Biomass to Energy Conversion Technologies

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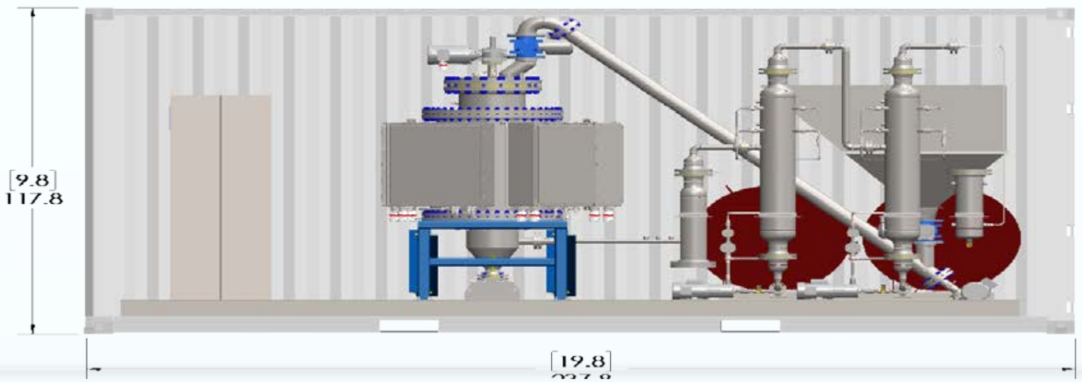
Resynergi Introduction
Mission: Collaborate to Free the World of Plastic Waste

Only 7% of Plastic is Recycled today

Resynergi

Resynergi

Converting Waste Plastic into Oil:
Environmental Stewardship, Economically



25 cents/ gallon
Road-ready diesel

Resynergi utilizes University of Minnesota and Sonoma County Combined Technologies

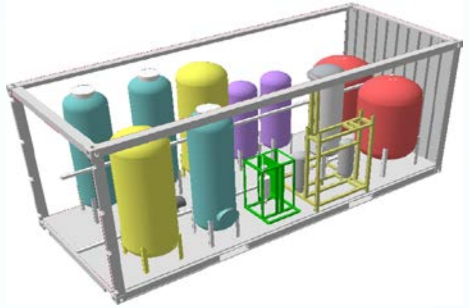
All kinds of solid wastes available

Wastes to Renewable Energy Pathways

- Plant-Derived Biomass (high in carbohydrates)
- Animal-Derived Biomass (high in proteins and oil)
- Waste plastics

Technologies	Products
Hydrolysis/ Fermentation	•Alcohols (methanol, ethanol, butanol) •Off-gas (CO2, CO, H2)
Anaerobic Digestion	•Bio-gas (CH4, CO_2, H_2S, NH_3) •Activated Sludge
Hydrothermal Liquefaction	•Bio-oil (highly oxygentated) •Syn-gas (CO, CO_2, H_2) and Biochar
Pyrolysis (>400°C)	•Bio-oil (highly oxygentated) •Syn-gas (CO, CO_2, H_2) and Biochar
Gasification (>700°C)	•Syn-gas (CO, CO_2, H_2) •Corrosive ash (Cl, K, etc.)
Combustion (>2,000°C)	•Heat (BTUs) •Electricity production

