



Renewable Energy & Products

DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Innovative Gasification to Produce Fischer- Tropsch Jet and Diesel Fuel

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Acronyms and definitions

- **BP – budget period (i.e., project phase)**
- **BPD – barrel per day**
- **BTL – biomass-to-liquids**
- **F-76 – military spec diesel fuel**
- **FT – Fischer-Tropsch process**
- **IE – independent engineer engaged by the DOE to monitor and review project details**
- **JP-5 and JP-8 – military spec jet fuel**
- **Syngas – process gases comprised of primarily hydrogen and carbon monoxide used to synthesize fuels, chemicals, or their intermediates**

Goal Statement

- **Frontline will demonstrate the performance of an integrated biomass-to-liquids (BTL) pilot plant utilizing innovative gasification and gas conditioning technologies coupled with an FT process.**
- **This project meets the goals of the innovative pilot integrated biorefinery by**
 - using renewable lignocellulosic feedstocks such as wood and other waste feedstocks
 - producing advanced biofuels in the form of military fuels F-76 diesel and JP-5 and JP-8 jet
- **This project supports the US Government and particularly Department of Defense's objectives of using 'alternative' forms of energy such as FT-based biofuels**

Quad Chart Overview

Timeline

- **Start Date: 10/1/2013**
- **End Date: 6/30/15 (BP-1B), 12/2016 Project**
- **Percent Complete: BP-1B~60%, Project~7%**

Barriers

- **Barriers addressed**
 - It-B. Risk of First-of-a-Kind Technology

Budget

	Total Costs FY 10 –FY 12	FY 13 Costs	FY 14 Costs	Total Planned Funding (FY 15- Project End Date)
DOE Funded	\$0.00	\$0.00	\$69,769.14	\$4,057,178.86
Frontline Cost Share	\$0.00	\$0.00	\$75,773.53	\$2,348,540.00
SGC Cost Share	\$0.00	\$0.00	\$0.00	\$2,502,915.00
Delphi	\$0.00	\$0.00	\$0.00	\$40,000.00

Partners

- **Partners**
 - FY14: Frontline (100%)
 - FY15: Frontline (48%); SGC (51%); Delphi(1%)
- **Other interactions/collaborations**
 - Stanley Consultants – engineering partner

1 - Project Overview - Partners

- **Frontline BioEnergy, LLC**, based in Ames Iowa, provides thermal gasification technology for the conversion of biomass and waste derived feedstocks
- **SGC Energia**, based in Houston Texas, develops alternative energy projects based on their XTLH[®] (carbon-based feedstocks to liquid hydrocarbons) platform that utilizes FT catalysis
- **Stanley Consultants**, based in Muscatine, Iowa and a 100 year engineering firm, currently ranked 75th on the ENR top 500, provides engineering and bid package services as requested by Frontline
- **Delphi Engineering and Construction LLC**, based in The Woodland, Texas, provides project and construction management services for federal projects

1 - Project Overview - History

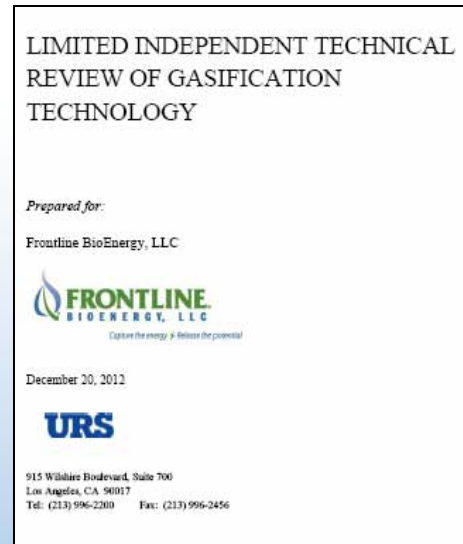
- **Thermal gasification is a centuries old process used for personal, municipal, industrial, and utility purposes**
 - Fuel for automobiles in times of petroleum scarcity
 - Gas works for providing fuel to gas lights and homes in the late 19th and early 20th centuries
 - Fuel gas production for firing boilers, internal combustion engines, combustion turbines, or natural gas displacement
 - Syngas production for fuel/chemical synthesis
 - Frontline has extensive experience in biomass gasification including the startup of a commercial gasifier in Benson, Minnesota
- **The Fischer-Tropsch (FT) process was developed in Germany in 1925 to produce lubricants and fuels from non-petroleum feedstocks such as coal, natural gas, and biomass**
 - Catalytic process that converts synthesis gas, carbon monoxide and hydrogen, into a broad range of hydrocarbon (HC) liquids
 - The HC liquids can be further refined into synthetic lubricants and fuels
 - SGC Energia is successfully operating a nominal 1-BPD FT pilot plant and are constructing an 1100 BPD commercial FT plant, both on the Gulf Coast

