Feedstock Pretreatment for Pyrolysis Upgrading (WBS 3.1.2.5)

DOE Bioenergy Technology Office

Heat & Power

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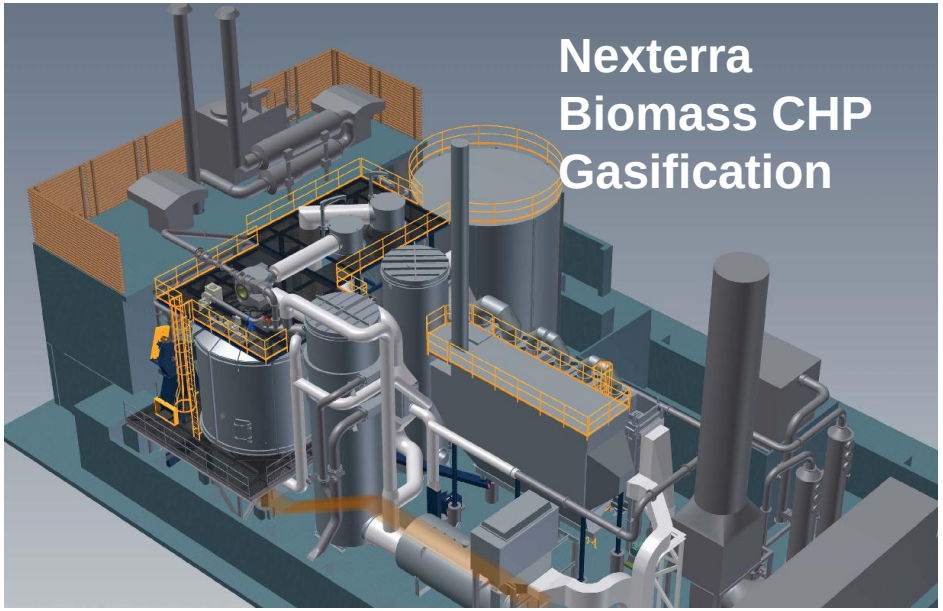
U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Goal



Provide a consistent quality feedstock to the conversion plant.

- **Densification**
- **Moisture content**
- **Particle size**
- **Ash, Chlorine**
- **Enhanced calorific value**

Quad chart overview

TIMELINE

Start date: 2011

End date: 2017

Percent complete: 40%

BUDGET

Total project funding (FY11-FY13): $160K
DOE Share: 100%

Funding Received
FY 11:$40K
FY 12:$40K
FY 13:$80K

BARRIERS

- Ft-G Biomass storage systems
- Ft-J: Biomass material properties
- Ft-K: Biomass physical state alteration
- Ft-L: Biomass materials handling and transportation
- Gt-A, It-A: Feeding dry biomass
- Tt-E, Gt-B: Pyrolysis & gasification
- Gt-I: Process control

PARTNERS

Idaho National Laboratory

University of British Columbia
CEATI International (Center for Energy Advancement through Technological Innovation)

CANMET Energy – Natural Resources Canada

Natural Sciences and Engineering Research Council - Canada

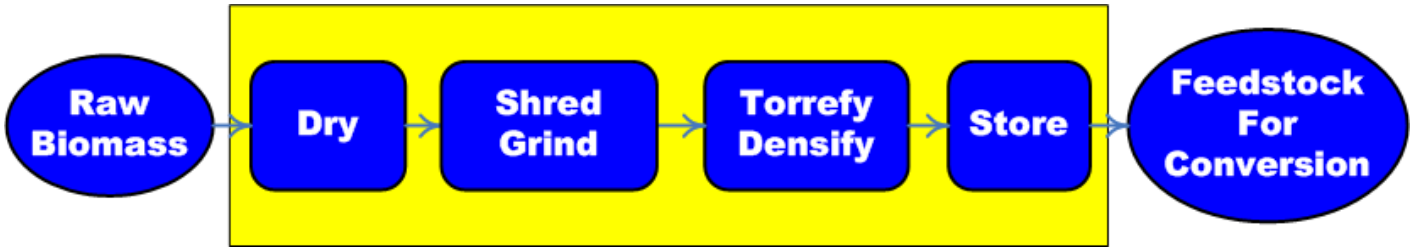
Biofuel Network Canada – Centers of Excellence