Environmental Impacts of Various Waste to Renewable Energy Pathways

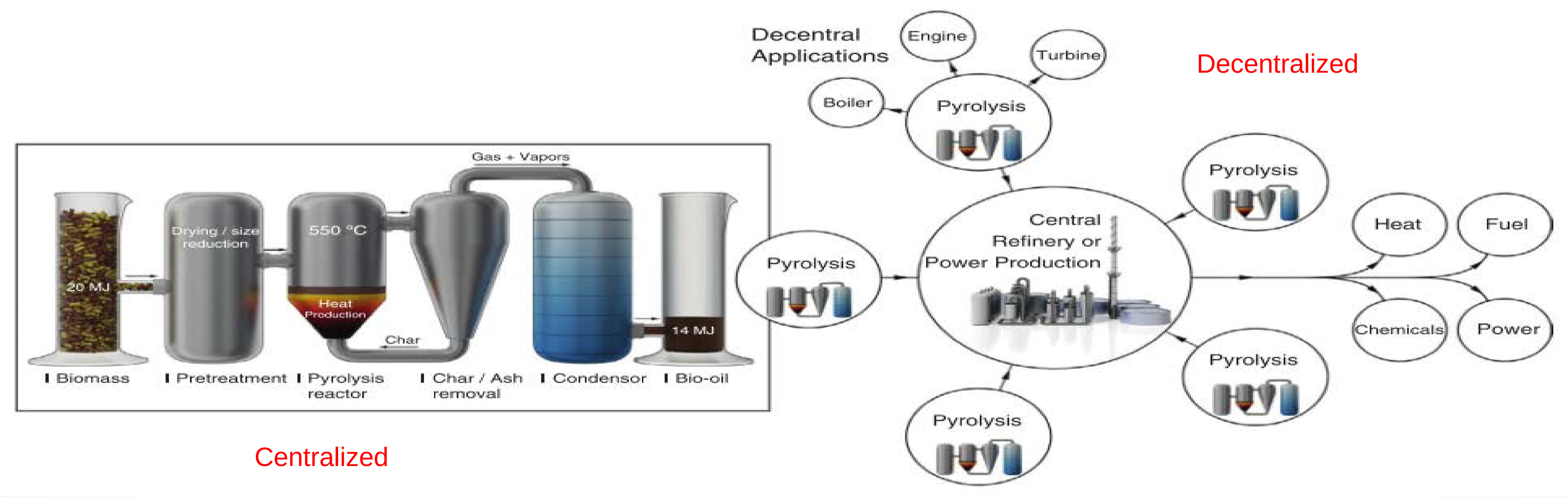


Technologies	Environmental and Economic Impacts and Considerations	
Hydrolysis/ Fermentation	• Food vs. Fuel (land sharing) • High capital cost for equipment • Large process footprint	• Requires high purity substrate (carbs) • Operates 24/7
Anaerobic Digestion	• Waste remediation • High capital cost for equipment • Large process footprint	• Biological uncertainty (Batch shutdown) • Operates 24/7
Hydrothermal Liquefaction	• Waste remediation • Very high capital cost • Small process footprint	• Residual carbohydrate stream, high energy input
Pyrolysis (>450°C)	• Produces bio-oil, bio-char and energy • Medium capital cost • Small process footprint	• Performs waste remediation and specialty chemical synthesis
Gasification (>700°C)	• Waste remediation to electricity • Medium capital cost • Small process footprint	• Produces inert ash as byproduct • Requires electricity generator to produce electricity
Combustion (>2,000°C)	• Waste remediation to energy (BTU) • Lowest capital cost • Small process footprint	• Produces inert ash as byproduct • Combustion gas requires cleaning

Thermochemical Conversion Technologies

- More specifically: torrefaction, combustion, pyrolysis and gasification
- Principal purpose: to completely convert biomass polymers for fuels, energy, chemicals, and materials production

Pyrolysis



Schematic of the pyrolysis process, centralized and decentralized logistic schemes, and proposed oil applications.

[Kersten, et al., 2013, Curr. Opin. Biotechnol.]

