a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

OAK RIDGE National Laboratory

TORREFACTION IN NORTH AMERICA

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Outline

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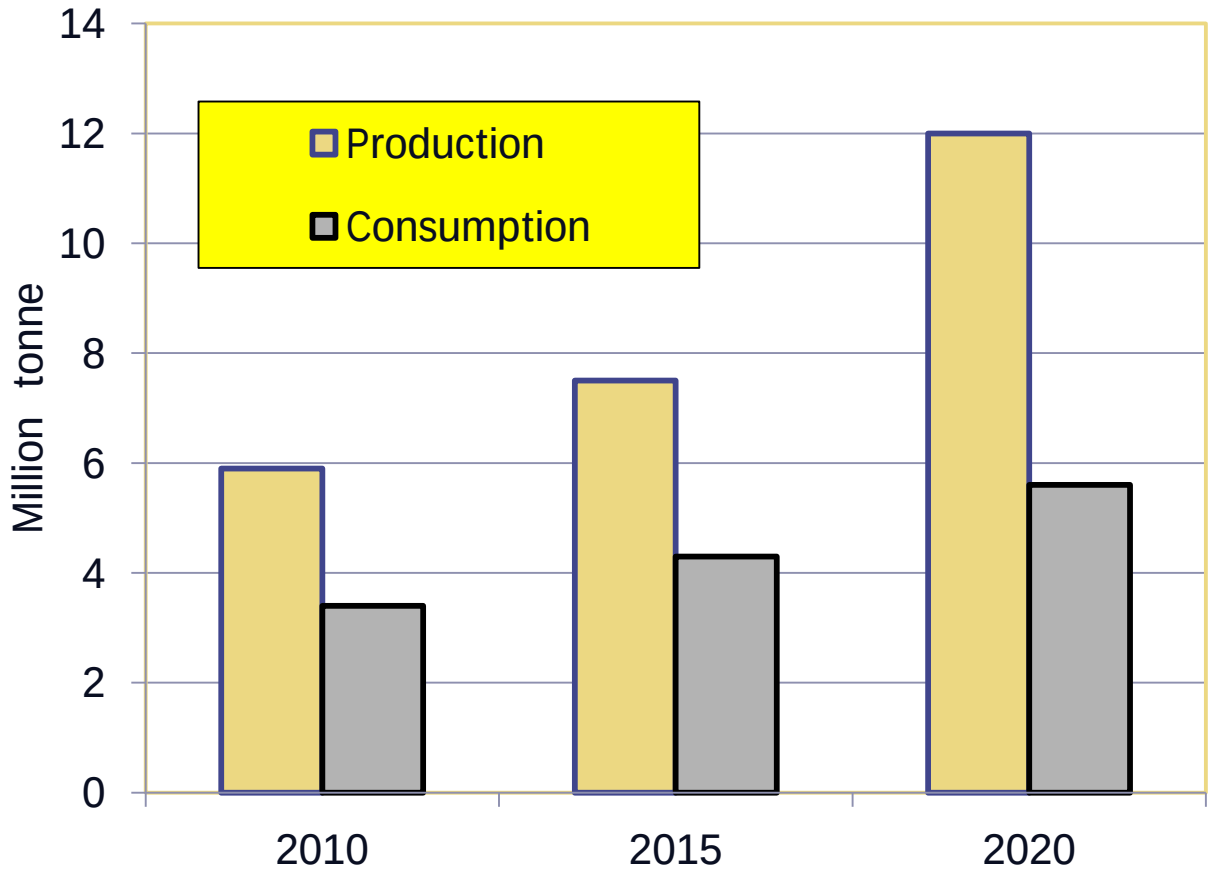
1. Introduction

Production and domestic consumption of wood pellets in North America.



Excess pellets are exported

Current size of wood pellet industry in the U.S. and Canada

- Wood pellet manufacturing and consumption began in the United States three decades ago.
- 147 pellet wood plants in the U.S., with a capacity of 3.5 million ton
  - Largest in the U.S. 750,000 ton
  - Raw material mostly logs from loblolly pine
- 37 plants in Canada with a capacity of more than 2.5 million ton
  - Largest 250,000 metric ton
  - Raw material mostly saw mill residue but recently logging residue and some limited beetle killed pine
- 20 enterprises are involved in torrefaction

  One known to me that is in its final phase of commercial testing of torrefied pellets

Challenges with regular pellets

- High cost ($/GJ) associated with long distance transportation of pellets to overseas markets in Europe and Asia
- Health and safety concerns over off-gas emissions, self-heating and spontaneous combustion associated with combustible gases and dust.
- Low heating value, flowability, and burn quality to be blended with coal for co-firing biomass with coal
- Increasing shortage of white wood saw dust is forcing pellet producers use logging residues and hog fuel as feedstock.
- Regular pellets degrade fast when exposed to weather elements

Torrefaction may alleviate some of the challenges

What is torrefaction?

