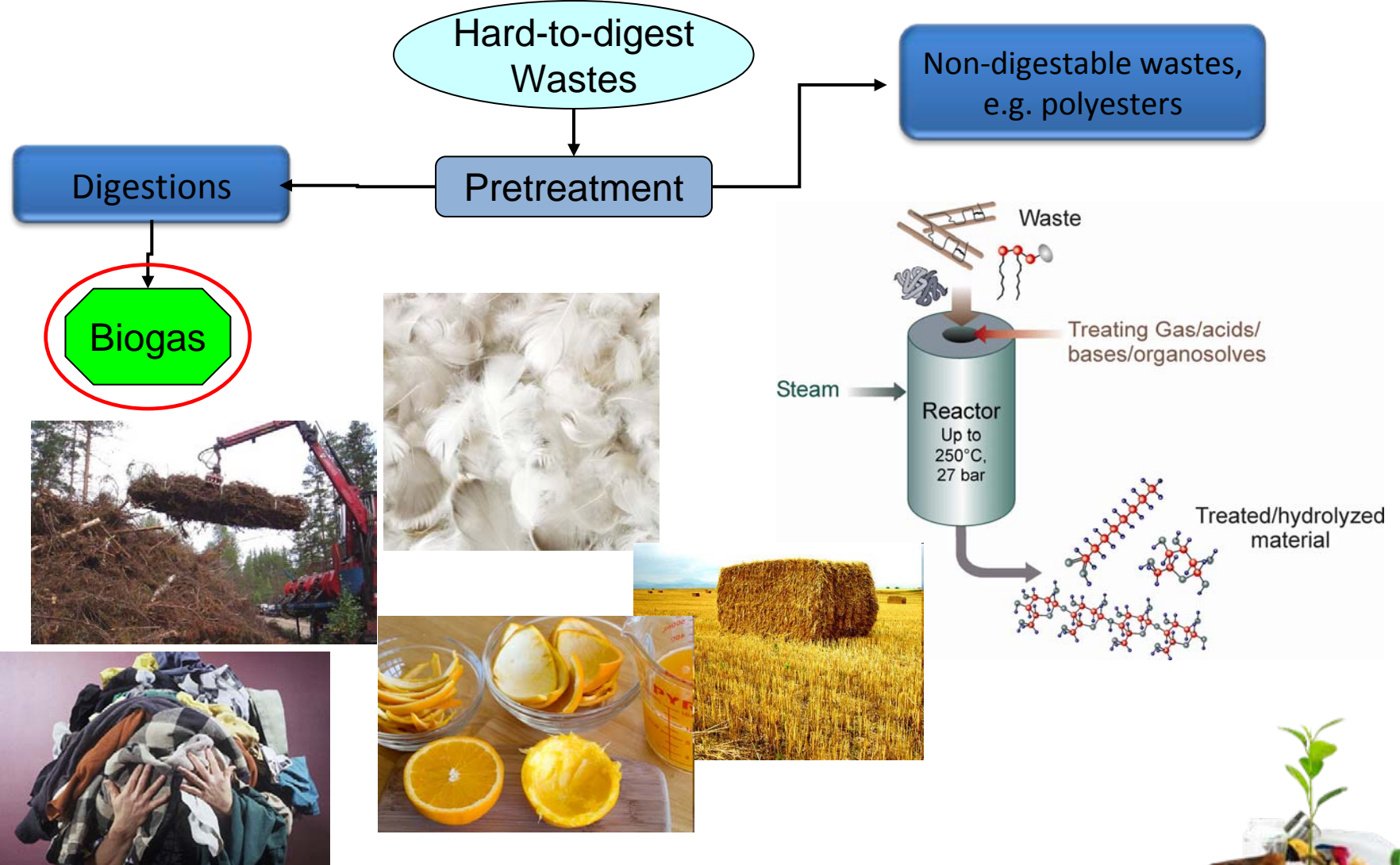
Waste to Energy and Materials



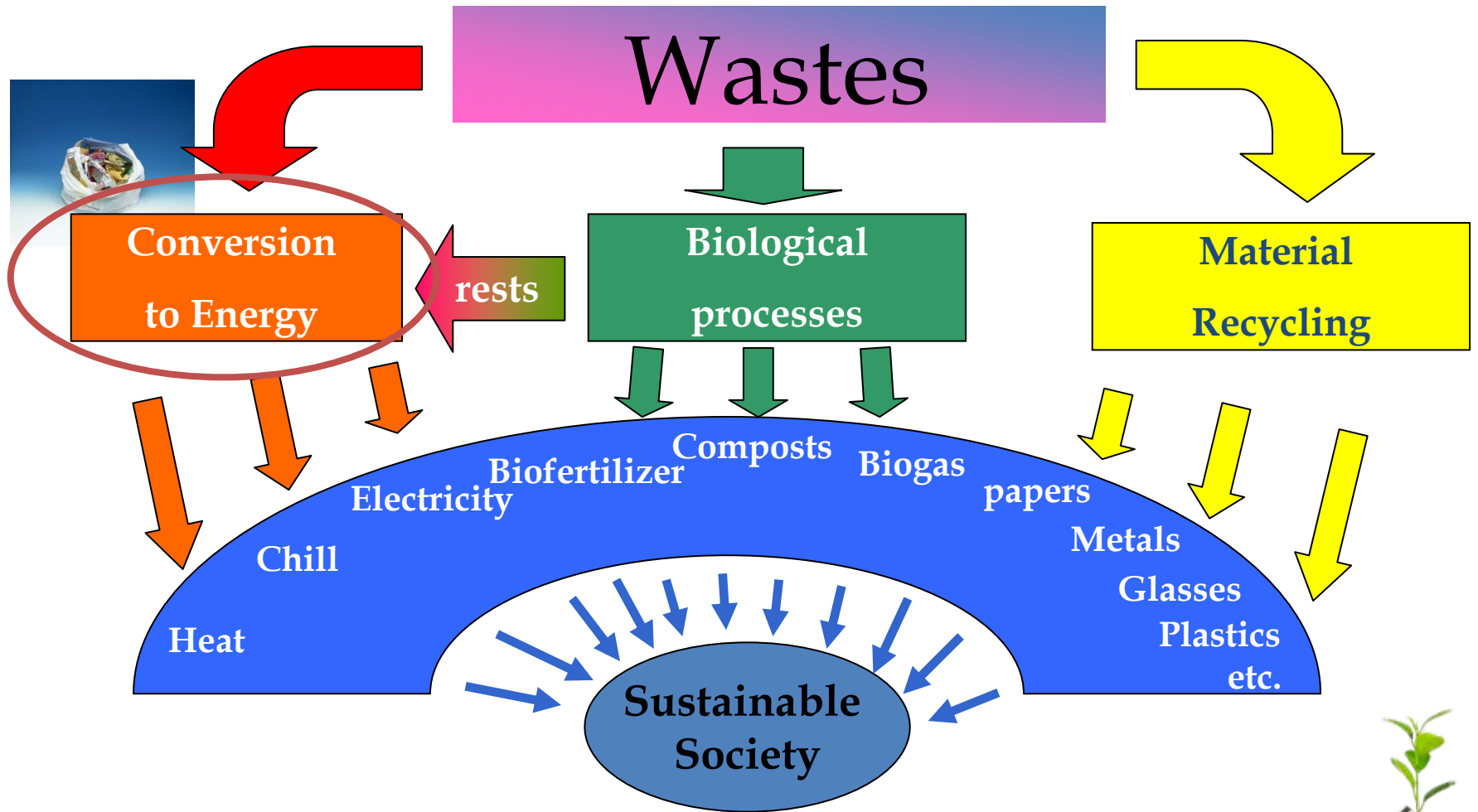
Biological wastes treatment