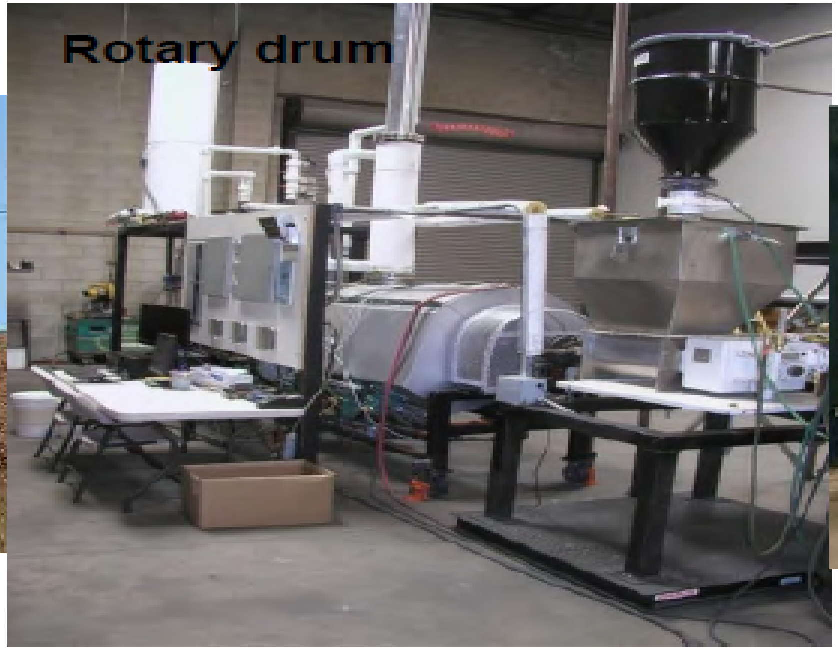
Fluidized-bed Pyrolysis Technologies

Current Issues:

- Complicated system with high capital cost, therefore has to be large scale to be economical
- High feedstock shipping and storage cost

Mobile Pyrolysis Reactors

Intermediate Pyrolysis Reactors



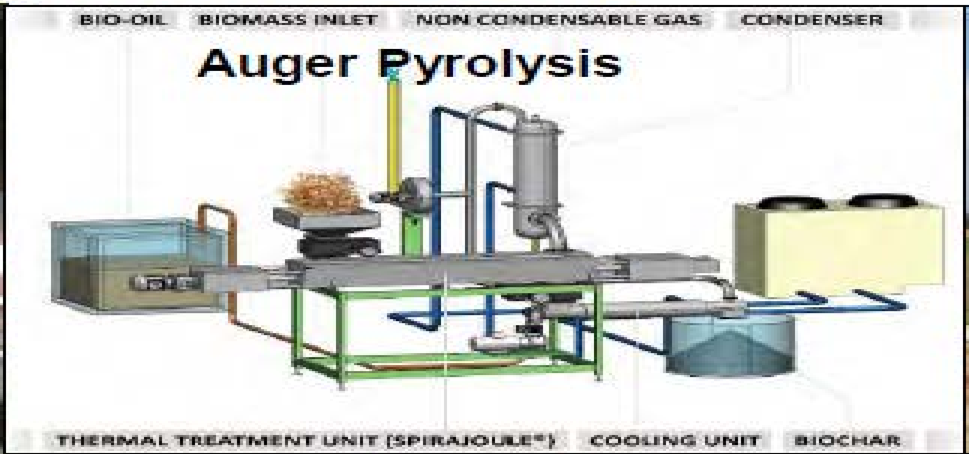
Black is Green Pty Ltd http//www.bio-char.com.au/about.html	Amaron rotary drum reactor (Coates Engineering) http://www.coatesengineering.com	Vacuum Pyrolysis Reactor (Pyrovac)

Comprehensive Methodology to Design Pyrolysis Reactors?
Could we increase bio-oil yields?

Mobile Pyrolysis Reactors

Intermediate Pyrolysis Reactors

Renewable Oil International Mobile Unit

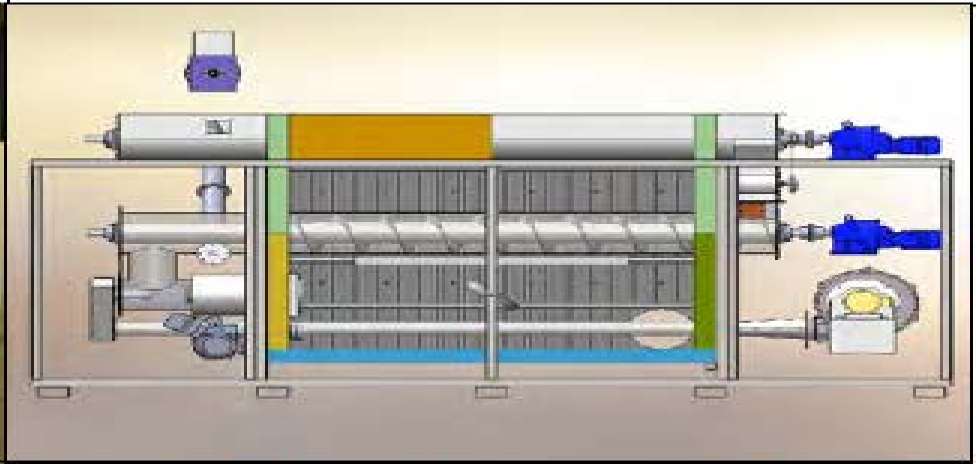


BiogreenR (http://biogreen-energy.com/bio-green.html)

