

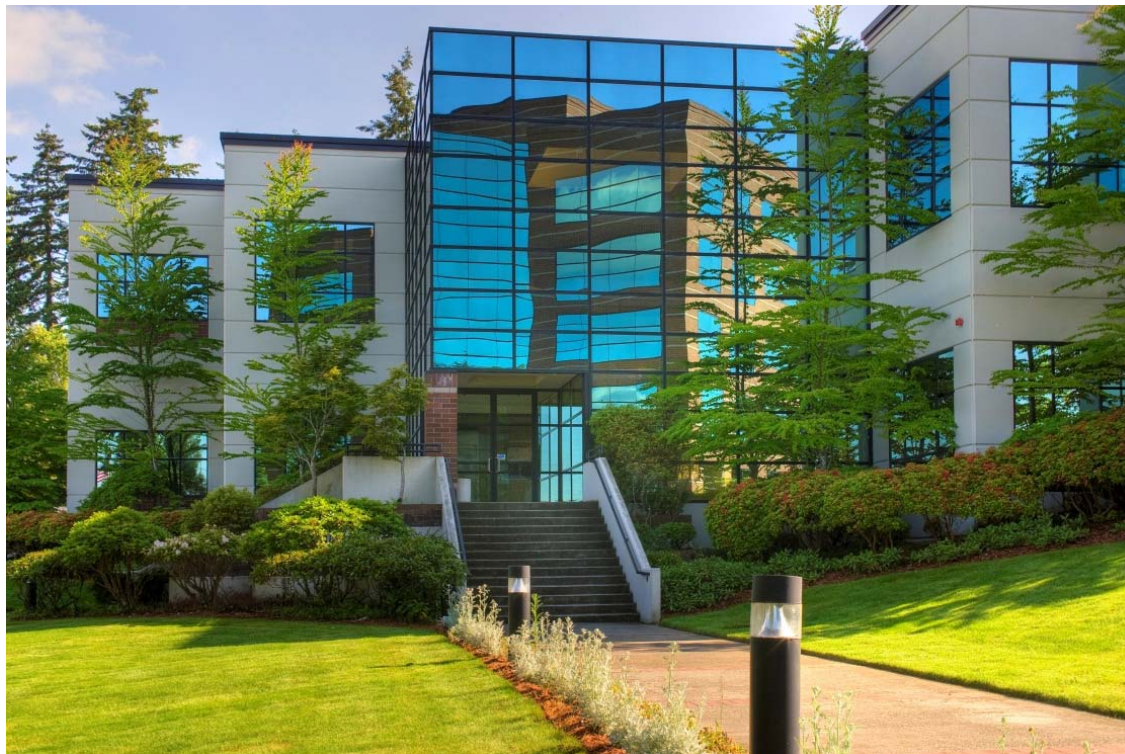


Torreactor

Systems for Carbonization

US Patent # 8246788

TSI

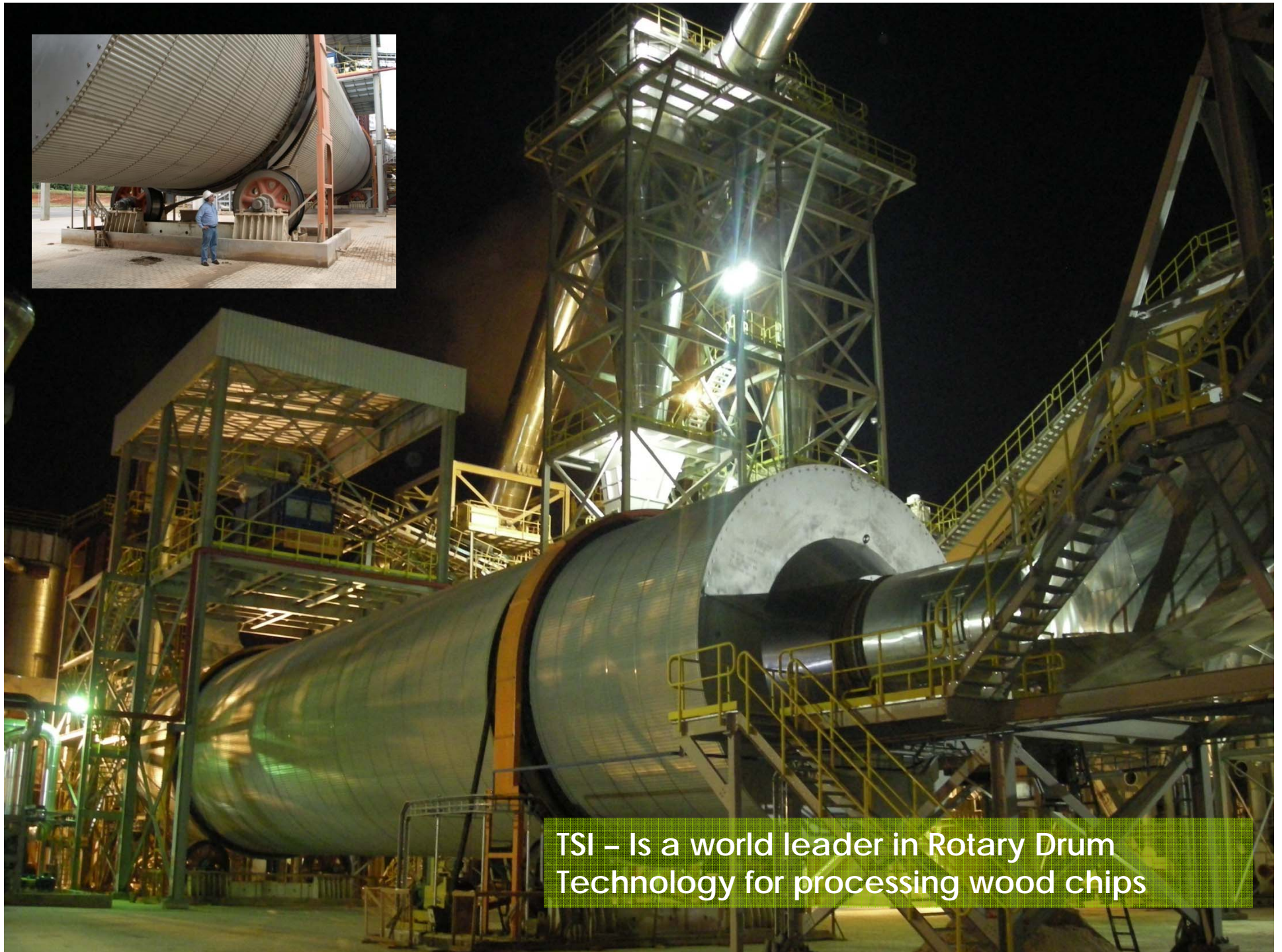


- Privately owned, founded 1992
- Based in Washington State – USA
- Aerospace and Wood Products (average 50:50 split)

Client Base

- Engineered Wood
 - Weyerhaeuser
 - Georgia Pacific
 - Louisiana Pacific
 - Ainsworth
 - JM Huber
 - Martco
 - ~ 75% of US OSB Ind.
- Biomass
 - Green Circle
 - RWE
 - German Pellets
 - Rentech
 - Enviva
 - Solvay
 - ~ 75% of US Industrial Pellet Ind.





TSI – Is a world leader in Rotary Drum Technology for processing wood chips

Georgia Biomass – 750,000 tpy white pellets. (Dryers, Furnaces and Emission Control equipment supplied by TSI)







