The potential role of Agrichar in the Commercialization of Dynamotive's Fast Pyrolysis Process

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Outline

- Dynamotive Corporate Information
- Pyrolysis Technology
- Biooil Properties
- Production Plants
- Agrichar Production Costs
- Carbon Sequestration Costs
- Implications for Energy/Food Crops

Current Position

- Dynamic company in a high-growth, global industry, with strong, management. Publicly traded Nasdaq OTCBB: DYMTF Mkt Cap > $ 200 million. Target to move to senior exchange in 2007. We meet reporting standards and are OS Compliant.
- Biomass to Energy fastest growing sector in the energy mix. (EU Directive, 25x25 US). Three commercial products produced: BioOil, Intermediate BioOil and Char. Technology is owned and patented.
- Two pilot plants built, one commercial demonstration plant completed. First full scale commercial plant to be completed this quarter.
- Business Development Activity in Americas, Europe, China and Australia. Some of our projects under development.
    - North America : 4 Plants Wood, Corn Husks
    - South America : 2 Plant Wood Based / corn redidue.
    - Europe : 2 Plants Energy Crops, Green Municipal Waste
    - China : 1 Plant Agricultural Residue
    - Australia : 2 Plants Green Municipal Waste

Strategic Alliances

Biomass Reserves Development	Consensus Business Group
Engineering Consultants	TECNA
Manufacturer of OGT-2500 modified to run on BioOil	MAGELLAN AEROSPACE CORPORATION ORENDA AEROSPACE CORPORATION
Fabricator of Pyrolysis Plant and Modules	RAMSAY GROUP
Feedstock Preparation systems	BRUKS KLÖCKNER WOOD TECHNOLOGY

Revenue Opportunities / Profit Making Centers

Territorial Licenses

Technology Licenses

- **Plant License**
- **Support Engineering**
  - **Product**
- **Royalties**

Plant Construction Services

- **Engineering**
- **Commissioning**

Plant Sales

Product licensing

Project development

- **Biomass assets**
- **Project Sales**
- **Equity Participation**

Product Sales

- **Bio Oil**
- **Char**
- **Intermediate Bio Oil**
- **Specialty Products**

Investment / Acquisitions

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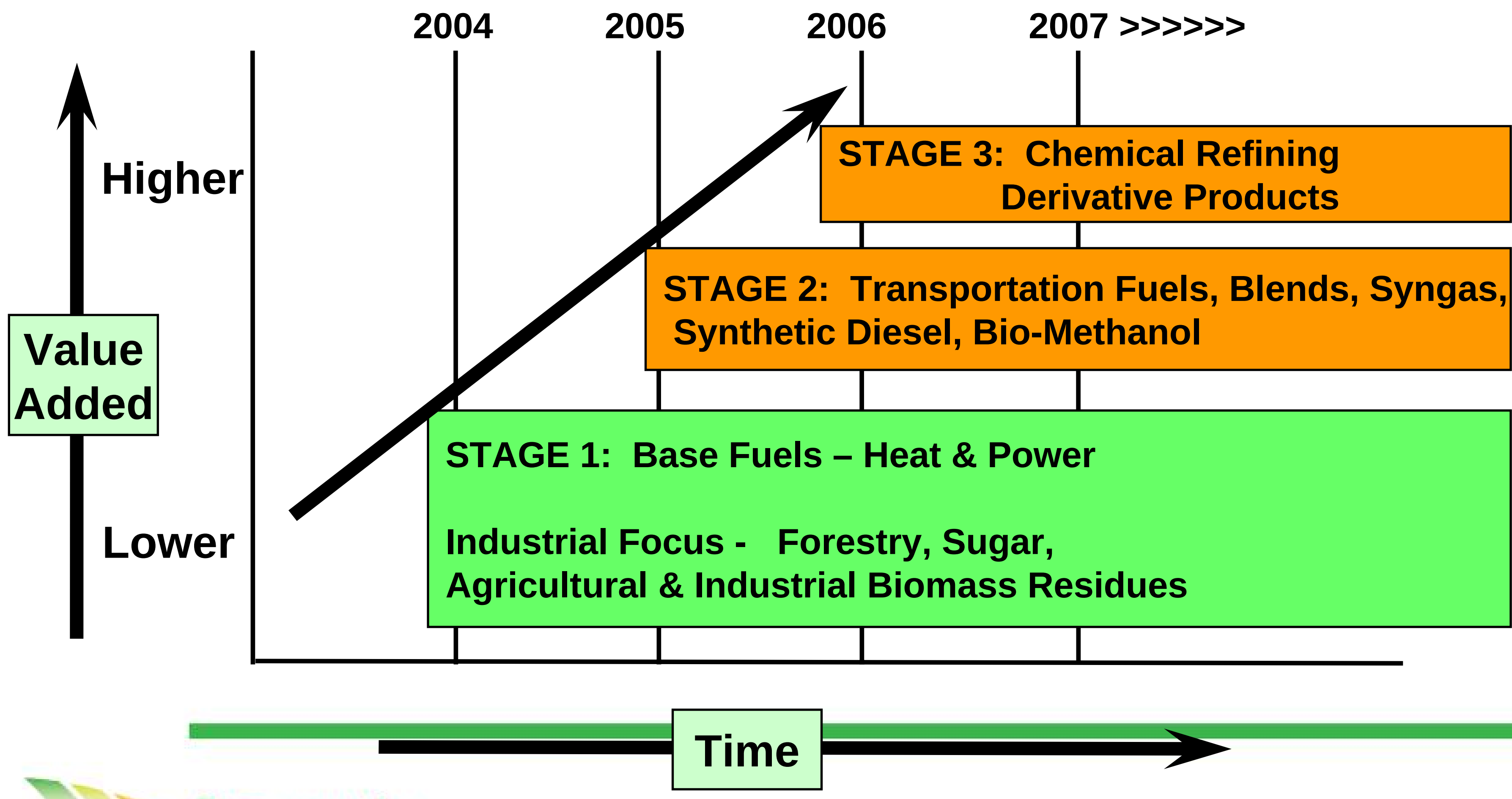
Product Application - Market Strategy



