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ClimaEast

Support to Climate Change Mitigation and Adaptation in Russia and ENP East countries

Optimising biofuels/biomass use in the energy mix for various end use purposes – EU examples

Pat Howes

7th April 2017

Introduction to Ricardo Energy & Environment

Pat Howes

- 30 years experience in biomass and waste to energy:
  - Technical support to public and private sector
  - Studies on biomass resources, combustion, advanced conversion, anaerobic digestion and associated infrastructure
  - International biomass networks on anaerobic digestion, energy from waste and biomass support; work on the environmental impact of biomass

Energy and resource efficiency teams

- International climate change & energy policy
- Renewables in UK and Europe
- Waste management, UK and international including Russia and Eastern Europe
- Combined heat and power
- Energy & Carbon management
- Economics & modelling

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Biomass for energy

- What is biomass?
- Options for bioenergy
- Waste for energy
- Agricultural biomass
- Wood for energy

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What is biomass?

- Renewable Energy Directive definition of biomass

‘biomass’ means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetable and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste

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Before we start: 6 important rules

1. **Biomass is heterogeneous.**
   - Each type of biomass has different chemical and biological properties that make a difference to how you convert it to energy, how you handle, store and transport it and what residues are left. **Best feedstocks for energy are homogenous**. **The cheapest are often heterogeneous**.
2. **Biomass is flexible: it can be stored and used when and where necessary.**
   - The best use of biomass involves an understanding of **what you want and why**.
3. **Biomass always belongs to somebody** (even if it is a waste).
4. **You will need help.**
   - To turn biomass into energy you need **multiple skills** to produce the biomass, build the infrastructure to use it and convert it to energy. One person does not have all of these skills.
5. **Biomass is commercial now**
   - A good place to start is going to see what other people have done: this will show what is possible.
   - No EU country has introduced biomass or energy from waste without some form of incentive.
6. **Biomass is part of a whole production cycle**
   - fitting bioenergy into higher value production cycles (e.g. food or wood processing) increases financial return, energy efficiency, the value of the original biomass resource and optimises carbon savings.

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Wood

- Forestry sources (brash, thinnings, unmerchantable wood)
- Wood processing residues
- Waste wood re-processing

Purpose grown sources

- Annual energy crops – maize, sugar beet, wheat, silage
- Perennial energy crops – energy grasses, short rotation coppice (SRC)
- Plantations – short rotation forestry

Agricultural residues

- Dry residues – straw, stover, cobs, chicken litter
- Wet residues – manures
- Food & drink processing residues (e.g. whey, DDGS, kernels, pips, expeller, meal, stones, peelings)

Wastes

- Residual municipal waste and processed waste
- Food waste
- Landfill gas

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Biomass

PRICE of Feedstock

Wood

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Wastes

- Residual municipal waste and processed waste
- Food waste
- Landfill gas

Clean

Dirty

Processing and O&M costs

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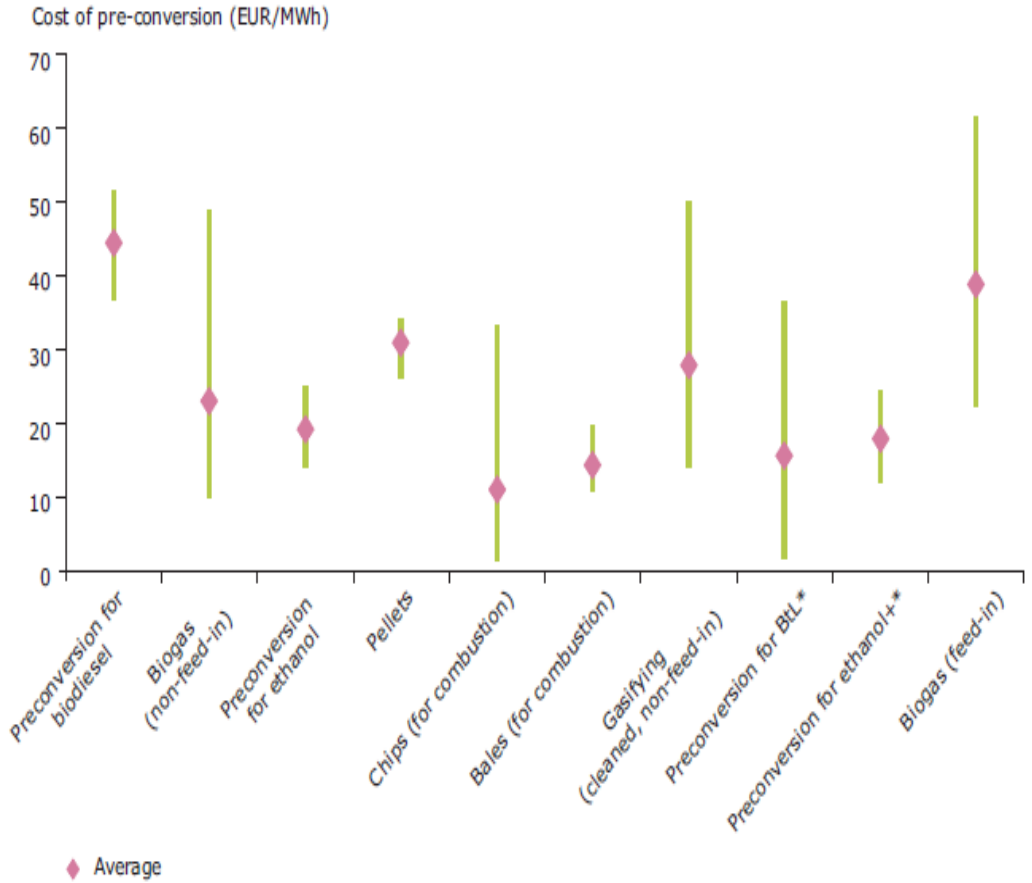
Cost of pre-processing feedstock for bioenergy

- Doesn't include waste
- Costs are for EU
- Shows that some pre-processing costs are significant, particularly for biogas and some biofuels



Note: * BtL and ethanol data are for 2020, the remaining costs are estimated for 2010.

