Integration of energy recovery into solid waste management

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Dr Pat Howes 14th November 2012

Contents

- IEA Task 36
- Global waste to energy trends
- European developments
- New technologies
- Other key issues

IEA Bioenergy Task 36

AEA

Integration of energy into solid waste management
www.ieabioenergytask36.org

Participating countries: France, Germany, Italy, Norway, Sweden and the UK

Aims:

- Share information on developments in energy from waste between participating countries
- Promote market deployment of technologies and systems for sustainable energy generation from waste
- Review impacts of changing policy
- Review environmental impacts of waste management and energy recovery options

What do I mean by 'solid waste'?

- Municipal solid waste plus commercial and industrial wastes
- Municipal and C&I waste processed to refuse derived fuel
- Waste wood is covered in Task 32 (combustion).
- Wet wastes (e.g. food, putrescible waste) is covered in Task 37 (Biogas)

World waste projections

Year	Urban residents	kg MSW/person/day	Total (t/year)
2002	2.9 billion	0.64	0.68 billion
2012	3 billion	1.2	1.3 billion
2025	4.3 billion	1.42	2.2 billion

Source: World Bank What a waste Urban development series March 2012 No 15

Trends:

1. UN and World bank predict rapid urbanisation of developing countries
2. Rural populations produce low waste volumes of high organic and moisture content, low CV. Urban populations produce more waste of higher CV.
3. Pressures on land: land costs are higher in urban areas - increases pressure on landfill costs.
4. Increasing waste triggered by consumer life styles: the higher the income and rate of urbanization, the greater the amounts of waste produced.
5. Local populations in urban area are increasingly concerned about environmental impacts
6. Landfilling and thermal treatment are most common in high income countries
7. Landfill, open dumps common in lower income countries

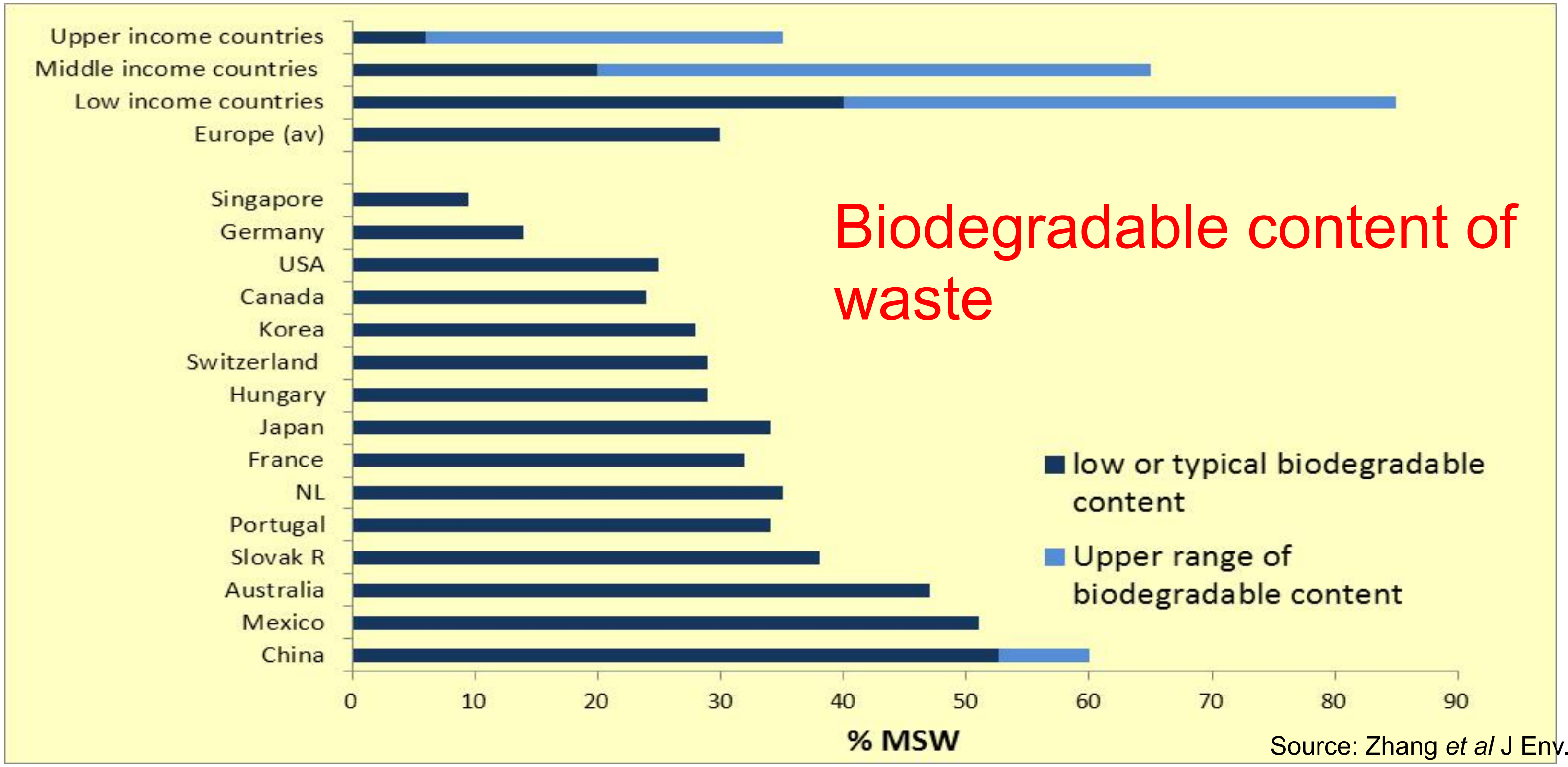
Why do municipalities invest in EfW?