1 - Project Overview - History

- **2005.** Frontline founded
- **2006.** Frontline begins pilot work on CLEAN GAS[®] technology, the frontrunner of TarFreeGas[®].
- **2008.** First commercial plant demonstrating its PMFreeGas[®] started up at CVEC in Benson, MN
- **2011.** SGC Energia becomes equity partner
- **January 2013.** Frontline successfully demonstrates TarFreeGas[®]
- **March 2013.** Frontline's TarFreeGas[®] technology selected by DenYon Energy for its poultry litter gasification project
- **April 2013.** Frontline awarded IBR project by the US DOE to produce drop-in military fuels



Frontline commercial plant



Gasification is a Thermochemical Process

- **Combustion**

Fuel + Excess Air → Heat + Hot Exhaust Gas + Ash

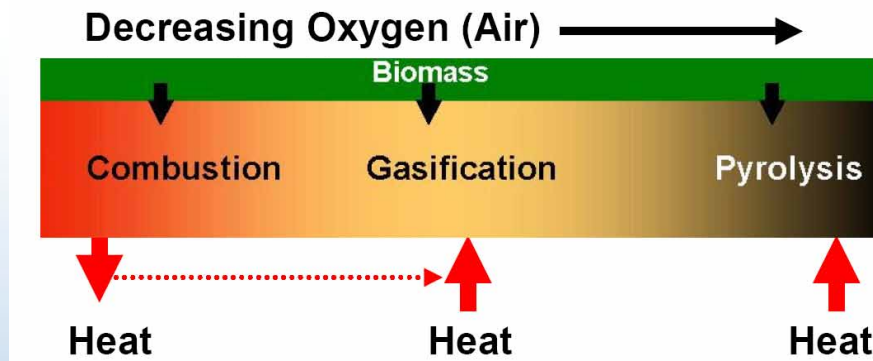
- **Direct Gasification**

Fuel + Limited Air → “**Producer Gas**” + Heat + Char-ash + **CH***

Fuel + Limited Oxygen → “**Syngas**” + Heat + Char-ash + **CH***

- **Indirect Gasification and Pyrolysis**

Fuel + Heat → “**Syngas**” or “**Pyrolysis Gas**” + Char-ash + **CH***



“Tars are the Achilles heel of biomass gasification.”

- Dr. Tom Reed

CH* ≡ condensable hydrocarbons, a.k.a. pyrolysis oils or “Tar”

1 - Project Overview - Objectives

- **Scale-up and demonstrate performance of Frontline's innovative TarFreeGas[®] gasification technology; low 'tar' syngas greatly simplifies downstream gas processing – reducing costs**
- **Demonstrate novel syngas conditioning process technologies to produce additional value streams such as fertilizer co-products**
- **Successfully integrate TarFreeGas[®], the gas conditioning processes, and an existing FT reactor to produce FT intermediate products, achieving a 1000 hours of integrated operation**
- **Convert FT intermediates to diesel and jet fuel samples conforming to military specifications**
- **Demonstrate a range of fuel flexibility by successful fuel production from wood and refuse derived fuel (from municipal solid waste) feedstocks**
- **Obtain performance data to inform commercial plant design**

