
Dr Hans Björk
School of Engineering
Director of Waste Recovery
University of Borås
Sweden
government university
~11,000 students (6000 full time)
~500 employees
~40 full professors
~20 Master programs
~130 PhD students
Borås
105,000 inhabitants
Closing the loops
Landfill reduction in Borås, From 1992 presented at RIO + 20

Today

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

Mohammad.Taherzadeh@hb.se  www.wasterecovery.se
Long development toward zero waste in Borås

- The first planning of biogas plant: 1940
- Investigation and planning: 1986
- Start of source sorting in 3000 households: 1988
- Full scale sorting with optical sorting system: 1991
- Anaerobic digestion and composting: 1995
- Interim storage of hazardous waste: 1998
- First collecting vehicle run with gas: 2002
- Waste plan 2001 - 2010: 2003
- First public gas station opened: 2003
- New digestor ready: 2003
- New incineration plant ready: 2004
- First bus inside the city run on biogas: 2004
- 39 buses inside the city run on biogas: 2008
- A second new gas station for private cars: 2009
- All 59 buses inside the city run on biogas: 2010
- A third new gas station for private cars: 2011
- Planning for a new energy complex: 2011
Waste planning is like doing a puzzle
Municipal waste landfilling in Europe (2010)
Drivers for the waste management in Europe & Sweden

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>Municipal waste treatment plan</td>
</tr>
<tr>
<td>1994</td>
<td>Producer responsibility</td>
</tr>
<tr>
<td>1998</td>
<td>The local investment program (LIP)</td>
</tr>
<tr>
<td>2000</td>
<td>Landfilling tax (~ 27 EUR/tonne)</td>
</tr>
<tr>
<td>2002</td>
<td>Landfill ban on combustible waste</td>
</tr>
<tr>
<td>2005</td>
<td>Landfill ban extended to include all organic waste</td>
</tr>
<tr>
<td>2006</td>
<td>Landfill tax increased for the 3rd time (~ 47 EUR/tonne)</td>
</tr>
<tr>
<td>2006</td>
<td>Incineration tax (~ 8 - 47 EUR/tonne)</td>
</tr>
</tbody>
</table>
- District heating
- District cooling
- Biogas
- Hydropower
- Waste management
- Drinking water production
- Waste water cleaning
- Producer of Electricity
- Services within waste management and effective energy use
SOBACKEN
Waste management plant

- Biological Treatment
- Contaminated Soil
- Landfill
- Combustible Waste
- Leachate water
- Hazardous waste
- Weighing station
Recycling of ~30 fractions
**Waste collecting methods**

Waste from residential and commercial buildings in Borås and surroundings

- Approximately 125,000 inhabitants.
- 4 methods – a complete solution towards our dream

**Total amount 420 kg/person**

48,500 households – Waste separation at home
80 Recycling stations
5 Recycling centers
800 Containers for delivery

[Images of waste collection methods and facilities]

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komposterbart avfall

övrigt avfall
Households In Borås: 
Source-separation in black and white bags

Combustible wastes

Organic wastes (food wastes, etc.)

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Burnable waste becomes district heating and electricity

- Transport to Sobacken
- Waste from households and companies is collected
- District heating and electricity
- Burnable waste is separated
- Preparation of combustible waste
- Transport to Ryaverket
- The waste is stored
- Incineration

Burnable Waste

www.wasterecovery.se
Food waste becomes biogas

Transport to Sobacken

Household and company waste collected

Food waste is separated

Pretreatment of combustable waste

To the digester

Biogas is returned to our customers in Borås

Bacteriums at work

Biodegradable Waste
Separation of organic wastes!
Biogas from waste
### Biogas production

#### Substrate [Ton]

<table>
<thead>
<tr>
<th>Description</th>
<th>Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogradable waste - Black bags (Household Borås)</td>
<td>4 000</td>
</tr>
<tr>
<td>Biogradable waste (Household suburbs)</td>
<td>7 500</td>
</tr>
<tr>
<td>Biogradable waste (Commercial)</td>
<td>2 464</td>
</tr>
<tr>
<td>Biogradable liquid waste (Commercial)</td>
<td>9 719</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23683</strong></td>
</tr>
</tbody>
</table>

#### Gas production [Nm3]

<table>
<thead>
<tr>
<th>Description</th>
<th>Nm3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Gas</td>
<td>2 546 629</td>
</tr>
<tr>
<td>Vehicle fuel</td>
<td>1 123 407 (11,2 GWh)</td>
</tr>
<tr>
<td>Methane gas for heating</td>
<td>308 976 (3,08 GWh)</td>
</tr>
<tr>
<td>Residual product (fertilizer)</td>
<td>1982 Ton</td>
</tr>
</tbody>
</table>

[Amount 2009, metric ton]
Use for the gas

- 12 waste collection cars
- 59 local busses

and a number of office cars uses biomethane as fuel
Preparing wastes for combustion!
RYAVERKET
Heat- and powerplant
Why combustion of Wastes?