Torrefaction is a mild pyrolysis of biomass

Possible pitfalls:

- Loss of value in mass loss
- Negative energetics – more energy input than output
- Poor environmental consequences
- Poor quality pellets

Like any other process, the idea is not to overdo it such that the economics of torrefied pellets become unattractive

2. Industry

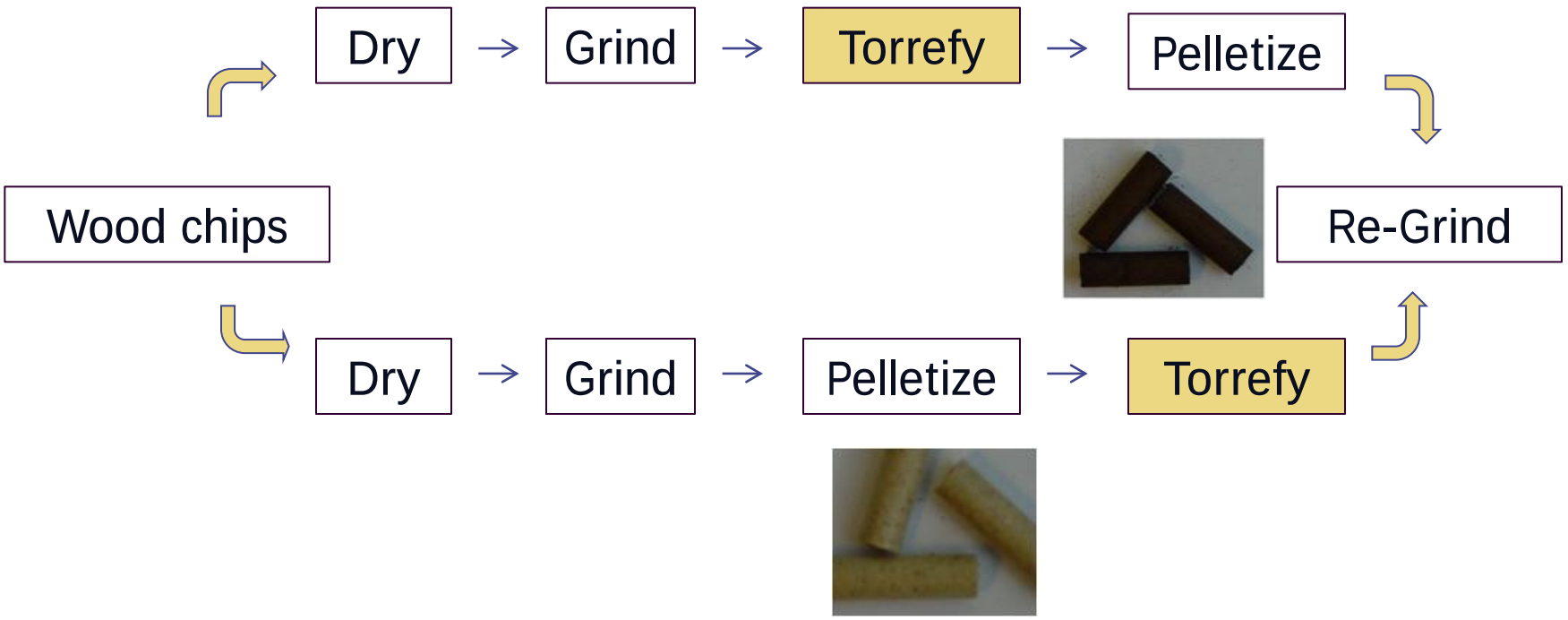
List of torrefaction companies in North America

	Name	Torrefaction	Densification	Remarks
1	zilkha.com	Steam treatment	Yes	Plans for 275k in Selma, Alabama
2	wyssmont.com	Dryer application	No	Several companies
3	torrsys.com	Bepex Continuous	Integrated with torrefaction	10-30% co mingled with coal
4	torrproc.com	Not known	Grind & pellet	Mostly conventional equipment, binder
5	torrefuels.com	Rotary counterflow	No	150-400^{o}C. CanMet is involved
6	threedimensionaltimberlands.com/	Fast pyrolysis batch – vacuum	No	Bio oil and bio char (1/3. 1/3)
7	terradyneenergy.com	Heat lock?	No	Little known – tested at University of New Brunswick
8	steeperenergy.com/hydrofaction	Supercritical pressure and catalyst	No	Low oxygen liquid fuel and char
9	riverbasinenergy.com/	Fluidized bed	Yes – no details	Coal upgrading Swiss company?
10	renewablefueltech.com/	indirectly heated, screw auger	No	California,
11	pcsbiofuels.com	Catalyst	No	Polymeric Carbon Solid or PCS Biofuels
12	nfibiorefinery.com/	NFI Hydro-Torrefied	Yes, outdoor storage is not recommended	Low ash, Low alkali salts, washing (?)
13	newearth1.net/about.html	ECO Pyro-Torrefaction (EPT).	Pelletized	Co product bio oil
14	hm3e.com/index.php	Torr B – not clear	Briquettes	Reduced drying cost
15	globalbiocoalenergy.ca	Wyssmont	Regular pellet to torrefied pellets	Initially on microwave
16	diacarbon.com/	Fast pyrolysis (400-900oC)	No	Co product bio oil
17	cnfbiofuel.com/index.html	Regular pellets torrefied	Regular pellets torrefied	Conduction heat in a liquid paraffin
18	bioenergyinc.ca/	Not known	Pelletization, briquetting	Mobile
19	agri-techproducers.com/	Screw indirect heat	No	Pilot scale
20	airex-energy.com/	Cyclonic fluidization	No	Pilot scale testing

