DROP-IN COAL REPLACEMENT FUEL

Overview of HM3 Energy Torrefaction Technology

Converting Biomass to Torrefied Briquettes as Fuel for Coal-fired Power Plants in the U.S. and Abroad

HM3Energy.com
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Why Torrefied Briquettes?

TorrB® torrefied briquettes are drop-in coal replacement fuel that:

- Can be burned without material modifications to the coal-fired plant
- Can be mixed in any proportion with coal (up to 100%)
- Have similar Btu content, pound for pound as western coal
- Are produced without binders, yet can be shipped and stored without cover
- Have similar Hargrove Index grindability as coal (45)
- Can be made directly from wood waste, agricultural residue or clean wood chips. *(Only torrefaction technology to do so.)*
What is torrefaction and its advantages?

Torrefaction (roasting at a high temperature in an oxygen free environment) is not new. It has been used to roast coffee beans for over a hundred years. It has taken time, however, to apply this technology to evenly roasting wood chips and ground biomass that is not uniform in size.

Densification of the torrefied biomass product into pellets or briquettes for economic transport has also taken time to perfect.

Advantages of torrefied biofuel as drop-in coal or raw pellet replacement fuel:

- Just like roasted coffee beans, torrefied wood grinds easily, and so can be fed into the same pulverizing equipment that is used to grind coal before it is fed to the coal boiler.

- Like coal, it is water resistant and can be stored without cover.

- Its Btu (energy) content is similar to that of coal and 25-30% higher than that of raw wood pellets.

- Harmful emissions such as mercury and sulfur are virtually non-existent, and nitrous oxides are reduced by 46%.*

*Data from test burns conducted at coal-fired boiler, Western Research Institute, Laramie WY.
TorrB® Briquettes vs Raw Pellets

- TorrB® Briquettes:
  - Uses cheapest feedstock, such as forest slash.
  - Water resistant, so can be stored and shipped without cover.
  - 30% more Btu content; higher bulk density for shipping.
  - Directly replaces coal without modifications to plant.

- Raw Wood Pellets:
  - More expensive feedstock: sawdust or wood shavings.
  - Disintegrates in water; needs cover for storage and shipping.
  - Lower Btu content and bulk density compared to coal.
  - Requires separate feeding system in coal-fired plants.
Advantages of HM3 Technologies

HM3 Energy technology roasts and densifies biomass into sturdy, energy dense and water resistant cubes for inexpensive transport in open rail cars, overseas shipping and outdoor storage at the coal or biomass plant. HM3 is licensing its TorrB® technology to others to build commercial plants.

Licensees using HM3 Energy TorrB® technology benefit from these advantages:

- Only torrefaction process that uses wood waste and ag residue as feedstock – much cheaper than clean wood chips
- Simple mass flow torrefaction system with only 1 moving part, a feedstock leveler:
  - Inexpensive to build
  - Easy to maintain
- Uses unique modification of agricultural cubing machine to produce briquettes without a binder
- Drop test results show HM3 Energy’s briquettes as sturdy as coal after 24 hours in water.
OVERVIEW: Cost of White Wood Pellets vs TorrB® Briquettes for Export via Rail and Ship

NOTES:

1. Tip cost includes 20% IRR
2. White wood pellet prices from FutureMetrics White Paper, “Forecasting Industrial Wood Pellet Prices,” Oct 1, 2018
3. Raw material moisture content, 40% by weight
4. Finished product moisture content: WWP, 6% by weight: TorrB® briquettes, 4% by weight
5. Power plant feeding modification cost based upon $100M for 300 MW capacity plant
6. Boiler inefficiency penalty due to lower steam temperature from white wood pellet firing

ENERGY CONTENT
17.5 GJ/MT
(15.88 GJ/short ton)

ENERGY CONTENT
22.5 GJ/MT
(20.4 GJ/short ton)
OVERVIEW: Cost of White Wood Pellets vs TorrB® Briquettes at a Local Power Plant

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5. Power plant feeding modification cost based upon $100M for 300 MW capacity plant
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Energy Content
- White Wood Pellets: 17.5 GJ/MT (15.88 GJ/short ton)
- TorrB Briquettes: 22.5 GJ/MT (20.4 GJ/short ton)

Burner Tip Cost
- White Wood Pellets: $9.18
- TorrB Briquettes: $8.05

NOTES:
Proof of Technology Viability Completed

In 2016 HM3 Energy completed construction of a 500 lb/hour small demonstration plant with partial funding from a consortium of five Japanese companies. All equipment was commercial in scale (torrefier and 50,000 tons/yr densifier) or commercial in design.