What is torrefaction?



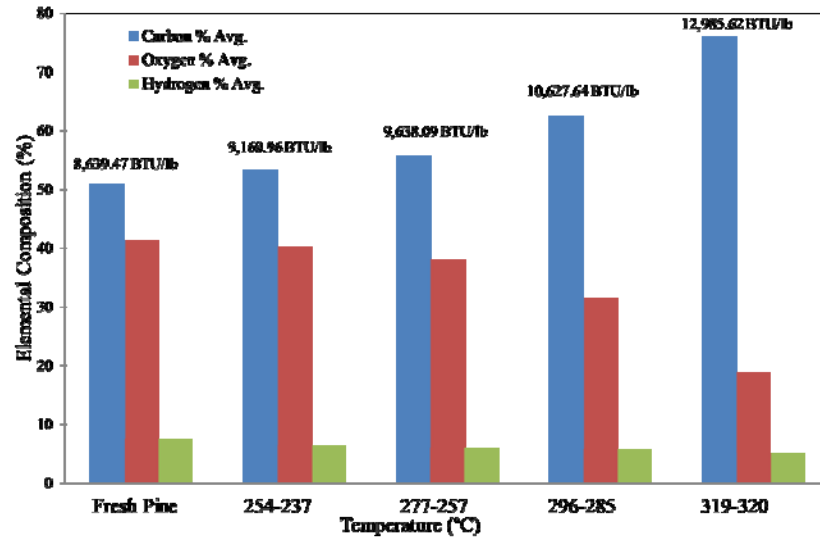
How do you achieve Carbonization?

- Biomass is primarily composed of 3 different elements: Cellulose, Hemicellulose, and Lignin
- Torrefaction is a partial gasification of biomass in a low oxygen, high temperature environment (typically around 250 - 400° C)
- Traditional torrefaction is used to ONLY convert the hemicellulose to a gaseous state
- Creating biochar or “Carbonizing” is a result of “heavy torrefaction” (temperature between 350 - 650 ° C)

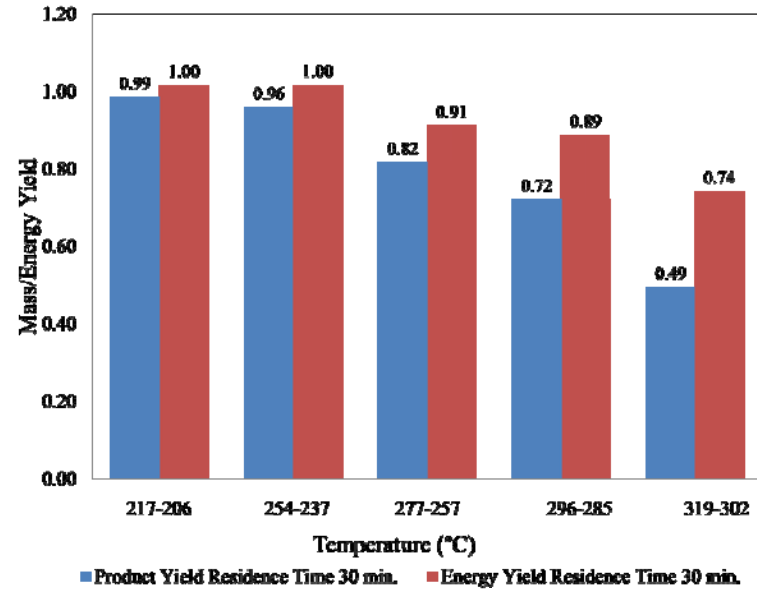


- Torrefaction is a progressive process
- The higher the level of torrefaction...
 - More energy dense
 - Hotter and cleaner burning
 - More dry basis Mass Loss
 - Progressively becoming Biochar