Agri-Tech Producers (http://www.agritechproducers.com)

International Tech Corporation (http://www.internationaltechcorp.org/IT-info.htm)

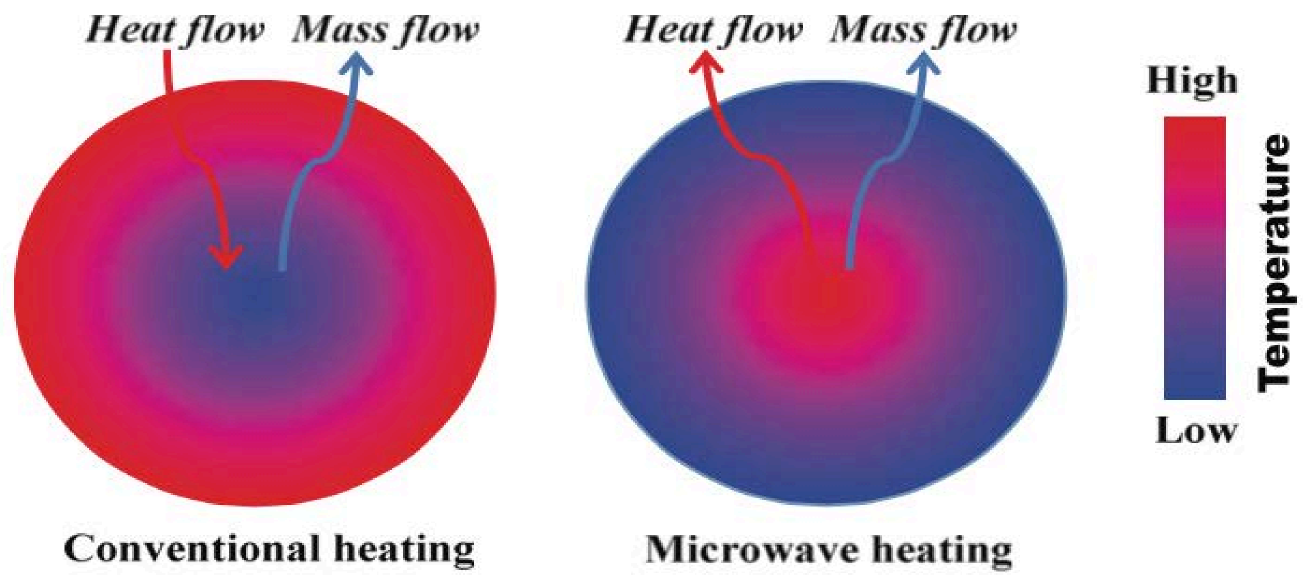
eGenesis CR-2 pyrolysis unit (http://www.egenindustries.com)

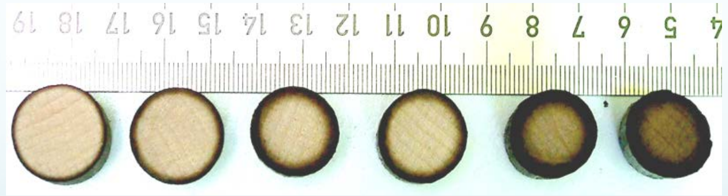


Whitfield Bio-char LLC

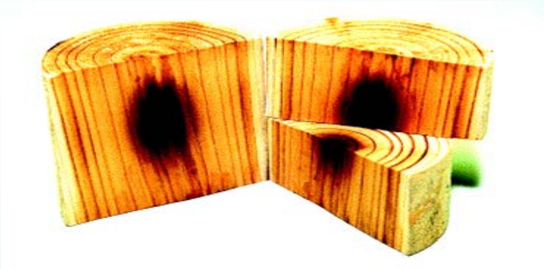
Advantages of MAP

- Microwave heating is more uniform, efficient and easy to control;
- The conversion products (pyrolytic gas and bio-oils) are cleaner than those from gasification and conventional pyrolysis because there is no need for fluidization;
- The syngas produced has higher heating value since it is not diluted by the carrying gas for fluidizing the materials;
- Microwave heating is a mature, and relatively more energy efficient, low cost technology; and
- Simple, scalable, portable, can be mobile for distributed conversion of solid wastes