Research on improving digestion process!



Waste to Energy and Materials



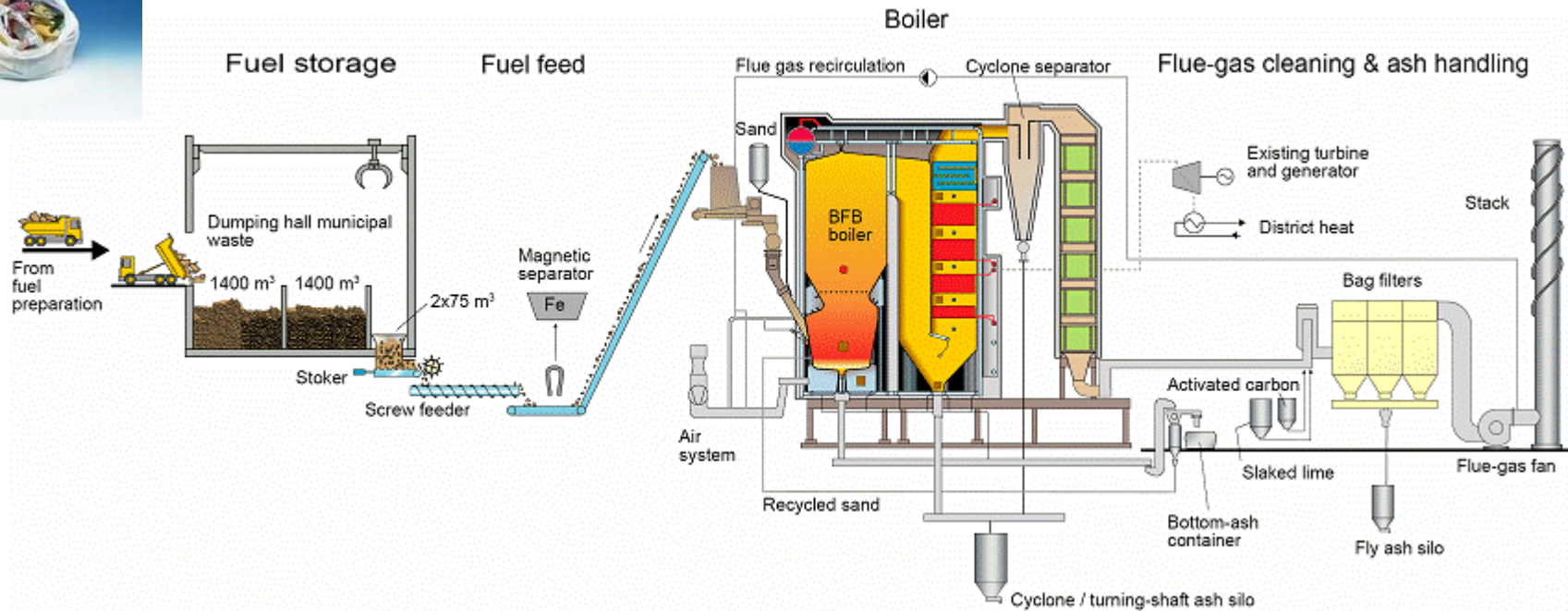
What is happened with white bags?