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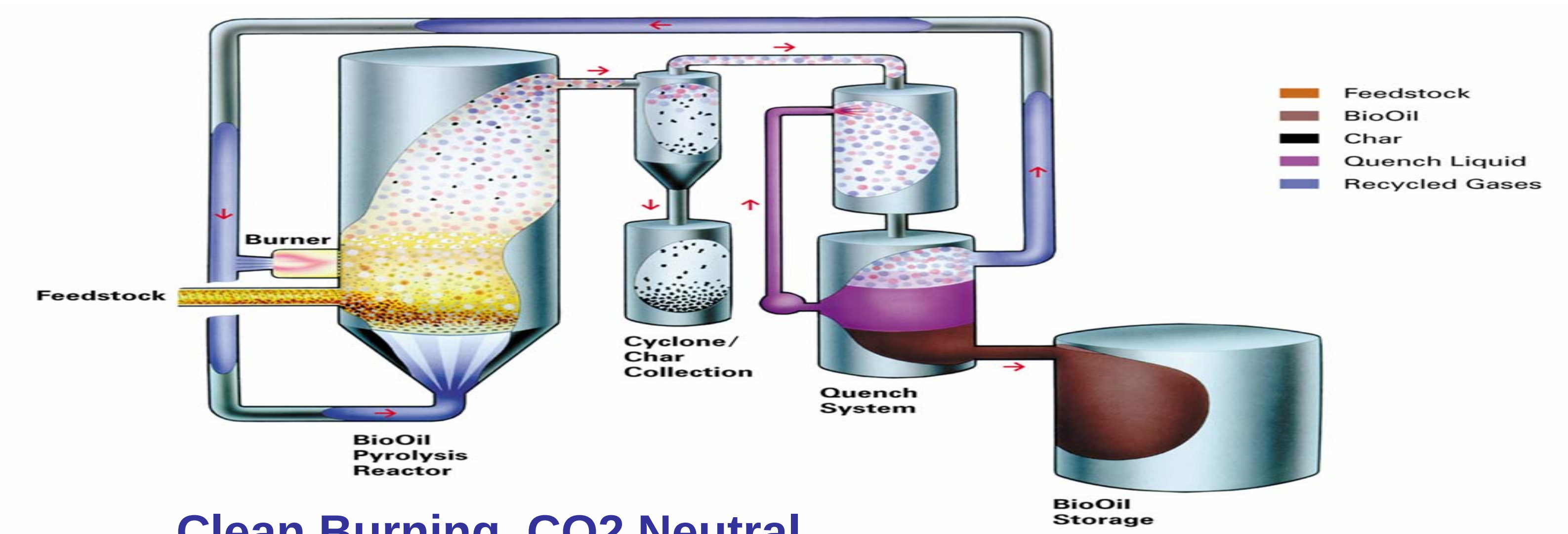
Key to Value - Our Fast Pyrolysis Platform – Patented

Rapid (< 2 sec's) heating of residual cellulosic matter in absence of oxygen.

Over 120 types of biomass sources tested – forest and agricultural clean residues.

Fuels: **Liquid yield 55 – 73%** **Solid yield 15 – 25%**

Non-condensable gases are recycled into the process.