Wood Pellet Association of Canada

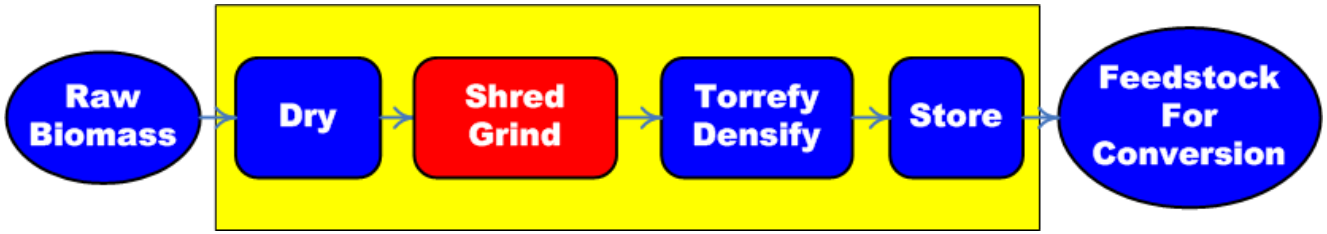
1- Approach (in stages)

- Understand physical and compositional properties of feedstock and engineering factors in pre processing operations.
- Develop engineering data and equations to describe material properties, mass and energy flows and balances.
- Contribute to the development of standards and engineering practices.
- Implement equations and data in logistics modeling, design and operation of equipment.

This Task is coordinated with the Feedstock Logistics Task (WBS 1.6.1.1)



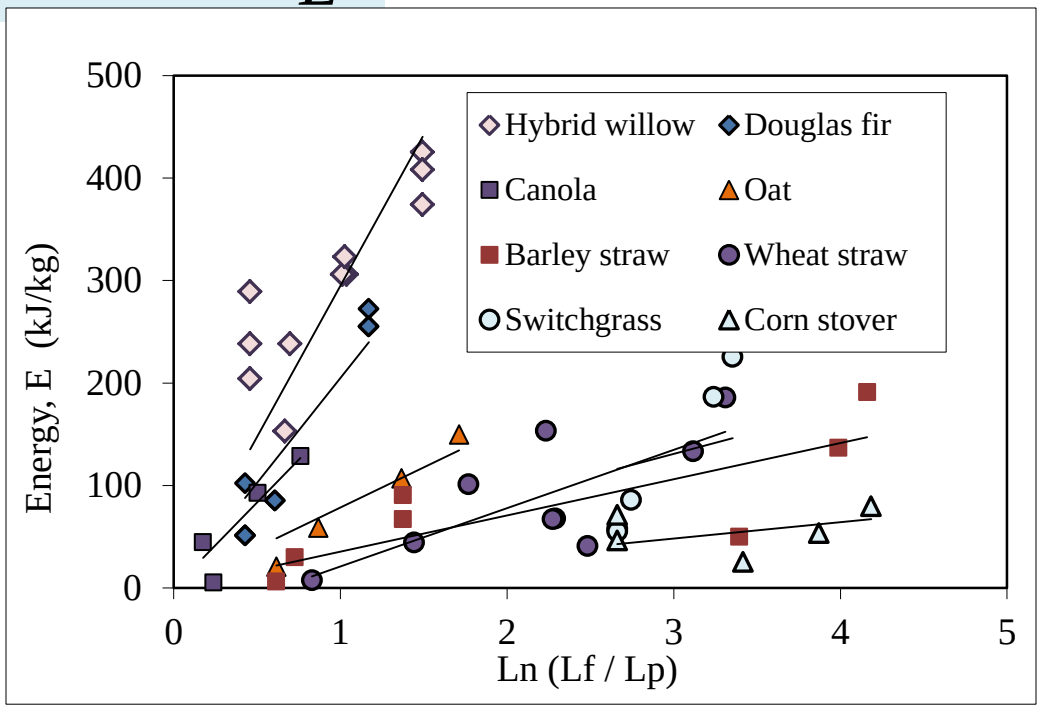
2. Results



Von Rittinger equation had best fit to size reduction data to predict energy consumption for grinding biomass from size L_f to size L_p