Source: EEA (2008) – maximising the environmental benefits of Europe's bioenergy potential

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Biomass

Options for decarbonisation using biomass in Belarus

PRICE

Wood	• Forestry sources (brash, thinnings, unmerchantable wood) • Wood processing residues • Waste wood re-processing
Agricultural residues	• Dry residues – straw, stover, cobs, chicken litter • Wet residues – manures • Food & drink processing residues (e.g. whey, DDGS, kernels, pips, expeller, meal, stones, peelings)
Wastes	• Municipal waste and processed waste • Food waste • Landfill gas
Purpose grown sources	• Annual energy crops – maize, sugar beet, wheat, silage • Perennial energy crops – energy grasses, short rotation coppice (SRC) • Plantations – short rotation forestry

Clean

Dirty

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End uses

Options for decarbonisation using biomass in Belarus

Biogas & syngas

- Landfill Gas: CO_2, CH_4 +others
- Biogas (and biomethane) CO_2, CH_4
- Syngas – CO, H_2, CH_4, CO_2

Combustion to electricity

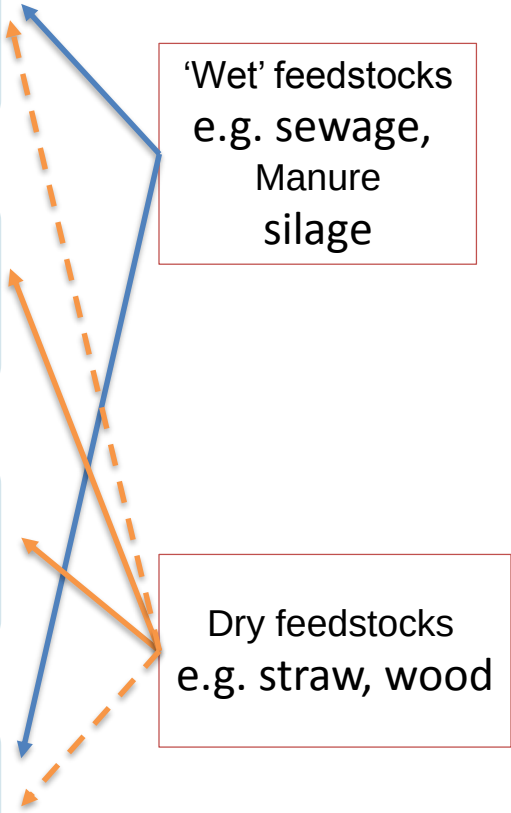
- Co-fire with coal
- Stand-alone biomass only plant

Combustion to Heat

- Combined Heat and Power
- District Heating
- Small commercial
- Domestic

Biofuel

- Biodiesel
- Bioethanol
- Methanol, biobutanol etc



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End uses

Options for decarbonisation using biomass in Belarus

		Options for Belarus
Biogas & syngas	• Landfill Gas: CO_2, CH_4 +others • Biogas (and biomethane) CO_2, CH_4 • Syngas – CO, H_2, CH_4, CO_2	√√ (√)
Combustion to electricity	• Co-fire with coal • Stand-alone biomass only plant	√
Combustion to Heat	• Combined Heat and Power • District Heating • Small commercial • Domestic	√√√
Biofuel	• Biodiesel • Bioethanol • Methanol, biobutanol etc	√

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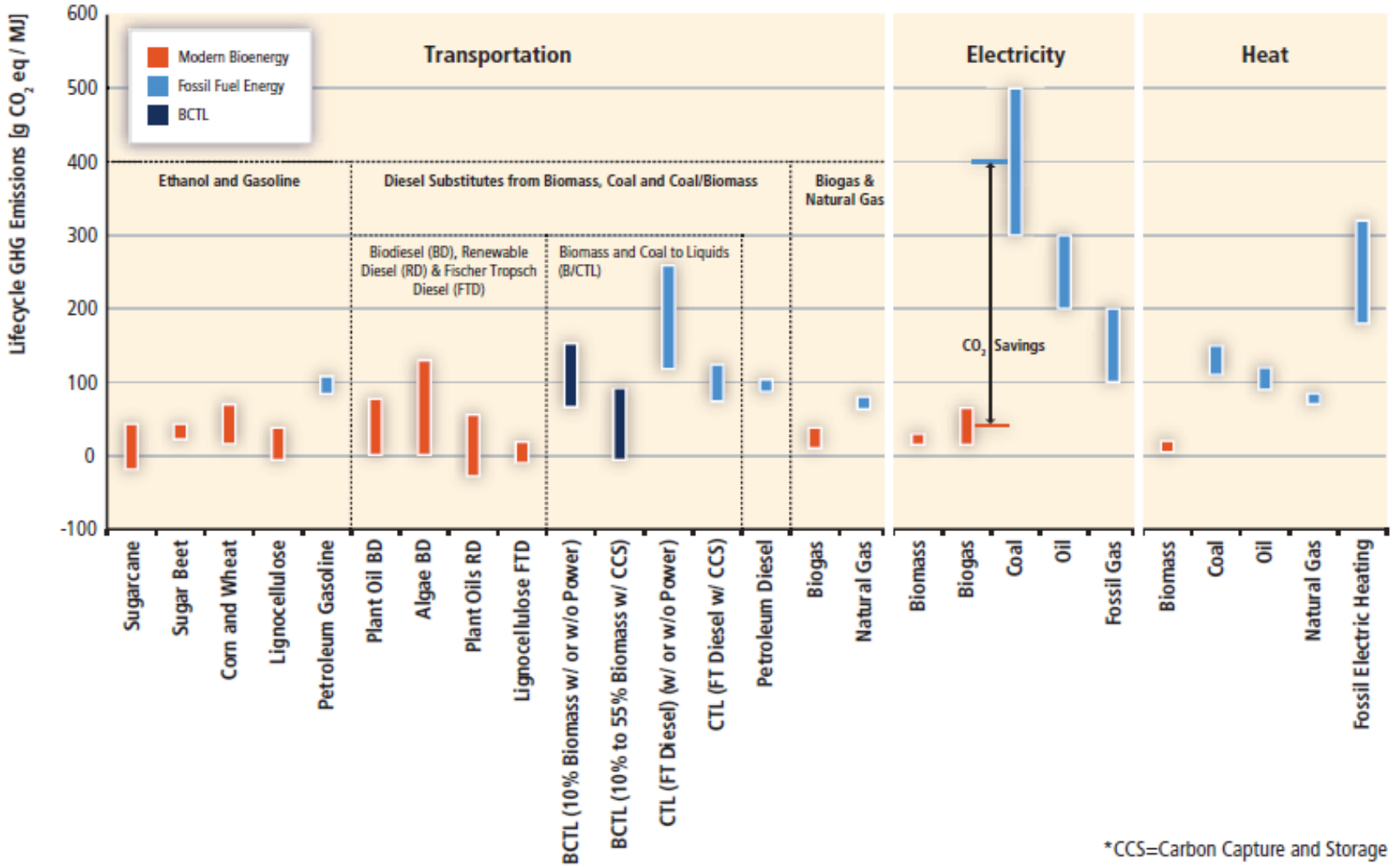
Can bioenergy reduce carbon emissions?