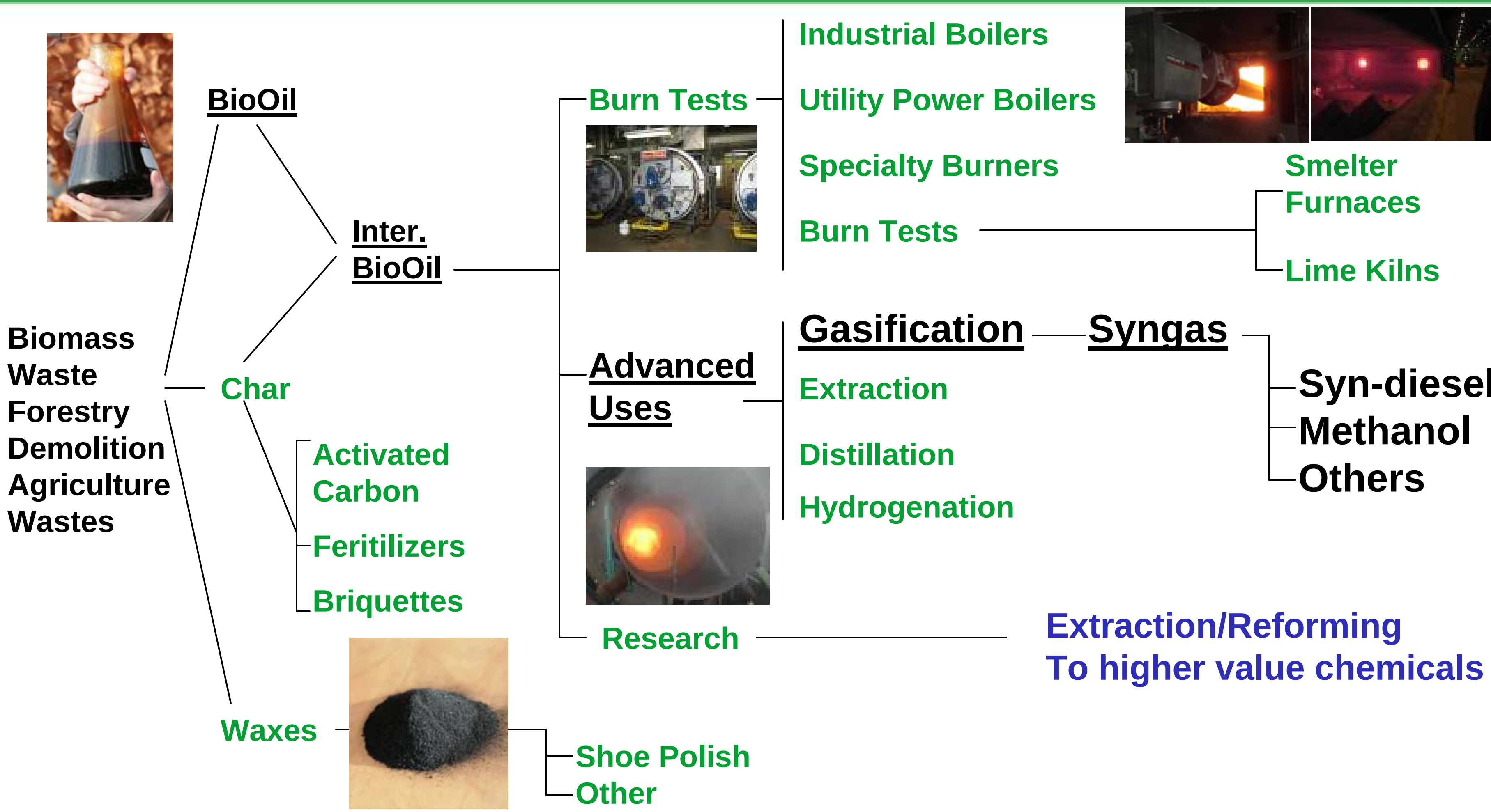
Clean Burning, CO_2 Neutral

BioOil and Char Yields

Yields from various tested biomass feedstock:

Feedstock	BioOil Yield (wt%)	Char Yield (wt%)	NCG Yield (wt%)	BioOil Energy (GJ/ton)
100% white wood	70	18	12	17.4
75/25 white wood/bark	64.5	22	13.5	17.2
50/50 white wood/bark	63	23	14	16.9
100% bark	58	27	15	16.5
Bagasse	68	20	12	16.7
Corn Stover	70	15.7	14.3	17.5
Eucalyptus	76	13	11	17.2
Wheat straw	58	18	24	16.5

Pyrolysis Product Utilization



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Path to Value Pyrolysis Technology Scale-up Stages

1/2 tonne per day up to 200 tonnes per day

Continued Improvement ensures leadership – protects shareholder value

Next Generation 2008 ?

Transportation of BioOil & Intermediate BioOil: 9-12 X Energy Density

	Volumetric Density	Energy Density	Ratio Compared to BioOil
Hog Fuel*	100-140kg/m3	=2.4GJ/m3	**9**
Sawdust*	100-140kg/m3	=2.4GJ/m3	**9**
Shavings*	50-100kg/m3	=1.7GJ/m3	**12**
BioOil	**1200kg/m3**	**=20.6GJ/m3**	**1**
Intermediate BioOil	**1260kg/m3**	**=23.9GJ/m3**	**.86**

***Approximate oven dry density, softwood. Source: Washington State University**

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Intermediate BioOil Yields

Yields from various tested biomass feedstock:

Feedstock	Intermediate BioOil Yield (wt%)	NCG Yield (wt%)	Intermediate BioOil Energy (GJ/ton)
100% white wood	88	12	19.6
75/25 white wood/bark	86.5	13.5	19.9
50/50 white wood/bark	86	14	19.8
100% bark	85	15	20.1
Bagasse	88	12	18.7
Corn Stover	85.7	14.3	19.0
Eucalyptus	89	11	18.4
Wheat straw	76	24	18.7

