



HM3 Biocoal™ Technology Advantages

- Better Torrefaction and Densification
- Lower Production Costs
- Test Burn Results
- Waste-to-energy
- Environmental Benefits

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HM3 Energy's Keys to Better Torrefaction

Uniform Torrefaction

HM3's patented **vertical** torrefier has uniform gas temperatures across the horizontal plane, with no mixing of material as it is torrefied.



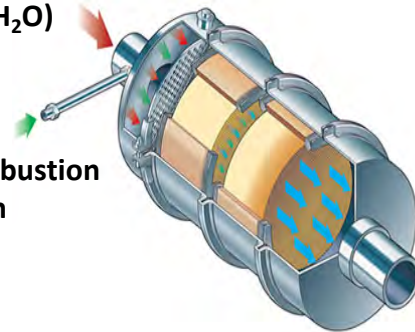
VOC Destruction

HM3 uses Advanced Torrefaction System's patented ATS TorreCAT™ Torrefaction Gas System to eliminate VOCs with an up to 99.5% conversion efficiency. This keeps torrefaction gases essentially VOC free with no tar formation on the torrefier walls when during operation or cool down.

Oxidation Catalyst

Process off-gas in (VOCs, CO and H₂O)

Combustion air in



CO₂, N₂, H₂O and heat out

No Die Plugging

HM3's patented die temperature control system keeps the dies at a constant temperature, providing uniform briquette production and no dies plugging or fires.



No Binders Necessary

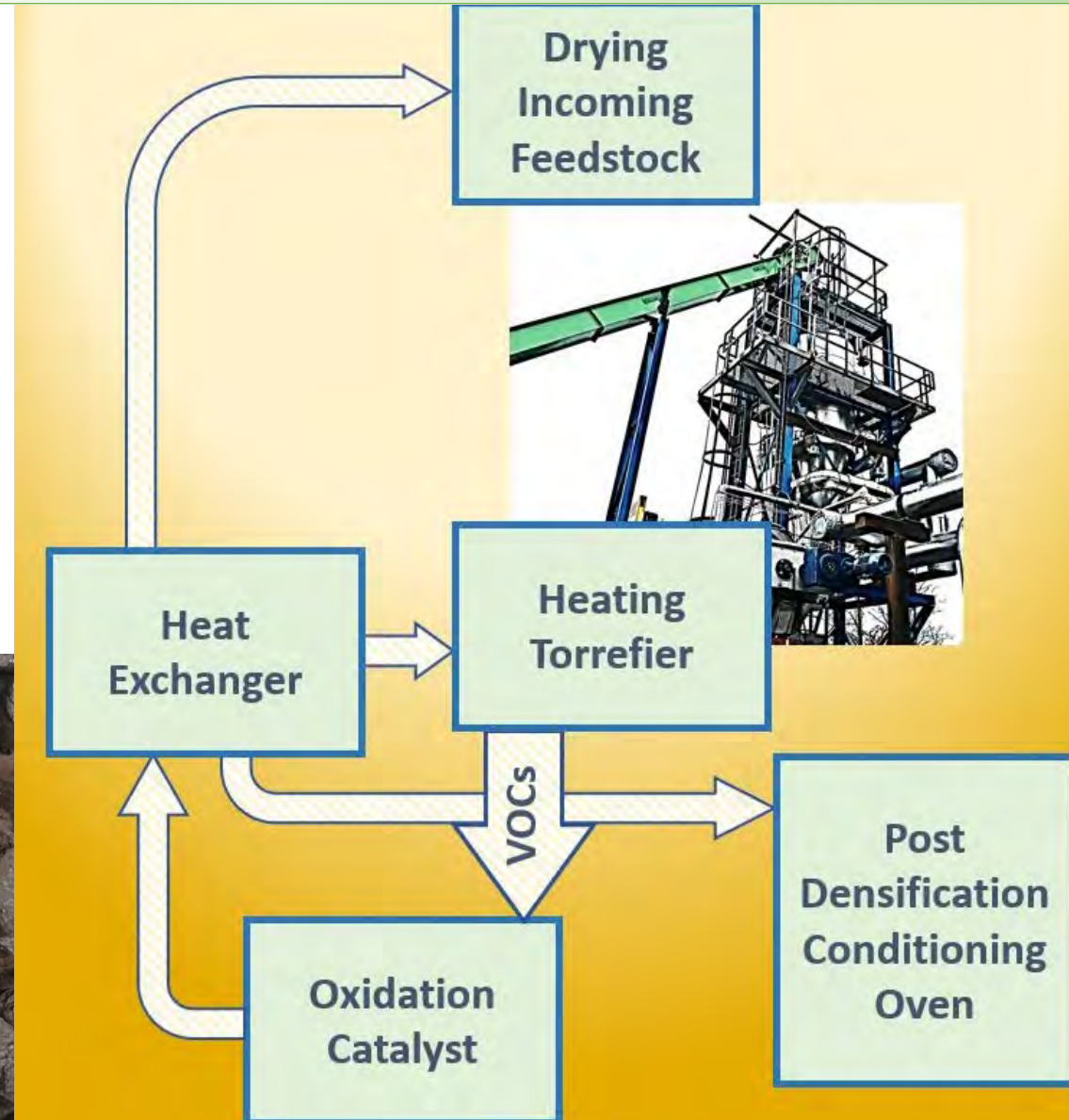
After densification, HM3 "cures" the torrefied briquettes for a period of time. This makes them hard and water resistant without the need for binders.