Mass Loss v Energy Loss



↑
= 24.66
Gj/ton



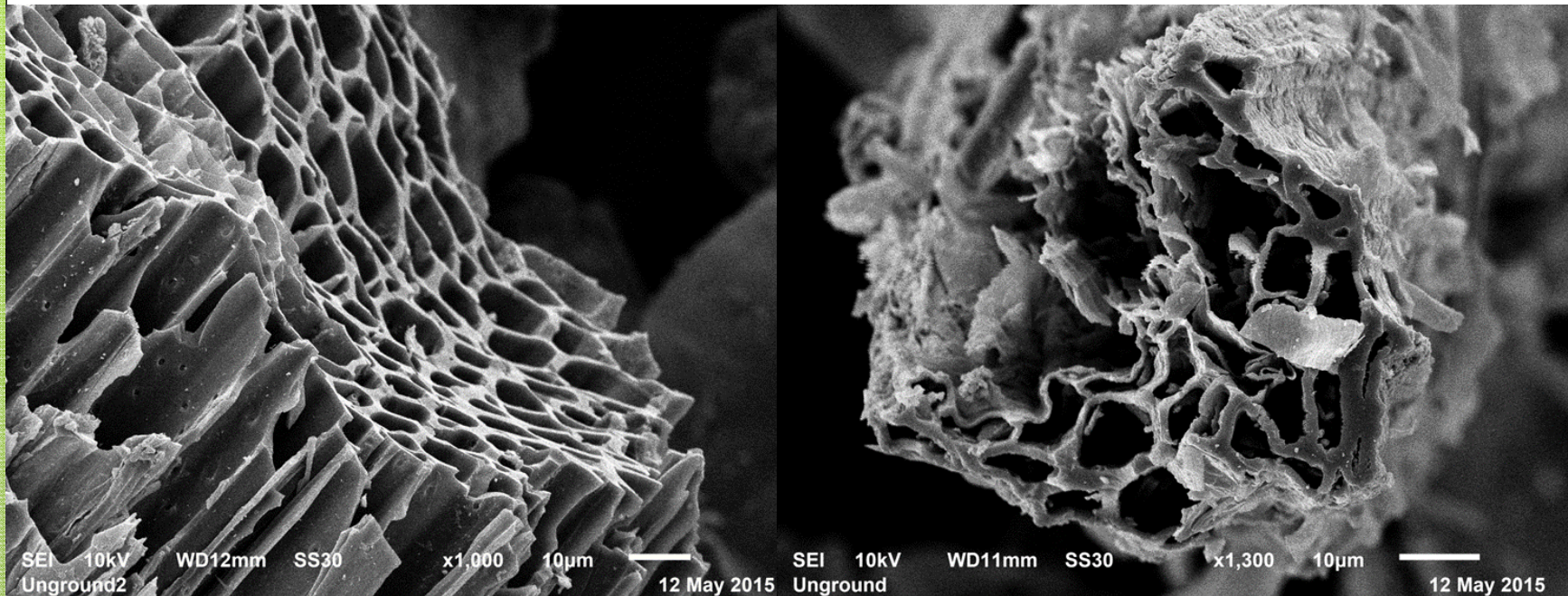
Courtesy of University of Louisiana at Lafayette

Hydrophobic?

Adsorption vs. Absorption

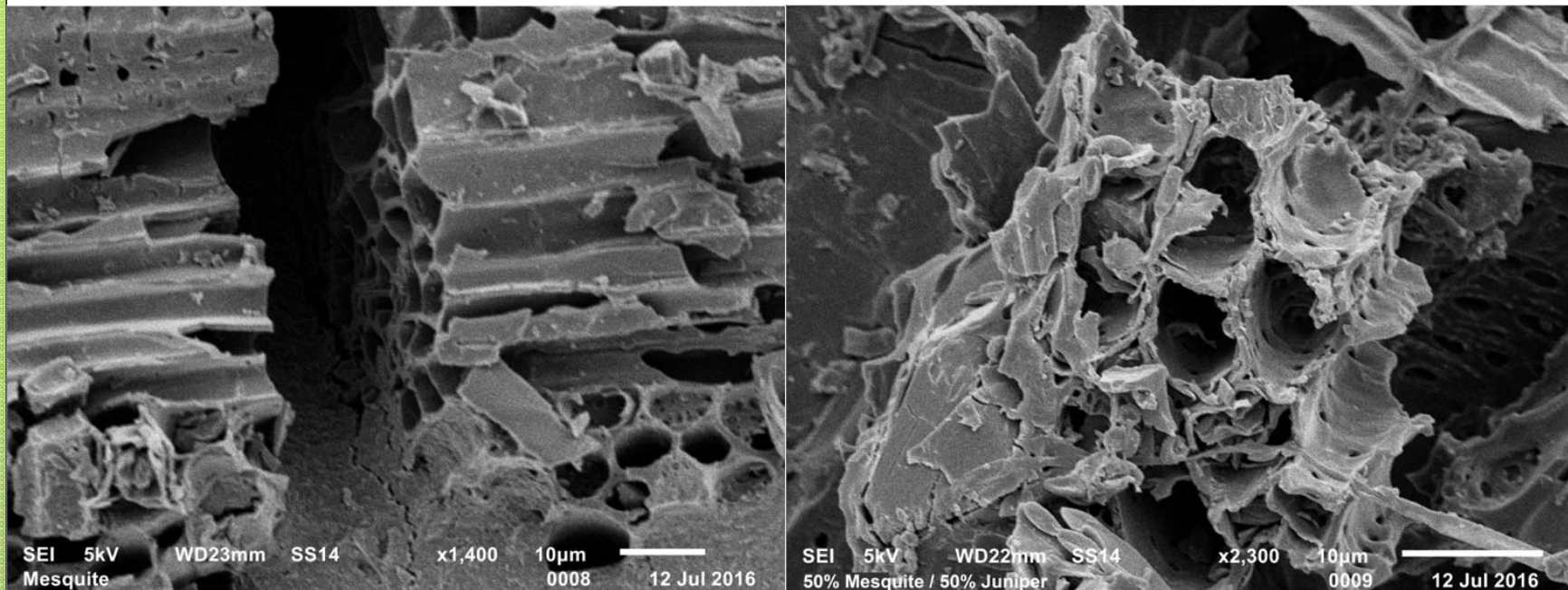
- Adsorption: The adhesion of molecules (such as water) to a surface
- Absorption: Molecules are taken on by the volume, not the surface
- Torrefied Material DOES NOT Absorb water, but DOES Adsorb water due to the microstructures created during Torrefaction
- The higher the “Level of Torrefaction” the more these microstructures are formed

Microstructures of Carbonized Material



Images taken using Electron Microscopy
On torrefied sugar cane remnants (bagasse)

Different Materials, Same Results



Images of Mesquite and Mesquite/Juniper Mix
Biochar made using a TSI torreactor

Why Drum Reactors?

