LCI/LCA Strawman Approach for Parametric Bio Processing Models
CORRIM Life Cycle Inventories
Extension to BioEnergy and BioChemicals

Joyce Cooper
Associate Professor of Mechanical Engineering
University of Washington
cooperjs@u.washington.edu

DFE Lab website:
http://faculty.washington.edu/cooperjs/
Straw-man Data and Model Collection Framework

- Framework is based on core parametric models of unit process performance
  - Unlike prior wood product LCI analysis, much of the information will be based not on current practice, but instead on computational models representing laboratory and prototype performance including impact of larger scale facilities.
  - Like prior LCI studies, the standards for collecting data/model results must allow consistency across methods, regional differences and researchers in order to develop aggregate burdens (carbon in particular), across stages of processing and regions.
Use of CORE process models

- **Life cycle inventories** can be built around core process models, representing unit processes in the development through commercialization
  - When the models are parametric, we have the ability to
    - Assess life cycle variations for important operating parameters
    - Engineer systems that are better for the environment
Example from the UWME DFE Lab: Producing Electricity from Cal Forest Wildfire Fuels Treatments

- We looked at
  - the acquisition and processing of residual biomass (harvest, chipping operations, and underburning within the forest),
  - transport of chips to a biomass power plant,
  - the conversion of the chips into electricity,
  - and wildfires
- for a 2.7 million-acre landscape encompassing both public lands (portions of the Plumas, Lassen, and Tahoe National Forests and Lassen National Park) and private lands surrounding the Mt. Lassen power plant in Westwood, California.
- for no-treatment and the treatment of Industrial Private & Public Multiple Use Forests (IPF + PMU)
Phase 1 of the B2E project provided a model of model interconnection.
Phase 1 of the B2E project provided a model of model interconnection.
Example from the UWME DFE Lab: Producing Electricity from Cal Forest Wildfire Fuels Treatments

Forest Treatment and Chip Transport Models and Data

- Forest treatment and chip transport included
  - off-road equipment use
  - on-road equipment use
  - underburning during treatment operations

13 prescriptions
(clear cut, pre commercial thinning...)

Equipment configurations for 24 different types of equipment
(feller bunchers, skidders, chainsaws...)

Fuel use and emissions data from the USEPA's NONROAD and MOBILE models and other B2E project models
Example from the UWME DFE Lab: Producing Electricity from Cal Forest Wildfire Fuels Treatments

- **Life Cycle Fuel, Oils, and Electricity Production Models and Data** - from GREET
- **Biomass Power Plant Models and Data**
  - representing Mt. Lassen *plant measurements* (a 20% eff. stoker boiler (Zurn travelling grate) and assuming electrostatic precipitators for PM control)
  - supplemented with data from AP-42, NONROAD, and GREET
  - included the use of supporting equipment (a dozer, 2 loaders, a bobcat, a tub grinder, a natural gas emergency generator) and grid electricity

- **Wildfire emissions** (the Fire Behavior Models)
- **Accounting for the Carbon in Chips and Sawlogs** (based on IPCC temperate forest data♪)}
Example from the UWME DFE Lab: Producing Electricity from Cal Forest Wildfire Fuels Treatments

- **Alternative Power Plant Technologies**
  - Although this project provided a model of model interconnection, it fell short in realizing the opportunity to integrate a range of parametric models of alternative power plant technologies and a wider variety of biomass use options.

Project included models of
  - The Mt. Lassen plant (a 20% eff. stoker boiler, Zurn travelling grate with electrostatic precipitators for PM control)
  - Current generation integrated gasification/combustion power plant at 22% efficiency
  - Next generation thermo-chemical conversion plant at 28% efficiency
Straw-man Data and Model Collection Framework

- The goal is to combine parametric models of technology performance to prepare LCI data

- Unit process hierarchy:
  - Biomass Collection, Sorting & Delivery
    - Forest residuals, fire risk reduction thinnings, short rotation woody crops, mill residuals, agricultural & municipal waste
  - Pre Processing
  - Processing
  - Reference Systems
  - The Rest
Unit Process Hierarchy

Biomass Collection, Sorting & Delivery:
- Forest residuals, fire risk reduction thinnings, short rotation woody crops, mill residuals, agricultural & municipal waste

Forest response (wildfires, growth, soil processes...)
- Nursery-plant/ seed trees
- Vegetation control/ chemical treatments
- Thinning and Harvest
- Sorting & densification (e.g., chip, pelletize, etc. on-site)
- Delivery