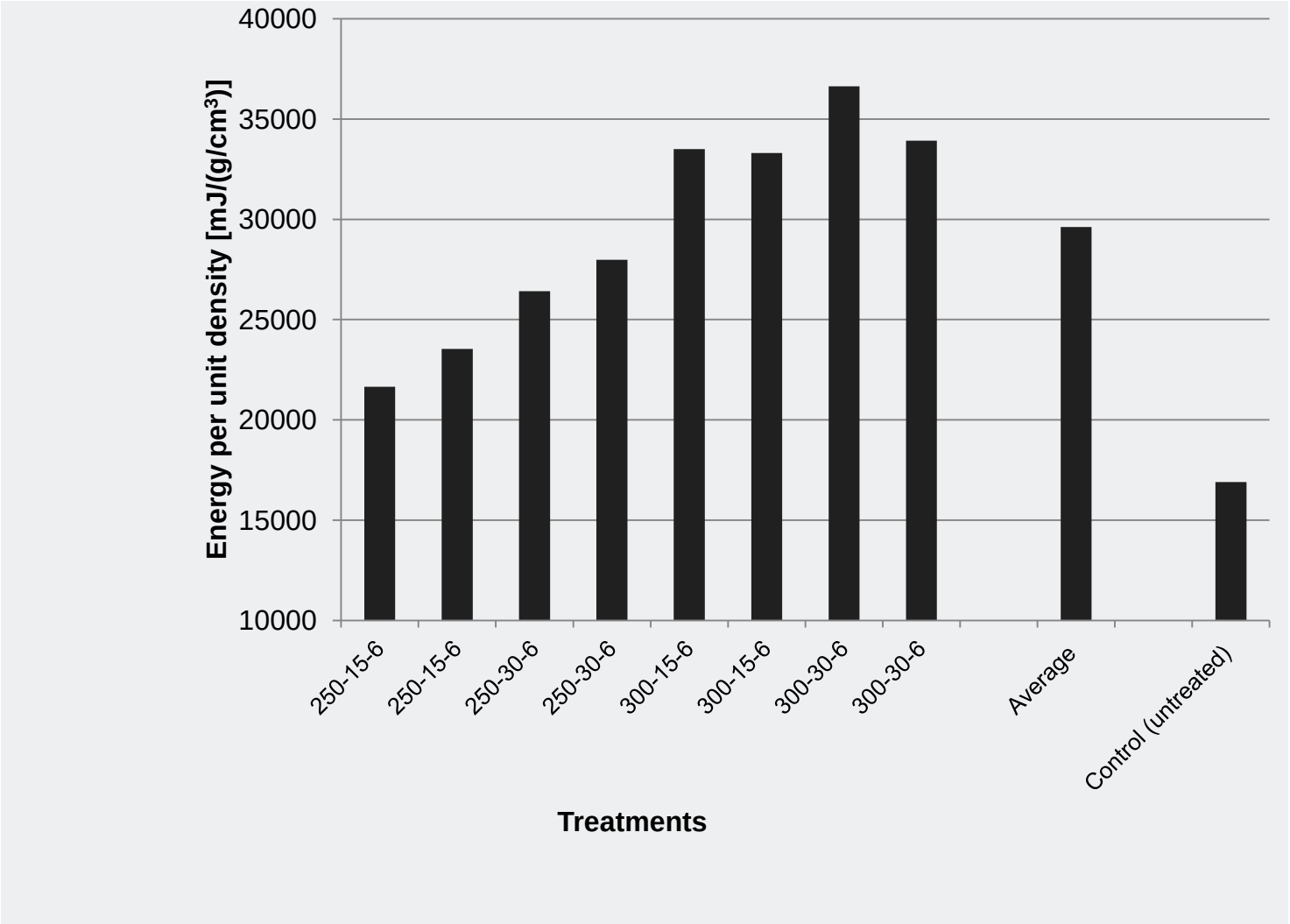
3. Research

The system

Torrefaction and densification are inter connected Two ways to make torrefied pellets