*CCS=Carbon Capture and Storage

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Before you start: Fuel properties

- Before you start you need to know your fuel:
  - Calorific values of typical solid biomass and wastes vary from 8 – 20MJ/t dry matter
  - Moisture content – affects CV and efficiency of conversion
  - Density – affects storage and transport costs
  - Particle size – impacts fuel processing and feed systems
  - Ash content (e.g. alkali metals, silica) – impacts efficiency of conversion, corrosion, slagging, fouling and operation and maintenance costs – and residue disposal costs
  - Metals – multiple effects, including ash treatment and disposal costs
  - Fines – affects combustion and ash disposal costs
- Heterogeneous fuels (e.g. waste) require more processing and appropriate conversion systems
- All of the above can have impacts on carbon emission savings

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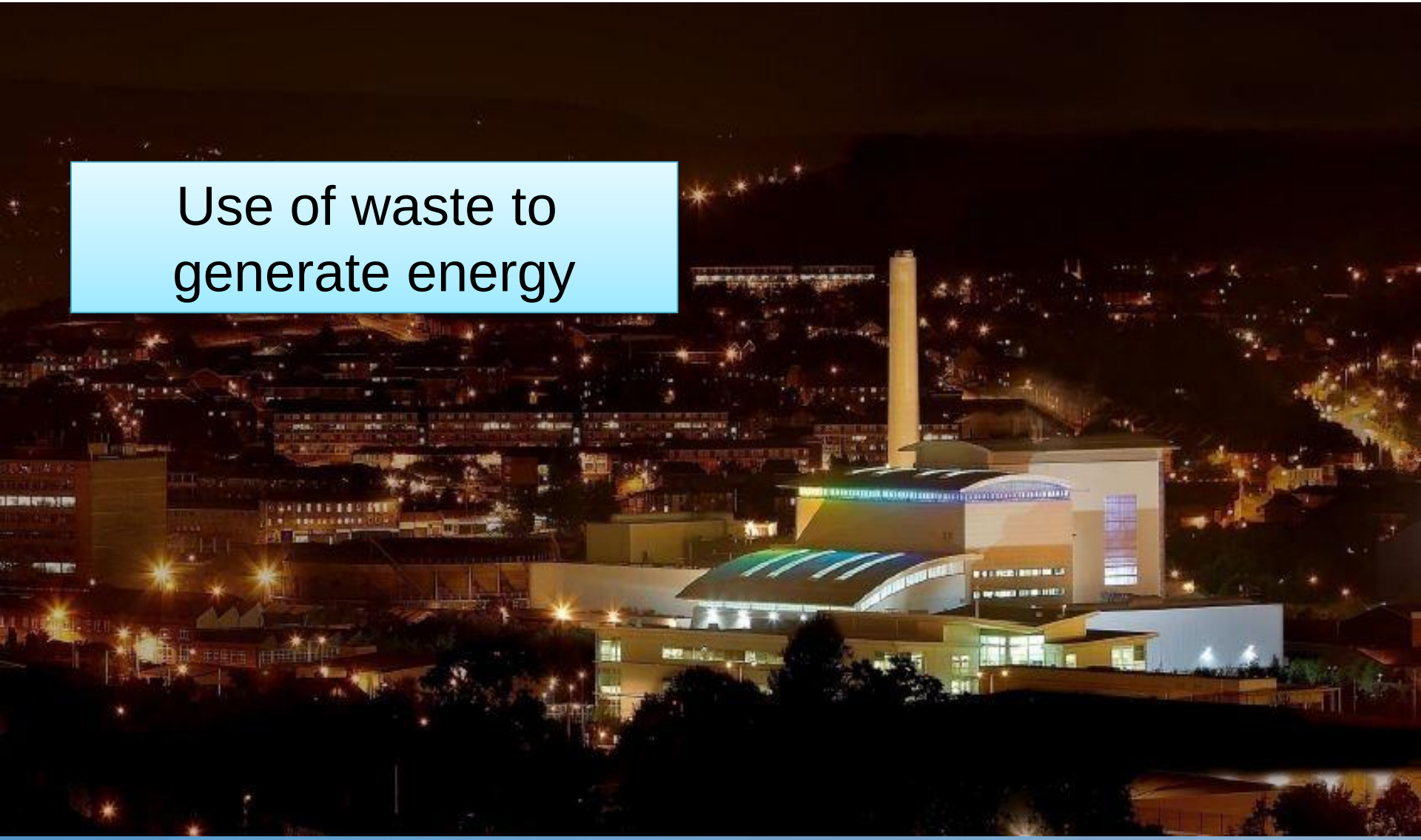
Waste



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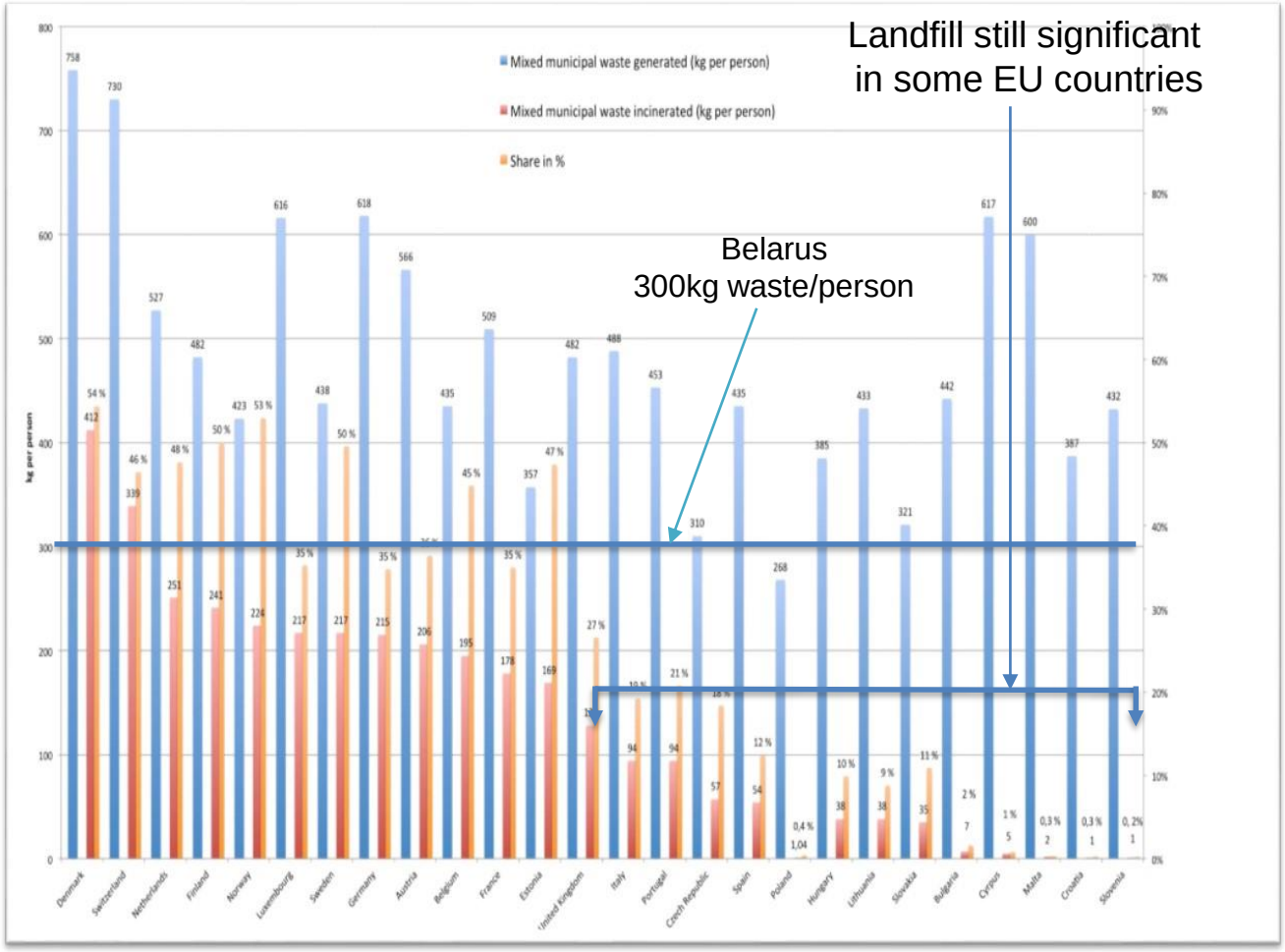
Belarus and waste decarbonisation options