West Lorne Plant

130 tpd (upgrade) – 100 tpd initial capacity
Grid Connected 2.5 MW modified gas turbine


Capital Cost	**US$15.0 million**

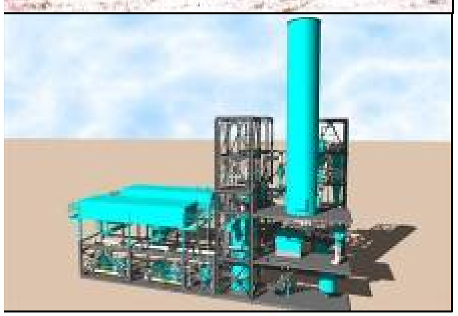
<u>Projected Annual Plant Operating Results:</u>

Sales: BioOil (270,000 GJ) + electricity (20,000 Mwh)	**$ 5.9**
Operating Expenses*	**<u>$ 2.3</u>**
EBITDA (as estimated)	**<u>$ 3.6</u>**
Projected Plant ROE (After Tax)	30%

Dynamotive 100% ownership

* Includes $ 20 per tonne delivered cost for biomass in excess of 70 tpd

Guelph Plant - 200 tpd – Q1 2007 Completion



Modular design allows rapid deployment and start-up.

Biomass: construction demolition wood residue.

Intermediate BioOil output 50,000 tonnes (1 Million GJ / yr.)

Capital Cost Turnkey	**US $ 16.5**
Projected Annual Plant Operating Income:	
Intermediate BioOil sales @ $ 8/GJ plant gate	**$ 8.0**
Operating Expenses*	**$ 4.5**
EBITDA (as estimated):	**$ 3.5**
Projected Plant ROE (After Tax)	25%
Dynamotive ROE **	40%+

* At $ 20 per tonne delivered cost for biomass

**Based on 50% Dynamotive ownership, royalties and other fees of $750,000/yr

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Biomass Reserves: 1 tonne = +/- 2.5 Barrels Oil Equivalent

Develop know how and technology to monetize biomass assets
Establish "Reserves" of BioOil. Strengthen Balance Sheet.
Finance Projects against Enterprise Value of BioMass Assets

Sugar Cane Bagasse

Wood Chips

Corn Stover

Waste Paper

Poplar

Peat

Miscanthus

Eucalyptus

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Comparison of Dynamotive fuels to other fuels

Fuel	Specific Gravity	Energy	Higher Heating Value
Light Fuel Oil	0.82	46 MJ/kg	19,800 BTU/lb
Heavy Fuel Oil	0.99	42 MJ/kg	18,050 BTU/lb
Diesel	0.84	46 MJ/kg	19,800 BTU/lb
Natural Gas	N/A	38.1 MJ/m^3	1,020 BTU/ft^3
BioOil	1.2	16-17.5 MJ/kg	6,500–8,500 BTU/lb
Intermediate BioOil	1.22-1.3	18-20 MJ/kg	7,740–8600 BTU/lb
Char	N/A	23 – 32 MJ/kg	10,000–13,800 BTU/lb

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Potential Char Applications

- Briquette Manufacturing
- Activated Carbon
- Manufacture of Black Powder
- Steel/Metallurgical
- Char Pellets for Combustion
- Synthesis Gas Production/Gasification
- BioOil/Char Slurry Production
- Agrichar/Fertilizers

Char for Carbon Sequestration

- Carbon can be sequestered as Agrichar for very long term carbon storage in the soil, or as Biochar simply by burying it
- A repository of charcoal could, for instance, be realized by filling up a natural valley with charcoal, which would finally be covered by a layer of soil to prevent fire by malicious arson.
- Another possibility for a large charcoal storage site could be an artificial mountain of charcoal, which could be cultivated if it has reached its final shape

(Ref: Should we store carbon in charcoal?, W. Seifritz,
Int. J. Hydrogen Energy, 18, pp. 405-407, 1993).

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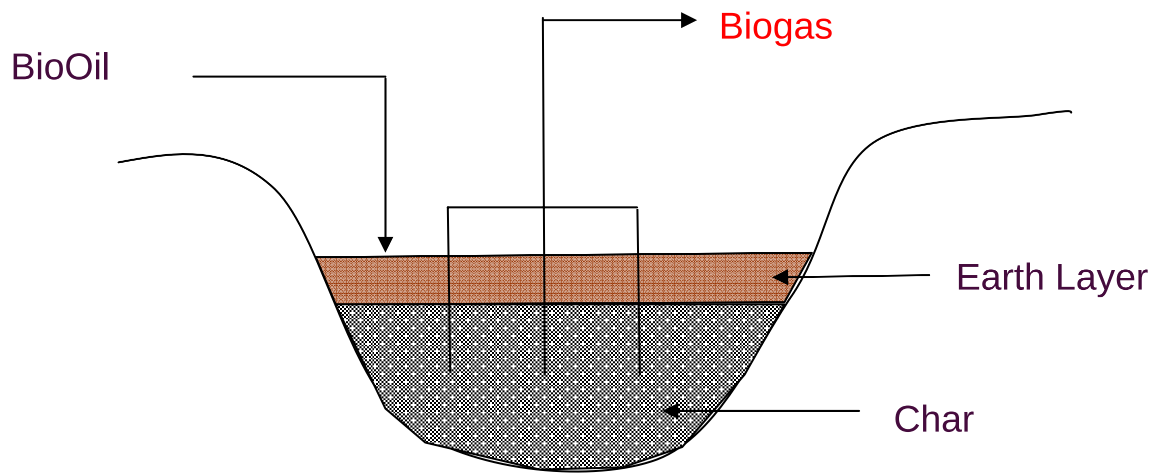
Could sequestered char be used as a resource?

