Torrefaction, Biochar, & Biofuels: Valued Added Products for Forest Biomass?

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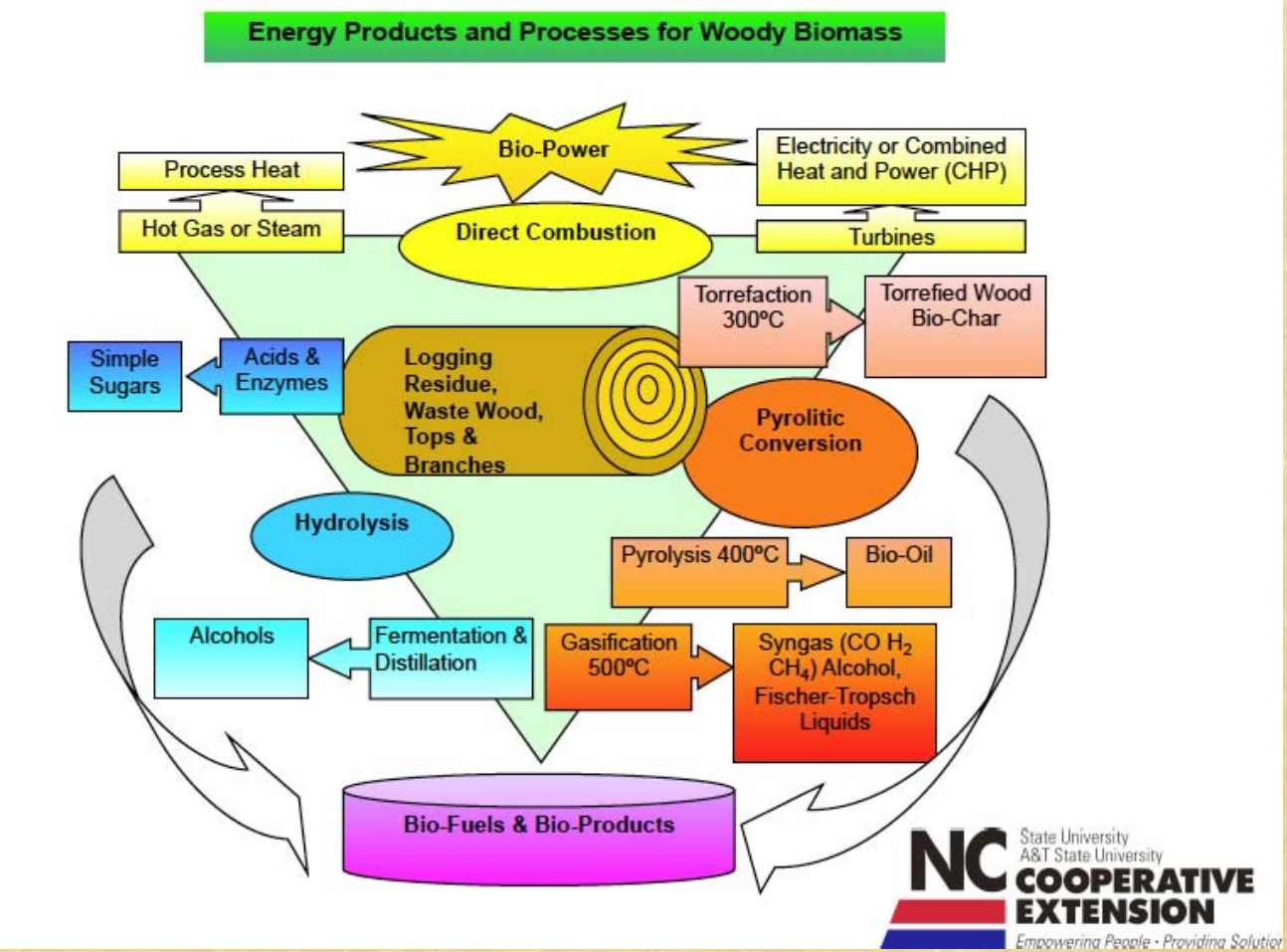
Energy Conversion Technologies