www.wasterecovery.se,
www.resourcerecovery.se



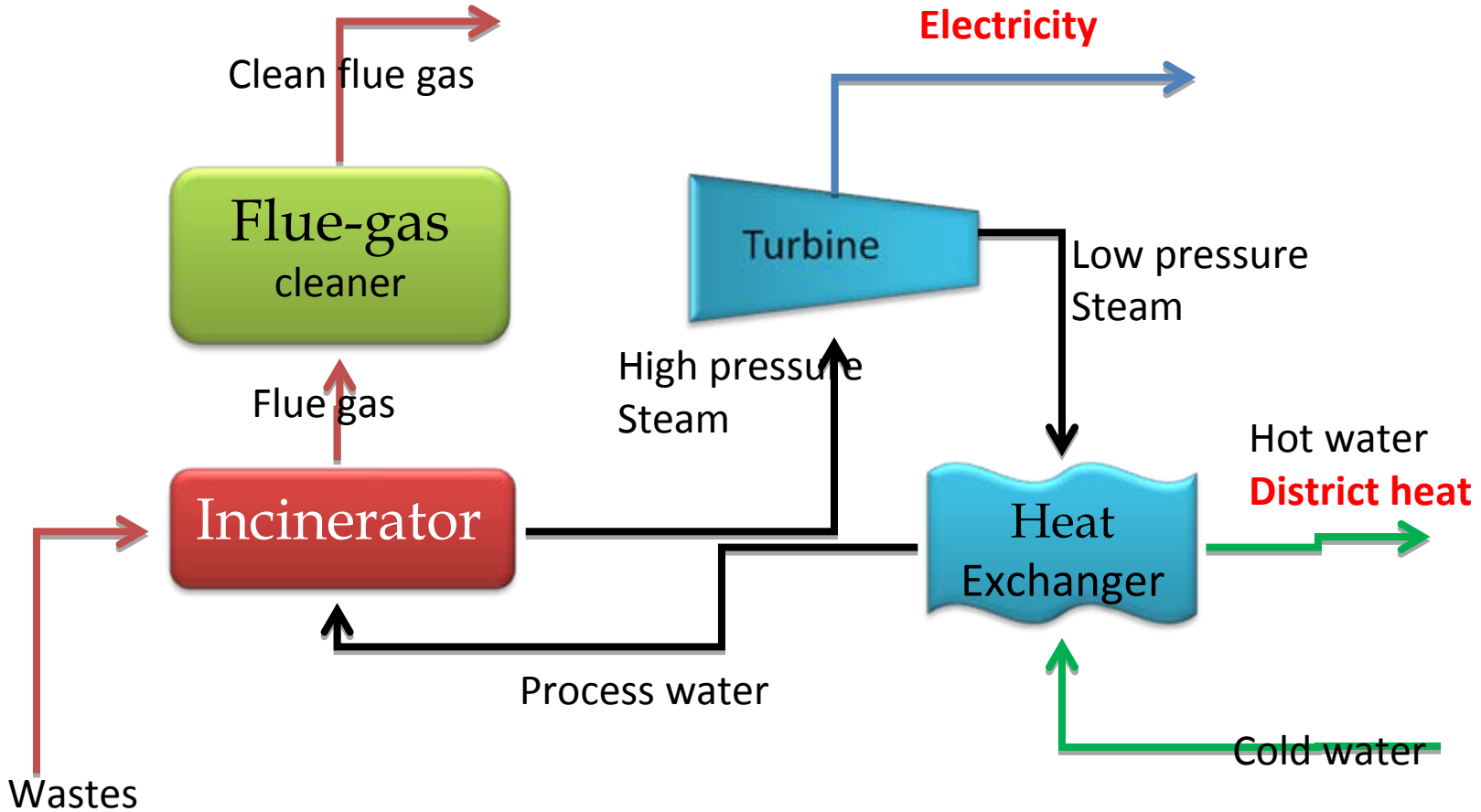
Incineration in Borås: Electricity and District heat!