One possibility is to use sequestered char as a support for microorganisms that convert Biooil to Biogas. E.g.



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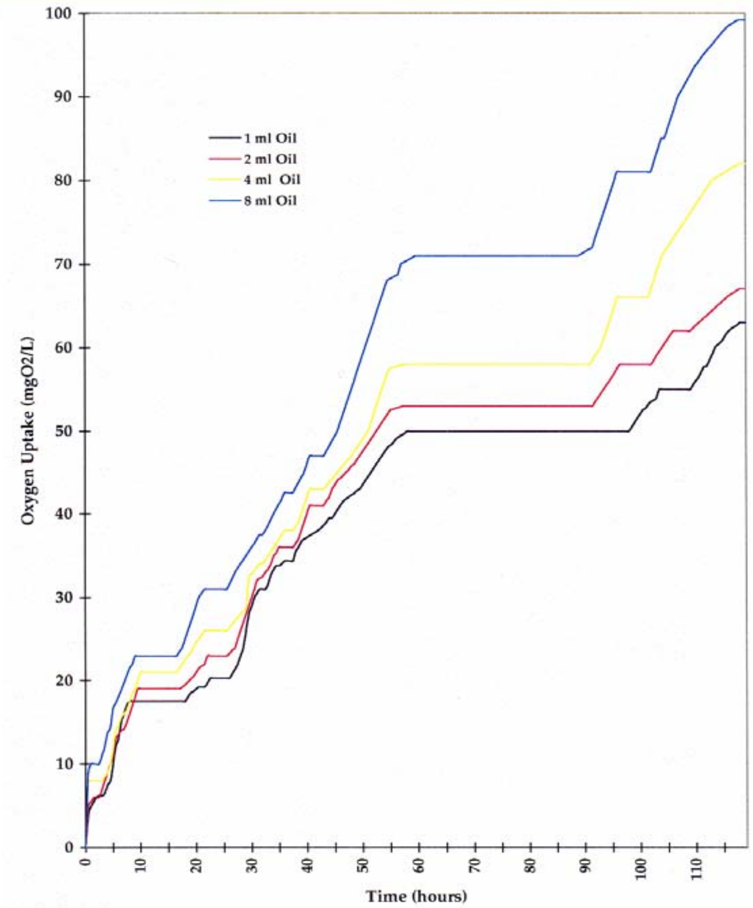
Biodegradation of Biooil

- **We have found that Biooil undergoes fairly rapid biodegradation when innoculated with Activated Sludge**
  - (J. Piskorz and D. Radlein, *Determination of Biodegradation Rates by Respirometry*, Final Report, CANMET Contract 23341-7-2050/001/SQ, Feb. 1998)
- **Biodegradability is enhanced by neutralization with bases like lime.**
- **We have also shown that Biooil readily binds with amino compounds, e.g. Urea, NH_3, proteins to give nitrogenous products that provide a slow release fertilizer**

(D. Radlein, J. Piskorz and P. Majerski, *Method of Producing Slow-Release Nitrogenous Organic Fertilizer from Biomass* US Patent 5,676,727, 1997)



Respirometric Plots of *Neutralized* Bio-Oil and Activated Sludge in Water

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Char Production Costs

- **Total (BioOIl + Char) production cost is:**

  US4/GJ (BCO + Char) + $0.05 × (Feedstock cost in $/T)

- **∴ if char is treated as a fuel its production cost is $4/GJ = $4/(37 kg char) ≅ $108/T at zero feedstock**

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Bio-Oil Value / T CO_2 offset

- 0.27 T Carbon is equivalent to 1 T CO_2
- Assuming FC (fixed carbon) content of char is 65%, 1 T CO_2 is equivalent to 0.42 T Char
- With 0.42 T Char, ~1.3 T of BCO is produced and ~2 T Biomass feed is required
- The total HHV of this BCO is ~17*1.3 ≅ 22 GJ
- At $8/GJ, its value is ~$177!!

