European Biorefining Feedstocks

With the support of the Seventh Framework Programme.

Daniel Hayes

DIBANET Networking Day

13/12/10

Important Biomass Characteristics

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- Yields in the DIBANET hydrolysis process will depend on:
  - Cellulose content
  - Hemicellulose content
- Yields in the DIBANET pyrolysis processes will also depend on:
  - Lignin content
  - Ash content.
- Feedstocks with higher total carbohydrate (cellulose + hemicellulose) content will be attractive for the DIBANET project.

Other Considerations

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- However there are other considerations:
  - Cost : Biomass can come at negative cost (e.g. municipal solid waste) or at a higher price for crops grown specifically for biorefining.
  - Seasonality of supply: Are the feedstocks produced all year or in restricted windows.
  - Environmental aspects: LCA of whole supply cycle of feedstocks is important.
  - Alternative uses for the feedstock: Are we competing with existing markets (e.g. sawdust).
- As a general trend: waste materials have lower carbohydrate contents but better costs/LCAs than energy crops.

Feedstock Classifications

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Energy Crop	Waste	Agric. Residues
Miscanthus	Sewage	Forest
Willow/Poplar	Manures	Straw
Switchgrass	Paper	SMC
RCG	MSW	
	Sawmill	
	Wood	
	Industrial	

Waste Feedstocks

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- Paper/cardboard and wastes from the paper industry (paper sludge) have the highest carbohydrate contents of all feedstocks (including energy crops). Up to 90%. However lignin content is low so there will be little residual material for pyrolysis.
- Paper can be recycled but often is not. In Ireland only 2% was recycled in 2009 with the rest exported (mainly to China where is it was burnt).
- Approx 1.5% of Ireland's petrol and diesel fuel requirements could be met by using this exported material instead in a DIBANET-type process.

MSW

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- Comprises the wastes from households and commerce.
- Includes paper, garden waste, food waste, and various plastics and non-organic components.
- Historically MSW has either been landfilled/incinerated.
- Incineration is the exact opposite concept to biorefining – everything is burnt!!
- We should focus on using our wastes more efficiently and consider them as valuable resources.
- There is an increasing interest in the segregation of MSW to obtain, among other fractions, a lignocelluosic component to be used for biorefining purposes.

Case Study – Dublin Incinerator

With the support of the Seventh Framework Programme.

- Max output of Poolbeg – 54MW electricity.
- Based on preventing plastics from being recycled.
- A biorefining alternative to Poolbeg could provide 0.76% of our transport fuel needs (DIBANET) or 84m litres of ethanol (BlueFire Ethanol process).
- To equal revenue from electricity sales – 35 c/l.
- Replacing other planned Irish incinerators (Poolbeg, Meath and Cork) – 1.1% (DIBANET), 1.27% (BlueFire Ethanol)

Wastes - Manures

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- Animal wastes are by far the most abundant resource (42m wet tonnes in Ireland).
- We have analysed these (cattle, pig) for carbohydrate contents and these can be reasonable (up to 40%).
- However, moisture contents of these are very high (>95%) so logistical problems arise.
- Poultry litter comprises the manure and the litter base (straw/paper/wood) and has a much lower moisture content (~30%) and higher carb. (60%) but ash content of ~20% may cause problems.

Agricultural/Forestry Residues

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- Ag residues: Predominately straws from wheat, oats, barley, rape and maize.
- Carbohydrate contents high (~70%).
- The collection of these residues for biorefining needs to be balanced against the need a portion of these materials to be left on the land to replenish soil fertility.
- This is also the case for forestry residues.
- Could biochar play a role here?
- Available resources vary greatly according to country – e.g. Ireland agriculture is more focused on pasture.

Energy Crops

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- Waste/residual materials are a limited resource.
- Mass substitution of fossil fuels will also require contributions from dedicated energy crops.
- Important Qualities:
  - High productivity (high tonnes(DM)/ha)
  - Low maintenance costs (i.e. low fertiliser, pesticides)
  - Low establishment costs
  - A high density for cheaper transportation
  - Frequent harvest periods.
  - Reasonably predictable yields.

Short Rotation Coppice

With the support of the Seventh Framework Programme.

