Investigating the feedstock quality of dedicated energy crops

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Ideal feedstocks: Development of energy crops

- Large quantities
- Robust yields
- Sustainably produced

- Developed for Energy
  - Technology dependent
    - Thermal Conversion
      - Combustion
      - Gasification
      - Pyrolysis
      - Biomass to liquid diesel
    - Non thermal conversion
      - Anaerobic digestion
      - Fermentation
  - Standard composition
    - Little variability

Major feedstock differences

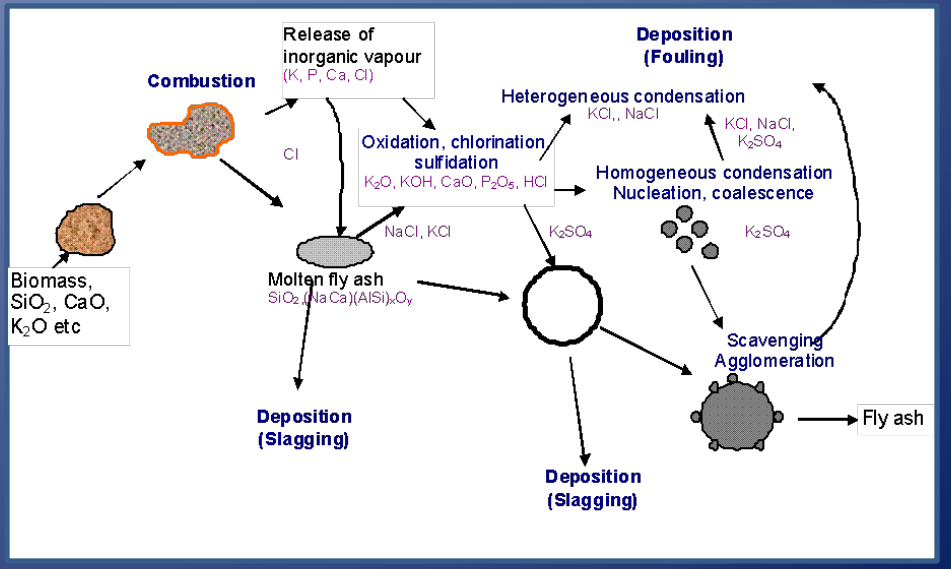
- High energy feedstock
  - Coal 25Mj/t
- High density
- Excellent shelf life
  - Million years
- Thermal conversion processes established
  - Markets developed for possible by products
- Transport network established
  - Located above or near coal seams
  - Near ports

- Lower energy feedstock
  - Miscanthus 16 MJ/t
- Low density
- Long term storage difficult
  - Highly combustible
- High in contaminants
- Limited commercial uptake in energy conversion
  - Limited/ niche markets for by products
- No established networks for transportation
  - Tapping into established food markets etc