Specific energy required to form pellets



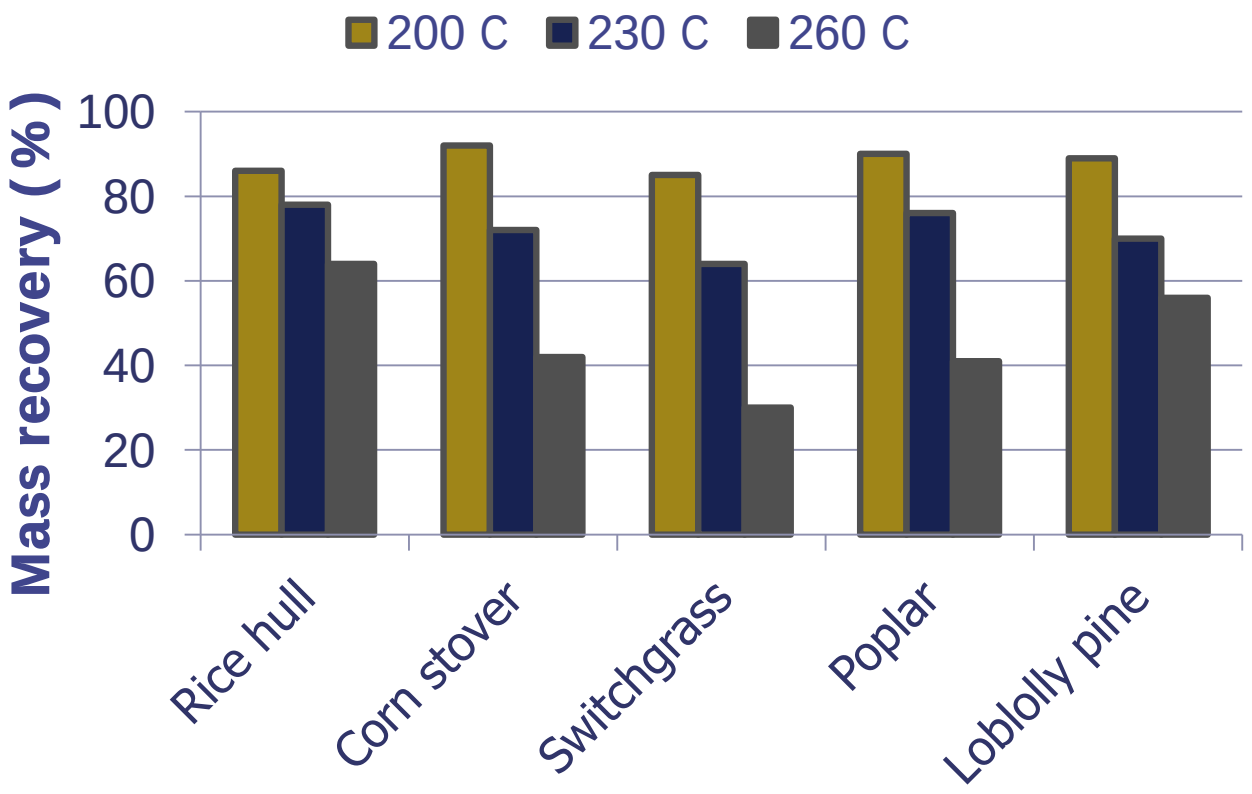
Wet torrefaction in hot water

Hot water 200-260^{o}C,

Duration 5 min.