- Reduction in waste mass and volume – can be 80-90% in modern system
- Lower land use than landfill.
- Destruction of organic pollutants that would otherwise be landfilled.
- Concentration of inorganic components into ash.
- Increased use of recyclables (bottom ash can be treated to recover ferrous and non-ferrous metal)
- Reduction in GHG compared to landfill
- Generation of energy (of which some may be classed as renewable energy)

Energy is just one factor in consideration of investment in EfW

Differences in EfW uptake world wide

- Regions with highest level of EfW: Europe, Japan, Singapore
- Regions with significant but low proportion of EfW: North America
- Increasing number of EfW plants: Korea, India, China
- Few/no EfW plants: Australia, Brazil, low income countries.



Source: Zhang *et al* J Env. Manag. 92 1623-1633 2010

EfW – Low income countries

Low income countries:

- Waste has high biodegradable content reflecting high % food waste and high moisture
- Low CV waste, ***not suitable for EfW***
- Low levels of waste per capita (0.3-0.4 kg/d)
- Waste management: LF dominates (in some regions alongside informal disposal open dumps and open burning)
- 1% increase in population = 1.04% increase in solid waste
- Future trends: population increase, urbanisation and increased consumerism
- Over past decade Sub Saharan African Economies have grown ~ 5%/year. The trend across all developing countries is ~6-7%
- Will alter amount and composition of municipal waste in developing countries, stimulating a need to improve management, investment in and treatment of waste.

Sources: World Bank, IMF, UN

Recent trends in emerging economies

India — 55Mt MSW (2012)

- CV 6.8-9.8MJ/kg (but putrescible content remains high)
- Waste production 0.2-0.87t/capita/y (Urban areas ~0.55-0.65)
- Landfill costs increasing (increased costs for land, construction and operation)
- Inadequate funding for treatment and disposal (Uncontrolled dumping &/or burning of waste common)
- Poor history of EfW in past.
  - Waste to energy capacity: low energy generation . Delhi plant: 16MW
  - Several RDF plants in India (50-700t/d, 2 generate 6MW when operating; 2 are co-combustion)

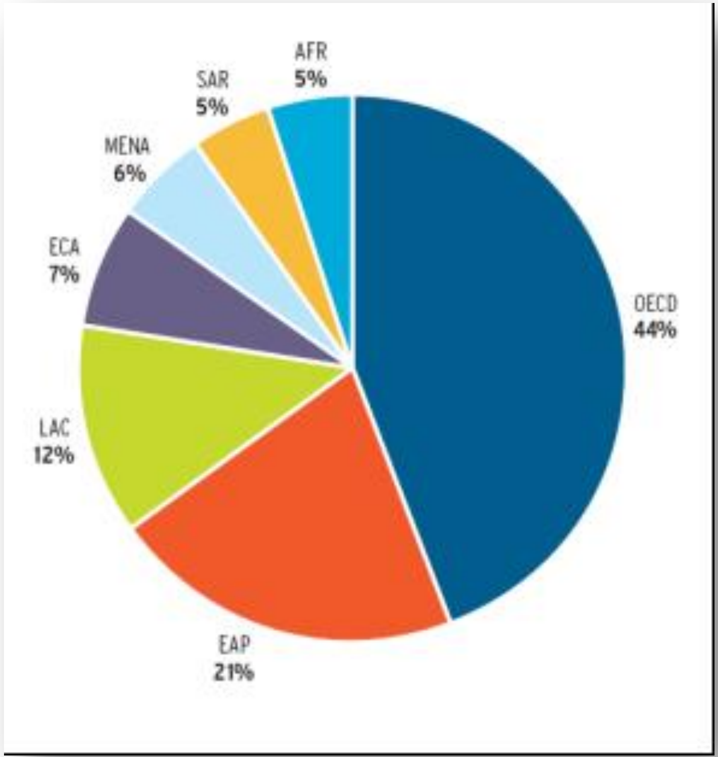
China — 150Mt MSW (2012)