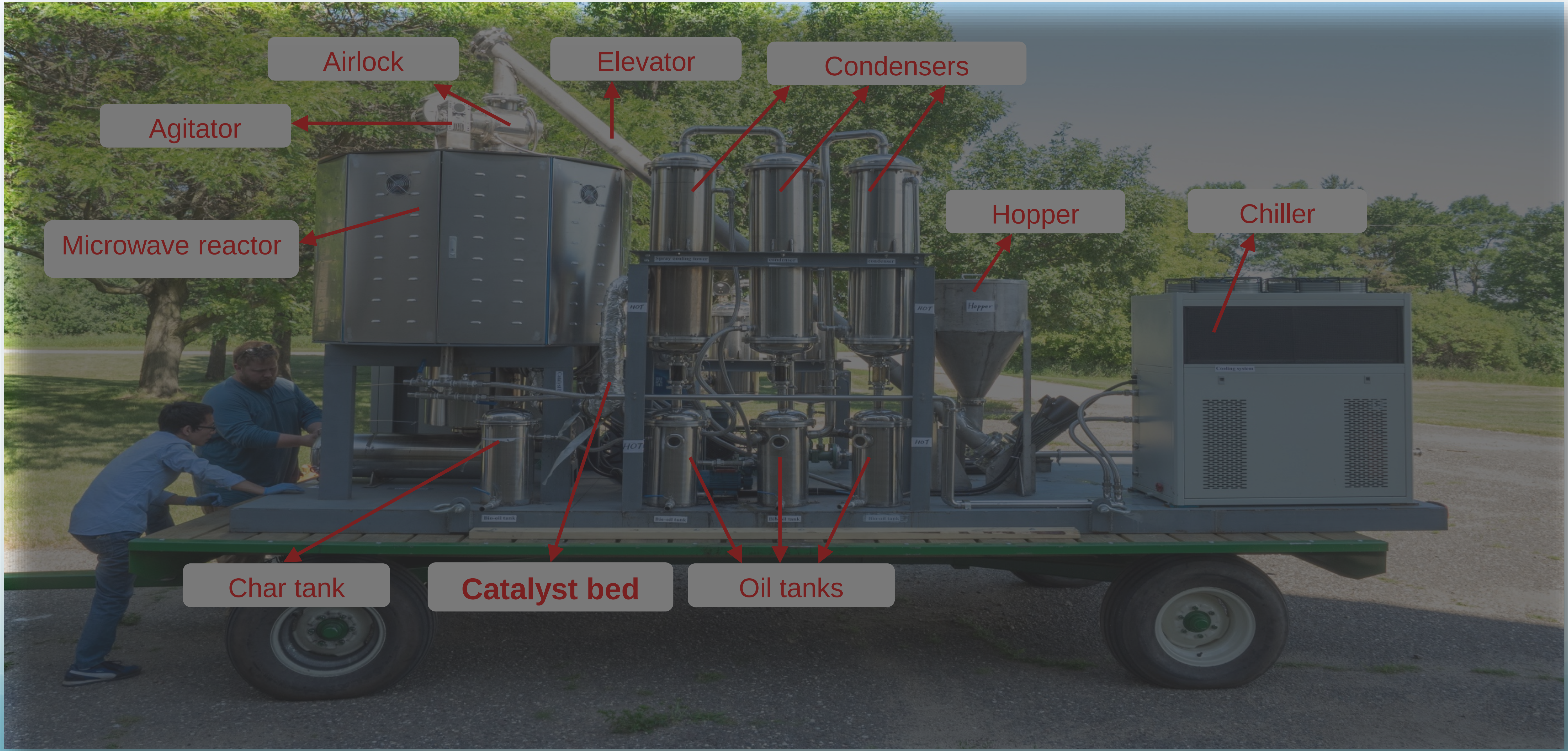
Pyrolysis front development with conventional heating



Pyrolysis front development with microwave heating

Comparison of the conventional heating and microwave heating *[Zhang, et al., 2017, in: Pyrolysis.]*

Mobile Fast Microwave Assisted Biomass Pyrolysis/Gasification Systems



Mobile Downdraft Two-Step Catalytic Fast Microwave Assisted Biomass Pyrolysis/Gasification System

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Thank you!

Questions?

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