- Proven and cost effective mechanism for getting heat into Biomass
- High Capacity
- There has been an evolutionary process whereby Drum technology has become the best technology in wood chip drying beating all other competing technologies.
- Safe technology, less prone to dust buildup, and easy to control in upset conditions
- Has the ability to classify – specific to TSI

Test unit...

- Built in 2010
- Used to develop process – underwent several rebuilds to perfect process
- Basis of patent
- Now used as test rig for different materials...
 - Various softwoods including Southern Yellow Pine, Doug Fir, White Pine, Ponderosa Pine, and Cedar
 - Hardwoods including mixed species (Oak, Ash, Birch etc.), Mesquite, and Eucalyptus.
 - Grasses and agricultural residue including Wheat Straw, Bagasse, Sugar cane, Arundo Donax, and Bamboo

TSI test unit in 2010 – Capacity 50 kg/hour



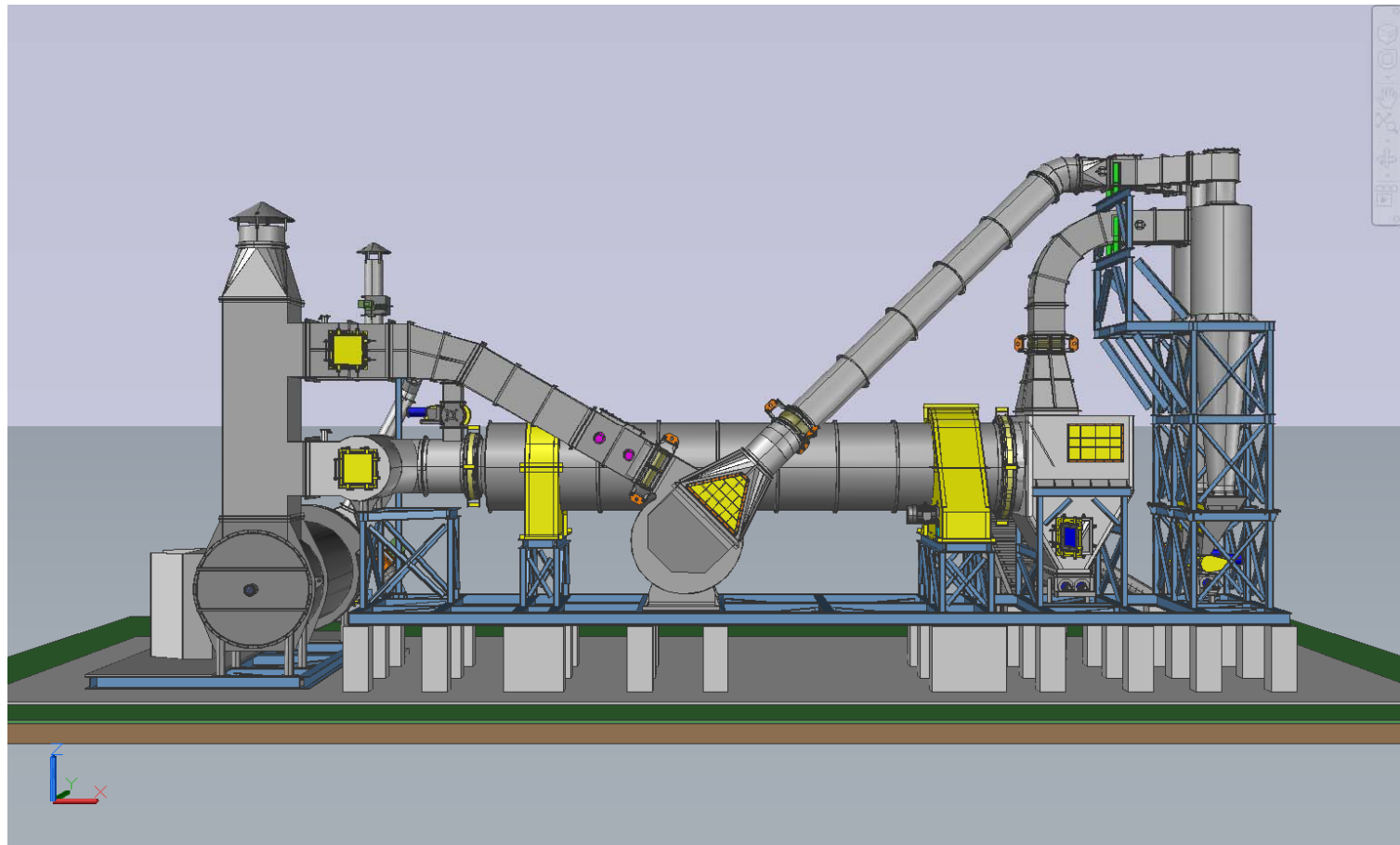
Key Features of Current - TSI Torrefaction System.