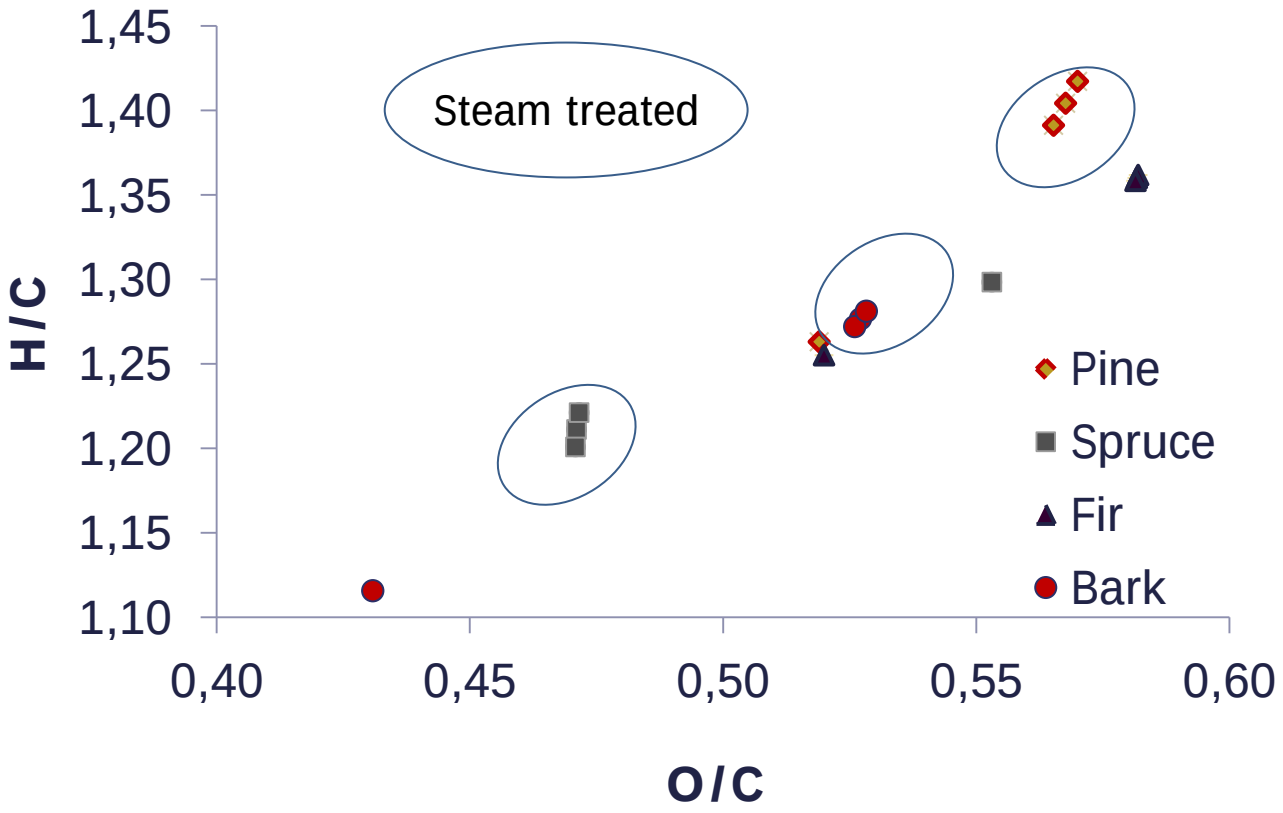
Water to biomass ratio 5:1,

Pressure 50 atm



Wei Yan, Tapas Acharjee, M. Toufiq Reza, Charles Coronella, Victor Vasquez. 2012. Wet Torrefaction of Lignocellulosic Biomass Chemical & Materials Engineering Dept. University of Nevada, Reno

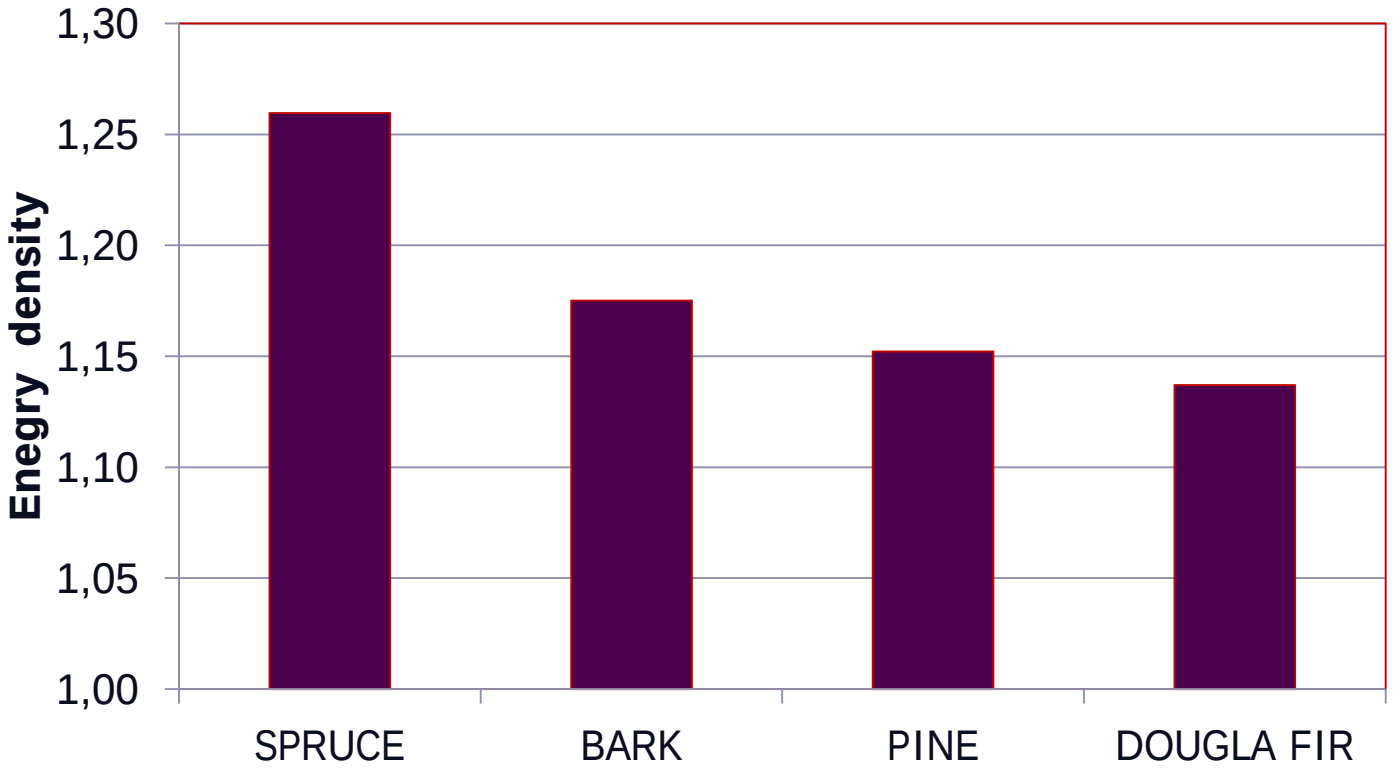
Steam treatment



Tooyserkani et al. 2012. Torrefaction and pelletization od steam treatment of soft wood species. Applied Energy (under review).