Qualities required for energy conversion

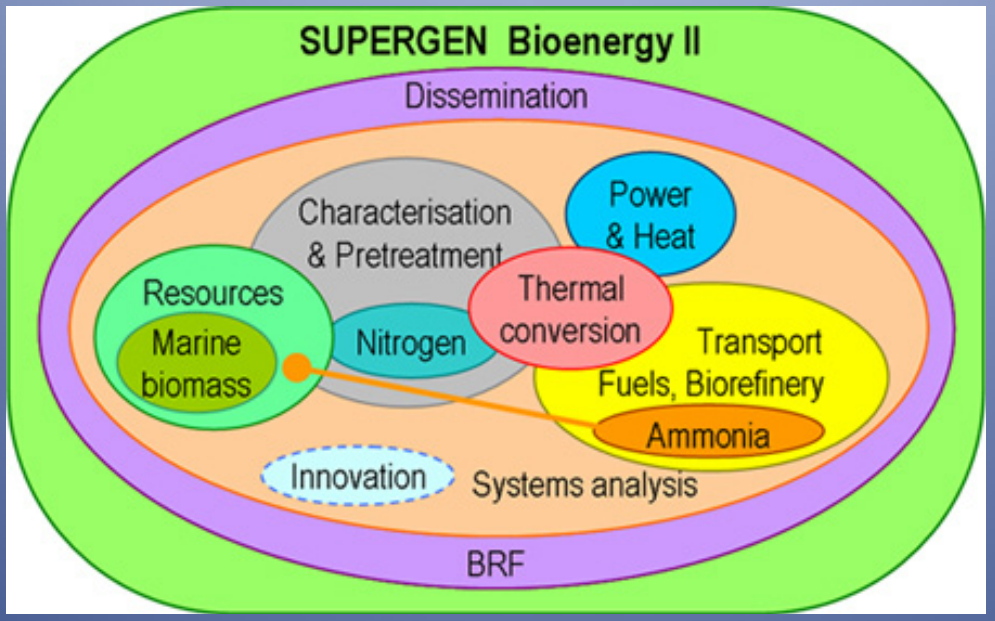
- Density
  - Volumetric density and energy density
- Moisture content and ease of drying
- Metal/ash/inorganics composition and concentration
  - Fouling and slagging
    - Alkali index
- Nitrogen
  - Emission's
    - NOx
- Organic composition (lignin/cellulose/hemicellulose)
  - Pyrolysis
  - Non thermal conversion routes
    - Fermentation

Photo courtesy of W. Livingstone, Doosan Babcock



Courtesy of Jenny Jones, Leeds University

Supergen II



- Supergen programme is funded my EPSRC
  - Commenced in 2003 with funding of 26M at its conception rising as new consortia were formed.
- Supergen Biomass and Bioenergy
  - Commenced in 2003 for 4 years and received a further 2.9M funding in 2007
- Supergen Phase II
  - 9 Academic partners and 12 industrial partners

Qualities influenced by agronomy, harvest date and storage

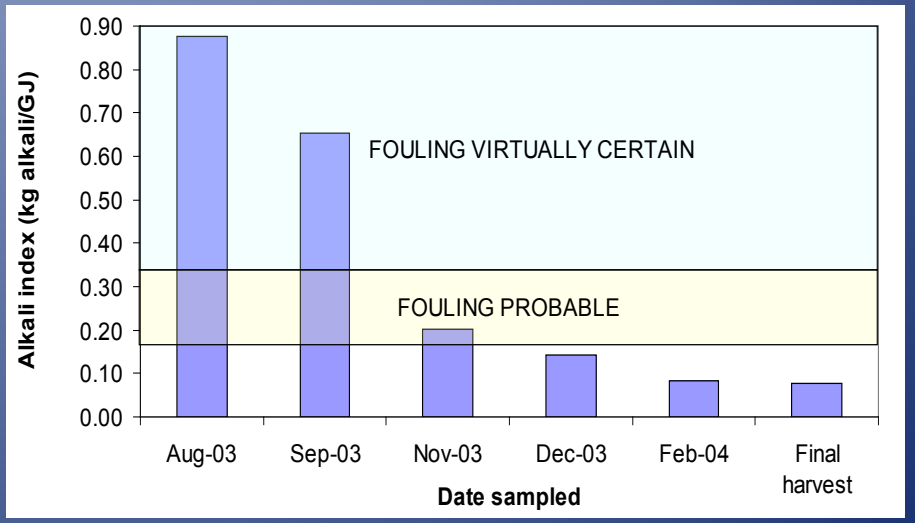
- The effect of fertiliser
  - Quantity and form
    - Nitrogen and Potassium
- Harvest dates
  - Grasses
    - Harvest autumn to late spring
  - Willow
    - Green harvest and conventional
    - 2 year and 3 year harvest
- Storage
  - Grasses
    - Conventional stacks
      - Variability of bales
      - Storage duration
  - Woodchip
    - Harvesting techniques
      - Chipping and billeting
    - Variability in commercial heaps