- Capacity – 3,000 kgs/hour input
- Operates at 0% oxygen
- Torrefies from 230°C up to 370°C
- Will increase GJ value up to 19 to 24 GJ/tonne (depending on species, outlet temperature and residence time)
- Works with a wide variety of feedstocks and chip size
- Auto thermal
- Classifies

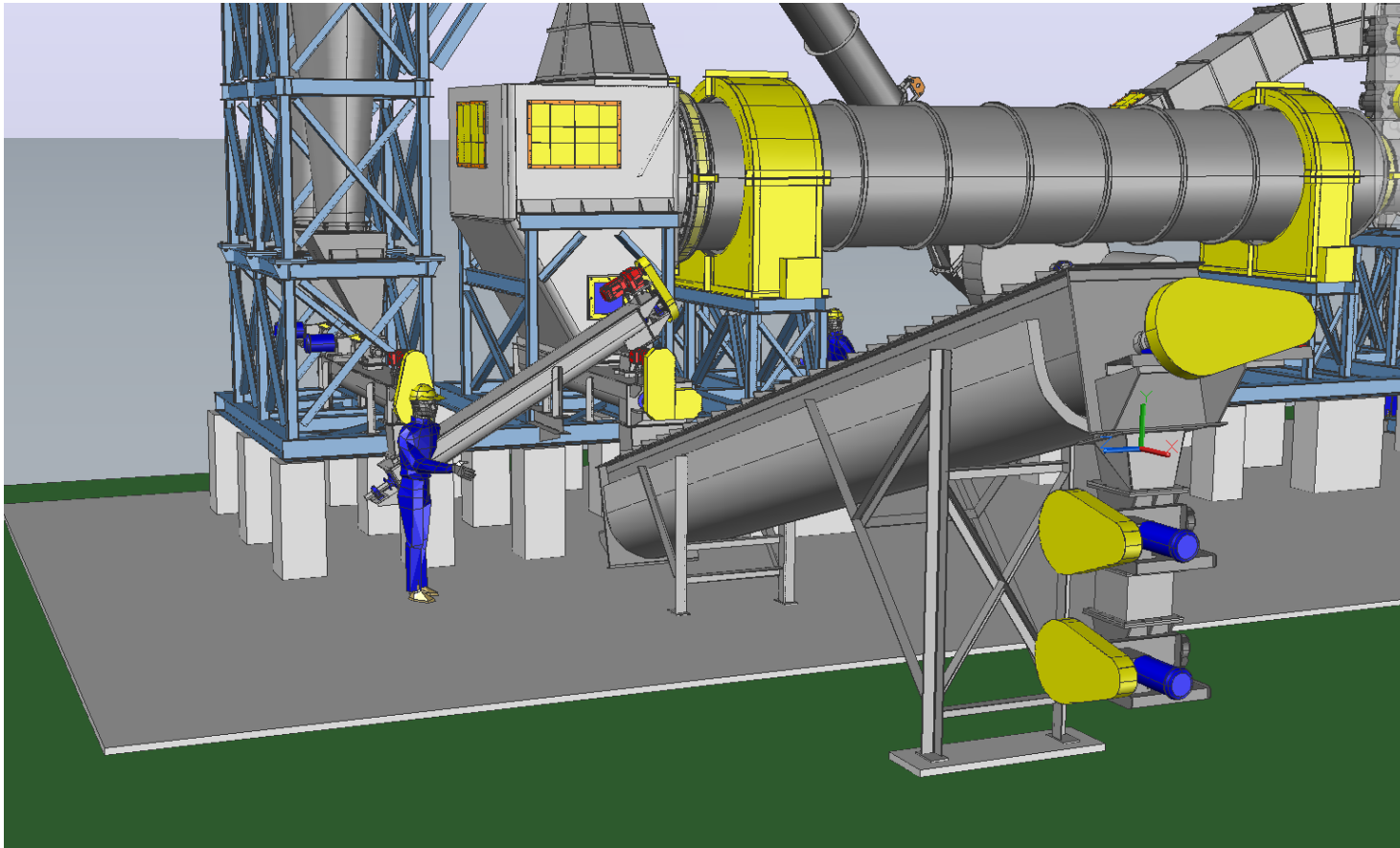


Schematic 1 – TSI Torreactor





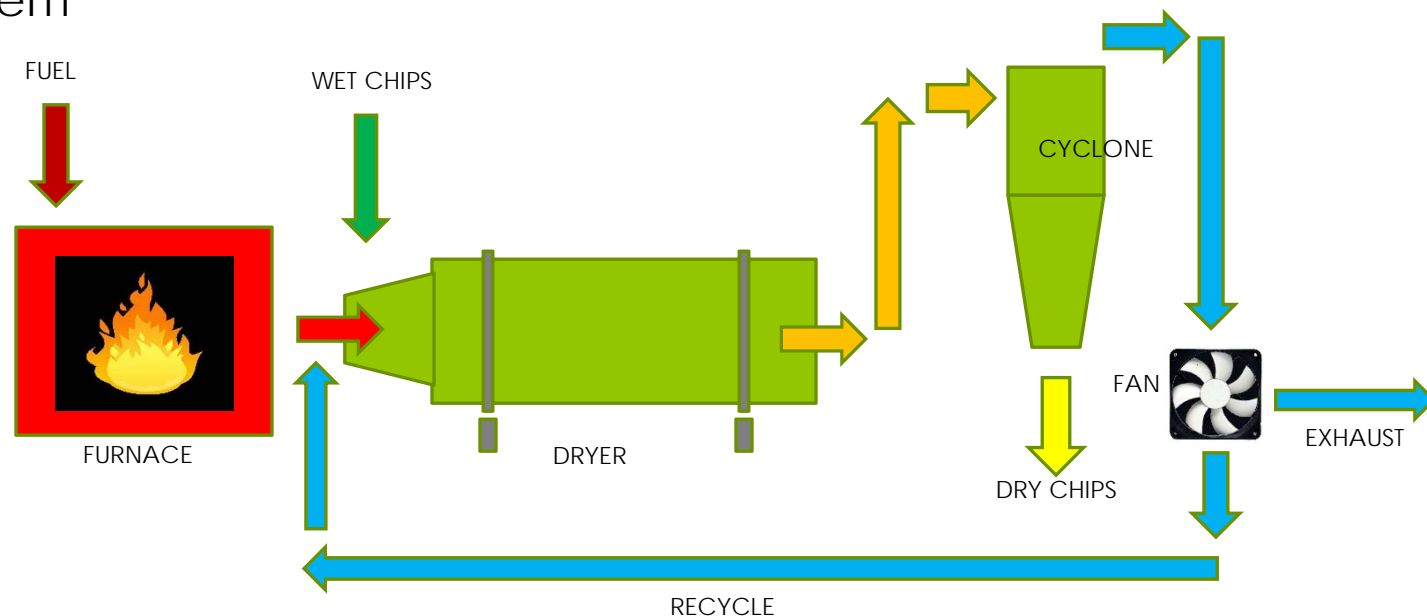