www.wasterecovery.se,
www.resourcerecovery.se



CHP on Waste Incineration

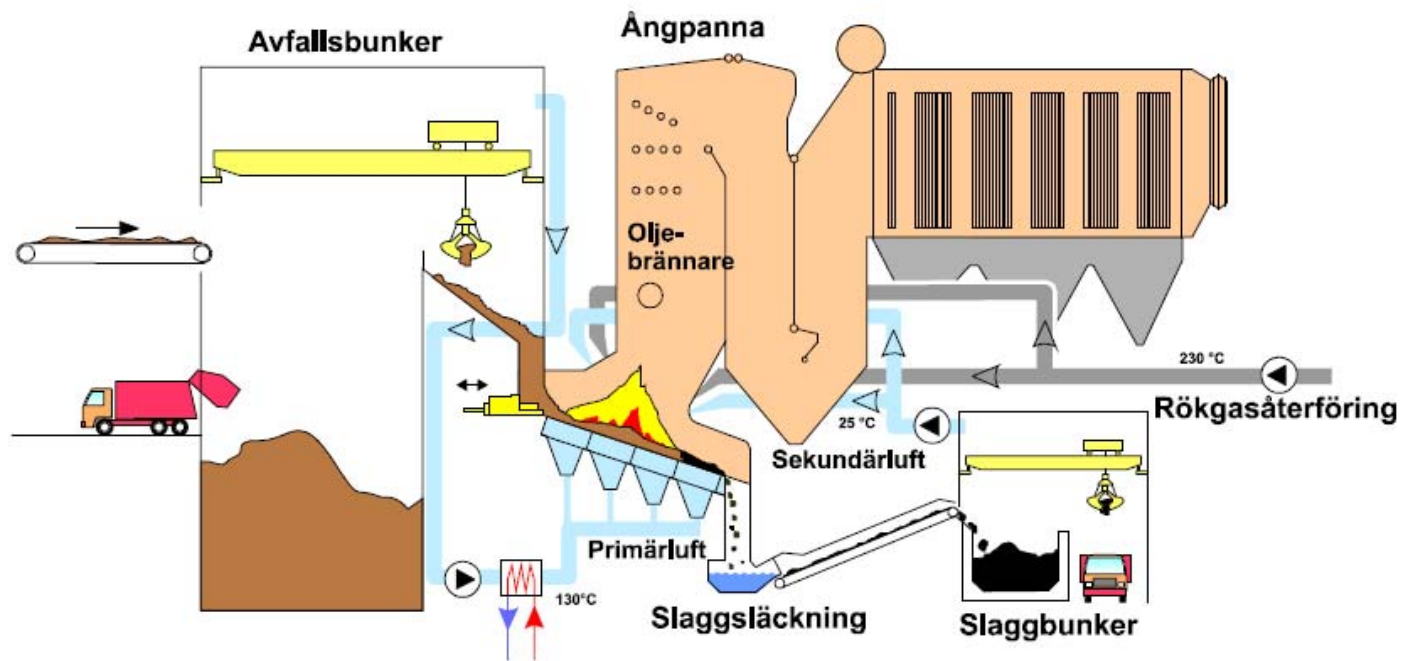


Waste to electricity and heat in Borås

- ❖ 300 tons/day waste materials are burned,
- ❖ 2 Incinerators,
- ❖ 10 MW electricity is produced
- ❖ 40 MW District heat is produced
- ❖ A few MW district chill for hospitals and shopping centers
- ❖ It is located in the center of the city!
- ❖ No harmful gas or smoke!



Incineration in Gothenburg



Waste to electricity and heat in Sävenäs

- ❖ 1240 tons/day waste materials are burned,
- ❖ 4 Incinerators,
- ❖ 26 MW electricity is produced
- ❖ 137 MW District heat is produced
- ❖ No harmful gas or smoke!
- ❖ Efficient water cleaning with a river recipient