- MSW growth fastest in China and East Asia.
- CV variable (4-11, av 6MJ/kg) – high moisture content, high ash content
- Waste generation: 0.98t/capita/y
- Only 55% is treated, 80% landfilled; 15.2% incinerated (697t/d) (2008).
- LF space scarce in big cities
- Rapid increase in EfW: 74 plants and many in planning 2008. 40,020t/d treated in EfW plants (2005)

Sources: National Solid waste Association India, World Bank, CEWEP, Annepu (2012); Eco Business April 2011,; University of Rostock; UN statistics; Zhang et al (2010), Qiu *et al* (2012), Vehlow et al (2009)

EfW - OECD countries

Waste generation by region

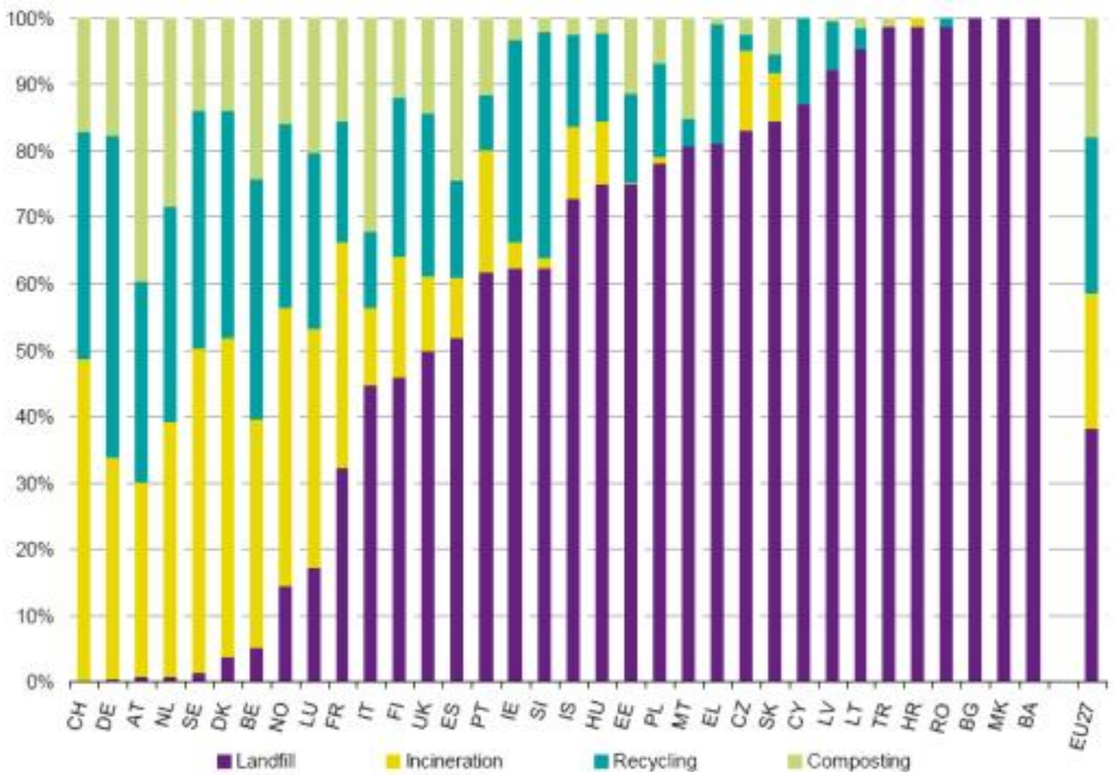


Sources: IEA Task 36, US EPA, EUROSTAT (2011), UN statistics, Australian Bureau of Statistics, Hyder (2009)