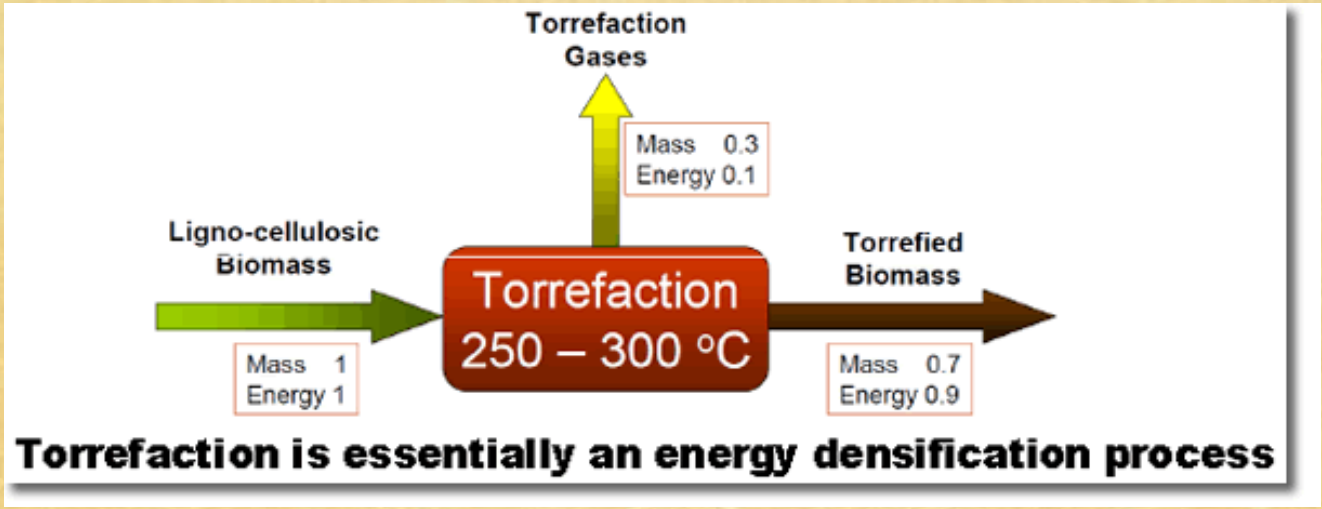


Torrefaction

- **Process**
  - Thermochemical treatment, similar to roasting (pyrolysis)
  - Separates water, some VOCs, & hemicellulose in woody biomass, leaving cellulose & lignin at 200-300°C
  - Produces a carbonaceous residue, lignin when warm acts as a binder during pelletization (when applicable)
  - Results yield 66%-75% of the original mass

Torrefaction

~30 percent decrease in mass, with only 10% loss of energy yielding a more energy dense output



Torrefaction

- **Benefits**
  - Higher Energy Content (per unit volume)
  - Lower Moisture Content
  - Makes biomass hydrophobic
    - Lower Transport Costs
    - Outdoor storage
  - Negligible decomposition or mold
    - Longer life without fuel degradation
  - Smoke producing compound removed
  - Homogeneous fuel when pelletized
  - Higher lignin fraction than green wood, yielding a stronger pellet

Price range: $70 to $110 per ton
Primary market: Cofiring w/coal, mostly Europe

Torrefaction

- **Drawbacks**
  - Low Volume enhancement
  - 10% loss of original energy content
  - All ash components are still present
  - Additional processing adds cost

    Limited commercial operations in U.S.

    Limited use in U.S.