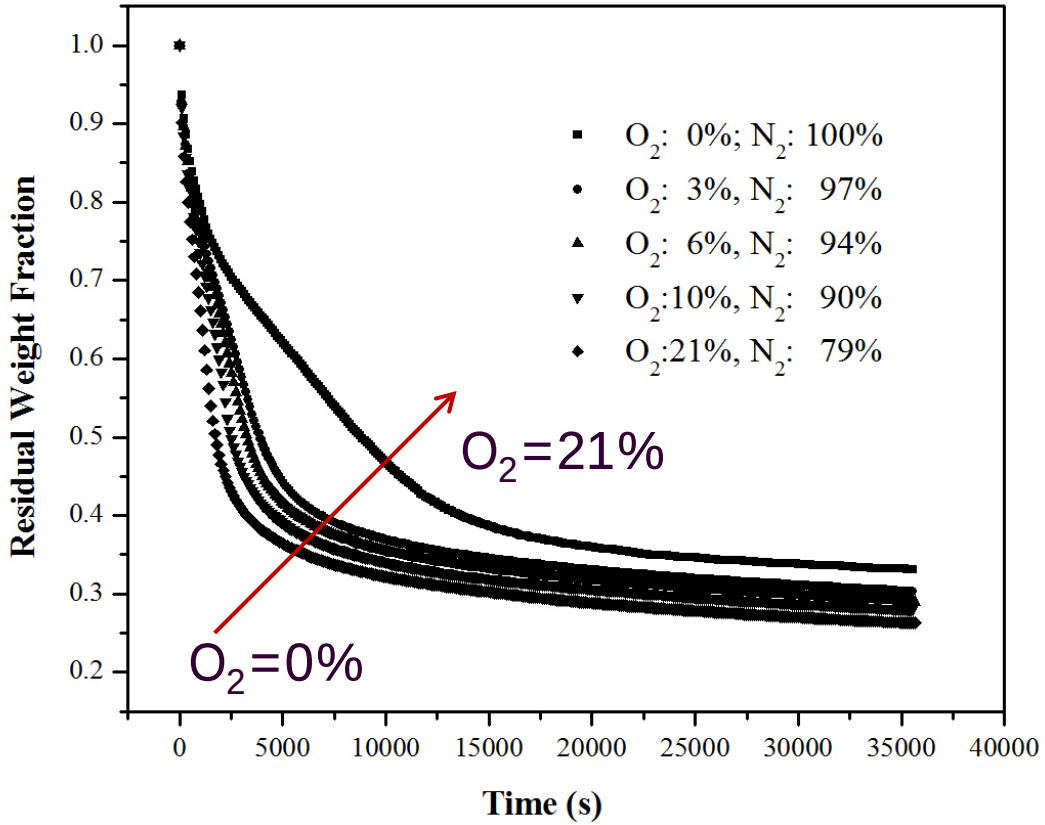
Steam treatment torrefaction

$$Energy\ density = \frac{Calorific\ value\ of\ treated\ biomass}{Calorific\ value\ of\ raw\ biomass}$$



Tooyserkani et al. 2012. Torrefaction and pelletization of steam treatment of soft wood species. Applied Energy (under review).