Energy from MSW incineration in Europe

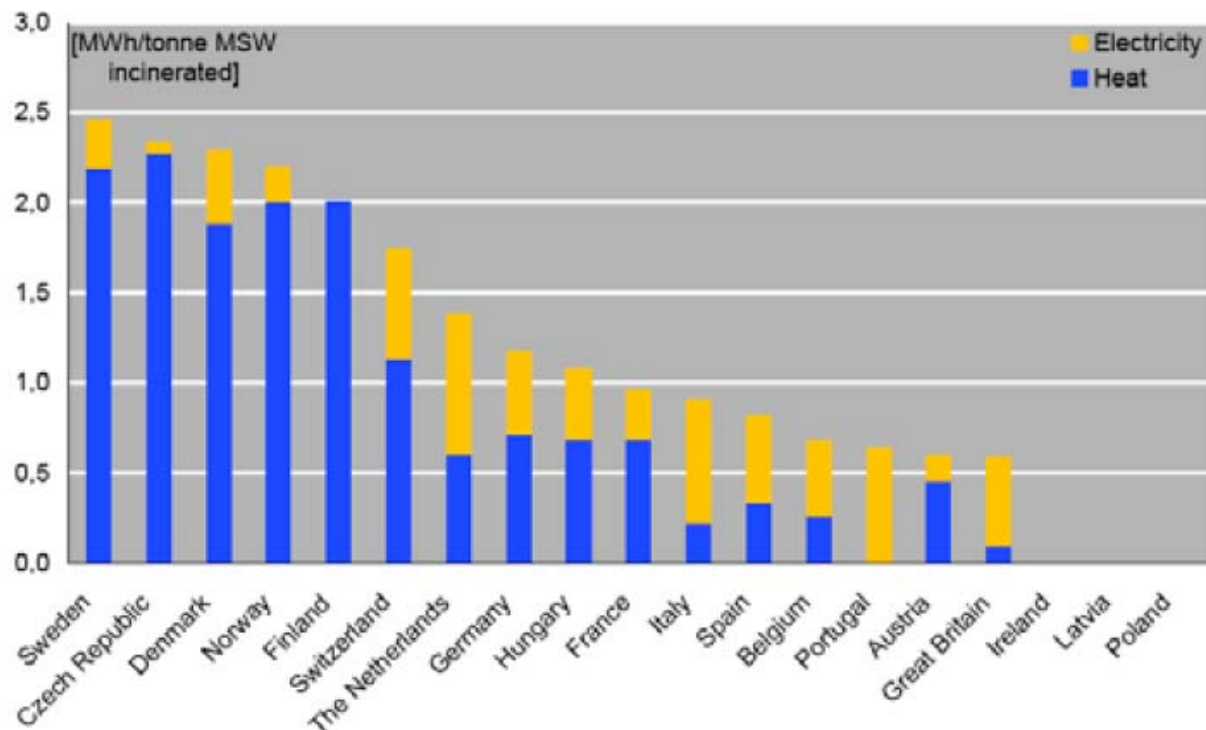


Figure 2.8 Production of electricity and heat per tonne of incinerated MSW in 2005. Source: Euroobserver (2007), data revised by Profu



How to increase utilization without district heating?

- Increase electricity production
 - Higher steam temperature and pressure in the boiler tubes
 - Risk of corrosion
 - Increase in boiler temperature may lead to increased release of inorganic material
 - Gasification followed by combustion
 - Gas engine
 - Gas turbine
 - Fuel cells