- Thus Bio-Oil worth $177 is produced per Tonne CO_2 offset

Production Cost of Carbon Offset in $/T CO_2

- **Assume C content of wet BCO is 46.5 %. Then the combustion of 1 Tonne BCO gives = 1.7 T CO_2.**
- **If this replaces fossil fuel it represents 1.7 (T CO_2 sequestered).**
- **Assume 1 T char has 3.25 T BCO co-product.**
- **$\therefore$ the effective amount of CO_2 offset per tonne of char is $3.25 \times 1.7 + 2.4 = 7.9$ (T CO_2)/(T Char)**
- **$\therefore$ effective cost of carbon offset by Char = $108/7.9 = $13.7/(Tonne CO_2).**

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Net Production Cost / T CO_2 offset

- The total heating value of the Char + BCO produced is ≅ 17X1.3+25*0.42 = 32.5 GJ
- Thus the total production cost for both products is
  - ~$4*32.5 = $130/(T CO_2 offset) *at zero Biomass cost,* and
  - $5.5.*32.5 = $179 /(T CO_2 offset) *at $30/T Biomass*

- ∴ Net cost of production for CO_2 offset = (Production cost - Value of BioOil) =
  - - $47/ (T CO_2 offset) at zero feedstock cost, and
  - + $2 / (T CO_2 offset) at feedstock cost of $30/T Biomass
  - Thus net carbon offset by char with BioOil fuel co-product can be cost negative!
  - (Note that amortization costs of capital are not included here)

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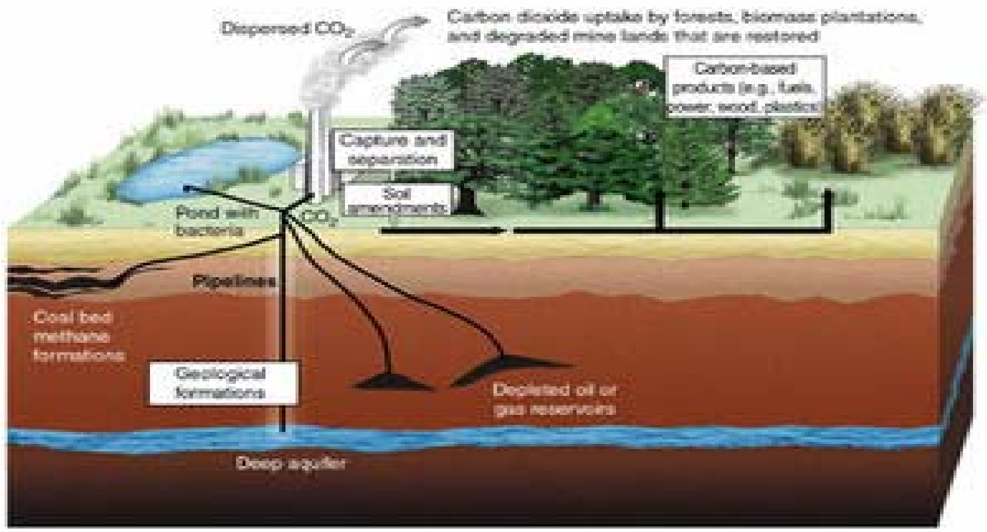
Comparison with “Conventional” Sequestration



Techniques available for capture and disposal of CO2 are expensive however. Costs can range from + $30 to + $90 to avoid the release of 1 ton of CO2 to the atmosphere according to Howard Herzog, MIT Energy Laboratory.

Carbon Offset Prices

- **EU Emission Allowances (EUA) futures (Dec. ’08) currently trade at ~$80/T Carbon or ~$22/T CO_2**
- **This price is greater than the estimated effective cost of sequestration by Char of $13.7/(T CO_2).**
- **But less than the cost of carbon offset <u>by Char alone</u>, ($45/T CO_2)**

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Carbon offset value of char

- **Assuming char contains ~65% carbon, then 1 T Char offsets ~ 2.4 T CO2**
- **∴if Carbon Offset Price is ~$20/T CO2, the char is worth ~$48-60/T for this purpose**
- **It could be argued here that char offsets should be worth a premium over biooil offsets as they represent carbon actually *removed* from the atmosphere**

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Should Biochar command a premium as a carbon offset?

- **At present Agrichar/Biochar would seem to be priced the same as a fossil fuel offset**
- **There are verification difficulties that need to be resolved however**
- **But Agrichar/Biochar represents carbon actually *removed* from the atmosphere. Use as a bio-fuel only prevents increases in CO_2**

Fuel value of char is low

- **The by-product of Bio-Oil, char, can be sold as charcoal briquettes or refined to make activated carbon. In a feasibility study by Huskywood, the selling price is suggested to be $20-$25 per ton (Brady).**

  T. Brady, *"Fast Pyrolysis: Wood to Gas, Bio-oil and Fuel-Grade Char: Preliminary Economic Analysis for Southeast Alaska"*, Jan. 2002.