Torrefaction at different gas O_2 content

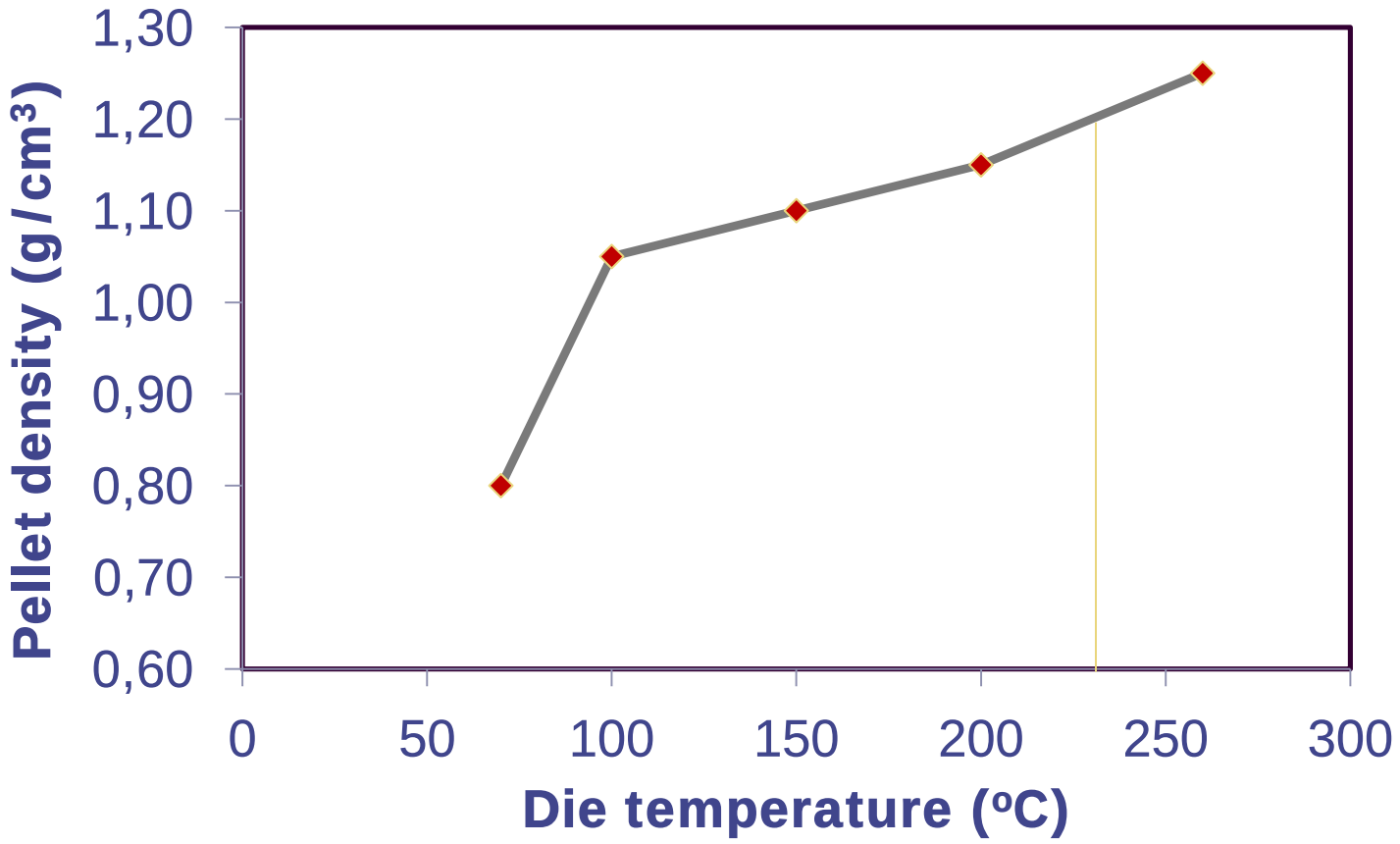


TGA

Peng, J. 2012. A study of softwood torrefaction and densification for the production of high density wood pellets. Ph.D. Thesis. University of British Columbia Canada.

Pelletization equipment

Density vs. compacting die temperature



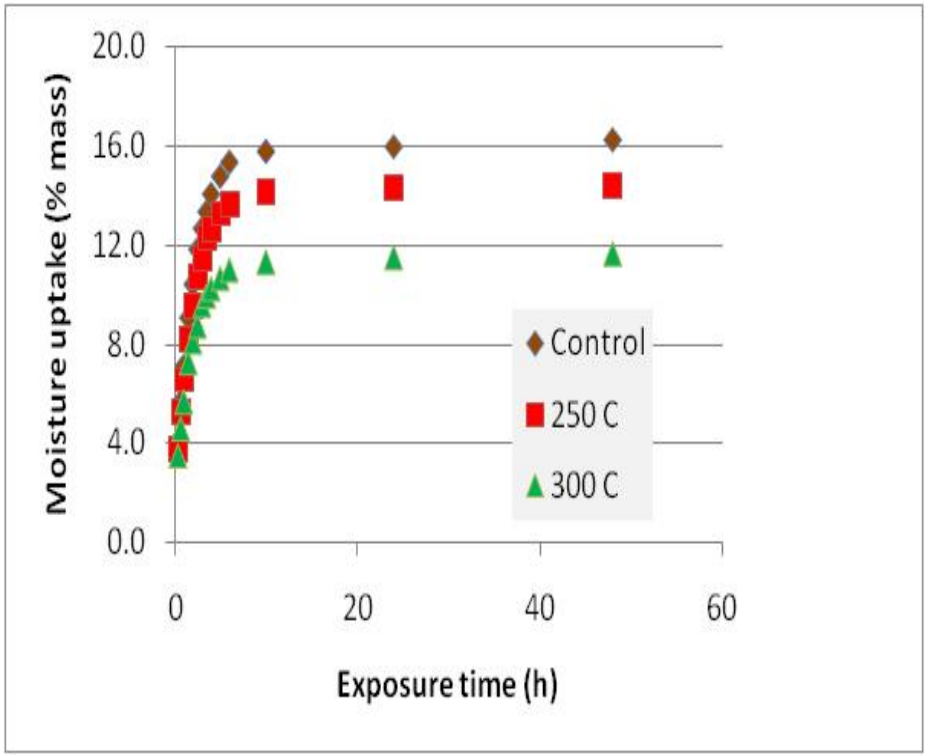
Tooyserkani et al. 2012. Torrefaction and pelletization od steam treatment of soft wood species. Applied Energy (under review).