Lower Torrefaction Costs

HM3 Energy spent ten years developing *a lower cost torrefaction technology that:*

- ✓ *Uses cheaper forest slash as feedstock*
- ✓ *Torrefies feedstock evenly and without mixing*
- ✓ *Produces water resistant briquettes without need for costly binders*
- ✓ *Efficiently uses energy by using heat from VOC destruction for other parts of the process*
- ✓ *Employs lower maintenance costs in both torrefaction and densification*



Western Research Institute Test Burn

Materials and Preparation

Portland General Electric provided Powder River Basin (PRB) coal from the western U.S. Torrefied biomass fuel was provided by 5 (five) different companies for test burns at Western Research Institute, where a coal boiler is used for testing coal samples.*

Only HM3 submitted a sample produced from actual forest waste rather than clean wood chips. HM3's large cube-shaped sample is easily identified as "*Sample B*."

All materials were prepared to specifications of 80% passing 200 mesh. Samples D and E could not be milled further than 50% passing 200 mesh.



Figure 6 As-received Biomass Samples; (left to right, top to bottom) A, B, C, D, and E

*Combustion Evaluation of Torrefied Biomass for Heat and Power Generation, Sept. 6, 2017

Western Research Institute Test Burn

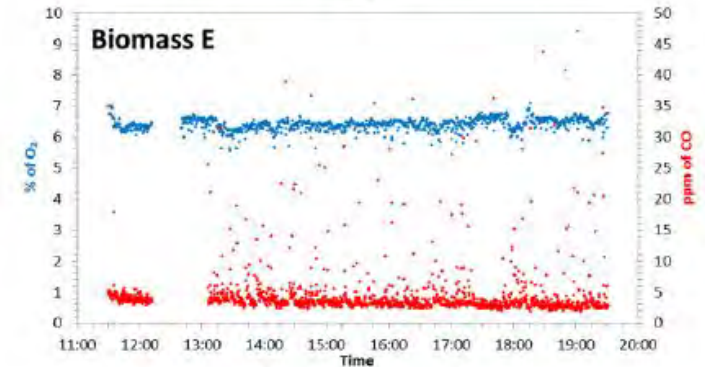
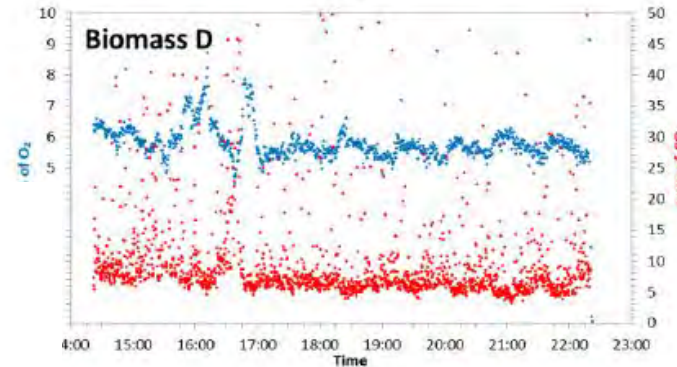
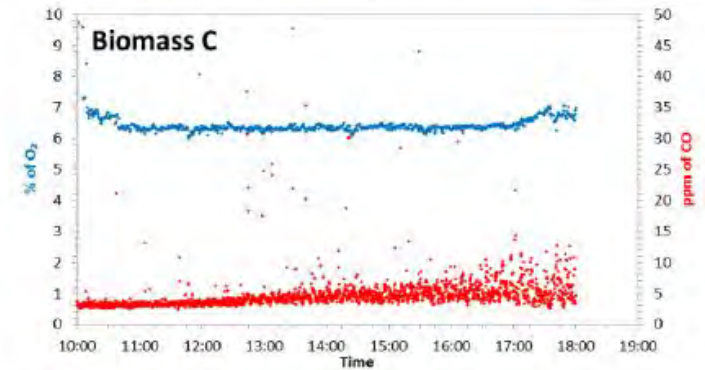
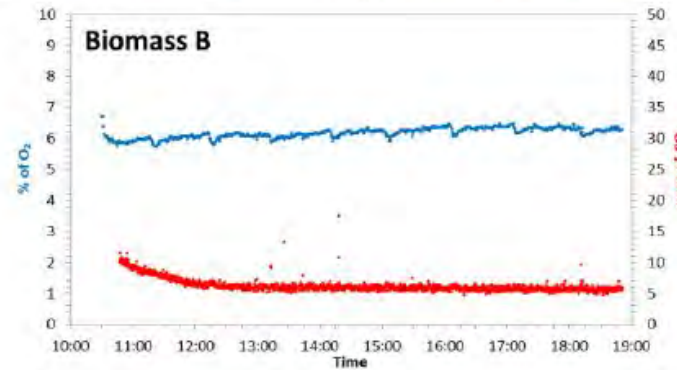
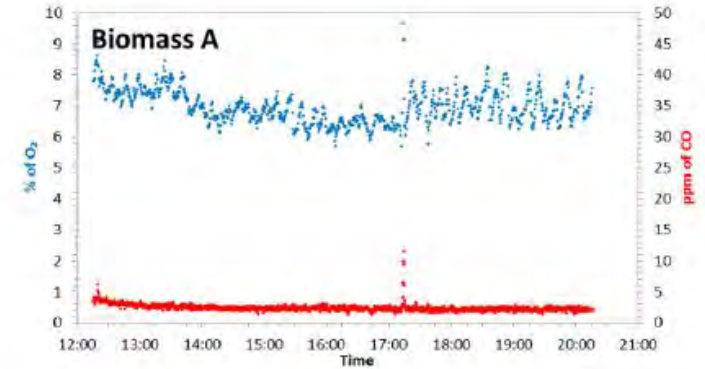
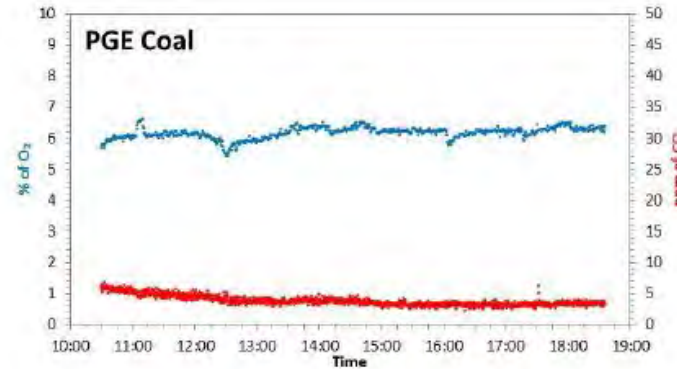
Sample B Summary