Schematic 2 – Outfeed Cooling Screw





Production Systems

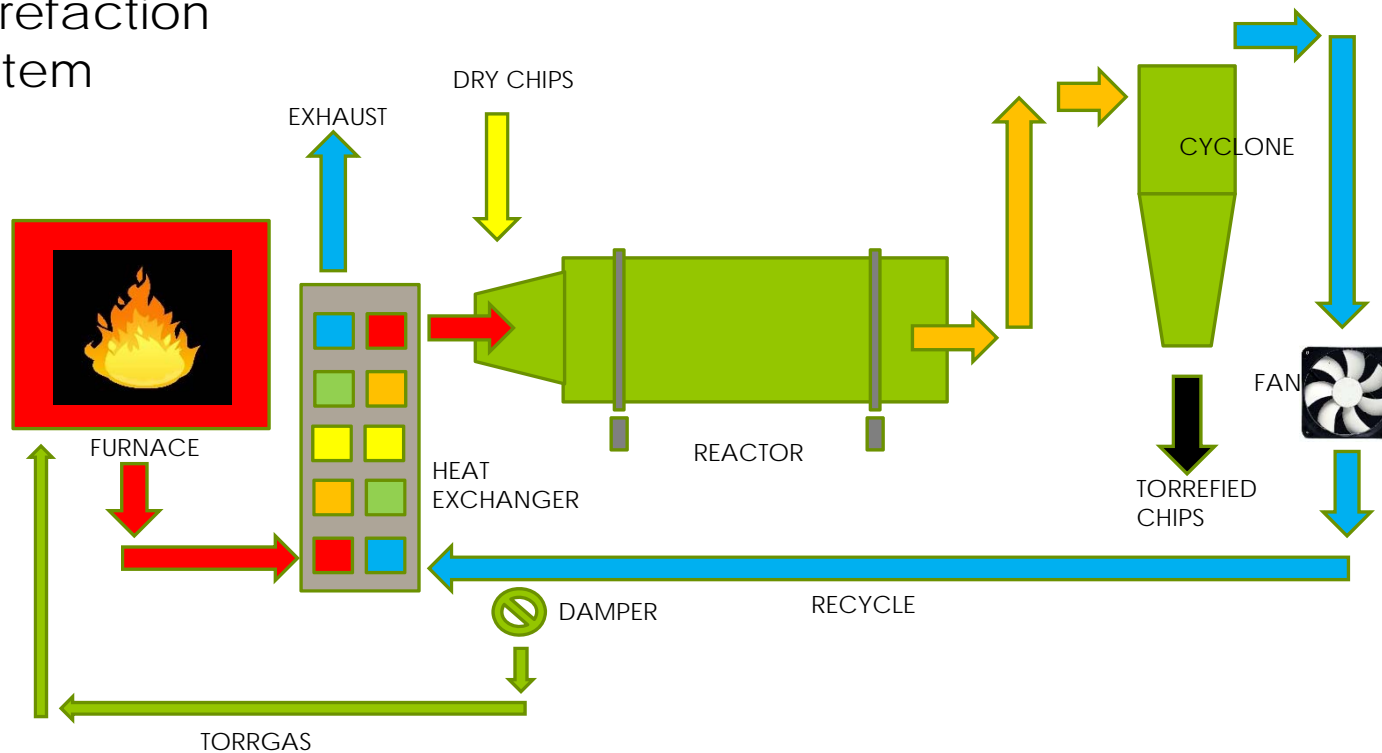
Standard Wood Chip Drying System



TSI technology is very energy efficient and most of the energy required comes from biomass (renewable).

Production Systems

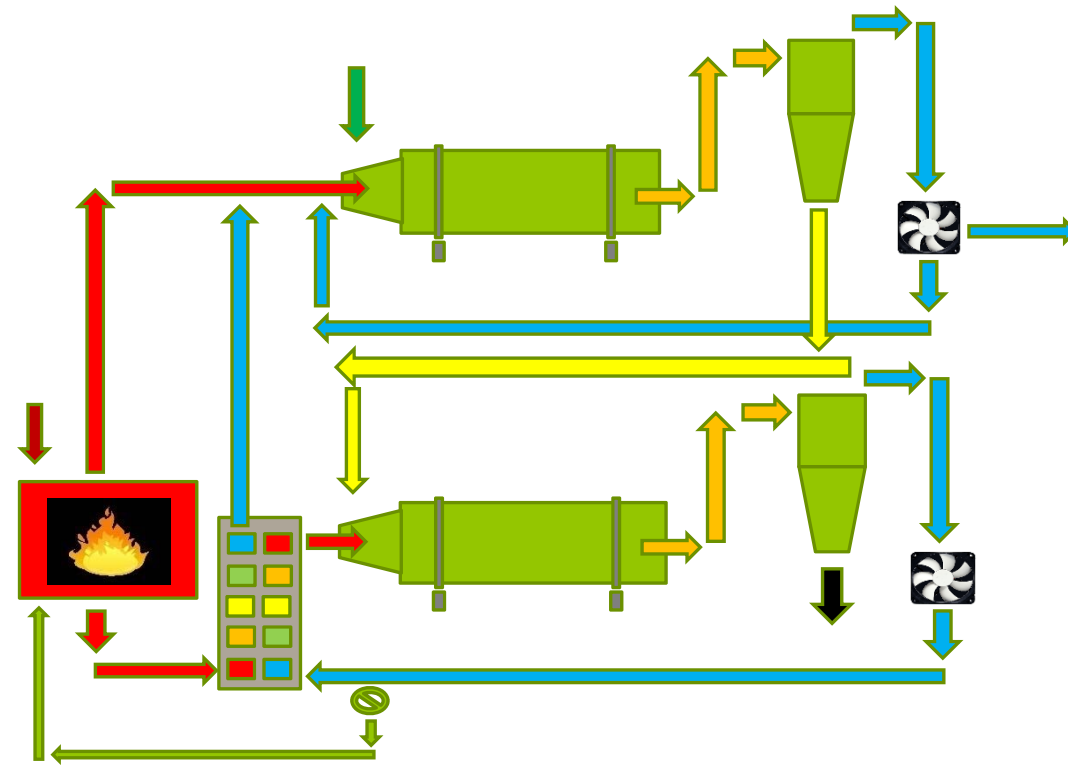
Standard Torrefaction System



The TSI reactor heats via a heat exchanger and is auto-thermal.

