Commercial experience in using the Economizer pre-treatment

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Future Biogas

- First Plants built near Norwich and Operational in 2011and then 2012.
- First Plants had CHPs only (1.5 kWh and 2.56 kWh).
- In 2013, First Plant to inject biomethane into the National Grid network (2.3 kWh; 500 kWh + 400 m^3CH^4/h).
- In 2014 – 3 new Plants.
- In 2015 – 3 new Plants, one of which 4.4 kWh; CHP only.
- In 2016 - Last Plant built.
- 11 built and currently 9 operational Plants.
- Generate 12 MWh (285 MW/d) and inject 2500 m^3CH_4/h (60,000 m^3CH_4/d) into National Grid
- 98 employees

Feedstock

- Source of energy to be transformed into methane: Feedstock.

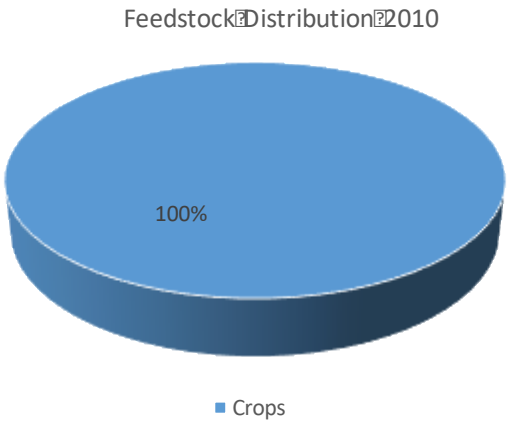
- In 2010:
  - Monodigestion of maize due to its high methane yields.
  - 630 ha harvested.
  - 9,800 t of maize harvested.

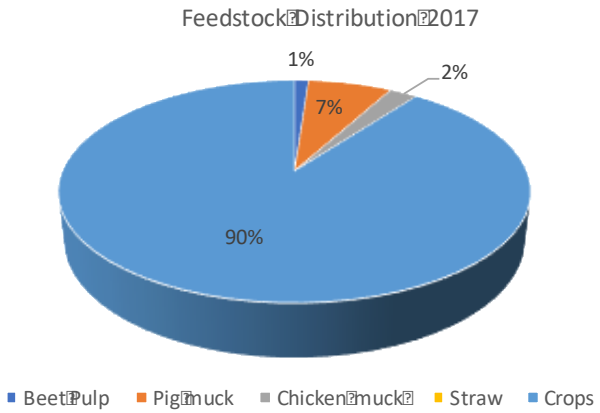
- Later years, trend of diversification:
  - High price of maize (~ £40/t). All crop fed biogas plants have reasonably high feedstock costs. Feedstock is the plants' largest OPEX position.
  - Reduce the risks of poor crop due to weather.
  - Better crop rotation.
  - Reduce harvest length and spread the harvest throughout the year (better harvest management).
  - Optimization of feedstock quality: harvested at optimum harvesting stage, improved ensiling process.

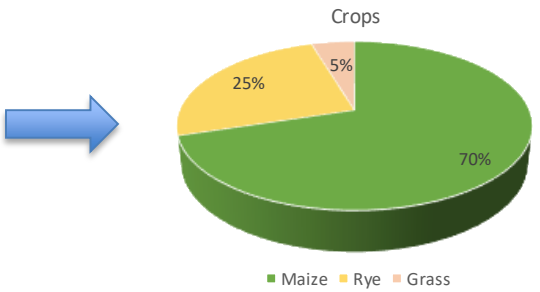
- In 2017:
  - Currently mainly Energy crops (maize, rye, grass), beet pulp, animal manure, recently straw.
  - 10,650 ha.
  - 310,000 t crops, 5,000 t beet pulp, 30,000 t pig muck, 10,000 t chicken muck.

Feedstock

- Future Biogas feedstock profile: change through time.







Feedstock

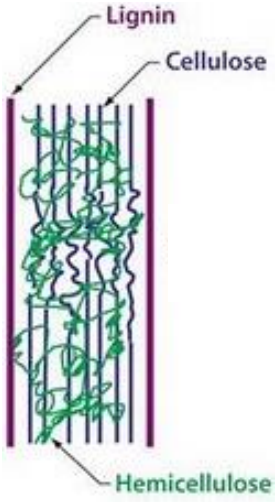
- Limitations of using wastes like animal manures:
  - Low biogas yields (high energy fraction of substrate is not present). Difficult to maintain Plant's output.
  - Low degradation rates (longer retention time).
  - Low C/N ratio; high ammonium-N (manure).
  - High protein content → high H_2S
  - Increased use of additives (eg. H_2S control).
- Straw is an alternative feedstock:
  - Lignocellulosic feedstock (high energy potential).
  - Widely available near the Plants (also available as animal bedding).
  - Far more affordable compared to energy crops.
  - High C/N ratio; good balance co-digested with animal manure.