Pre Processing:
- Torrefaction
- Pelletization
- Chipping
  - Pyrolysis
  - Gasification
  - Fermentation

Processing/ Conversion:
- Conventional boiler
- Boiler cogeneration
- Turbine cogeneration
- Refining for fuel
- Refining as a chemical feedstock
- Solid & Composite Structural Products CORRIM Ph1&2
- Wood Products CORRIM Ph1&2
- and more
Reference Systems

- The “Processing and Conversion” group reflects our reference systems

Reference Systems = conventional ways to produce system products

Production of electricity (regional grids, NGPP, coal, ...)
Production of mobile fuels (conventional gasoline, diesel, ...)
Production of chemical feedstocks (alcohols, ...)

Processing/Conversion

Conventional boiler
Boiler co-generation
Turbine co-generation
Solid & Composite Structural Products CORRIM Ph1&2
Wood Products CORRIM Ph1&2

Refining for fuel
Refining as a chemical feedstock
LCI/LCA Strawman Approach for Parametric Bio Processing Models

- So these are the DRAFT SET of unit processes that will be represented by parametric models
- The LCI/LCA strawman approach for the use of the parametric models is.....

**Sensitivity analyses** on unit process models will be used to identify the important performance parameters FOR EACH UNIT PROCESS

Unit process data SETS will be formulated for each box in the hierarchy, explicitly identifying the value of each performance parameter in the data set name

SimaPro will be used to link unit process data sets to each other and to other LCI data (electricity gen., diesel production...)

<table>
<thead>
<tr>
<th>Process Type</th>
<th>Data Set Name</th>
<th>Performance Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bark/Wet Wood, 22% at: Non-PCR Combustor; Wet Scrubber</td>
<td></td>
<td>total energy, petroleum energy, fossil energy, PM10 emissions to air, CO2 emissions to air</td>
</tr>
<tr>
<td>Dry Wood (&lt;20% MC); 20% at: FIC Combustor; Electrolyzed Gravel Bed</td>
<td></td>
<td>total energy, petroleum energy, fossil energy, PM10 emissions to air, CO2 emissions to air</td>
</tr>
</tbody>
</table>
Ground Rule 1: Unit processes will often have multiple products

- Unit process data should not be allocated in any way or include any system expansion
  - Such computational remedies for multi-functionality MUST BE DONE AT THE LCI LEVEL
- Unit process models should be technology specific and include all relevant inputs and outputs

We WANT this

- Bio-diesel production
  - All the materials
  - All the energy
  - All the wastes

We DO NOT want this

- Bio-diesel production
  - Some fraction of the materials
  - Some fraction of the energy
  - Some fraction of the wastes

Assuming research in/ models of each unit process will tell us what is relevant
Ground Rule 2: Pre-processing and Processing and Conversion Unit Process Data should NOT be SITE-SPECIFIC

- Unit process inputs **should not include**:
  - Specific transport modes and distances
  - Specific electricity grids
  - Specific on-site energy generation technologies
  - Specific waste management technologies
  - .......

We DO NOT want this

- 5 tkm medium duty truck transport
- 5 kWh from the WA State grid
- 5 MJ diesel generator
- Bio-diesel production
- Bio-diesel
- Raw glycerol
- 5 kg to the Cedar Hills Regional Landfill

Instead, we want this

- X kg feedstock transport
- 5 kWh electricity
- 5 MJ on-site heat
- Bio-diesel production
- Bio-diesel
- Raw glycerol
- 5 kg of “waste” with what constituents

So in the LCI, we can put a processing plant wherever we like (Seattle, Davis, Denver...)

UWME Design for Environment Lab

Assessing the life cycle environmental aspects of emerging technologies
**Straw-man Data and Model Collection Framework**

- Like prior LCI studies, the standards for collecting data/model results must allow consistency across methods, regional differences and researchers in order to develop aggregate burdens (carbon in particular), across stages of processing and regions.

  **Proposal**

  **1st interim report**
  Goal and Scope Definition

  **2nd interim report**
  Inventory Analysis

  **3rd interim report**
  Impact Characterization

  **Final report**
  Interpretation

  **Distributed unit process data preparation**

  **Domain lead**

  **Central preparation and dissemination of LCIs**

UWME Design for Environment Lab
Assessing the life cycle environmental aspects of emerging technologies
Straw-man Data and Model Collection Framework

- Questions?