Production Systems

Combined
Dryer and
Torrefaction
System

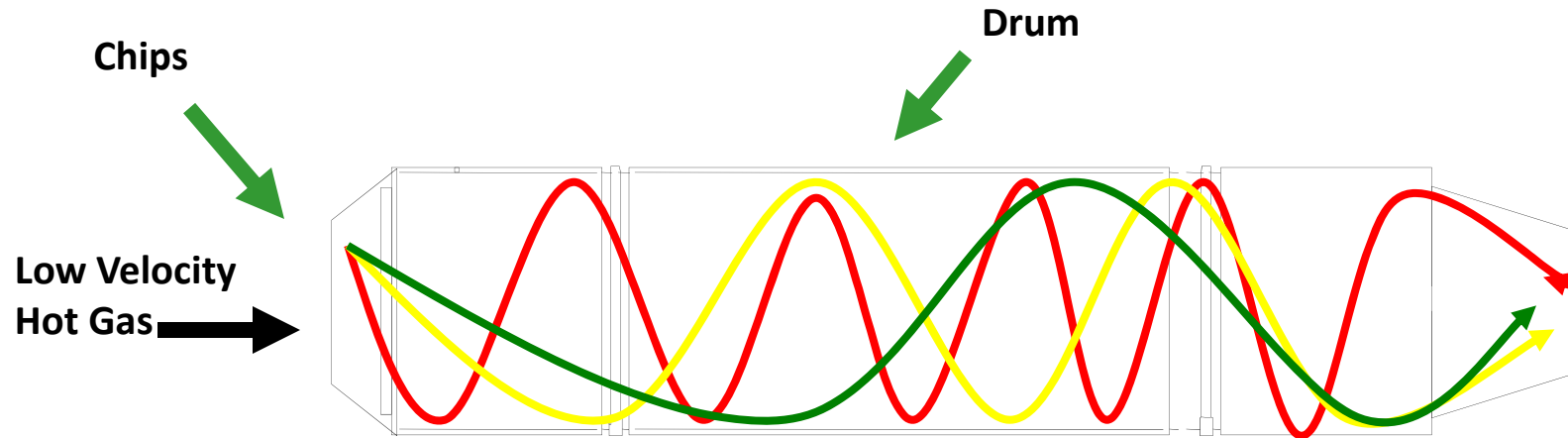




Inside the drum...

The unique flighting system in the drum creates a convection heating environment for the chips and allows for classification

Classification



Classification allows heavier or larger chips to dwell longer creating a more even heat treatment

EXAMPLE AVG.. DWELL

Red 9-15 Min.

Yellow 5-9 Min.

Green 1- 5 Min.

The advantage of classification

With - TSI



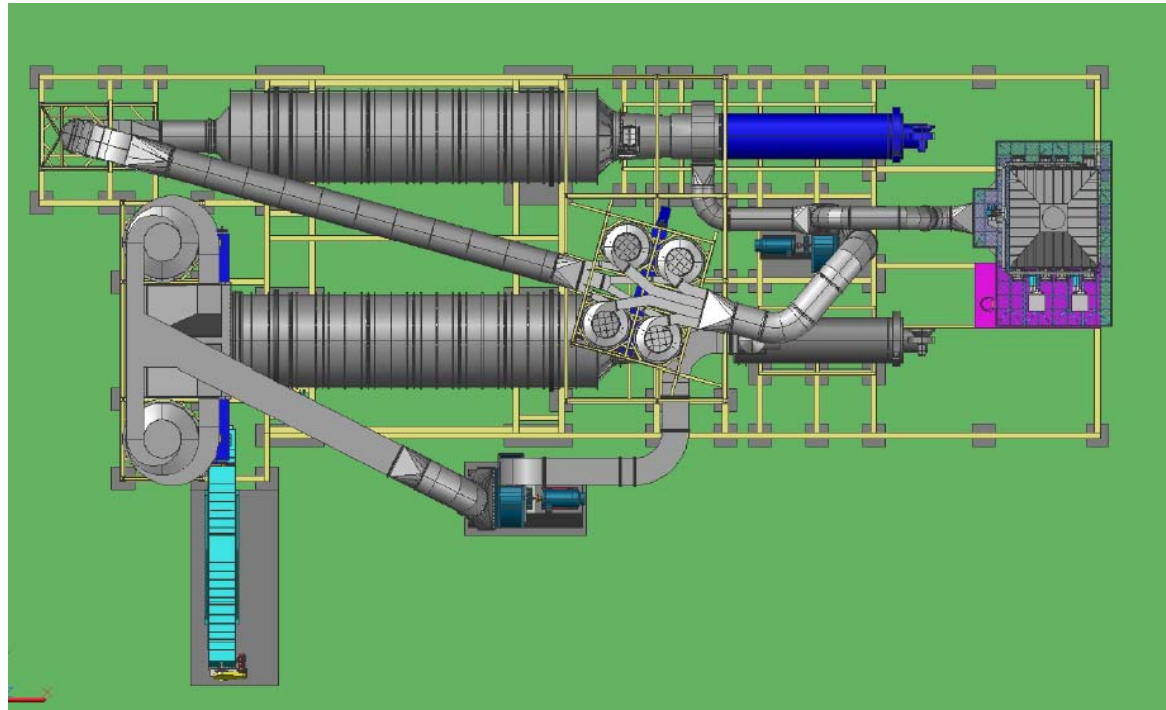
Without - Others





TSI – Scalability – One of the World’s smallest to the World’s largest. The algorithm remains the same.