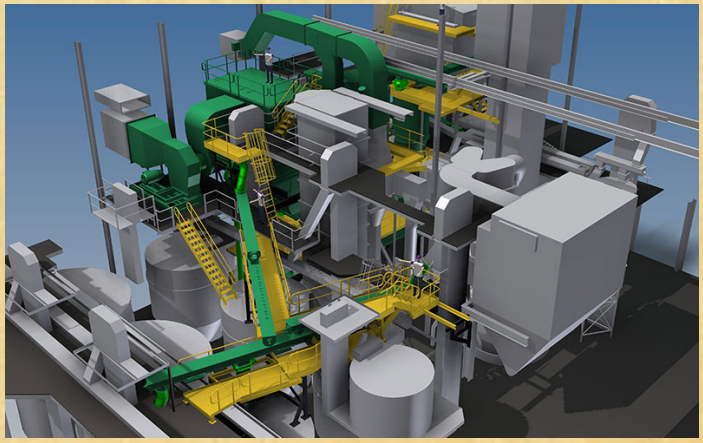
Torrefaction Facilities

Operating

- New Biomass Energy (Mississippi)
- Energex (West Virginia and Virginia)
- Alterna Energy (Canada and South Africa)

Planned

- Terra Green Energy (PA)
- PacWest Global (OR)
- Agri-Tech Producers (SC)
- Integro Earthfuels (NC)
- ConocoPhillips



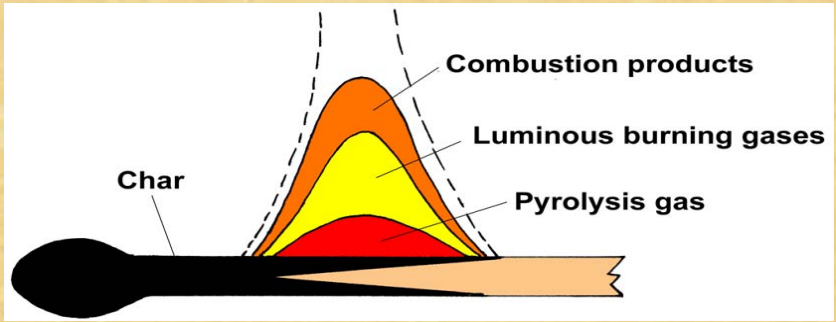
Torrefaction

- Source for torrefaction info: http://www.agrireseau.qc.ca/references/32/presentations_guelph/2Torrefaction%20-%20Pros%20and%20Cons%20By%20Mathias%20Leon%20UoG.pdf