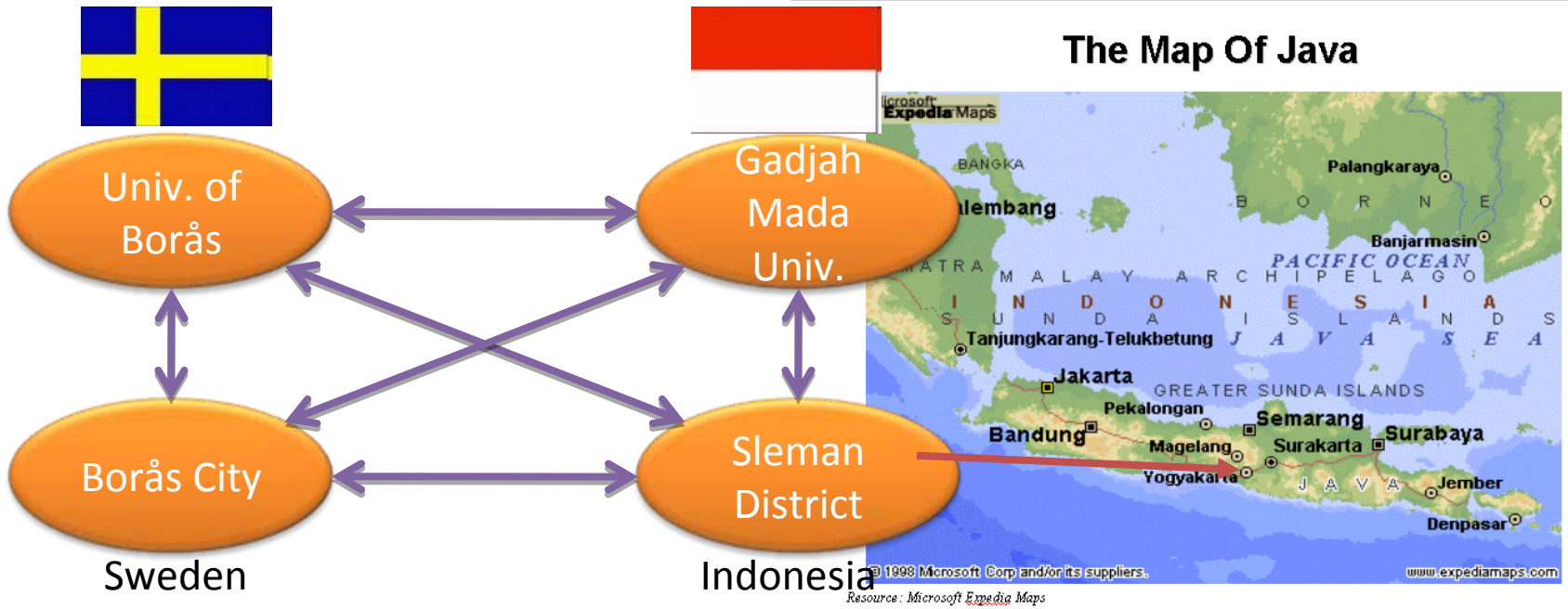


Our experience with Indonesia

www.wasterecovery.se,
www.resourcerecovery.se



Sleman



Goals:

- Culture, technology and regulations for “Waste recycling”
- Making visits, educational collaborations and workshops,
- Production of biogas in Demo size at Sleman District
- Running a couple of buses on the produced biogas!
- Adaptation of the technology to the Indonesian culture!



We started with education and research...

- 2 MSc students (2-years) in Borås
- ~20 MSc students for 6-months project work at:
 - University of Borås
 - Chalmers University
 - SP Research institute
 - Technical service department of the city
- Starting reserach at UGM about digesion
- A Sandwich-PhD student (starting 2010)



Learn from Borås and start research in Indonesia on Biogas



www.wasterecovery.se,
www.resourcerecovery.se



Waste sorting has already started at UGM...



www.wasterecovery.se,
www.resourcerecovery.se



Fruit wastes

Biogas Pilot Plant



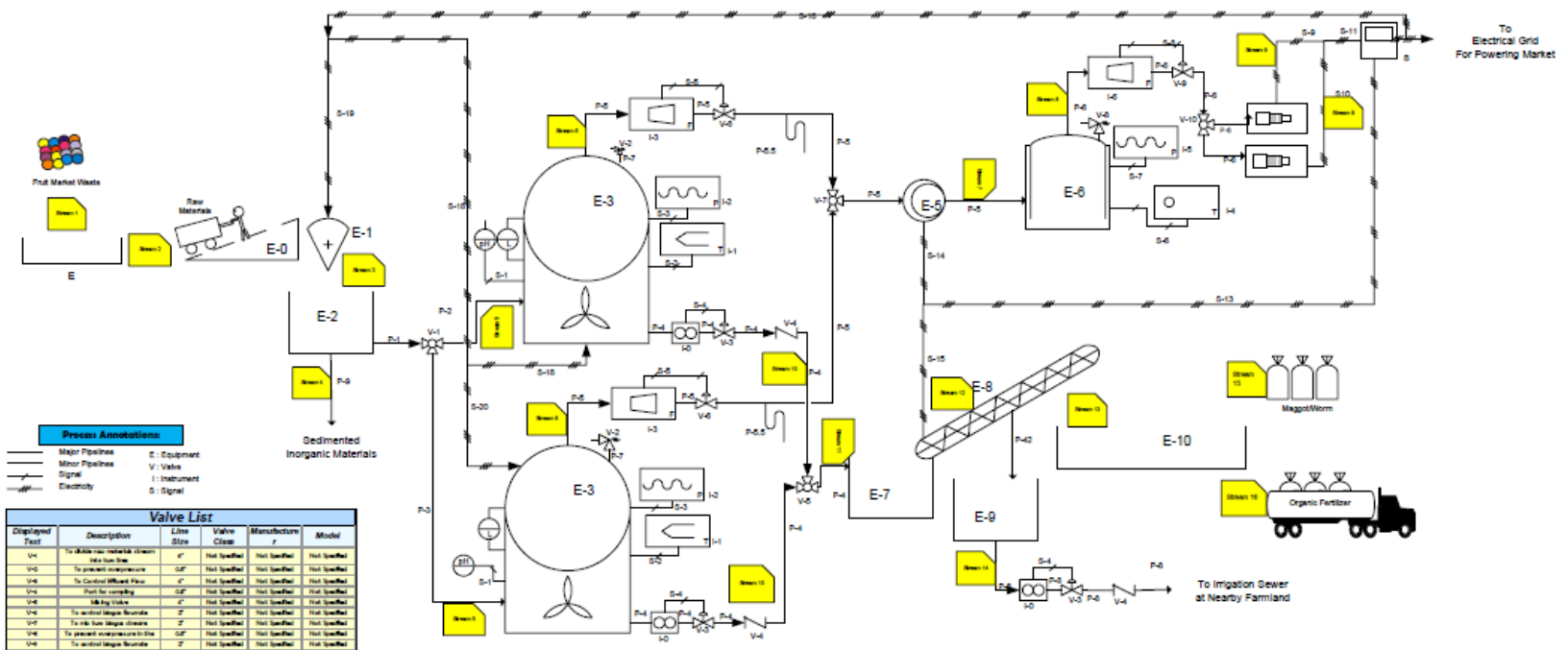
Electricity



Biogas in Fruit Market

PROCESS ENGINEERING FLOW DIAGRAM (PEFD) BIOGAS PLANT

PROCESSING FRUIT MARKET WASTE WITH CAPACITY 4 TONS/DAV IN YOGYAKARTA, INDONESIA



Process Annotations
 --- Major Pipelines
 --- Minor Pipelines
 --- Signal
 --- Electricity
 E: Equipment
 V: Valve
 I: Instrument
 S: Signal