2 - Approach (Technical)

- **Syngas production**

- Leverage unit operation data and critical operating parameter testing from Frontline's lab-scale TarFreeGas® system
- Unit operations include pressurized gasification, filtration, quench, shift, compression, acid gas removal, polishing

- **FT catalysis**

- Syngas to SGC Energia's nominal 1 barrel-per-day FT pilot plant
- Production of 'light' and 'heavy' FT intermediates

- **Intermediate upgrading**

- Employ conventional hydroprocessing unit operations, hydrotreating and/or hydrocracking, and distillation and blending with petroleum-based fuels; an outside lab (i.e., Wright Patterson AFB) will produce gallon quantities of spec fuels

2 - Approach (Management)

- **Frontline is the lead organization; Jerod Smeenck is the PI**
- **Critical success factors include**
 - Technical performance – integrated operation of the gasifier, gas conditioning, and FT unit operations to produce FT intermediates suitable for upgrading to military spec diesel and jet fuel
 - Feedstock flexibility – demonstrate the ability to use low-cost, non-food feedstocks
 - Product optionality – produce military spec diesel and jet fuel
- **Challenges to achieving successful project results include**
 - Technical risk: on-spec operation of each unit operation and the integration of the many unit operations
 - Budget risk: the procurement, installation, and operation costs are greater than the available budget; nothing in work-to-date suggests we are over budget
 - Schedule risk: Frontline has a small team which governs the progress rate

3 – Technical

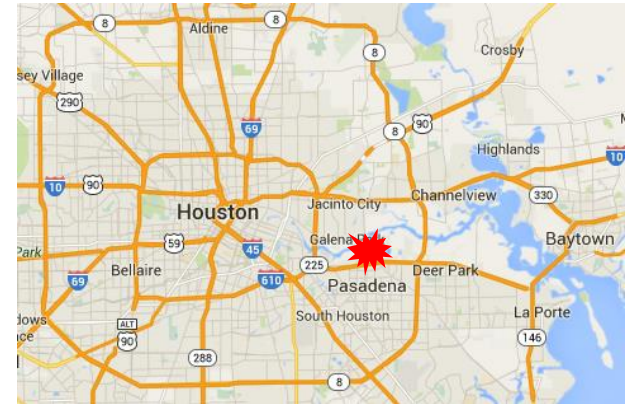
Accomplishments/Progress/Results

- **Project is parsed into three phases/budget periods (BP)**
 - BP 1A (complete) – due diligence review by the DOE and independent engineers
 - BP 1B (in progress) – detailed design of the integrated system including all equipment specification; includes all equipment and contractor costing
 - BP 2 (future) – procurement, construction, and operation
- **Schedule status**
 - BP 1A completed July 2014; issuance of IE report and ‘Go’ decision by the DOE for BP 1B
 - BP 1B started in August 2014 and scheduled for completion in June 2015; presently two months behind but working hard to complete on schedule; primary reason for schedule slip is Frontline’s desire to obtain additional lab-scale data to inform design of the pilot gasifier
 - BP 2 scheduled for 18 months