- The most widely used energy crop for biomass power generation in the world. Willow salix is most common.
- Generally harvested in winter as chips every 3-4 years. Estimated plantation lifespan of 20-25 years.
- Reasonable productivity of 8-15 t/ha
- Approximate Carbohydrate contents (poplar): Cellulose 40%, Hemicellulose 25%, Lignin 24%, Extractives 7%, Ash 2%
- High start-up costs and rust problems

Miscanthus

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- A C4 grass that is native of asia
- Grows quickly, harvested annually (maximum yields achieved ~3 years after plantation and maintained for at least 15 years).
- Low nutrient requirement – nutrients translocated to rhizomes following senescence.
- Extremely productive (up to 20 odt/ha,yr in Ireland, 40+ in hotter countries with irrigation).
- No real pest problems. Very competitive against weeds

One year growth of miscanthus

Miscanthus (2)

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- Numerous varieties exist and there is ongoing research into new varieties for improved yields/biorefining properties.
- Currently, Miscanthus x giganteus is by far the most abundant variety in Europe.
- Commercial operations require the planting of Miscanthus rhizomes harvested from standing stock, leads to high establishment costs.
- However subsequent costs are low.

Miscanthus – Analysis in DIBANET

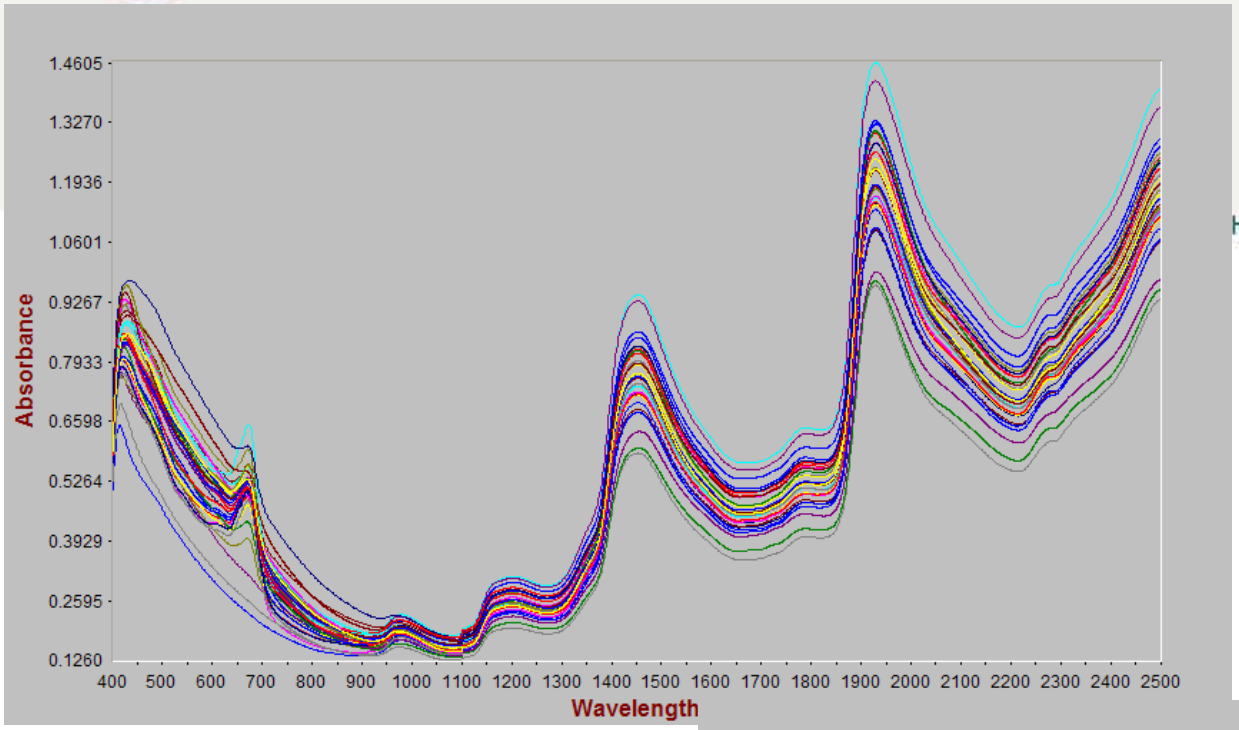
With the support of the Seventh Framework Programme.