- Europe: sophisticated waste regulation
  - Av: 520 kg/capita/year
  - 50.7 Mt (20% MSW) incinerated (2009)
- North America, Australia have high landfill and increasing recycling, low EfW
  - USA(2010)
    - 760kg/capita/y, 250Mt total,
    - 29Mt or 11.7% EfW
  - Canada (2006)
    - 835kg/capita/y, 35Mt total,1.63 (4.6%) EfW
  - Australia:
    - 600kg/capita/y
    - 12.7Mt MSW & C&I waste, 60% to LF, rest recycled
- Japan has high incineration reflecting scarce land resource
  - 54.4 Mt (2003), 74% incinerated

Per capita figures are for MSW only

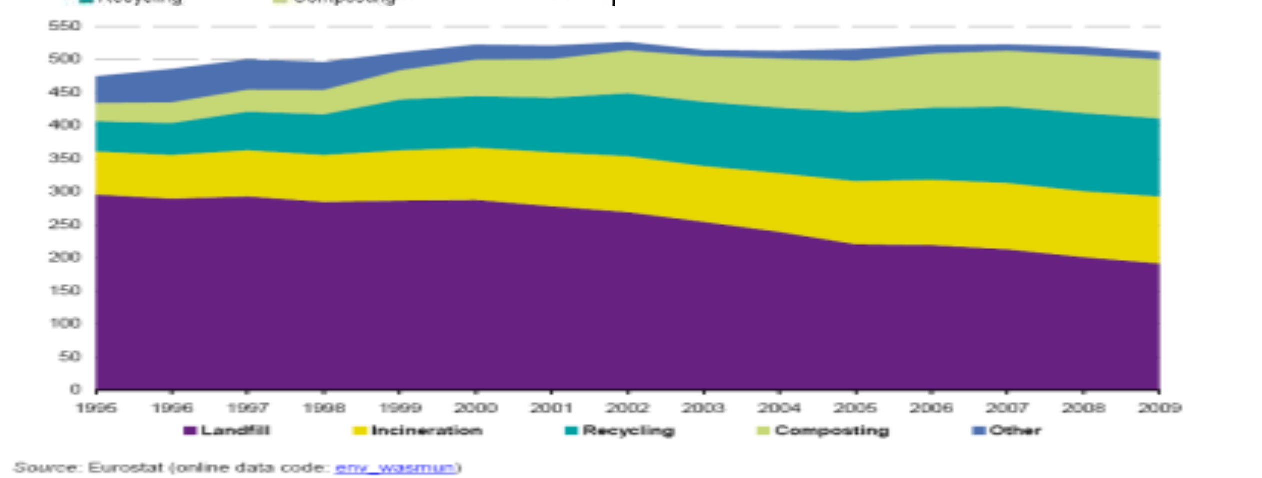
Europe



Europe's waste treatment: 50.7Mt/year to EfW in 2009

EU: MSW net CV:5.1 – 10.9
Biogenic energy: 45-70%

Kg/capita/y



Source: Eurostat

Policy trends globally

- **Pressures for change:** increased population, waste production & environmental impacts from waste disposal.
- **Policy:** adoption of Waste Hierarchy is common theme

Low income countries

- Population increases, waste production increases – recognised need to improve waste management

North America

- Recycling and reduction dominate.

Australia

- Recycling, reduction, zero waste dominate.