Results
Fouling potential of switchgrass influenced by harvest date

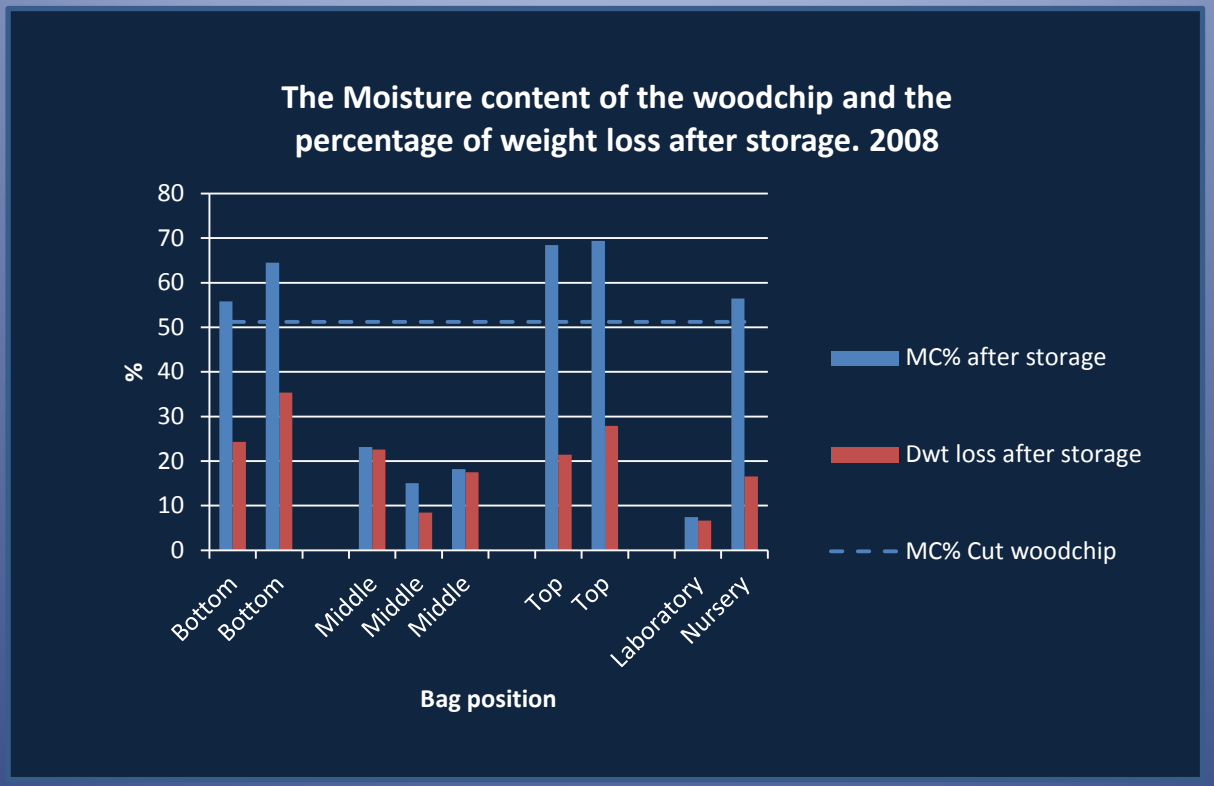
- The presence of potassium and sodium in a feedstock increases the alkali index
  - Ash, silica all contribute
- High levels of potassium are found in plant material
  - Straw 20,000ppm
  - Coal 720ppm
- Alkali index decreases during the sampling period
  - The crop starts to senesce in September
  - Potassium remobilisation, weathering
- However, yields also decrease after senescence
  - Up to 30% dry matter loss over the winter period