- Approx. 850 samples of Miscanthus have been collected and analysed (NIRS and/or wet chemical methods).
- An extensive database of important properties (cellulosic/hemicellulosic sugars, lignin etc.) is being composed.
- Various anatomical parts of the plant have been analysed and compared over different harvesting periods.
- Potential yields have been considered for both early harvests (high leaf content) and late (spring) harvest (no leaves but lower moisture content).

NIR Analysis

With the support of the Seventh Framework Programme.

- Conventional wet chemical analysis takes approx. 10 days in our labs.
- We are developing methods that use Near Infrared Spectroscopy to analyse samples and predict important properties (e.g. cellulose).
- The novel area in DIABNET is that these models are being developed for wet samples of a heterogeneous particle size.
- Reduces analysis time to ~10 minutes!!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0.6598
0.5264
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0.1260
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Wavelength


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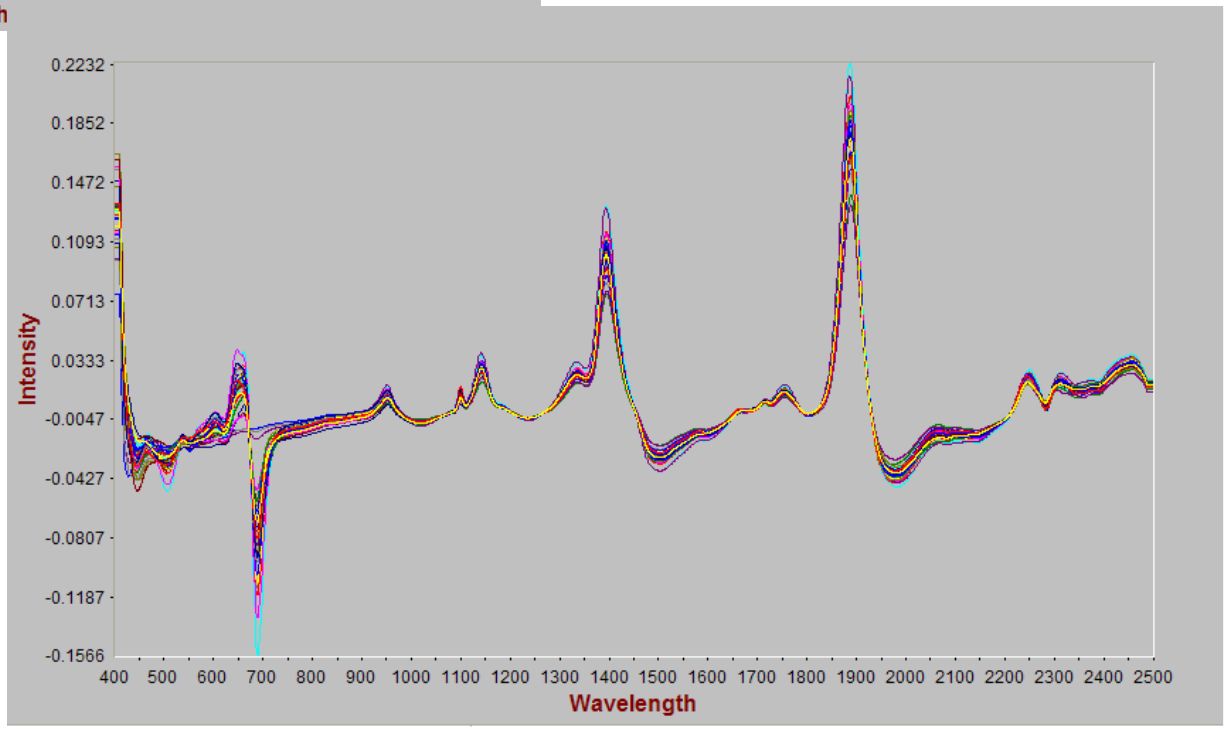
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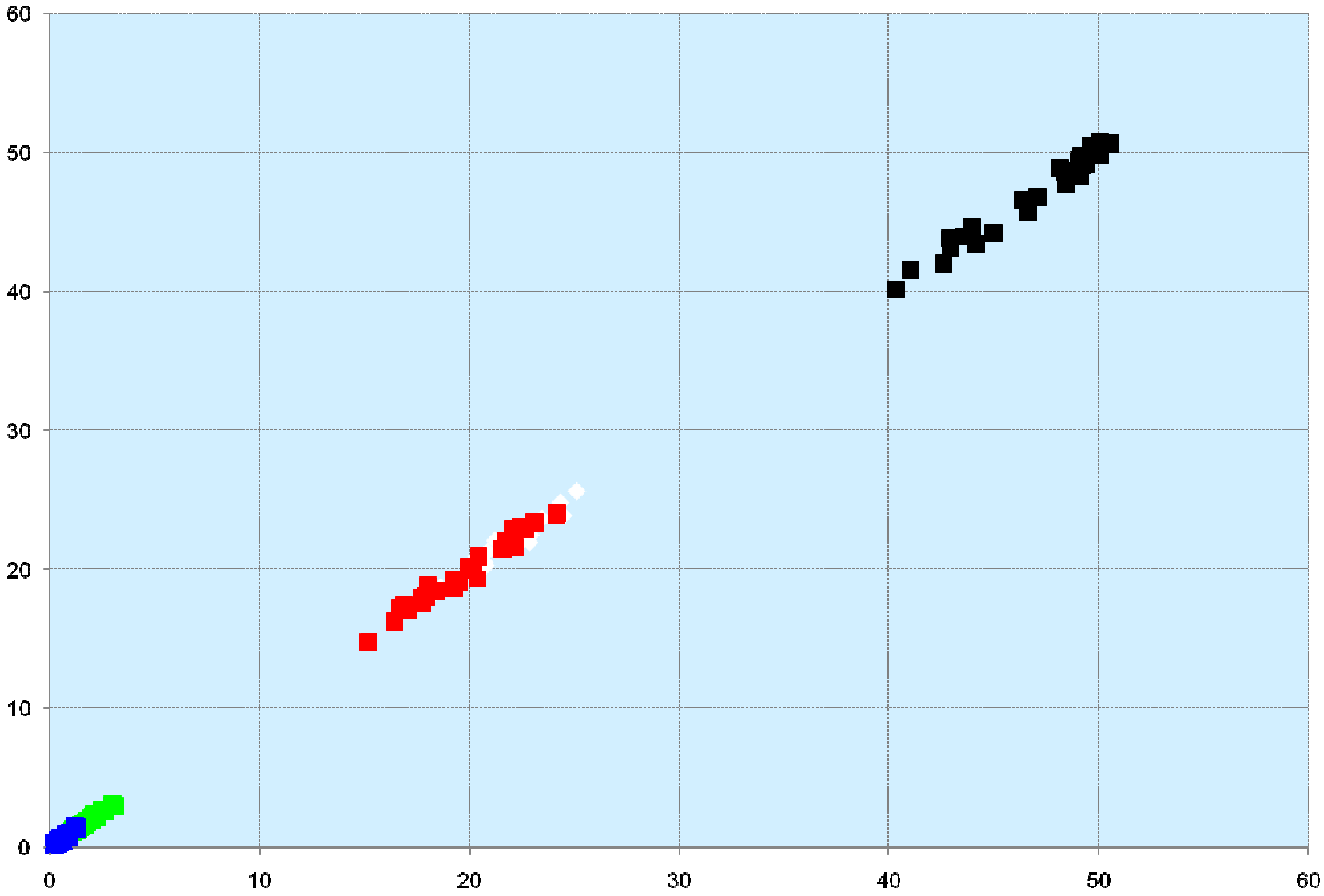
0.0713
0.0333
-0.0047
-0.0427
-0.0807
-0.1187
-0.1566
400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500
Wavelength