$$dE = -K\,ln\frac{dL}{L^n}$$

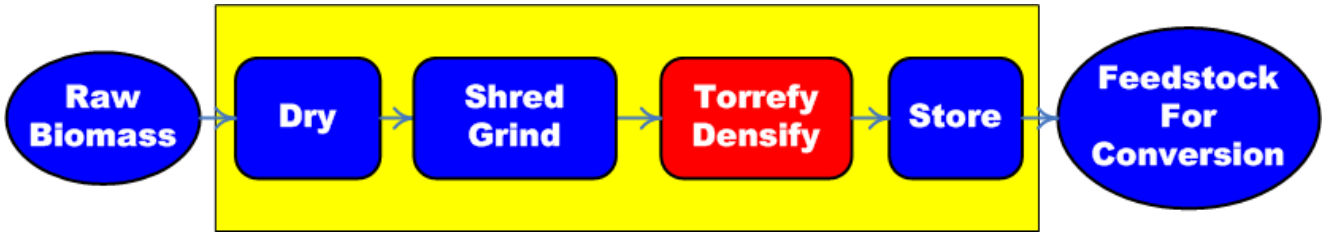
von Rittinger n=2
fits best to the data



Knife mill

Hammer mill

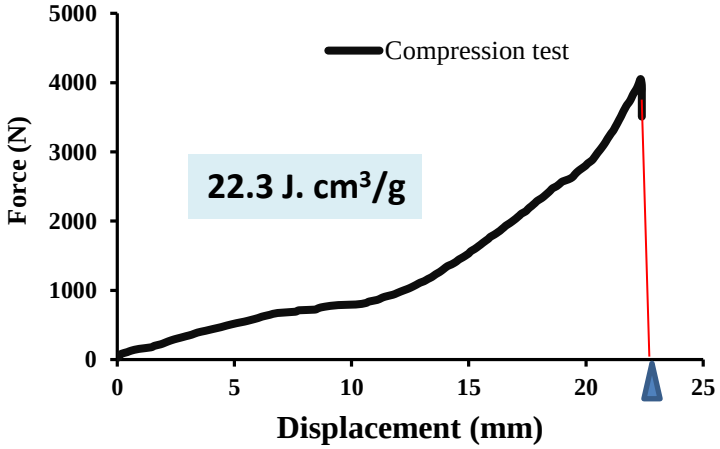
2- Results

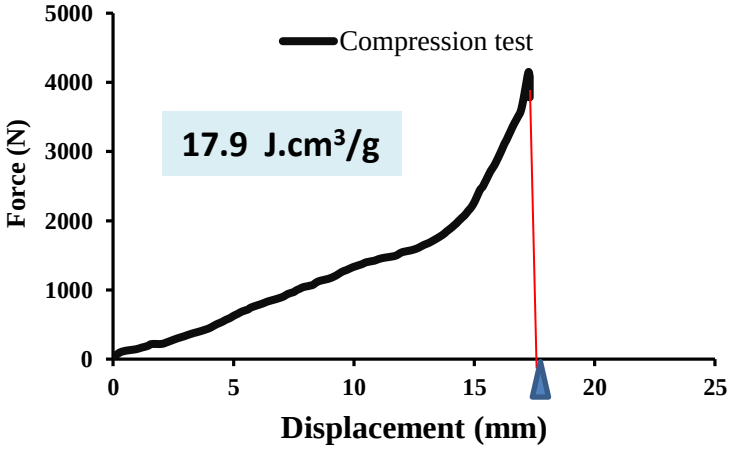


Steam treatment of wood chips using SO2 catalyst reduced grinding, reduced compressive energy input to form pellets