- Belarus produces ~3Mt of household waste
- Most of this is produced in your towns and cities
- 90% is landfilled

- Waste production and management in Europe is shown on right



Source: Wilts H. et al (2017) Assessment of waste incineration capacity and waste shipments in Europe for EEA.
http://forum.eionet.europa.eu/nrc-scp-waste/library/waste-incineration/etc-wmge-paper-waste-incineration-capacity-and-waste-shipments

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How does Europe generate energy from waste?

- Landfill gas
  - the land fill site must be constructed to high standards for the landfill gas to be efficiently captured.
- Energy from waste
  - combustion of residual waste after recycling on a grate system or in a fluidised bed boiler.
- Anaerobic digestion of biodegradable wastes
  - mainly food waste separated at source
- Use of contaminated post consumer wastes in energy e.g. use of waste wood for heat and/or power.
- Production of fuels from waste – refuse derived fuel or solid recovered fuel

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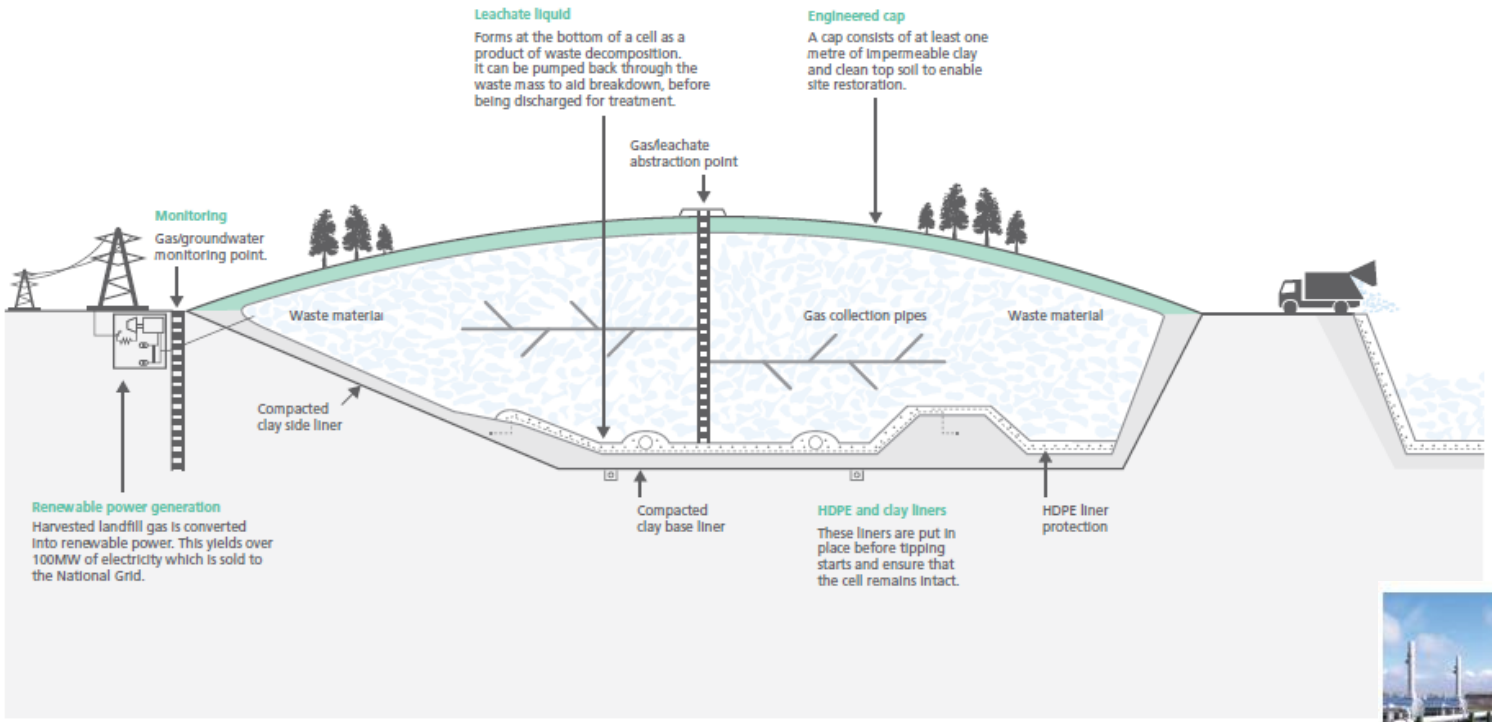
Landfill gas use – European best practice



- Modern landfill sites should be lined to prevent leachate polluting ground water and to allow landfill gas collection
- Waste deposited in cells that are compacted and then capped when full allows landfill gas to be captured effectively and enables reclamation of site.
- Landfill gas engines are typically in modules of 1 MWe
- Landfill gas often only used for electricity due to remote location of site
- A first step in improving waste management is to introduce recycling