• Treatment
  – Volume reduction

• Prevention
  – Decrease green house gas emissions
    • Avoid methane formation
  – Control emissions – leakages

• Production
  – Energy recovery

• MSW can be a raw material and not only waste

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Mix of fuels

- Biofuel: 57%
- Waste: 32%
- Biooil: 2%
- Biofuel: 1%
- Oil/gasoil: 8%
- Electricity: 1%

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What is combustion?

• Chemical reaction with oxygen
• Exothermic = generates heat
• Mainly carbon and hydrogen
  – $C + O_2 \rightarrow CO_2$
  – $2H + \frac{1}{2} O_2 \rightarrow H_2O$
Combustion of Wastes

Tobias.Richards@hb.se

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## Energy and customers

### Energy amounts

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Amount (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District heating</td>
<td>632</td>
</tr>
<tr>
<td>District cooling</td>
<td>10</td>
</tr>
<tr>
<td>Electricity</td>
<td>132</td>
</tr>
</tbody>
</table>

### Number of customers

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>District heating</td>
<td>4137</td>
</tr>
<tr>
<td>District cooling</td>
<td>53</td>
</tr>
</tbody>
</table>

[Amount 2009]
Low Emission

Red CO2
Blue Nox
Green SOx

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Waste collecting methods

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- 4 methods – a complete solution towards our dream

48.500 households
- Waste separation at home

80 Recycling stations

5 Recycling centers

800 Containers for delivery

Total amount 420 kg/person

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Recycling of materials
at recycling stations

Collection of packages and papers

• Paper packages
• Newspaper
• Metal packages
• Hard plastic packages
• Batteries
• Glass (no colour)
• Glass (coloured)
Other wastes at the recycling centers (ex big size)
Recycling Gold
Stena Metall AB
The Group in figures

- Operations at 250 locations in 15 countries
- Net sales 4 billion $US
- Number of employees, 3500

Stena Technoworld, WEEE

Stena Aluminium AB

Stena Recycling, AB, A/S, AS, OY

- 10 car shredders
- NF-plants
- Cable Recycling plants
- Plastics separation plants
- Transformer / Capacitor recycling plant
- Hazardous waste treatment plants
- Paper recycling plants
Driving forces

1. Legislation (Environmental, Tax, Producer responsibility, etc.)

2. Material value
Value of Recycling

**Metals** (energy requirement, compared to virgin production)
- Aluminium (Al) 5%
- Copper (Cu) 20%

**Plastics**
Energy content in plastics about the same as in oil. To replace plastics, energy recovered, 2-9 kg of oil/kg of plastic is needed

Stena recycling avoids emissions corresponding to 8 million ton CO₂
OUR DREAM
A CITY FREE FROM FOSSIL FUELS
The journey to realise our dream
– from infrastructure to the environment

1959. District heating introduced in Borås.
1965. Completion of Ryaverket plant.
1996. Local heating, district cooling and biogas.
2005. Return to waste incineration!
What is our challenges?

- Fossilfree heating
- Fossilfree vehicle fuels
- More renewable electricity
- Save energy!
- Recycle material and energy
- The energy facility of the future.
- Necessary to achieve the vision of a city free of fossil fuels!
Collaboration model of “Waste Recovery - International Partnership”

Waste Recovery in Sweden

City Council
Research Inst.
University
Private Companies
Municipality

Political support
Financial support
Research & Competence development
Education
Vision & Goals
Laws & Legislation
Planning
Projects & implementations

Waste Recovery in other countries

City Council
Research Inst.
University
Private Companies
Municipality
NGOs

Political support
Financial support

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Resource Recovery

two international master programs

<table>
<thead>
<tr>
<th>Program</th>
<th>Prereq</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industrial Biotechnology</strong></td>
<td>BSc in Chemical engineering or chemistry</td>
<td>Industrial application of biotechnology for a sustainable development</td>
</tr>
<tr>
<td><strong>Sustainable Engineering</strong></td>
<td>BSc Engineering or chemistry (chemical, industrial, electrical or civil) course in thermodynamics</td>
<td>Resource management and recovery of energy and material resources</td>
</tr>
</tbody>
</table>
Resource Recovery

PhD-program

A multidisciplinary PhD-program with specialities in:

- Biotechnology
- Polymer technology
- Energy technology
- Simulation technologies
- Social aspects
All competence on waste treatment in one organization: ”Waste Recovery International Parnership”

Plus:
• Biogas System
• F.O.V. Fabrics AB
• KTH Architecture and the Built Environment
• Läckeby Water AB
• Metso Power
• Navet Science Center (for children)
• SAAB AB
• Scandfiltet
• Sweco Architects
• Uponor
• Sakab
• Stena Metal
• VA – Teknik (SP)
• ....

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Waste Recovery in Asia, Africa and America
Pilot plant Biogas Yogyakarta Indonesien

4 ton fruit waste/day
⇒ 550 kWh/day electricity

Reduced amount of greenhouse gases
2716 ton CO₂/year

The total cost for the plant:
340,000 US dollar
Together we can work for a sustainable world

Converting Waste into Value-added Products

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