Regular chips

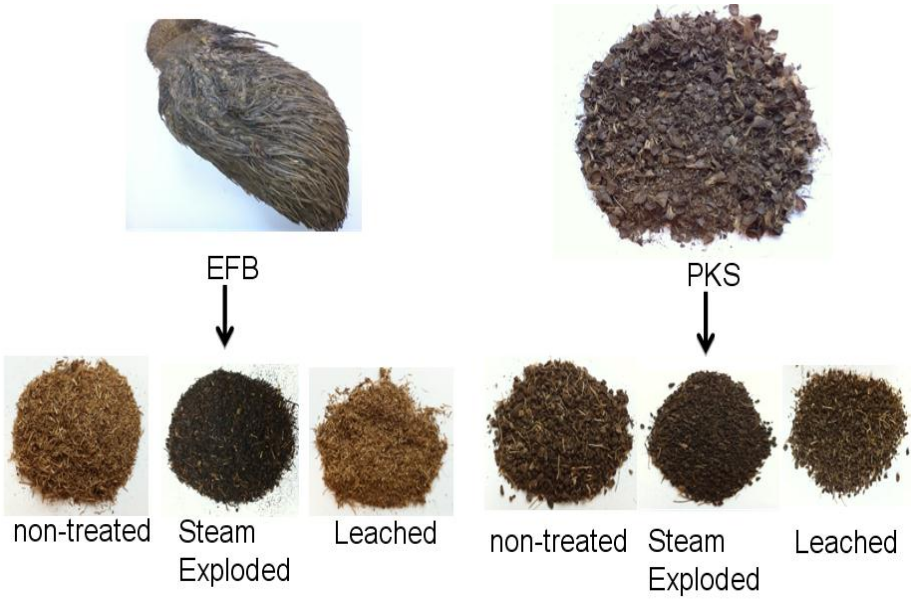
SO_2 - catalyzed chips

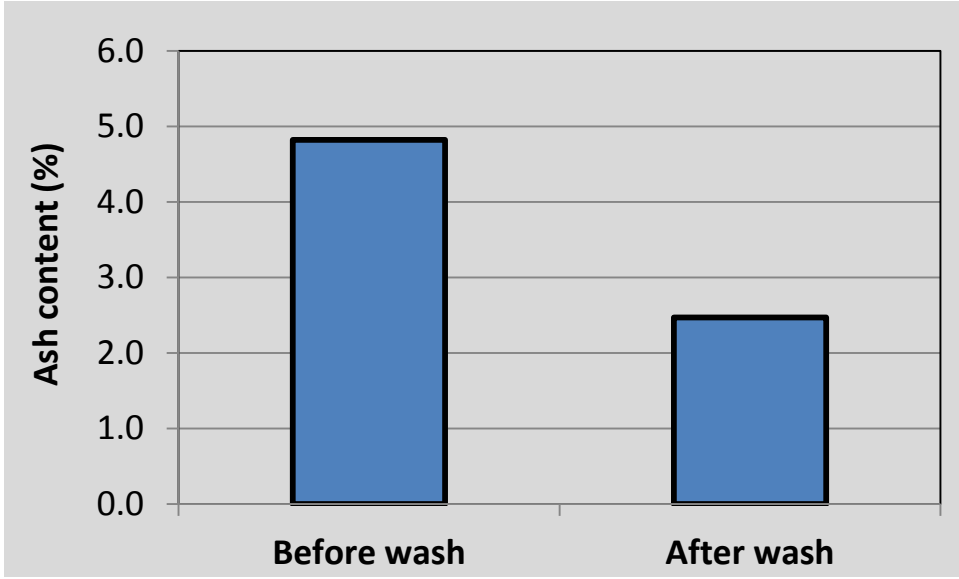




2- Results

Leaching reduces ash when palm residue (Empty Fruit Bunches and Kernel Shells) is washed with water (25°C)