NIRS Predicted Composition vs Reference Values



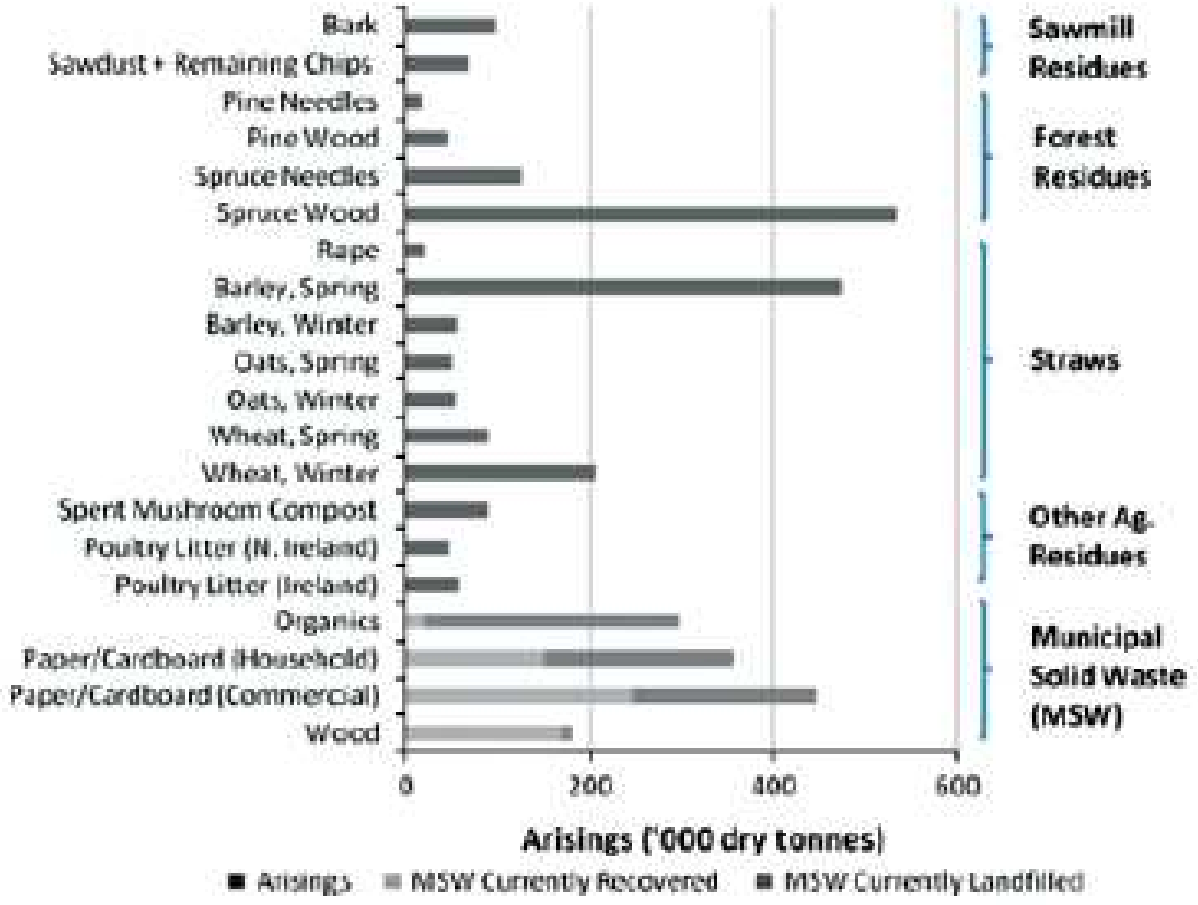
Glucose Lignin Xylose Arabinose Galactose

Case Study - Ireland

With the support of the Seventh Framework Programme.

- Hayes and Hayes (2009), The role that lignocellulosic feedstocks and various biorefining technologies can play in meeting Ireland's Biofuel Targets, **Biofpr**

- How can wastes contribute to our biofuel needs (EU → 10% by 2020).



Biofuels from Wastes/Crops

With the support of the Seventh Framework Programme.

- Eight technologies evaluated. Near-term, DIBANET-type technology gave second highest yields.
- If all waste: 10.67% of 2008 demand met by EL Practical levels: 5.01%
- To meet 10% - 1.3% of agricultural area (57,200 ha)
- No wastes - 50% biofuels: 12.7% of agricultural area (16.9% spring harvest).

Summary

With the support of the Seventh Framework Programme.

- Various feedstocks exist in Europe.
- These range from low quality and low costs (some municipal wastes) to higher value but also higher costs (dedicated energy crops).
- The feedstock mix needs to consider the balance between cost, level of supply, environmental effects, and the need for rural development.
- However, large scale production of biofuels from second generation feedstocks are practical in the near term.