What's next for TSI...



Full scale industrial systems – 200,000 tpy

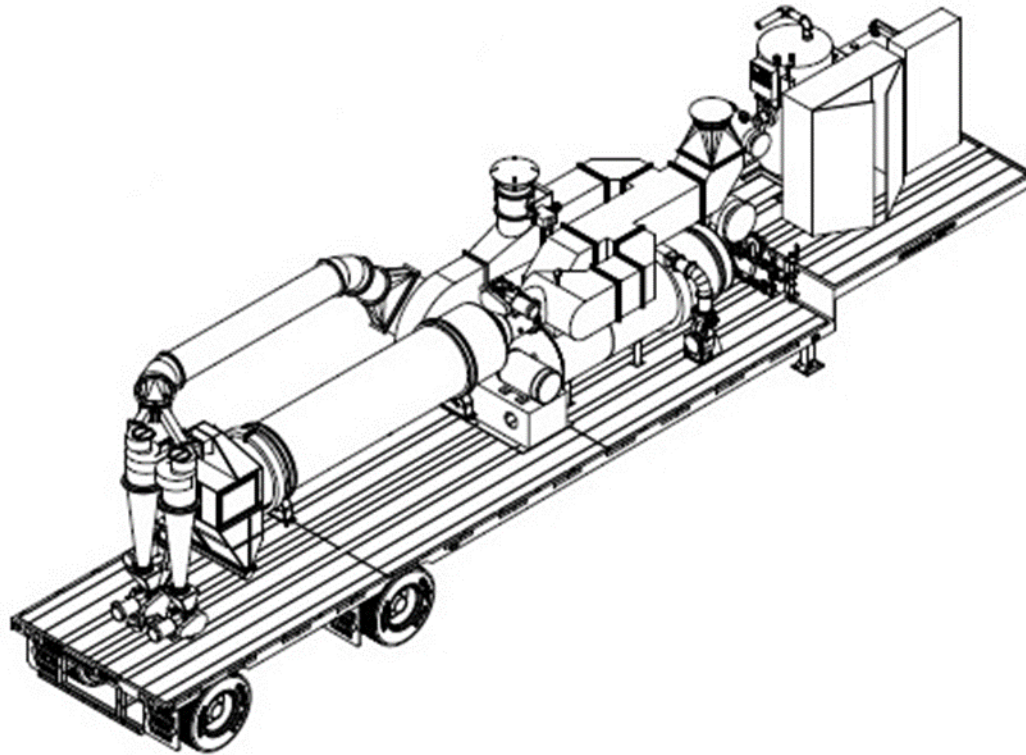


Construction underway on phase 1 of
200,000 tpy plant in Louisiana. (Feb 2016)

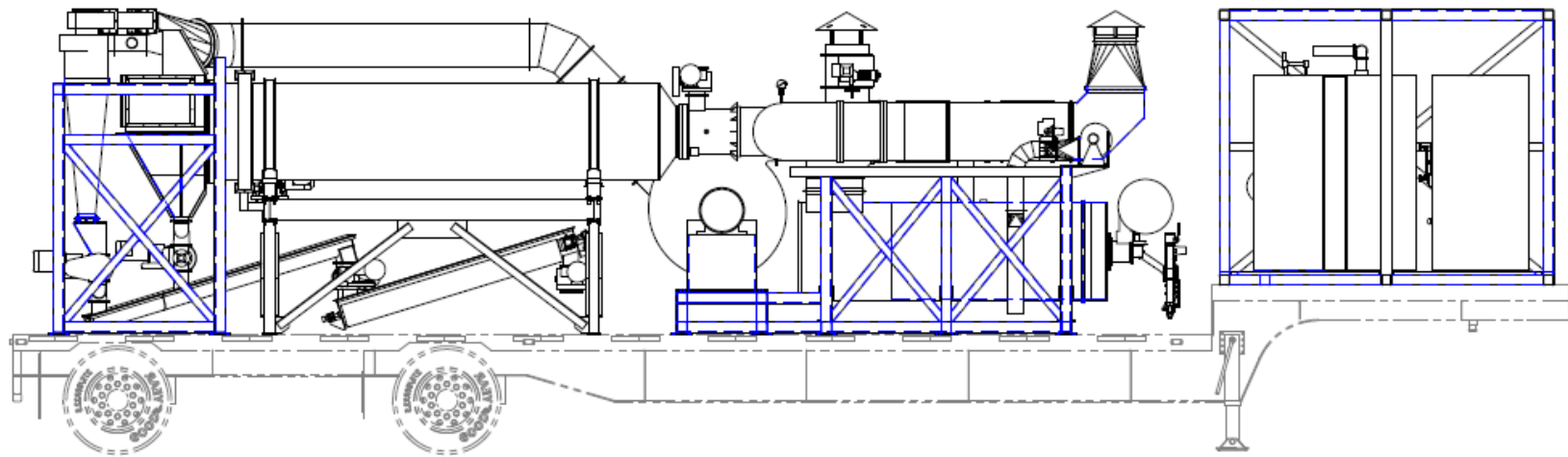


Other Design Concepts

TSI ½ Ton/hr Truck mounted system



Truck Mounting allows remote processing ability



TSI Advantage

- Twenty years of experience of processing woody biomass through these types of machines
- Twenty years of experience building very large industrial processing plants
- System modeled on proven equipment, (no mechanical risk) with proven ability to scale to very large capacities.
- Unique classification action ensures thorough and very even torrefaction results (no under or over-torrefied fibers in the final mix). Best quality of product
- Proven know-how for energy efficiency and best investment cost per ton of production.

Thank You

James Sabo

Torrefaction Sales Manager

jsabo@tsi-inc.net