Alkali index

$$(1/Q)Y_f^a(Y_{K2O}^a + Y_{Na2O}^a)$$



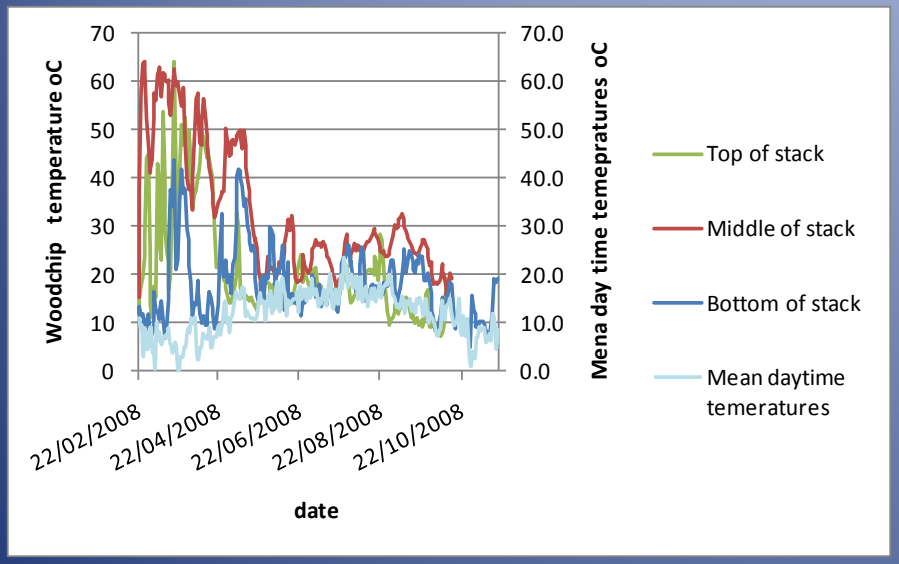
Willow chip storage



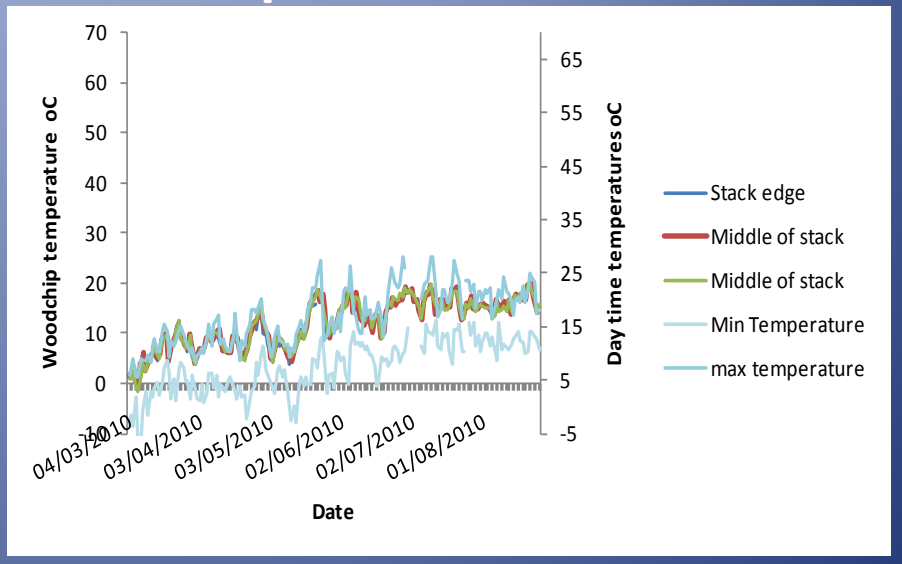
- The newly harvested woodchip was at 51% MC.
- The moisture content of the crop is dependent on the positioning of the chip in the heap.
  - The majority of the woodchip was in the “middle” section.

Temperature of willow heaps during storage

Woodchip heap



Billet heap



- The temperature of the woodchip heap increases to approximately 60°C in the first two months of storage
- The billet heap has no such temperature surge
- Both heaps actively dry the wet wood (approximately 50% moisture) to < 20% moisture
- However, dry matter is lost from both heaps but greater from the woodchip heap.
  - Composting?
- Does the feedstock quality change?

Thankyou