Feedstock

- Limitations:
  - It’s slowly degradable (requires very long retention times).
  - Physically difficult to handle (chop or shred) and may cause floating layers in the digester and makes stirring difficult.
  - Low yields (maintaining the same retention time).
- Options to improve the above:
  - Pre-treatment (physical, chemical or biological).
    - Biological: Enzymes, aerobic pre-treatment (cost-benefit?).
    - Chemical (usually expensive; may lead to inhibitors; may require separation step before AD).
    - Physical (few options in the market: Cavitation, Heat pre-treatment: **Economizer SE, Biogas Systems**).
- How does the Economizer work?

Economizer SE

- Steam treatment in a high pressure environment that strips the lignin shield that encases cellulose/hemicellulose fibres, making all this organic material more easily available for hydrolysis (substrate breakdown).



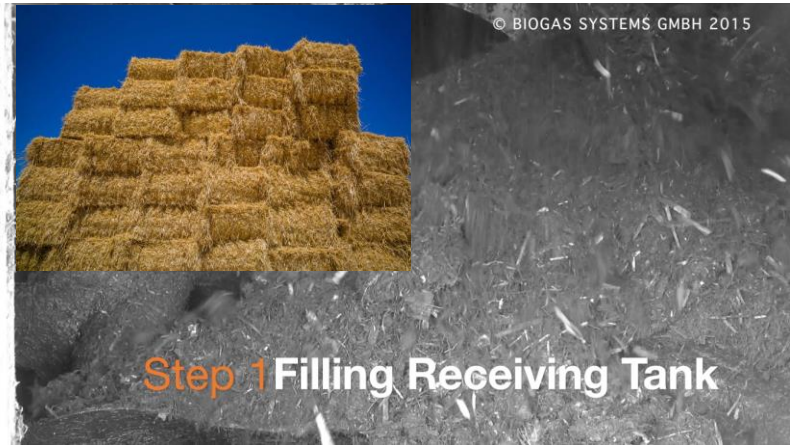
Lignin is not digested anaerobically

Enzyme access to cellulose difficult due to matrix of lignin

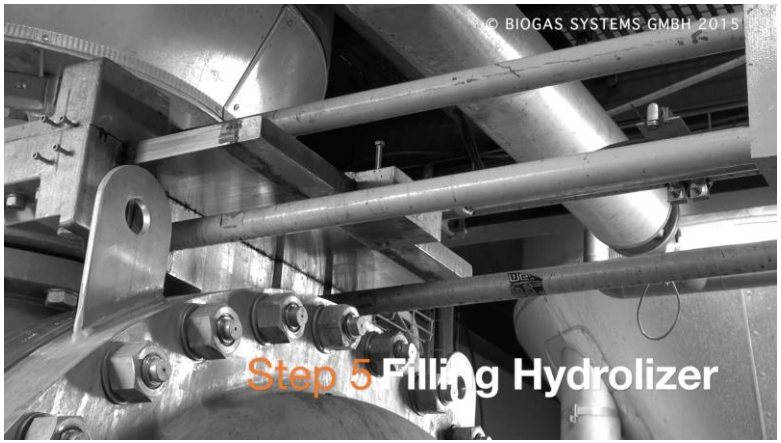
- The Economizer SE comes in 3 sizes:
  - The Economizer SE 1.5 produces 12,600 tonnes of output p.a.
  - The Economizer SE 2 produces 16,800 tonnes of output p.a.
  - The Economizer SE 2.5 produces 21,000 tonnes of output p.a.
- Feedstock, once mixed, should be max 30% dry matter.
- The Economizer SE can process many other substrates other than straw.

Economizer SE

Economizer SE



Economizer SE



Economizer SE - pre-treated straw

- Biogas yields depend on “harshness factor” (temperature, pressure and time related).
- Laboratory trials showed that optimum conditions for biogas production is 155^{o}C and 5.8 bar. Temperature in continuous mode depends on how long tanks fill/empty.
- Biomethane Potential Test (first trials at Rainworth Energy):
- Pre-treated straw could produce ~500 m3/t
- On a Fresh matter basis, 1 t straw can replace ~2.5 t of maize.