- **If the calorific value of char is ~25GJ/T, it implies that its energy value is only ~ $1/GJ.**

Increasing the fuel value of char

- **If** the char could be sold for energy at a price similar to BCO, namely $8/GJ, then it would be worth ~$200/T

- The value of char as an energy product is low because the mineral matter (ash) content only allows combustion in low grade industrial applications, e.g. kilns

- The higher value of $200/T could be approached by de-ashing since it would enable the char to burned in a gas turbine

- Higher fuel value for the char would make the Agrichar option less favourable

Bioenergy Perspective

- **Since there is no carbon offset premium for carbon sinks, Agrichar as a bioenergy option must be justified in other ways**
- **In so far as Agrichar application increases biomass productivity, the *rate* of CO_2 conversion to Biomass also increases.**
- **Hence a greater rate of BCO/Char production can be sustained. Thus this approach has a positive feedback loop.**
- **This is particularly important for *energy crops*.**

Agronomic Value

Possible benefits of Agrichar for Bio-energy Production

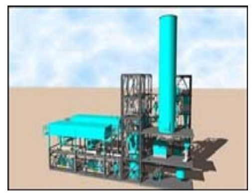
- **Very little is known about biomass yield increases on char application. Ranges of 0-300 wt% have been reported for crop yields**
- **In the context of bioenergy crops, yield increases effectively reduce the cost of biomass feed.**
- **Very roughly, a 100% yield increase would decrease biomass costs by 50%, other factors being assumed equal.**

- **Sequestering char in the soil is preferred to its use as fuel only if it decreases the cost of production**

Bioenergy Values

$88

0.65 T BCO



1 T Biomass

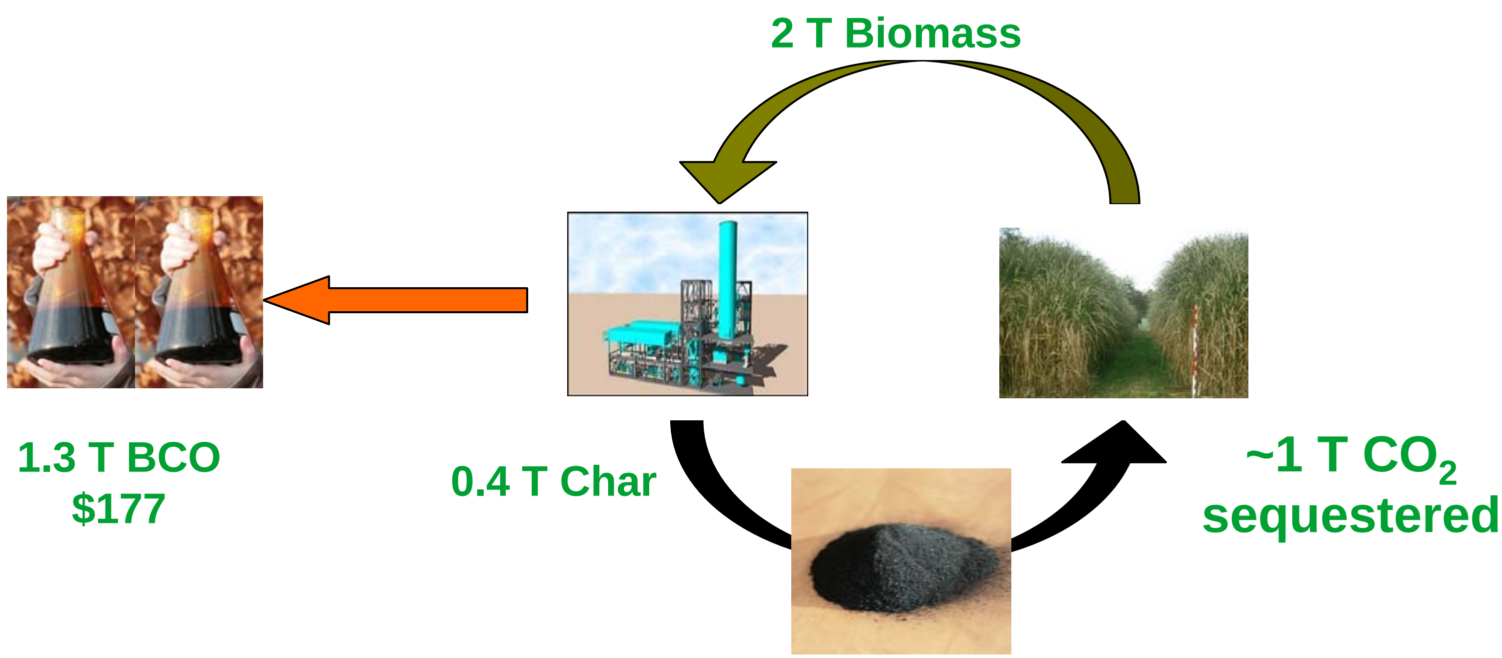
0.25 T Char

$7

Net Value = $95 - (Biomass Cost/T)

Recycling Agrichar to Energy Crops

- Assume 10 yr average productivity increase is 100%
- Assume *ALL* char is recycled
- Then on the same acreage:



Net Value of Energy = $177 - 2X (Biomass Cost/T)