Hydrophobicity equipment

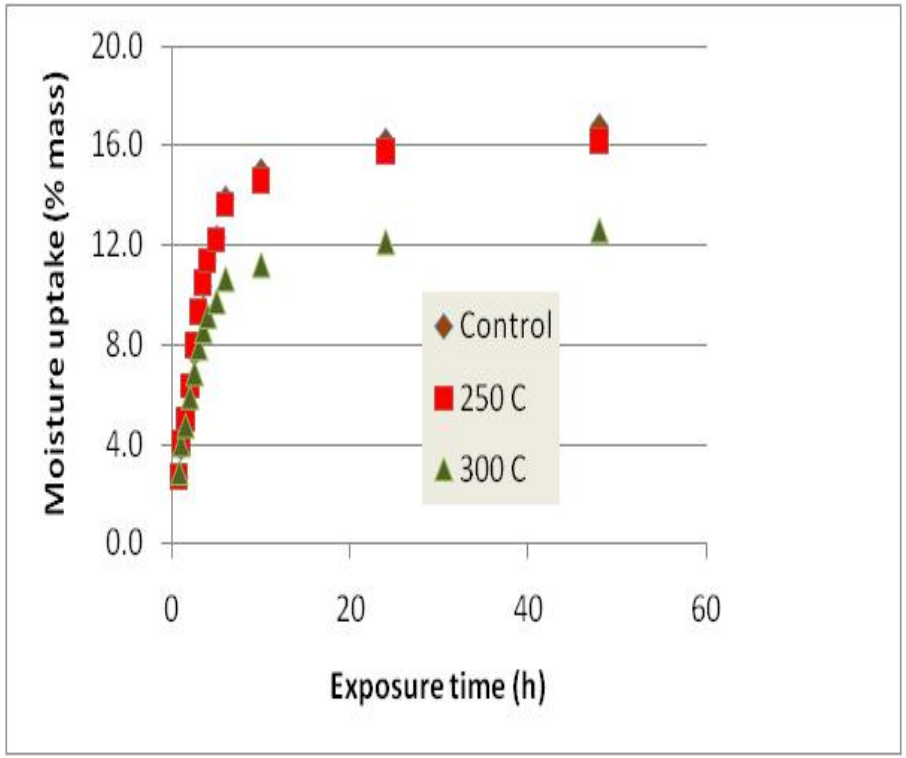
- Chamber to maintain constant temperature and humidity
- Temperature: 30ºC
- Humidity: 90%
- Duration: Variable
- 2 - 3 pellets in a petri dish
- Weigh at time intervals

Results on hydrophobicity

Pellets from small particles 0.8 mm



Pellets from large particles 6.2 mm



Humid chamber at 30°C 90% RH

Summary

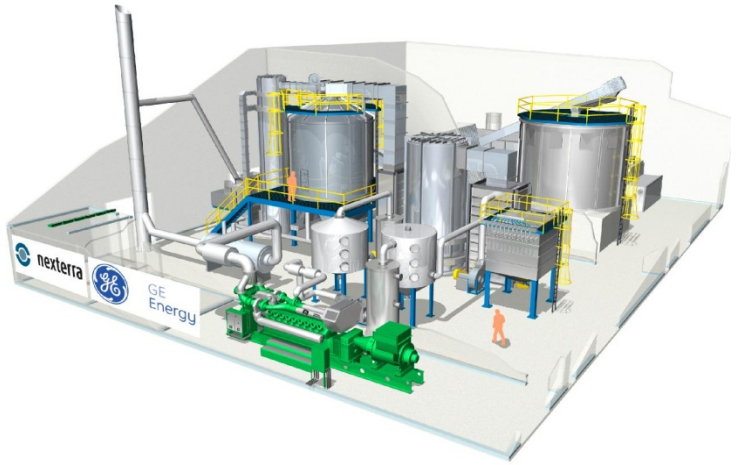
- Manufacturing and marketing wood pellets in Canada and the U.S. is well underway, albeit with emerging technical challenges.
- Technical challenges are associated with variability in feedstock and safe handlings.
- Commercial production of torrefied pellets is where every body else is at, going through growing pains.
- Research and developments in torrefaction and pelletization is at its infancy in the U.S. and Canada.

Research institutions / universties working on torrefaction pelletization

University of Minnesota	Dr. Vance Morey	U.S.
University of Georgia	Dr. Sudhagar Mani	U.S.
Auburn University	Dr. Oladiran Fasina	U.S.
University of Reno	Dr. Charles Coronella	U.S.
University California, Davis	Dr. Bryan Jenkins	U.S.
Idaho National Laboratory, DOE	Dr. Boardman	U.S.
Gas technology Institute	Dr. Larry Felix	U.S.
University of Saskatchewan	Dr. Lope Tabil	Canada
NRCan - CanMet	Dr. Fernando Preto	Canada
University of British Columbia	Dr. Shahab Sokhansanj	Canada

Biomass & Bioenergy Research Group current research

- Safe handling and storage of wood pellets
  - Off-gassing
  - Self heating
- Development of new pellets:
  - Steam treatment and explosion
  - Torrefaction (enhancing carbon conte
- Integration with biomass utilization
  - Gasification
  - Pyrolysis oil
  - Ethanol production
- Modeling
  - Logistics
  - Life Cycle Analysis



Acknowledgement

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  - NSERC
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  - US Department of Energy
  - BC Ministry of Forest
  - BC Bioenergy Network