Economizer SE – Operational Features

- Operational Features interesting for Future Biogas:
  - Technology applied over 5 years in a 500 kWh Plant. Experience with Operations.
  - Developed hand in hand with Research Institute. Scientific understanding/development and optimization.
  - No chemicals. Low Opex.
  - Can treat different types of feedstocks. Flexibility.
  - Heat recovery (Steam from previous batch is used to pre-heat the feedstock for the next batch). Low heat requirement, heat demand peaks are flattened.

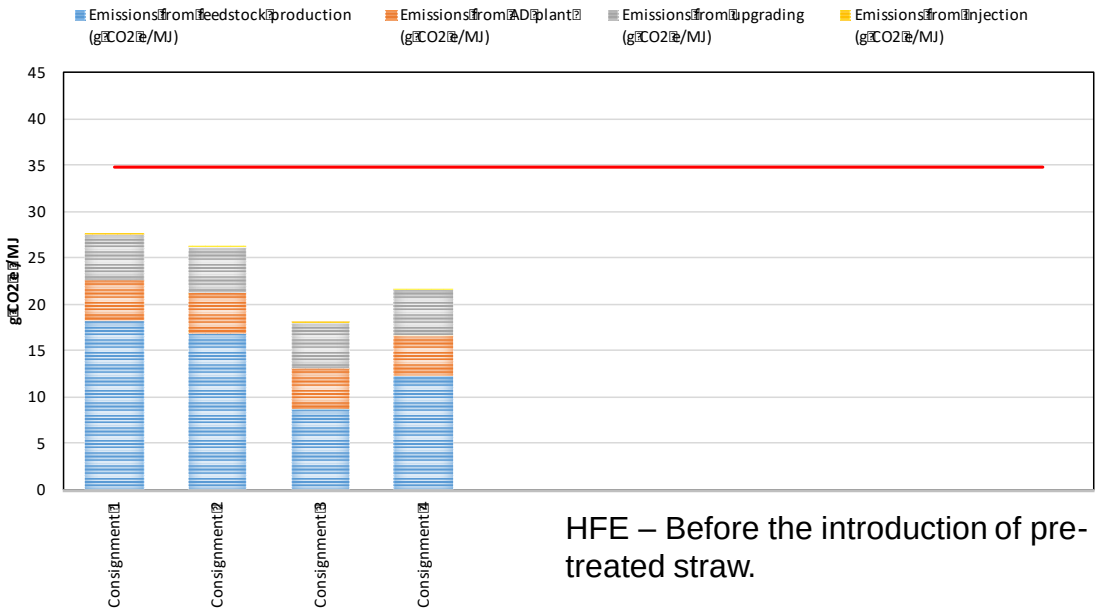
Economizer SE – Sustainability

- Replacing energy crops will improve overall Plant sustainability, especially when reporting on sustainability.
  - Operators must report evidence on land use and green house gas emissions and demonstrate that this is compliant with limits set by BEIS (Dept. of Business, Energy and Industrial Strategy). Renewable Energy Directive (RED), European Community.

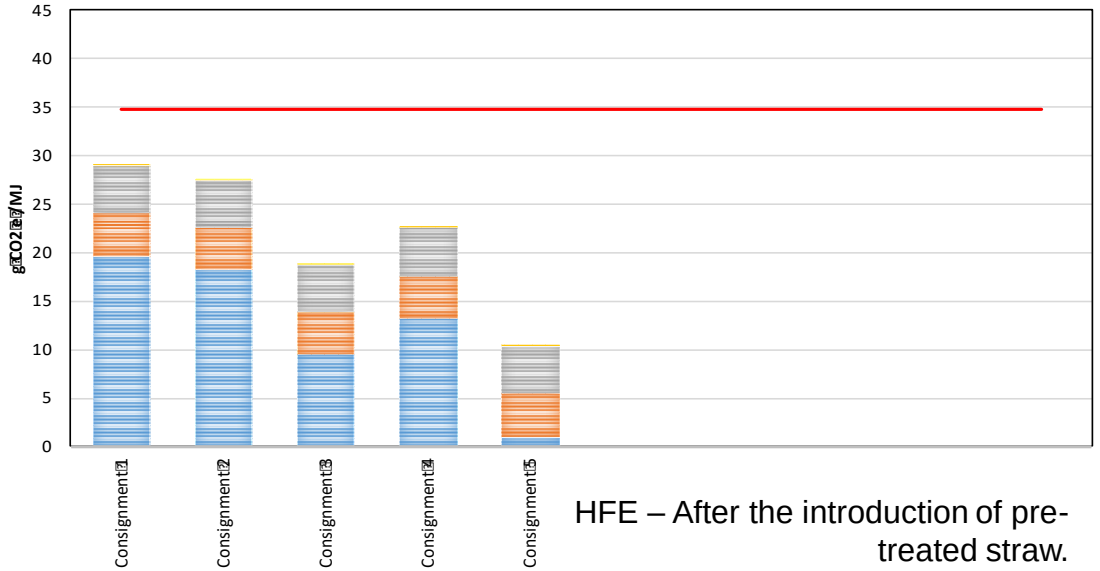
- Only emissions from the Plant and digestate removal are considered (for crops, emissions all the way to the Plant are considered).