Schematics and photos courtesy Viridor

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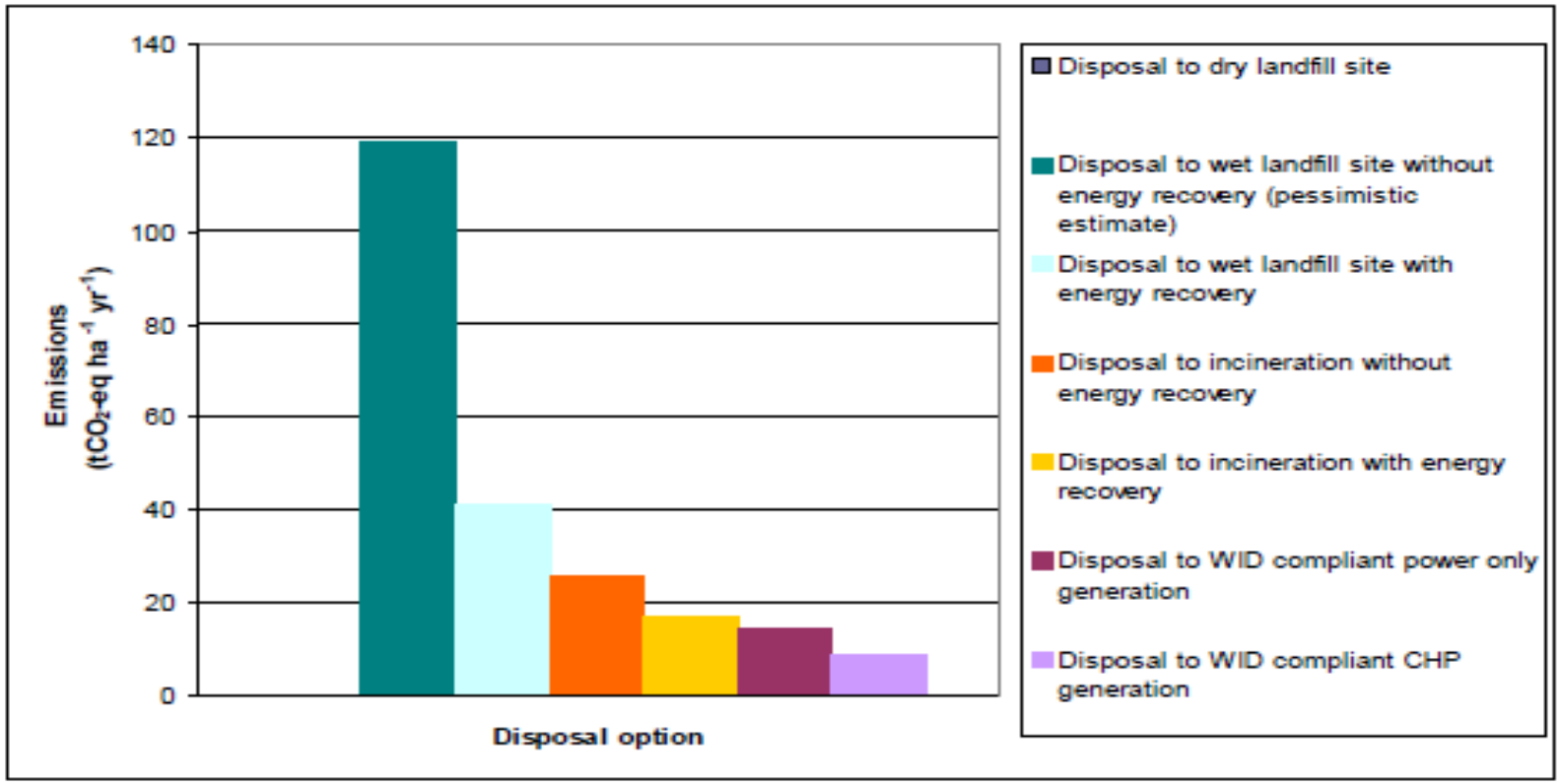
Carbon emissions from waste disposal



- Graph shows carbon emissions from different waste disposal options for end of life wood products (i.e. waste wood)
- Landfill emissions are very different depending on whether or not landfill gas is used
- Using the same waste in an energy from waste plant with good emissions control is the best option (in terms of carbon).

Source: Matthews et al Carbon impacts of using biomass in bioenergy. DECC 242/08/2011

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Introduction to waste hierarchy

Household waste recycling centres

Bulk collection of waste

Collection of household source separated waste

Separation of waste at municipal sites

- To decrease waste production and improve environmental impact of waste management the EU introduced the waste hierarchy:
  - Reduce waste, reuse waste, recycle waste before treating and disposing of waste
- To stop disposing of waste many countries introduced landfill taxes and banned recyclable waste and combustible waste from landfill.
- This makes recycling and treatment cost effective.
- For larger towns where there is a good energy demand it makes energy from waste economically attractive as part of the waste management system.
- Most successful energy from waste plants are integrated into local heat use and local recycling.

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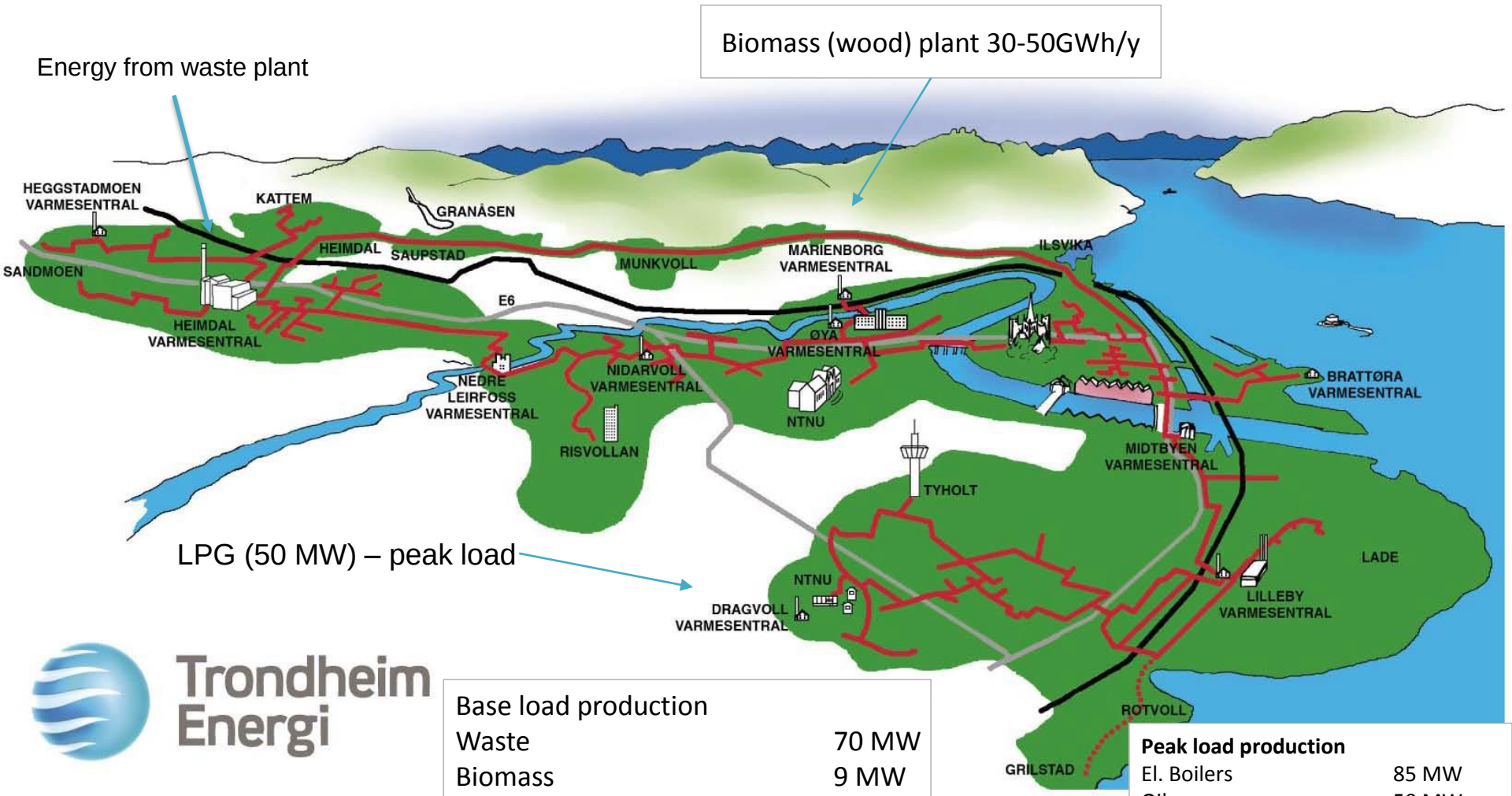
Trondheim District heating system