Europe

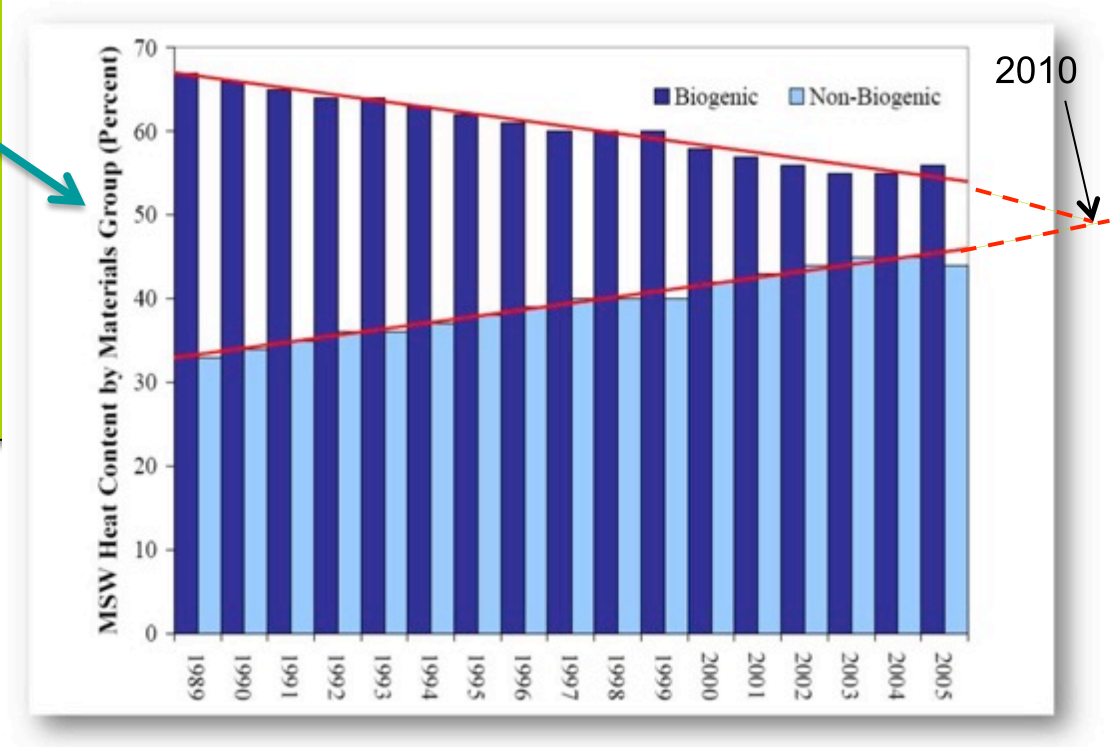
- Landfill diversion, control of biodegradable waste to LF, some countries controlling combustible waste to LF, increased processing and reprocessing of waste
- Trends in processing – MRFs, MBT, AD of food waste
- Trends in EfW – public perception, environmental issues, efficiency improvements, Refuse derived fuel, interest in advanced technologies.

Policies that influence recovery of energy in waste management

- Environmental policies e.g.
  - waste policies (control of landfill, waste hierarchy, waste management, recycling targets, waste prevention targets, food and biodegradable waste targets, end of waste rules);
  - carbon policies (e.g. Trading schemes and carbon caps)
- Energy policies e.g.
  - renewable energy (including higher incentives for some parts of the waste stream e.g. waste wood).
- Economic policies e.g.
  - taxes on raw material use, on energy, on waste disposal (landfill tax, increased gate fees).

Renewable content of solid waste

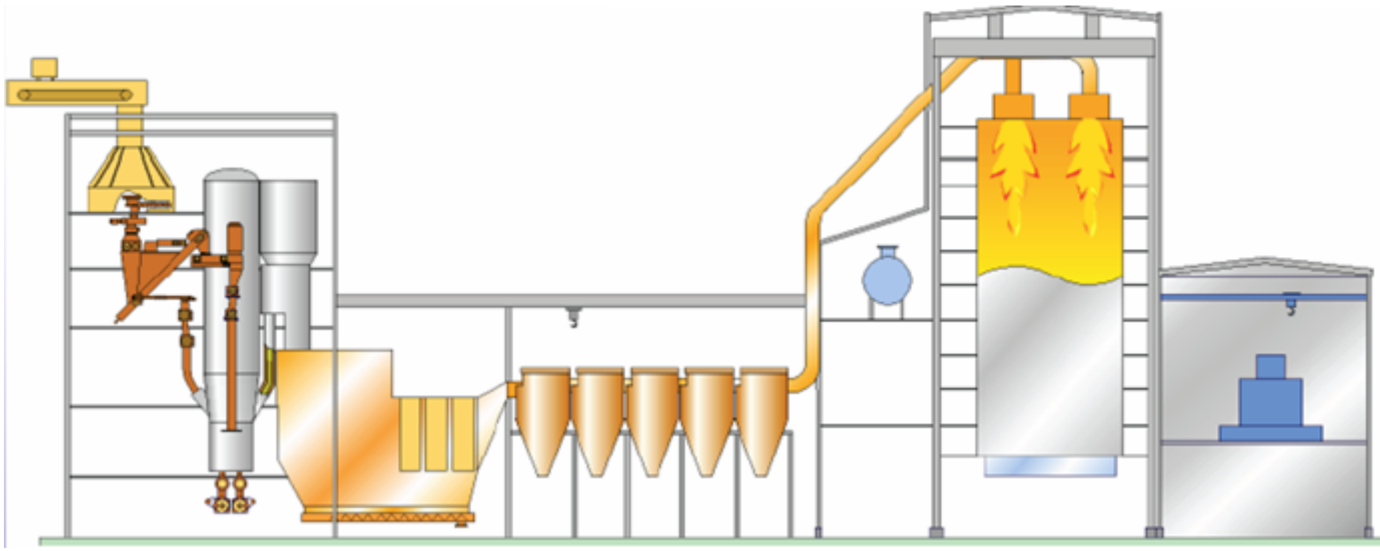
- In Europe renewable or biomass content of waste determines carbon savings from energy and incentives for renewable energy
- **Europe:** Estimated 30 - 50% of power generated by waste combustion is from biomass fraction of waste.
- **2010: 118-138Mt biomass in waste in the EU** (changing with time).
- **US** waste has similar biogenic content
- Changes with time due to reduction, recycling & changes in packaging.