- Higher yields per tonne, use of less tonage of straw, amongst other factors.

Sustainability report



HFE – Before the introduction of pre-treated straw.



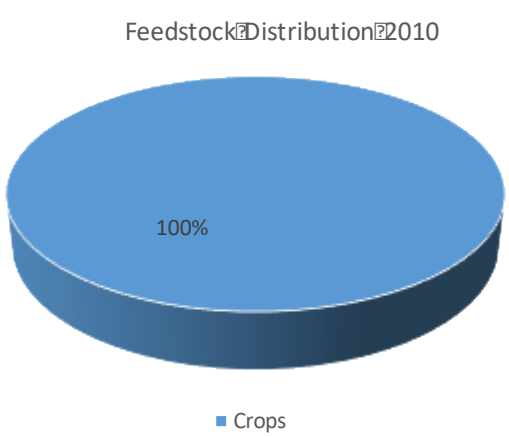
HFE – After the introduction of pre-treated straw.

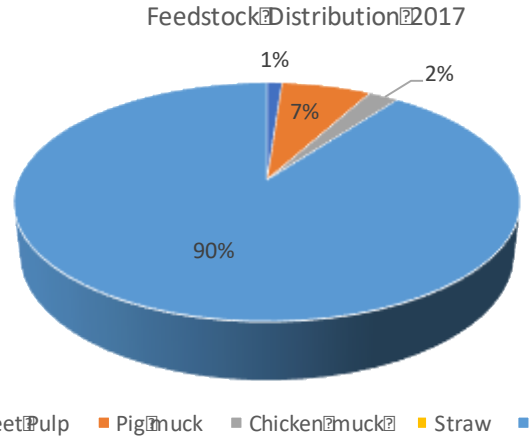
Consignment 1 – Maize
Consignment 2 – Rye
Consignment 3 – Grass
Consignment 4 – Beet Pulp
Consignment 5 – Straw

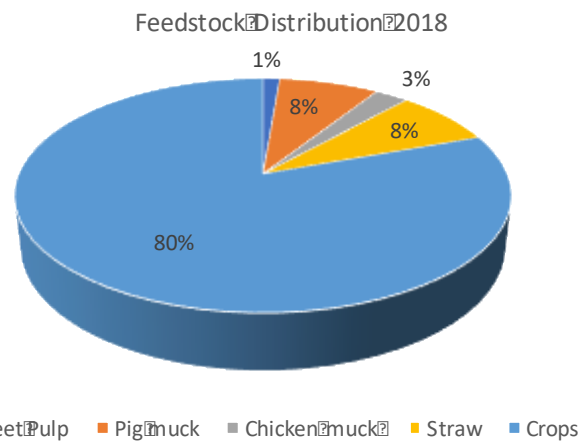
In total, the CO2 emissions of the Plant will be 23% lower.

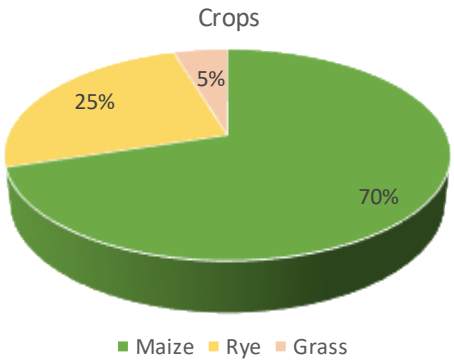
Feedstock profile: looking forward

- Future Biogas feedstock profile: change through time









Conclusions commercial view

- Crop fed Anaerobic Digestion Plants pay ~£40/t for feedstocks that produce 200 cube of Biogas.
  - Fresh straw brought for £40/t and put through the Economizer can generate ~ to 525 cube of biogas (processing cost is circa £10/t).
- One Economizer can off set an existing OPEX cost of few hundreds thousand pounds (depending on the size of the Economizer, price of straw, etc).
- The use of straw overcomes a lot of the sustainability issues facing crop fed plants.

Thank you!