Trondheim Energi

Base load production	
Waste	70 MW
Biomass	9 MW
Landfill gas/biogas	3 MW
Heat pump	1 MW
Sum	83 MW

Peak load production	
El. Boilers	85 MW
Oil	50 MW
Natural gas (LNG)	30 MW
Propane gas (LPG)	50 MW
Sum	215 MW

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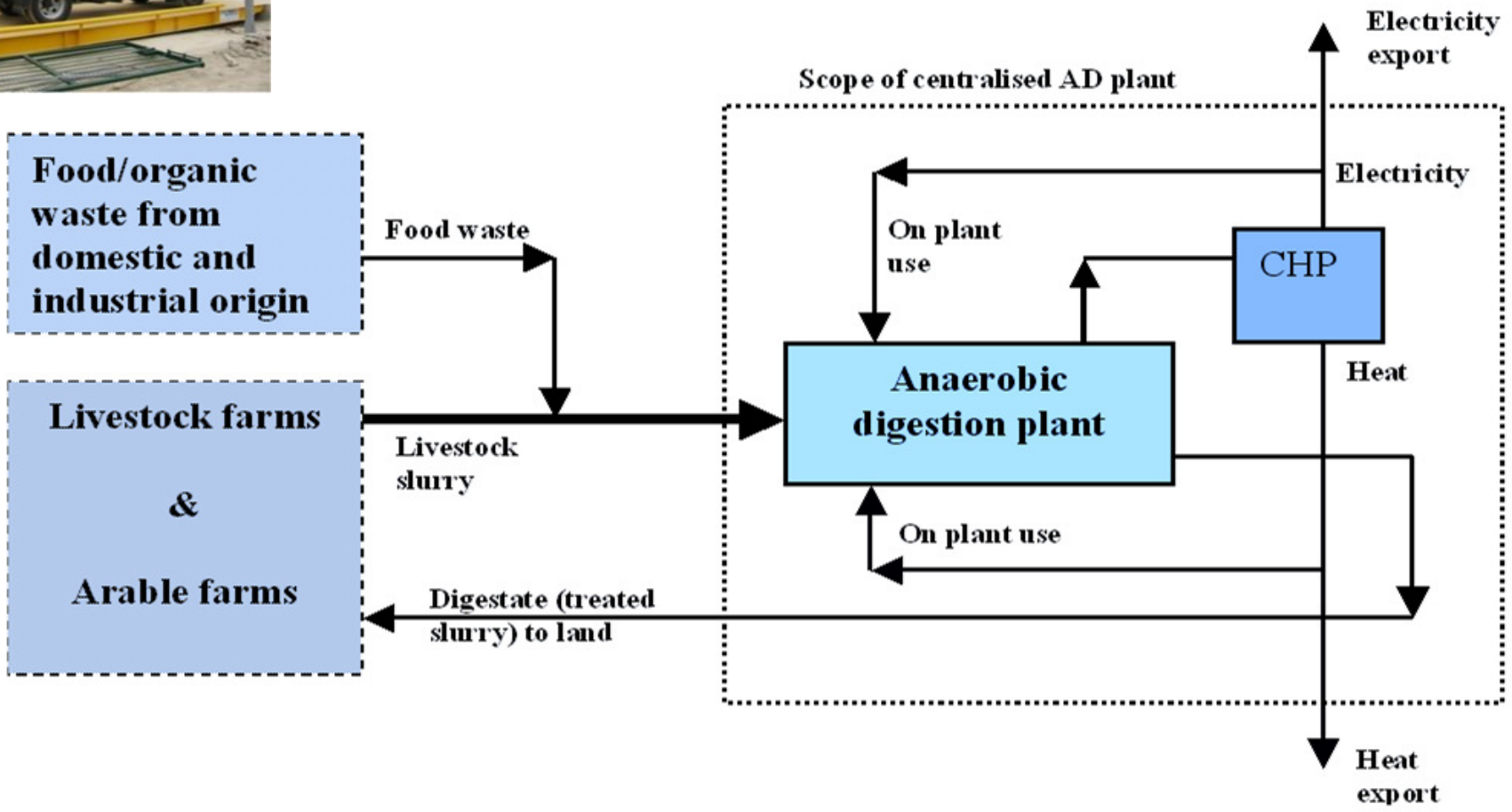
Waste: Anaerobic digestion

Organic waste, such as food waste and some garden waste can be anaerobically digested to produce biogas



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Anaerobic digestion of organic waste

- >240 biogas plants in Europe (8 million tonnes/y in 17 countries)
- Typical size 8000 – 60,000t/y.
- Germany Spain NL France, Italy, UK, Sweden and Switzerland – major countries; Poland, Austria, Denmark - fewer plants
- Best to source separate waste
  - Waste that is mechanically sorted is likely to produce poor quality digestate that cannot be used as a soil conditioner (see right, compared to digestate below)

Digestate from a European waste anaerobic digestion plant – not source separation. Note that the plastic bags are still part of the digestate

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Waste options: summary

- Landfill gas is cheap, but associated with high environmental impacts and leakages mean carbon impacts are high
- Energy from waste is more energy and carbon efficient and enables improvements in waste management, but it should be introduced as part of a whole waste management system designed to decrease waste production and increase recycling.
- Energy from waste has expensive emissions clean up and results in fly ash that must be disposed of
- Food waste digestion works where there is a large population willing to separate its food waste. The waste can be digested with other biodegradable biomass. The gas can be used for heat, electricity and upgraded for use in transport.
- Digestion also results in a digestate that can be used as a fertiliser or soil conditioner providing the original source separation is done properly
- Waste wood can be easily recycled to produce high quality recycled wood for panel board manufacture and low quality wood chip that can be used in energy from waste.