Displayed Text	Description	Line Size	Valve Class	Manufacturer	Model
V-1	To allow raw material stream into line	4"	Not Specified	Not Specified	Not Specified
V-2	To prevent overpressure	0.5"	Not Specified	Not Specified	Not Specified
V-3	To Control Inflow Flow	4"	Not Specified	Not Specified	Not Specified
V-4	Not for complete	0.5"	Not Specified	Not Specified	Not Specified
V-5	Mixing Valve	2"	Not Specified	Not Specified	Not Specified
V-6	To control sewage flowrate	2"	Not Specified	Not Specified	Not Specified
V-7	To allow flow sewage stream	2"	Not Specified	Not Specified	Not Specified
V-8	To prevent overpressure in line	0.5"	Not Specified	Not Specified	Not Specified
V-9	To control sewage flowrate	2"	Not Specified	Not Specified	Not Specified
V-10	To allow sewage into line stream	2"	Not Specified	Not Specified	Not Specified

Displayed Text	Description	Manufacturer	Material	Model
E-0	Interim storage	Not Specified	Concrete	Open Tank
E-1	Heap (PMT) to carry to the material for crushing	Not Specified	Steel	Trough/Heap
E-2	Crusher (To reduce the raw material size)	Not Specified	Steel	Cylindrical Blade Roller
E-3	Mixing Tank (To store crushed raw material, temperature and the powder addition for adjustment)	Not Specified	Concrete	Open Tank
E-4	Digester	HERFOSIP	Hard Stone Digester	Not Specified
E-5	Digester	Not Specified	Hard Stone Digester	Not Specified
E-6	Compressor	Not Specified	Stainless Steel	Not Specified
E-7	Gas holder	Not Specified	Pressure Vessel Tank	Not Specified
E-8	Outlet Tank (To store effluent from digester temporarily)	Not Specified	concrete	Open tank
E-9	Lawsoning Unit	Not Specified	Steel	Screen Pump & Press
E-10	Impaction Valve Tank	Not Specified	Concrete	Open Tank
E-11	Composting Area	Not Specified	PRECAST CONCRETE	Not Specified

Displayed Text	Description	Line Size	Design Pressure	Design Temperature
P-1	Feeding Pipe	6"	1 bar	30 C
P-2	Feeding Pipe	6"	1 bar	30 C
P-3	Feeding Pipe	6"	1 bar	30 C
P-4	Effluent Pipe	4"	3 bar	40 C
P-5	Biogas Pipe	1.5"	2 bar	40 C
P-6	Biogas Pipe	2"	3 bar	40 C
P-7	Rubber Pipe	0.5"	2 bar	40 C
P-8	Impaction Pipe	3"	1 bar	40 C
P-9	Inorganic Material	2"	1 bar	40 C

Substance	Unit	Stream															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Raw material waste	ton/day	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wastewater	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sedimented Inorganic Material	kg/day	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CH ₄	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO ₂	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maggot/Worm	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pathogen	kg/day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		4	4	4,000	1	2	100	100	100	100	1,700	3,000	3,000	700	2,700	0	100

WASTE REFINERY CENTER, FACULTY OF ENGINEERING GADJAH MADA UNIVERSITY

Date: June #2010
 Designed by:

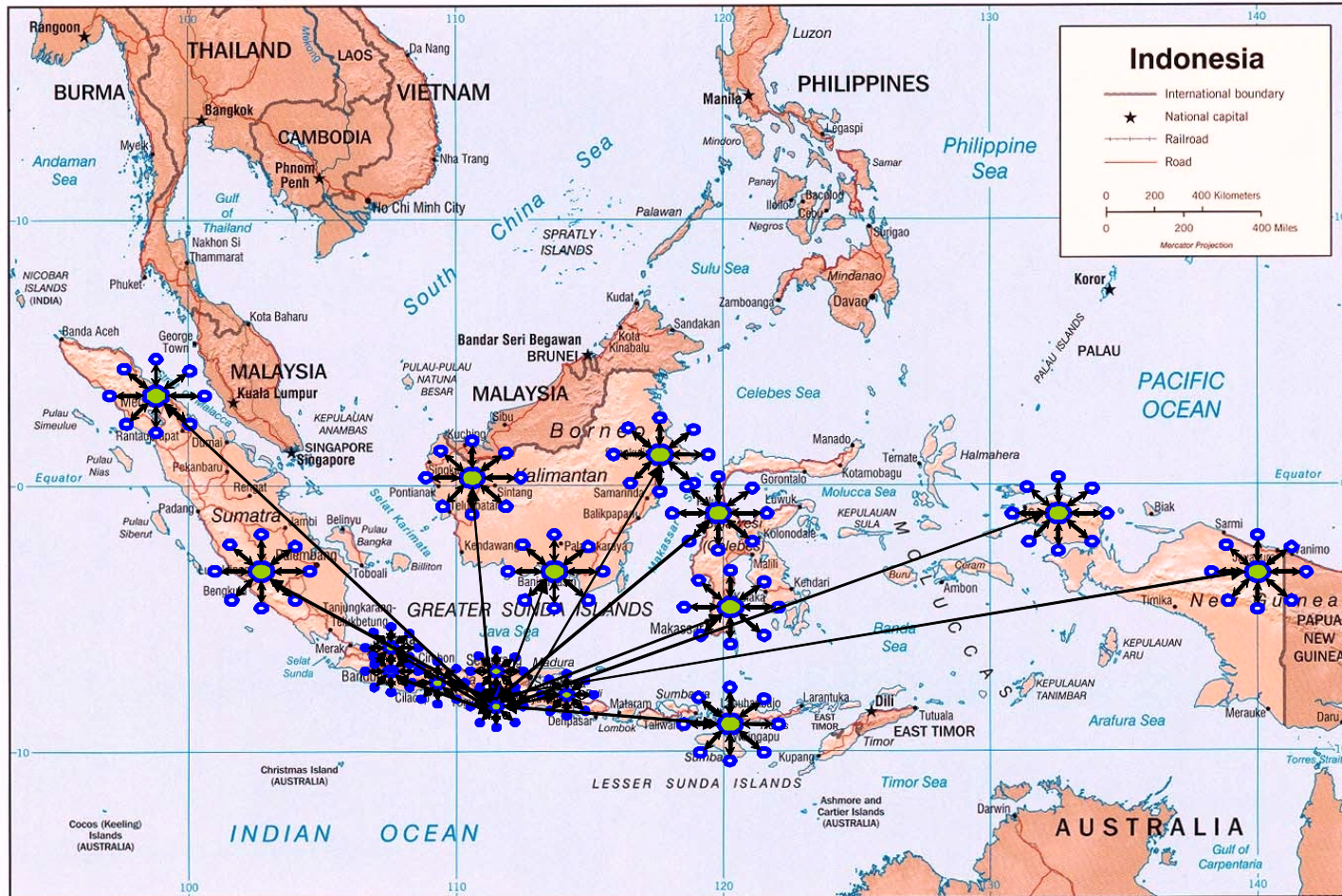
Date: 2010
 Approved by:

Date: 2010
 Approved by:

W. IB Sidiqul M. Pratiwi
 W. IB Sidiqul M. Pratiwi
 W. IB Sidiqul M. Pratiwi



Network "Waste Refinery Indonesia" and in each city e.g. "Waste Refinery Palu"



Base 802899AI (C00429) 11-02

www.wasterecovery.se,
www.resourcerecovery.se

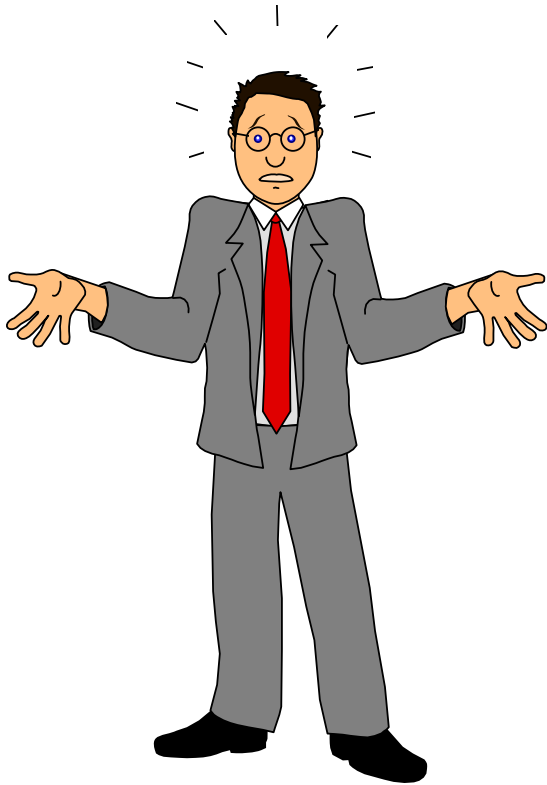


Now we can initiate a similar collaboration with you:

- ❖ Building local network & with Sweden
- ❖ Educational exchange and programs
- ❖ Research
- ❖ Giving vision to the decision-makers
- ❖ Implementation (companies)



Thank you!



Questions?

www.wasterecovery.se,
www.resourcerecovery.se