Sources: Renewable waste barometer 2010;
Energy Information Administration (2007) & (2012)

Other trends in EfW

- Interest in advanced conversion technologies
- Other issues



Lahti 160 MW fuel stand alone gasification plant

Advanced Technologies

Increased interest in gasification:

- Box on left shows headlines from Waste Management World 2012
- Recent call for demonstration Facility by ETI (UK) (0.5-2MWe demonstrator leading to 5-20 MWe plant. Must be operationally robust >80% availability)

"The ETI believes that Integrated Gasification of Waste with Gas Clean-Up and the subsequent combustion of the cleaned gas in a gas reciprocating engine or gas turbine offer the best way forward, in terms of improved flexibility and higher recovery efficiencies"

- *Canadian Firm Acquires W2E's Waste Gasification Technology IP*
- *Gasification to Generate Power from Various Wastes in BC*
- *$40 Million Waste to Energy Gasification Contract for Dallas Firm*
- *U.S. Air Force Awards Plasma Gasification Contract*
- *50 MW Plasma Gasification Facility to Treat Waste in Tees Valley*
- *Proposed Plasma Gasification & Waste Incineration Facility in Perth*
- *12 MW Plasma Gasification Facility Completed in France*

Gasification

Source: IEA, Lamers, ETI

Why the interest and why now?

1. Economic performance: Claimed to be better than combustion. Claims are:
   - Higher conversion efficiency
   - Lower temperature (reduces alkali volatilisation, fouling etc.)
   - Lower use of air= lower emissions and lower emissions abatement costs
   - Flexible use of syngas
   - Modular plants
2. Environmental performance: Claimed to be gasification's greatest strength. Claims are:
   - CO_2 friendly; reducing atmosphere reduces emissions of dioxins & furans; lower NOx
   - Is better performance due to lower volumes of air?
3. Size
   - 120 kt/y - makes it easier for connection to heat load.

All of the above are of interest to decision makers faced with environmental, carbon and land pressures

Gasification: Evidence required

1. Operational experience: need unbiased, bankable data
   - Difficult to get a complete mass and energy balance. Need to demonstrate that these are better than conventional EfW
   - Need proven operational performance over long time period.
2. Heterogeneous nature of waste
   - Need information on feedstock preparation
3. Is there a need to develop chemicals as well as fuel?
4. Performance
   - Complex and susceptible to interaction of parameters during the combustion process, so performance is not controlled by one parameter but a number.
5. Is improved environmental performance dependent on design? If so, which types of gasification system give best performance?
6. Syngas cleaning is costly. What is the energy requirement for this?

Indicates that we still need good quality evidence of performance.

Other important EfW Issues

1. Air pollution – providing evidence to reassure public remains important.
2. Ash disposal
3. Changes in composition due to waste management practices and policy targets – important issue for operating and proposed plants
4. Costs – larger plants give economies of scale: but high level of investment needed and paybacks over many years (decades) makes political decision difficult. Important for low income countries.
5. Total capacity of EfW in some countries exceeds demand (e.g. Germany and Sweden) – has impact on neighbouring countries.
6. Need for smaller scale plants – particularly in rural areas.
7. Increase in RDF/SRF production – impact on conventional EfW
8. Tailored solution for local needs – assessment not just on economics, but on technology maturity & sustainability
9. Improvements in energy efficiency – need for heat loads.
10. Public perception of EfW - core issue worldwide
11. Low income countries – need to improve waste management practices

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