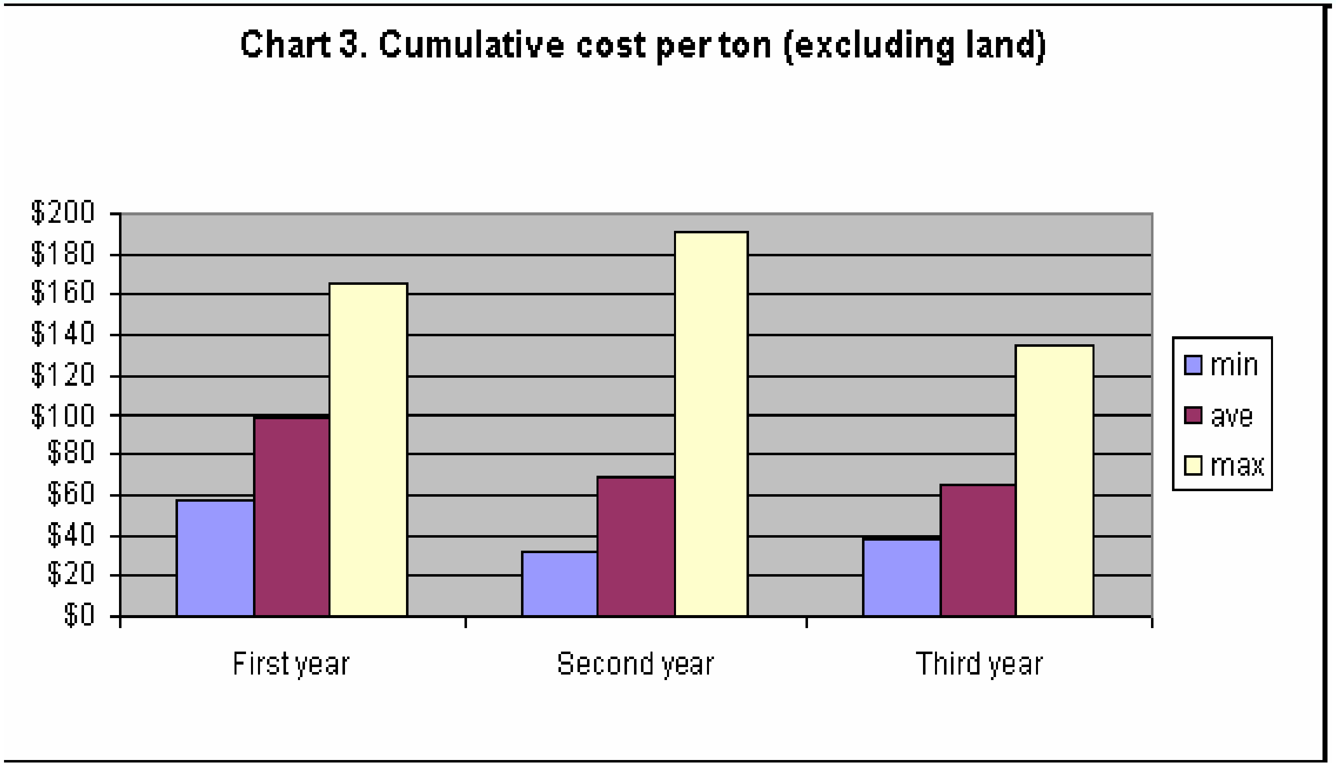
Energy Crop Examples

Reported Yields

		Yields (Dry Tonne/ha/yr)
Switchgrass		5-15
Miscanthus		15-25
Elephant Grass		30-40

Switchgrass Production Costs

From: "Switchgrass – A Biomass Energy Crop for the Midwest", (http://www.ag.ndsu.nodak.edu/streeter/2003report/Switchgrass.htm



"We believe that total production costs of $30/ton for switchgrass biomass will be achievable by Great Plains producers with good establishment techniques on land that is of marginal value for row-crops. … Transportation costs from farm to processing plants are likely to add another $10/ton for the average producer."

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Energy Crop Production Costs

- Various studies seem to suggest that, generally, under optimal circumstances energy crops like switchgrass can be produced for ~ $30-60/ton (or ~$1.5-2/GJ), excluding land costs.

- The most important variables affecting production cost are Biomass Yield, Harvesting Cost and Land Cost.

- Agrichar is likely to have a significant impact only on Yield

Advantages of Recycling through Energy Crops

- Essentially char recycling reduces the net delivered cost of biomass
- E.g., if biomass cost is reduced by recycling to say \$15/T, through increased productivity, the net *value* of BCO is \$(177-4.75*32.5) = \$23
- Compare with +\$47 at zero feedstock cost and -\$2 at \$40/T Biomass
- If a carbon credit of \$20/T CO_2 is added, the net value becomes \$43
- Thus initially free waste feedstock could be used, later switching to energy crops as the scale increased

Conclusions

- It may be more profitable to sequester char as a carbon offset rather than to sell it at its (low) fuel value
- But it may be possible and practical to enhance the value of the char, for example by de-mineralization
- Agrichar application for bioenergy production is an interesting option but the potential is unclear.
- Tests of char on energy crops like Sugar Cane, Corn, Elephant Grass, etc., need to be carried out to assess its impact on biomass feed costs and yields, if any, of co-products like cornstarch. Specifically:
    - Productivity increase for relevant energy crops
    - Methods and costs for application of Agrichar
    - Optimal levels of Agrichar (This is particularly important as excess char for sale as an energy product enhances the value of the operation)
    - Optimal schedule of Agrichar application

Thank You