HM3's **Sample B** had no difficulty feeding to the system. Combustion was sustained throughout the test with the steadiest O₂ and CO values compared to other biomass tests. The time temperature profile and heat recovery was very close to baseline coal.

Overall pollutant level was lower than that of coal. Fly ash distribution was different compared to that of coal, with higher ash rate and different partitioning of fly ash throughout the plant. As such, modifications on the particulate control systems, especially the ESP, will be required to fine tune fly ash removal.

RED DATA = Parts per million of CO

BLUE DATA = Percentage of O₂



HM3 Technology Uses Forest Waste

Problem: Many western U.S. forests are dying and burning from *too many trees*

After over a hundred years of fire suppression, fuel stocked forests and rangelands in Western North America are experiencing more frequent, hotter, longer burning wildfires. Costs to fight these fires have skyrocketed. The fires produce harmful air pollutants and pose significant danger to lives and personal property.

In recent years, the fire season has grown longer and more intense in all western U.S. states.



Selective thinning restores forest health

Forest managers are working to reduce fuels and risk of unnaturally severe wildfires in the forests and rangelands. Forest thinning and prescribed burning are among the methods used. Thinning operations often result in small diameter wood that has little to no commercial value. The biggest challenge, is what to do with the small diameter wood and forest residue. With little or no market for the residues, most forest slash piles are burned at the thinning site or left to rot, producing methane. **HM3's technology provides a market for the forest residue, accelerating forest restoration work.**

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. They also may store more carbon.

Reduction in CO² and Toxic Emissions

- Pile burns waste the energy in the wood and emit toxic VOCs (volatile organic compounds) into the atmosphere. HM3's process turns the biomass into biocoal which is then burned in a controlled environment in a coal or biomass power plant.
- Removal of stocked fuel creates better resiliency to wildfires. Research shows healthier forests store more carbon.
- Conversion of coal-fired power plants to cleaner biocoal fuel results in fewer toxic emissions, notably mercury.

Slash piles after forest thinning near the Grand Canyon in Arizona



Reduces Risk of Harm to 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 HM3Biocoal™ eliminates mercury and other toxic emissions going into water and soil.



HM3 Energy Bio-coal Technology Advantages

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