Oroville, September 14 2010

Pyrolysis of Biomass

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In partnership with:
USDA Forest Service Region 5

http://ucanr.org/WoodyBiomass

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Making a Difference for California

Pyrolysis

- Pyrolysis is thermal decomposition occurring in the absence of oxygen
  - Heat for process may be external or internal (part of biomass load)
- It is the first step of combustion and gasification
- Family of related processes including:
  - Slow pyrolysis
  - Torrification
  - Torrefaction
  - Airless drying
  - Destructive distillation
  - Fast pyrolysis

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Slow pyrolysis – batch carbonization

- Proven technology (1000+ years)
- Low temperature, long residence time (550-750^{o}F, 30mins-days)
- Flexible feedstock specification
- Burns part of the load for the heat input
- Charcoal is main product
- Equipment available for large and small scale production
- AQ issues
- Works in the woods!

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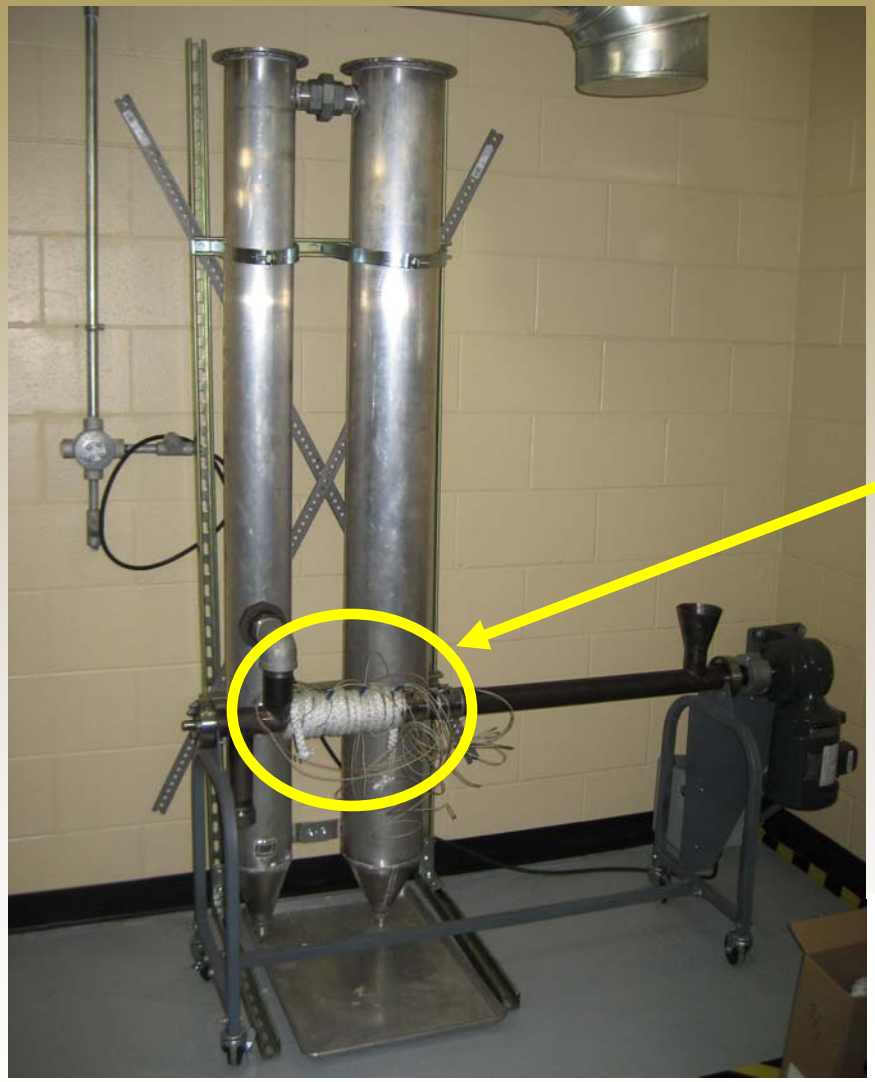
Slow pyrolysis – continuous auger system



External heat source (electricity)

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Fast pyrolysis

- An emerging technology
- Moderate temperature, short residence time (930°F/~1s)
- Products are bio-oil, char (and gas)
- Tight feedstock specification (clean, $^{1}/_{16}$-$^{1}/_{8}$”, <10% moisture)
- Energy balance can be a problem (energy required for drying and process heat)

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Fast pyrolysis – ROI mobile equipment demo, Oregon, Aug ‘09

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Torrefaction or Torrification

- Mild pyrolysis
- 400-600^{o}F
- Product is char (“bio-coal”)
  - ~Loss of mass (cheaper transportation)
  - Higher energy density (10,500 BTU/lb vs 8,500 BTU/lb)
  - Hydrophobic (store outside)
  - Easier to grind than wood
  - Potential fuel for coal power plants
- Scale-up and financing is an issue

Pyrolysis outputs

1. Liquid (bio-oil - C, H, O and other constituents)
2. Char
3. Gas

Vary depending upon process conditions (residence time and temperature)…

Mode	Conditions	Liquid	Char	Gas
Fast pyrolysis	moderate temperature, short residence time particularly vapour	75%	12%	13%
Carbonisation (slow pyrolysis)	low temperature, very long residence time	30%	35%	35%
Gasification	high temperature, long residence times	5%	10%	85%

Source: PyNe

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Bio-oil

- Potential to substitute for conventional fuels in boilers, engines, turbines (*note*: may damage equipment, invalidate warranty)
- Heating value 40% of fuel oil/diesel (~17 MJ/kg at 25% wt. water)
- Does not mix with hydrocarbon fuels
- Acidic (pH 2.5)
- Not as stable as fossil fuels (storage issues)
- Needs further refining steps for most applications

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Char, Biochar, Charcoal, Torrefied wood

- Charcoal – barbeques, restaurants
- Filtration (water and air) using activated carbon
- Soil improvement
- Growth media (substitute for vermiculite)
- Artists charcoal
- Fuel for coal (or other power plants)
- Prices vary with quality and end-use

Current status – fast pyrolysis

- Many demo projects (inc OR and CA)
- Few commercial installations (~2 in USA producing liquid smoke)
- 10+ vendor US/Canada companies (eg, Dynamotive, Ensyn, ABRI, ROI, RFT)
- Potential mobile in-woods units – unproven
- Pricing unclear
  - $250,000+ for 1ton/day unit
- Tampere, Finland integrated pilot facility (Metso/UPM/VTT) linked to BFB boiler

Key points

- Slow pyrolysis
  - Proven technology
  - Markets exist for product (charcoal)
- Mild pyrolysis (torrefaction)
  - Almost proven technology
  - Proven markets
  - Scale-up issues (finance, feedstock and market for product)
- Fast pyrolysis
  - Emerging technology
  - Limited markets
  - May use more energy in process than it produces
  - Cost basis unclear – need high value products or zero cost feedstock
  - Use of bio-oil as a chemical feedstock or for liquid smoke makes sense
  - Larger scale integrated systems (eg with power plant) may work
- Carry out due diligence

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Questions?

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Key Questions to Ask

- Is the technology commercially deployed (proven)?
- What is the feedstock specification?
- What are the markets for the output products?
- Do the economics work?
- Is the process a net energy user?
- Permitting requirements?
- Do not rely on technology vendors for balanced information

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