Biochar

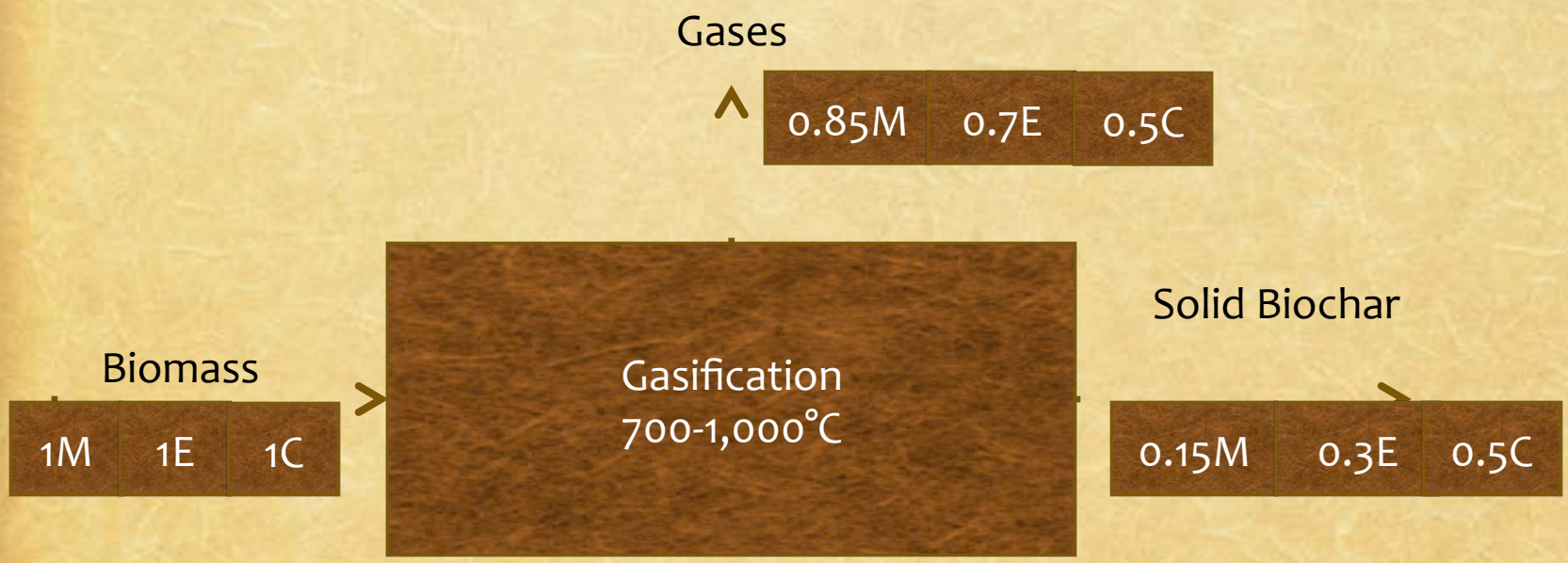
- **Process**
  - Thermochemical treatment, developed through gasification
  - Separates water, VOCs, & hemicellulose in woody biomass. Also breaks the cellulosic structure of the wood at 700-1000°C
  - Produces a carbonaceous residue

    Biochar can be between 75%-85% fixed carbon
  - Results yield 7%-20% of the original mass



Biochar

~85 percent decrease in mass, with 70% loss of energy yielding a more energy dense output



Biochar

- **Benefits**
  - High fixed carbon content makes it ideal for soil amendment
    - Retains about 50% of the total carbon in 15% of the mass
  - Moisture Content is effectively 0%.
    - Makes biomass hydrophobic
    - Lower transport costs
    - Outdoor storage
  - Negligible decomposition or mold
    - Longer life without fuel degradation
  - Can be a byproduct of syngas production

Price range: $500 to $4,500 per ton
Primary market: Soil amendment

Biochar

- **Drawbacks**
  - When biochar is the primary product, the yield per unit input is very low, for 1 ton of biochar, a gasifier must consume 5-10 tons of wood feedstock – syngas produced and must be flared if not used for energy source
  - Expensive to process biochar into a combustible form, biochar is typically crushed through the gasification process (by screw augurs)

Biochar Facilities

- Phoenix Energy (CA)
- Ambient Energy (WA)
- Advanced Biorefinery (Canada)
- Agritherm (Canada)
- Alterna Biocarbon (Canada)
- Avello Bioenergy (IA)
- Biochar Solutions (US and Canada)
- Carbon Brokers International (CO)
- CarbonChar Group (NJ)
- Carbon Resources (US)
- Dynamotive Energy systems (Canada)
- Ecovolve (NY)
- Eprida (GA)
- Genesis Industries (CA)
- HM3 Energy(OR)
- Landscape Ecology (HI)
- New England Biochar (MA)
- Pyrolyzer (FL)
- R&A Energy Solutions (OH)
- Rocket Stove (WA)
- Renewable Oil International (AL)
- Syngest (IA)

