Black Diamond, Black Char, (new) Black Gold

BRDI project ----
Integration of Biofuels and Bioproducts Production into Forest Products supply Chains using Modular Biomass Gasification and Carbon Activation

Technical Area 1: Feedstocks Development

1. Evaluate existing and new systems of harvesting, processing, and transporting forest biomass feedstock from the forest to biomass conversion facilities
2. Develop enhanced system logistics
3. Develop new trucking and processing equipment
4. Produce next-generation landscape-level spatial feedstock supply models

BRDI project ----
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Technical Area 2: Biofuels/Bio-based Products Development

1. Research, develop and improve the performance of a modular biomass gasification system (Tucker unit)
2. Evaluate the suitability of biochar outputs for the production of activated carbon
3. Develop and test pelletizing processes that can be used to improve the transport and storage characteristics of the carbon output, as well as its suitability for filtering and soil amendment applications.
4. Research and develop equipment and methods of spreading biochar on forest and agricultural sites.

BRDI project ----
Integration of Biofuels and Bioproducts Production into Forest Products supply Chains using Modular Biomass Gasification and Carbon Activation

Technical Area 3: Biofuels Development Analysis

1. Evaluate net life cycle greenhouse gas emissions and energy balance of Tucker System products (LCA)
2. Evaluate the impacts for forest biomass utilization
3. Develop financial models for biomass on economic conditions in the US West
4. Develop an economic synthesis of modular gasification at forest industry facilities

Our part:
Life-cycle analysis

Evaluate net life cycle greenhouse gas emissions and energy balance of Tucker System products using consequential life cycle assessment syngas for heat and electricity and **biochar** for activated carbon for filtering applications.

Life-cycle Inventory Analysis of Bio-products from a Modular Advanced Biomass Pyrolysis System

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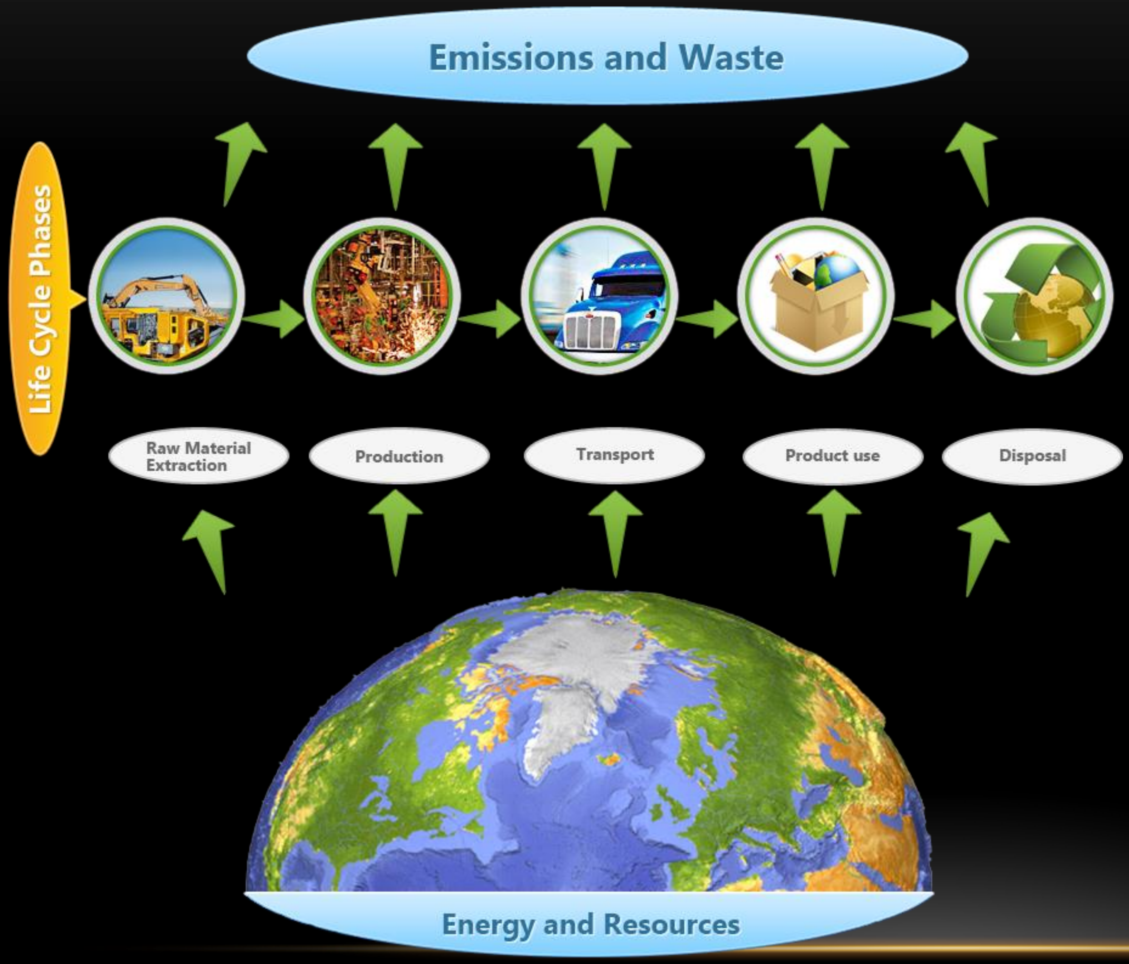
Illinois Biochar Group Spring meeting