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Agricultural biomass

Miscanthus grown by New Energy Farms, UK

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Dry agricultural residues

Examples: straw, stover, maize cobs, chicken litter

Advantages

- Versatile fuel:
  - Can be densified and transported (pelletisation)
  - Co-fire with coal
- Good experience of using as a fuel, particularly in Denmark and UK
- Conversion technologies for heat and electricity are proven and commercially available

Disadvantages

- Widely dispersed, bulky, expensive to transport
- Storage issues – can deteriorate (e.g. straw can rot in wet weather)
- Competing markets – for feed
- Issues with slagging, fouling and corrosion so specially designed plant are needed

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Straw boilers

- Belarus has experience of straw boilers - in plant on right 1 tonne of straw replaces 550 kg of coal or 350 cubic metres of natural gas
- Boilers of 500 kW to 15,000 kw area available commercially
- Denmark and UK have considerable experience
- Logistics of harvest over (up to) 60 days and use over 365 days per year need to be considered
- Consider handling issues: - mechanism to introduce straw to boiler should be part of the straw plant package.

4 ECONOMY

The Minsk Times Thursday, July 18, 2013

Straw bio-fuel in use

Agro-town in Kletsk District heated by straw harvest for two years

Agro-town of Zaostrovechie, in Kletsk District, using straw eco-fuel

By Nina Stasova

Straw is very useful, being suitable as litter and livestock food, as fertiliser and as a building material, besides making hats and baskets

expensive, so it made sense to build a new boiler-house.

One hundred stacks for warm winter

The experimental boiler-house

while that from the new one is almost invisible."

In fact, one tonne of straw replaces 550kg of coal or 350 cubic metres of natural gas. The boiler-house produces nearly 3,600 giga-

Happy journey on Lida bus!

'Neman' bus soon to join fleet, made in Lida

Late last year, Lida presented a new, compact bus produced using some components made by well-known European companies: Deutz, Raba and ZF. Its latest model, the 'Neman' bus, uses a Euro-4 class engine, made in Germany, as well as domestic components, explains Andrei Myakish, the Deputy Director of JSC Lida. He tells us, "The new bus is designed for intercity routes, with an attractive design inside and out, conforming to world standards."

He notes that Lida does not have an overstocked warehouse, having more orders than its production capacity can cope with. "As soon as a bus rolls off the production line, there is a client to buy it. In the near future, the factory plans to produce ten buses a month. About 60 - 70 percent of our vehicles are currently sold on the home market, while the rest go to Russia and Ukraine. Co-operation with Kazakhstan is also being considered, as they are keen to enjoy our high-tech goods."

Wet agricultural residues – Biogas production

Advantages

- Good experience of using as a fuel – lots of experience across Europe
- Conversion technologies for heat and electricity are proven and commercially available
- Good way to treat manure and the liquid can be used as a fertiliser
- Gas can be converted to heat or electricity or injected directly into the grid (bio-methane)

Disadvantages

- Relatively expensive – for most of Europe digestion of farm waste has to be supported through feed in tariffs or capital grants
- High moisture content in fresh wood
- Poor yield on manure only plants – co-digestion can increase yield considerably

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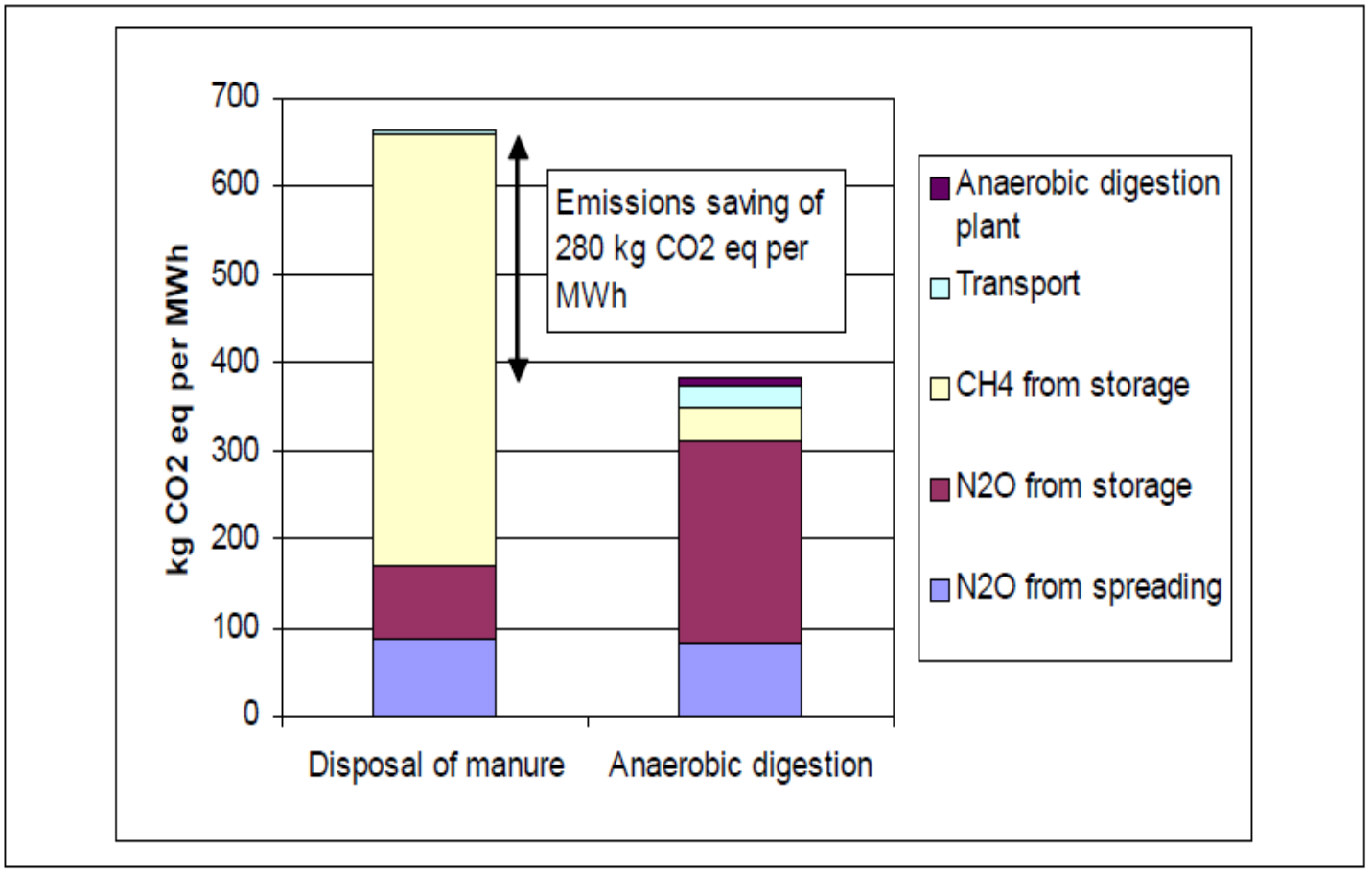
GHG emissions from dairy manure and AD of diary manure to generate electricity (UK)