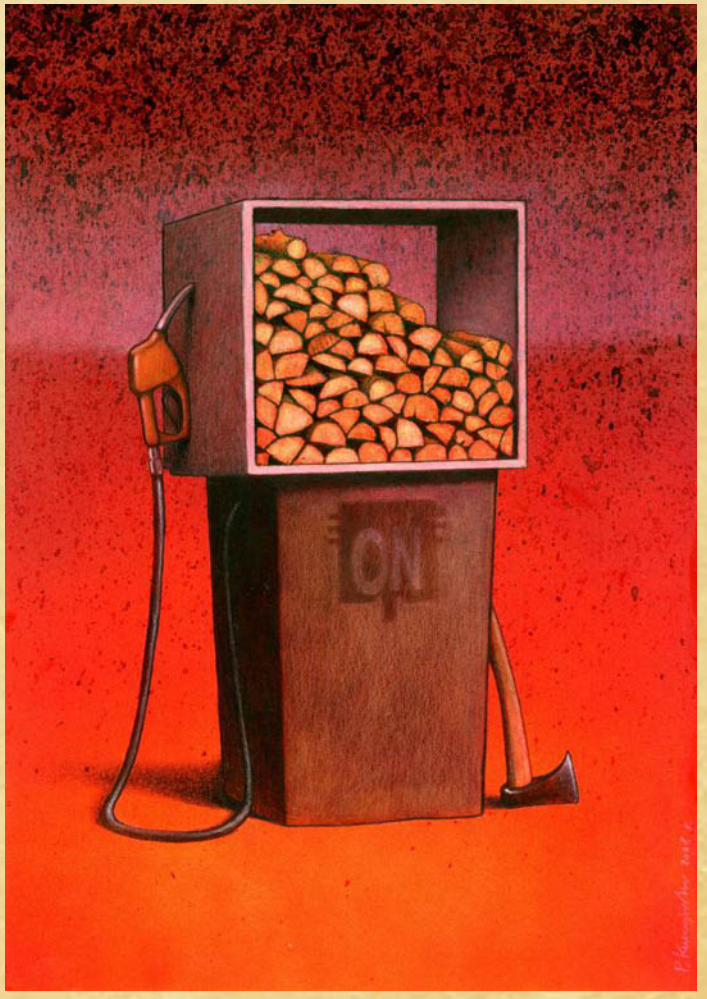
Biochar

- A good place to start:

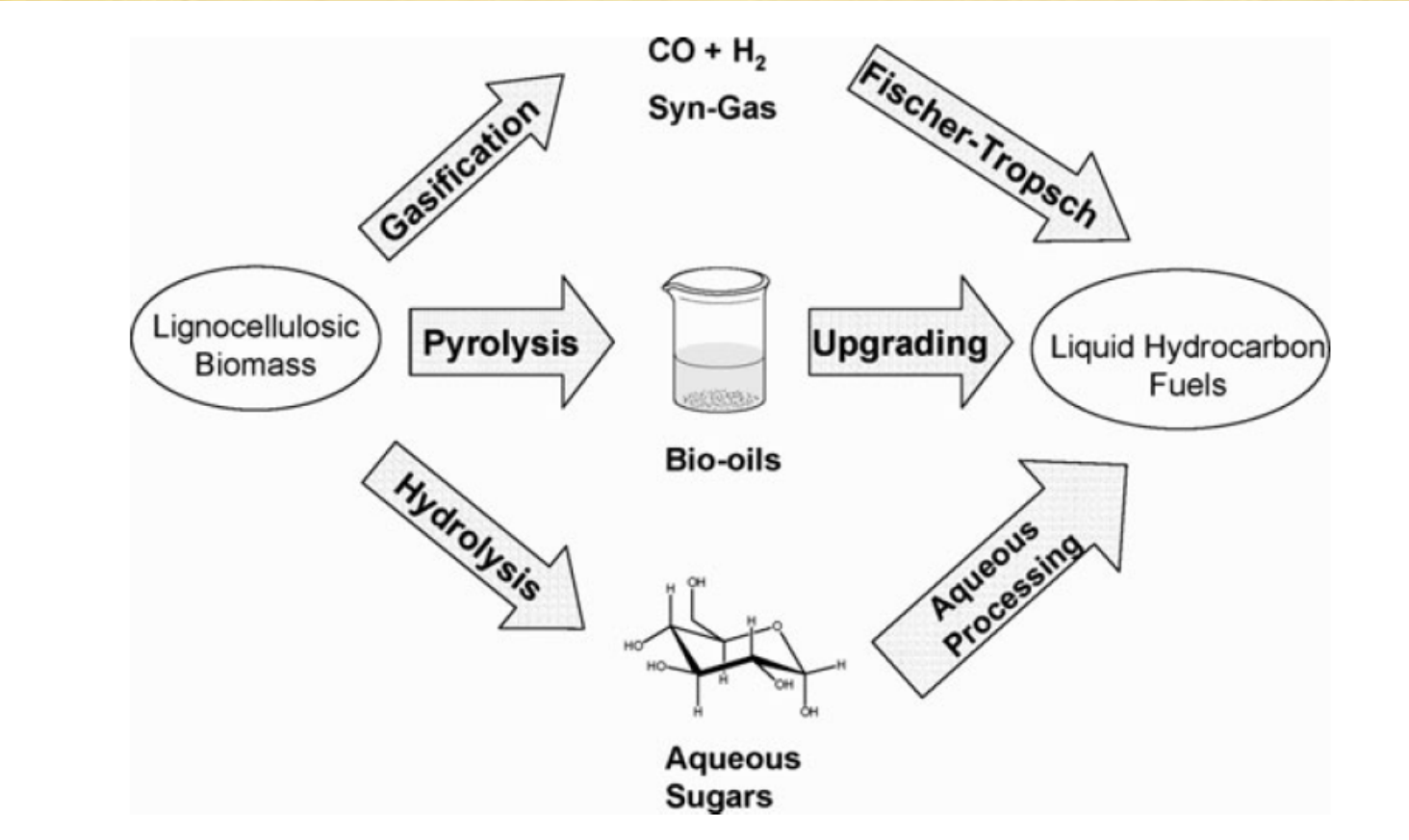
http://www.biochar-international.org

Biofuels

- Cellulose to biofuels is coming – facilities are under construction and beginning to produce fuel
- Transportation fuel diversity and security
- Potential value-added use for forest biomass



Three Primary Pathways to Fuels



➔ A potential fourth pathway is to Renewable CNG

Types of Biofuels

- Ethanol
- Renewable Diesel and Gasoline ("Drop-in Fuels")
- Bio-oil (needs upgrade)
- Biomethane (Renewable CNG)
- Butanol
- Methanol
- Dimethyl Ether (DME)

Forest Biomass-Based Biofuels

- **Benefits**
  - Economic stimulation - Potential long-term market for forest biomass waste
  - Various environmental benefits – greatly reduced carbon emissions, improved air quality, improved forest health
  - Renewability
  - Energy security
  - Potential for less expensive fuel (in the future)

Forest Biomass-Based Biofuels

- **Drawbacks**
  - Current higher costs of feedstock from forests
  - Biofuel production facilities will need to be large with significant initial capital costs
  - Need for extensive infrastructure to supply large facility
  - Lower energy output for current principal biofuels

Forest Biomass-Based Facilities

Operating

- KIOR (MS) – Renewable gasoline and diesel via gasification, 62.5 MGY

Planned (or at least contemplated)

- KIOR (Southeastern U.S.) – 3 more facilities @ 62.5 MGY each
- Mascoma (MI) – Ethanol via fermentation, 40 MGY
- Cleanfuels/Rentech (Ontario) – Renewable diesel via gasification, 23 MGY
- Core Biofuels – Renewable gasoline via gasification, 18 MGY

There are several demonstration facilities in the U.S.

Biofuel Economics

- There are four primary factors that determine the cost of the finished product: the feedstock, chemical processing (e.g., pyrolysis), refining and finishing the crude product, and the transportation and distribution of finished biofuel.
- Depending on who you talk to, oil needs to be at $80 to $100-plus per barrel for biofuels to compete.
- And, depending on who you talk to, feedstock costs must be $35/BDT or less (much less). Emerging technologies may change this.