Numerous runs were made in the facility using mostly juniper waste wood as well as pine waste wood and palm oil agricultural residue. The plant was purchased and has been moved to Japan where it will be used to produce samples for Japanese power companies and to showcase the technology.

A detailed functional design for a 50,000 tons/yr commercial plant has been completed.

HM3 is engaged with licensees seeking off-take agreements for plant construction.
HM3 Energy is the sole owner of the following patents:

- Dec. 8, 2015: US 9,206,368 B2 System and process for producing torrefied biomass using a mass flow reactor
- Nov. 8, 2016: US 9,487,721 B2 Refined torrefied biomass
- August 1, 2017: US 9,719,040 B2, Methods and process for producing a water-resistant, mechanically stable form of torrefied biomass
- October 14, 2016 (pending): Application No. 62/408,523, Pretreatment of fibrous biomass by cubing
Environmental Benefits

Improves Forest Health

Studies have shown selective forest thinning to positively impact forest health. Remaining trees grow better, with increased access to sunlight and increased resiliency to fire, insects and disease. Watershed function is improved.

Improves Air Quality

- Burning slash piles wastes the energy in the wood while introducing toxic VOCs (volatile organic compounds) into the atmosphere. HM3 Energy’s process creates biofuel from the valuable energy present in the biomass while preventing the VOCs from entering the atmosphere.
- Removal of stocked fuel creates better resiliency to wildfires and smoke.
- Conversion of coal-fired power plants to cleaner biomass fuel results in fewer toxic emissions, notably mercury.

Improves Water and Soil

- Catastrophic wildfires can damage watersheds, cause erosion into streams.
- Extremely hot catastrophic wildfires can sterilize soil, making reforestation harder.
- Replacing coal with TorrB® briquettes reduces mercury and other toxic emissions into water and soil.
Economic Benefits

Creates Permanent Rural Jobs
- Up to 30 family wage jobs including plant manager, operators, maintenance person.
- 30 biomass collectors needed per plant
- 2 or more transporters

Creates Construction Jobs
- 86 construction jobs over a 2-year period.

Creates Market for Biomass
- Economically beneficial to forest harvesting, restoration and thinning
- Provides fuel for existing coal-fired plants
- Provides fuel for export to Asia

Reduces Wildfire Risk
- Pre-emptive forest restoration and thinning reduces risk of wildfire and costs of fighting catastrophic fires
- Wildfires impact tourism and community health
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<tr>
<th>YEAR</th>
<th>AWARD</th>
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<tr>
<td>2015</td>
<td>USDA-NIFA SBIR Phase 2 Grant ($500,000) “Development and Evaluation of Continuous Biomass Torrefaction and Densification Process for Commercial Briquette Production.” Business Oregon “Oregon SBIR/STTR Program Matching Grant” ($40,000)</td>
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<td>2014</td>
<td>USDA-NIFA SBIR Phase 1 Grant ($100,000) “Development of Reliable, Economical Briquetting of Torrefied Forest Residue Without Binders to Produce Sturdy, Water Resistant Briquettes.”</td>
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<td>2012</td>
<td>Oregon BEST Commercialization Grant ($85,000) Collaborative project with Oregon State University to perform pre-commercial emissions testing of Oregon biomass feedstocks. Regional Winner, Cleantech Open ($10,000)</td>
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<td>2011</td>
<td>USDA-NIFA SBIR Phase 2 Grant ($460,000) “Practical Torrefaction of Forest Waste into Clean Fuel for Coal-fired Power Plants” Endowment for Forestry and Communities Award ($241,000) “Torrefaction Process and Equipment Testing Facility”</td>
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<td>2010</td>
<td>USDA-NIFA SBIR Phase 1 Grant ($90,000) “Forest Waste Contaminant Removal into Clean Fuel for Coal-fired Power Plants”</td>
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Video

Learn more about HM3 Energy’s process in this 3-minute You Tube video:

https://www.youtube.com/watch?v=411oHmyleeI

Torrefied Biomass Briquettes to Replace Coal

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