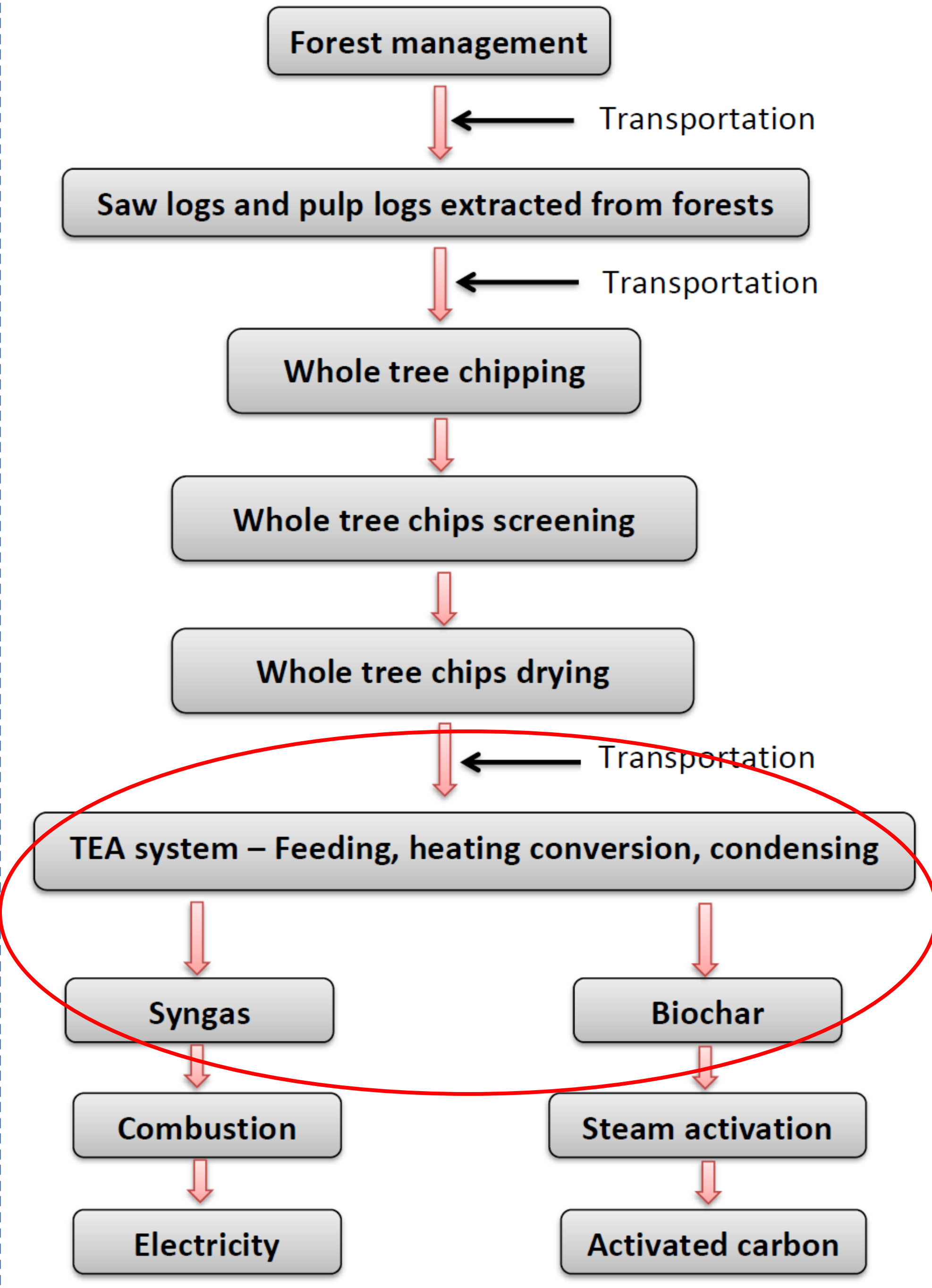
WHAT IS LIFE-CYCLE ANALYSIS (CONT.)?