Element	Before wash (mg/kg)	After wash (mg/kg)
Al	0.22	0.17
Ca	1.57	0.86
Fe	0.59	0.36
K	10.47	2.38
Mg	1.53	0.74
Na	0.45	0.27

3 - Relevance of feedstock pretreatment

Enhanced Feedstock properties	Benefit
Grindability	Uniform small size particles for high heat transfer (Ft-J,Gt-A, It-A)
Hydrophobicity	Less water content due to a decrease in OH and COOH groups , lower storage losses (Ft-G, Ft-K)
Low moisture content	Increased calorific value, increased storage stability (Ft-L, Tt-E)
Homogeneity	Predictable conversion performance in the combustion reactor (Tt-E, Gt-B).
High density	Reduced cost of shipping and storage (Ft-L, Ft-G)
Refined (Washed)	Less chlorine and ash (Tt-E, Gt-I)

4- Critical factors

- Benefits must offset the cost of additional operations.
- Wood pellet production in North America has tripled over the past 4 years to more than 6 million dry ton, mostly for export. The demand is driven by European subsidies for green heat and power.

- Safe handling of biomass is a major critical factor
  - Pellets emit gases during storage and could be toxic in confined area.
  - Dust from regular and torrefied pellets are prone to fire.

5- Future research

- More leaching and blending work to access low quality feedstock hog fuel and MSW.
- Understand binding mechanisms and the role of steam treatments, catalysts, binders increase feedstock density.
- Understand interaction of torrefied pellets with environmental (e.g. direct contact with rain), leaching and leachates.
- Test preprocessed feedstock in gasifiers, pyrolysis reactors, and combustion chambers.

Summary

- **This task addresses Feedstock quality, cost, and logistics barriers Ft-G, Ft-J,** Ft-K, FT-L, Gt-A, It-A, Tt-E (MYPP 2012)
- **This task focuses on preparation of feedstock to improve logistics, handling, and conversion performance of feedstocks.**
- **Equations are developed for scale up of grinding of biomass**
- **Steam treatment (and catalyst) and washing are among techniques that improve the quality of feedstock.**
- **Cost and safety of handling biomass are among critical factors.**
- **Future research includes leaching studies, pelletization, and techno economics**

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Responses to Previous Reviewers' Comments

- I have a concern that thermal pretreatments may increase capital cost and decrease net energy. Program needs to better explain capital and energy implications of additional treatments being proposed or explored.
- It is not clear what the research pathway is in this project. A number of tasks are being researched, and although each appears to be important, there is not a clear linkage to a roadmap or critical path that results in higher biomass use and lower total costs.
- Concurrent, yet independent development of densification process methods and more fundamental equations for materials and operations may dilute the effort and create tension between allocation of time to tasks that are not necessarily in sync.

Response: We have separated activities related to improving the quality of feedstock from the logistical issues. Research on quality of feedstock is pursued as part of feedstock conversion and interface tasks. Feedstock logistics is focused solely on modeling effort and analysis.

- There does not appear to be triage of need for which models and algorithms are most urgent, particularly those not available in the literature.
- The model needs to be verified adequately to have confidence in the results. Who will use the model?

Responses to Previous Reviewers' Comments

- There was no description of how the technology will be transferred to potential end-users. Good collaborations with universities.

The five logistics projects have provided an opportunity to acquire real data from the field, work with the logistics projects to develop the model, test the models, and conduct analysis.

- There was no description of how the technology will be transferred to potential end-users. Good collaborations with universities.
- It was not described how the universities and industry partners were contributing to the project. Logistics is important so I was pleased to see that this project was focused on this. Weak tech transfer part of the powerpoint presentation.
- PI Shahab Sokhansanj is located in Vancouver. He collaborates with industrial engineering, chemical and biological engineering faculty at the University of British Columbia. As an Adjunct Professor at UBC, Shahab receives support from the Natural Sciences and Engineering Research Council of Canada in support of students' research.
- We are continuing publishing and presenting research results in various forums including holding workshops at ASABE AETC on modeling, logistics, and IBSAL. A version of IBSAL is accessible through KDF to www.biomass.ubc.ca.