Source: Environment Agency: minimising greenhouse gas emissions from biomass energy generation

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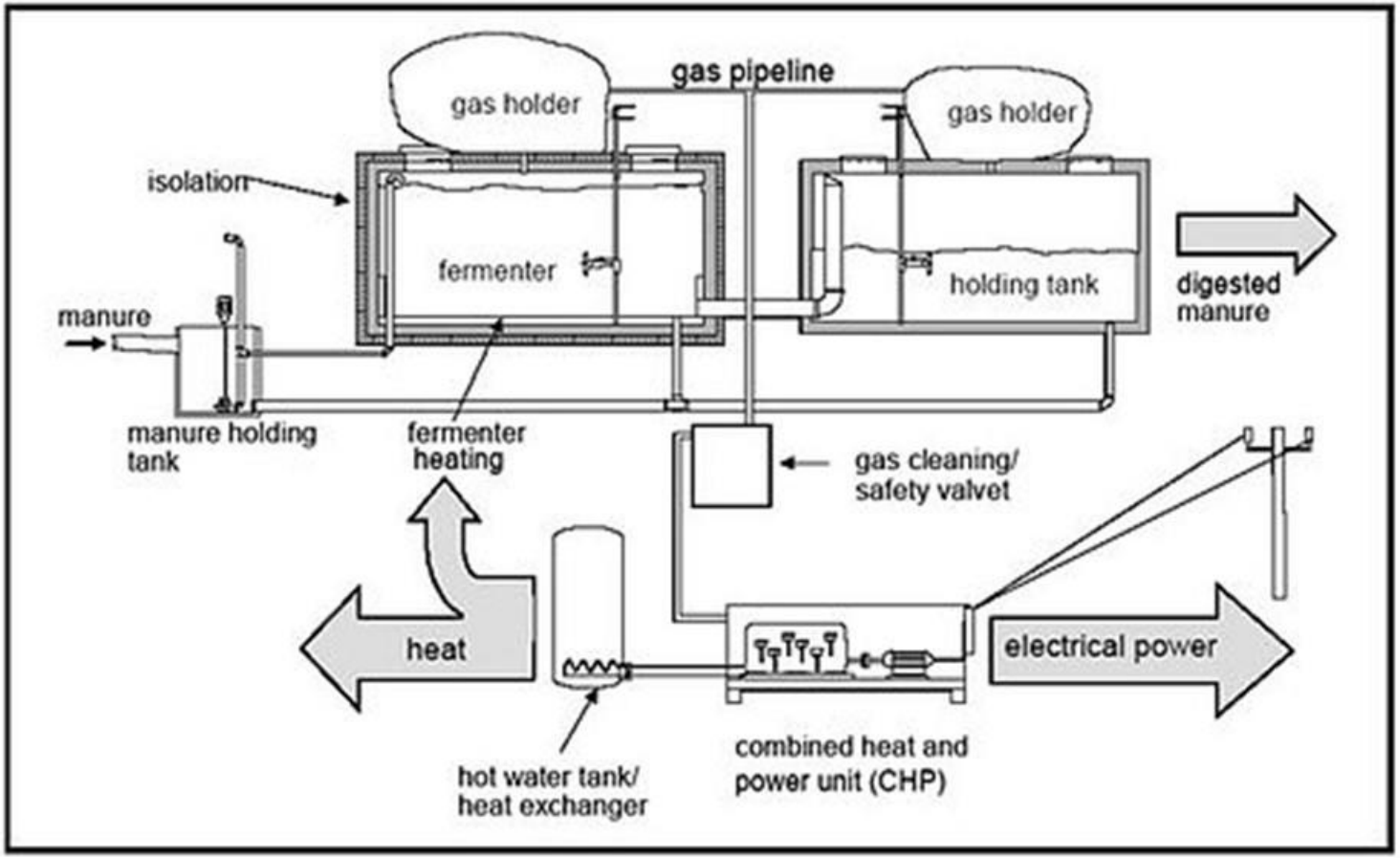
Agricultural digester design



Courtesy German biogas Association

Farm scale Anaerobic digester in NL

- Feedstock:
  - manure from: chicken, cattle, pig and rabbit manure + mink waste + whey + sugar beet tails
- Income from manure, but other feedstock are paid for
- 2.4MW combined heat and power, 5000 tonne manure/year
- Cost: 5 million Euros

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Anaerobic digestion at Olesno, Poland

- Combined heat and power – 1 MW electricity and 1 MW heat
- Manure and agricultural residues (4000 t manure)
- 500 MWh of energy sold to local grid
- 300,000 cubic m in first 6 months of operation
- Cost: 4 million Euro

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Wood

Advantages

- Versatile fuel:
  - Co-fire with coal
  - Can be densified and transported over large distances (50-60km by HGV)
- Good calorific value
- Good experience of using wood as a fuel
- Conversion technologies for heat and electricity are proven and commercially available
- Generally clean but there may be issues with some wood sources in Belarus

Disadvantages

- Relatively expensive fuel
- Competing markets e.g. panel board for small round wood
- High moisture content
- Carbon savings are dependent on harvesting methods – very dependent on what would happen to wood in absence of bioenergy

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Kozjanski Park Slovenia

- Biomass from the regional park used for local district heating
- 1500 cu m of biomass used to generate 900 MWh/y
- Supported by EU Intelligent Energy Europe programme

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Conclusion

- First know your biomass – its properties, who owns and what competing uses there are
- Get agreement from all stakeholders about your bioenergy plans: what, why and where? If necessary initiate a local strategy clearly setting out what you want to achieve
- Visit similar communities, businesses, farms etc. that are already doing what you want to do
- Seek help – there are plenty of organisations that provide advice at EU, international and national levels - there are many case studies and best practice examples on the internet
- Set out business plan so you know your costs, incomes and sources of finance
- Recognise your strengths and weaknesses – know when to seek help
- Do your due diligence – make sure your plant supplier will support you if you have problems
- Work with similar like minded organisations locally to pool resources and costs (particularly for operation and maintenance)
- ALWAYS aim to save carbon!

This project is funded by the European Union

How to contact ClimaEast

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