LCA calculates all kinds of environmental impacts (Carbon footprint, energy, water, acidity, toxicity, etc.) for a product or service across the entire life cycle – from raw material extraction, to product making, to distribution, use, and end of life.

CARBON SEQUESTRATION BY BIOCHAR

- One metric ton of oven dry building timber stores roughly 510 kg of carbon, corresponding to 1.8 metric ton of CO_2;
- One metric ton of biochar stores roughly 880 kg of carbon, corresponding to 3.2 metric ton of CO_2;



SYSTEM CHAIN

- Up Stream: forest management, extraction, chip production
- Tucker (TEA) system – pyrolysis
- Down Stream: syngas to electricity, biochar to activated carbon

GOAL OF PROJECT LCA

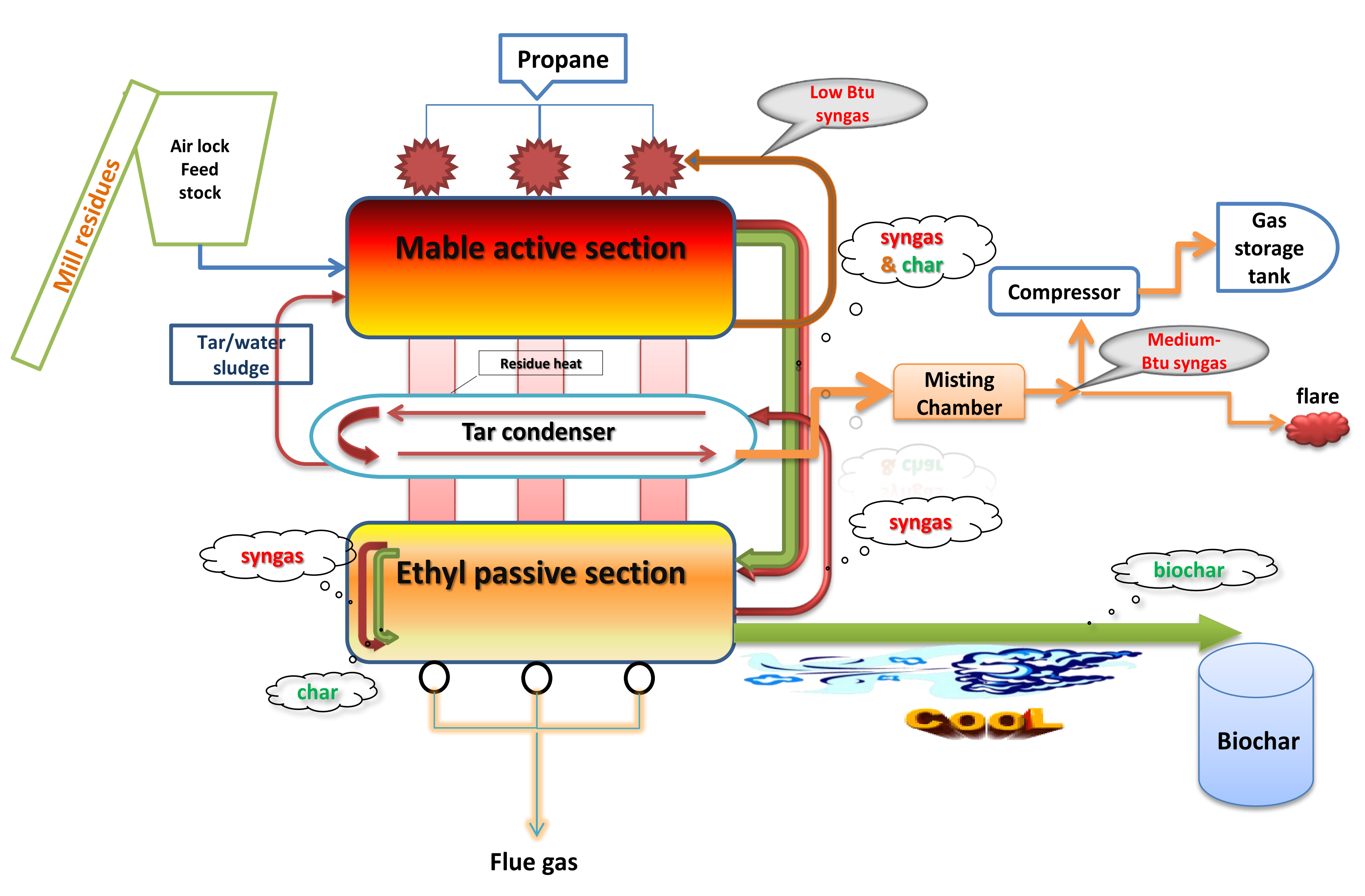
Conduct comparative LCA for the following:

1. Activated carbon from coal or biochar
2. Electricity from fossil fuels or syngas

Determine the following:

- Mass and energy balance of biomass pyrolysis
- Net GHG balance of bio-based products
- Major environmental impacts

Process flow diagram for Tucker system



MASS AND ENERGY BALANCE

Initial analysis -- Functional unit is 263 kg (580 lb) of pine/fir chip

Mass and Energy Inputs				
Source	**Mass (kg)**	**Energy (MJ/kg)**	**Total Energy (MJ)**	**Percent (%)**
Feedstock	**263**	18.4 [(1)]	4,848	72.0%
Propane	36.4	51.8 [(2)]	1,885	28.0%
Total Thermal			6,732	100%
Parasitic				
Electricity	2.87 kWh	3.6 MJ/kWh [(2)]	10.3 MJ	

[(1)] As measured from wood chips with 8.19% moisture (wt)
[(2)] Propane and electricity unit energy HHV values are taken from Franklin Database

MASS AND ENERGY BALANCE

Initial analysis - Functional unit is 263 kg (580 lb) of pine/fir chip

Mass and Energy Outputs					
Source	**Mass (kg)**	**Mass (%)**	**Energy (MJ/kg)**	**Total Energy (MJ)**	**Percent (%)**
Syngas	172	65.4	17.96[(3)]	3,091	64.1
Tar, oil/water	54.3	20.6	10.54	572	11.9
Biochar	36.4	13.8	31.74	1,156	24.0
Total	263	100		4,819	100

[3)] unit energy value for biochar and tar oil/water were obtained from the proximate analysis and syngas unit energy value obtained from ASTM-D1945/3588 standard tests.

ENERGY RESULTS

Total energy gain	Net energy gain	Fossil energy input into the system	Bioenergy output from the system	Fossil Energy Replacement Ratio
(MJ)	(MJ/kg)	(MJ/kg)	(MJ/kg)	(MJ/MJ)
2,924	12.0	7.79	19.80	2.54

- Zaimes and others (2013) reported EROI for miscanthus and switchgrass to convert into biofuel for bioelectricity at 2.5 to 4.5 MJ/MJ;
- Gaunt and Lehmann (2008) showed a net energy gain for a slow pyrolysis-based bioenergy system for biochar and energy production of 2–9 MJ/MJ;
- Patzek (2005) and Metzger (2006) reported net energy gain for ethanol from corn at about 0.7 – 2.2 MJ/MJ
- Steele and others (2012) reported an EROI of 2 MJ/MJ for cradle-to-grave production and use of bio-oil derived from southern pine whole tree chips

MODELING OF TUCKER UNIT – SIMAPRO 8

SUBSTANCES			
Air emission	Unit	Quantity	Percent, by mass
Carbon monoxide	g	2.14	0.3%
Carbon dioxide, biogenic	g	0.43	0.1%
Carbon dioxide, fossil	**g**	**709**	**98.4%**
Methane	g	2.01	0.3%
Sulfur dioxide	g	3.32	0.5%
Water emissions			
Suspended solids, unspecified	g	43.54	46.7%
Chloride	g	34.17	36.7%

Most fossil CO_2 and water emission are from burning propane and transporting the chips from Montana to North Carolina. Electricity use of Tucker unit operation is minor.

CONCLUSION – TUCKER UNIT LCI

- Cumulative energy consumed - 12.1 MJ/OD kg chips
  - Generated from primary energy
  - Includes indirect energy used to make fossil fuel energy products
- Fossil Energy Replacement Ratio (FERR) is 2.54,
  - On the low end of other bioenergy systems
  - Does not include upstream and downstream processes
- Most air and water emission are from propane and diesel
  - Co-locating unit
    - Substantially lower diesel fuel use (i.e. GHG emissions)
    - Lower cumulative energy/increase FERR

FUTURE BIOCHAR WORK

- Tucker unit has been upgraded
  - Selling electricity on grid (Renewable Energy Credits (3x))
  - Fixed carbon of biochar has less variability
- Making activated carbon from new biochar
  - Steam activation – rotary calciner (Alston?)
  - Plan to re-characterize
  - Find environmental impacts (LCA)
  - Use for filter applications

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QUESTIONS?

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