3 – Technical

Accomplishments/Progress/Results

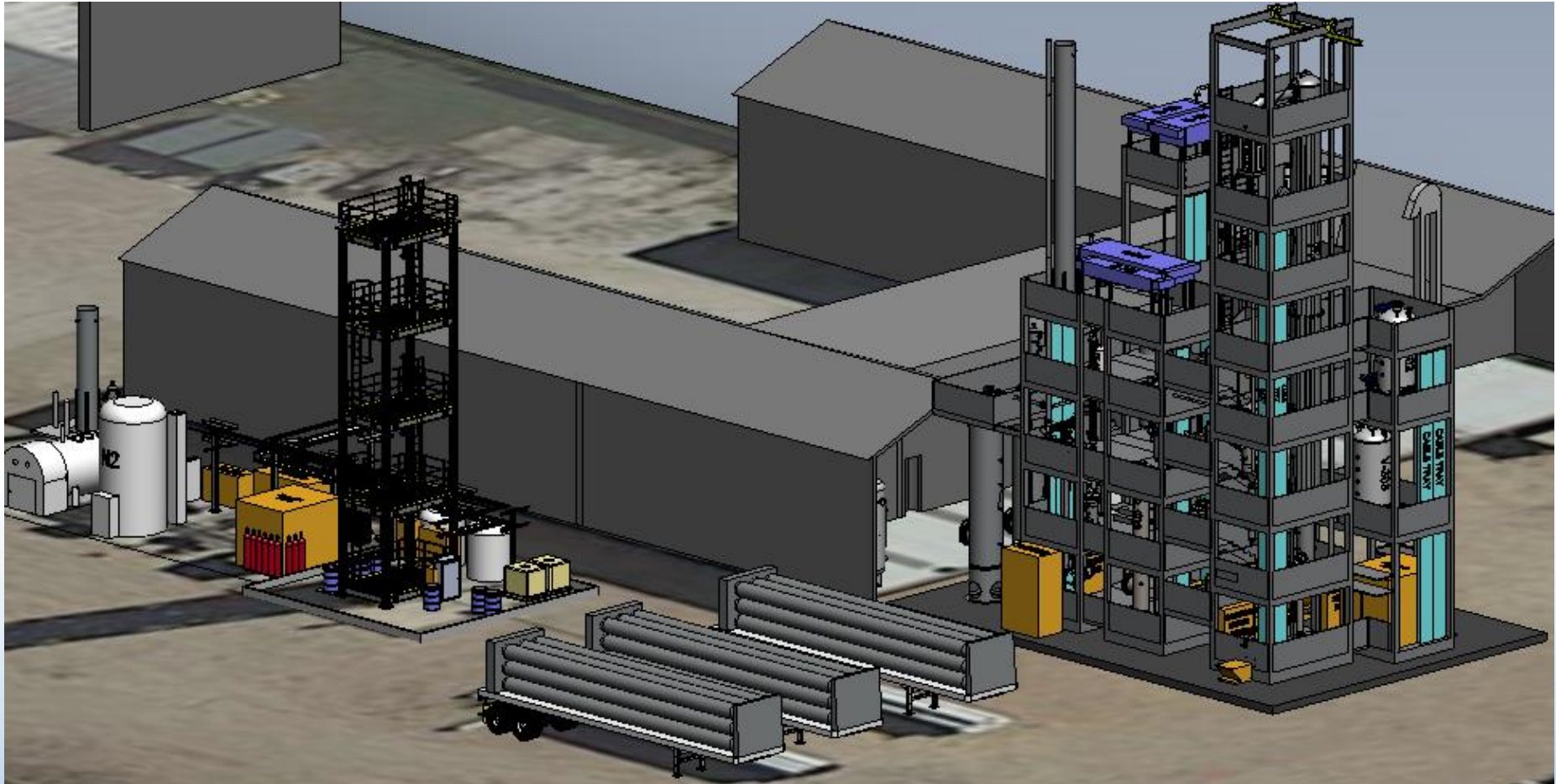
- **Building on success**
 - Frontline commercial gasifier and pilot plant
 - SGC FT pilot plant and forthcoming commercial project
- **Project site is secured and being prepared for construction**
 - Located in Pasadena, Texas at SGC Energia's XTLH[®] Technical Center US
 - Home to the FT pilot plant; currently operating on bottled syngas from tube trailers
 - Utility upgrades are in progress to accommodate the gasifier system
 - SGC's Technical Center supports this effort as well as their commercial project



3 – Technical Accomplishments/Progress/Results



3 – Technical Accomplishments/Progress/Results



3 – Technical

Accomplishments/Progress/Results

- **Detailed design status**
 - Frontline process engineering deliverables completed: design description/basis, process flow diagrams, heat and material balances, piping and instrumentation diagrams
 - Other Frontline detailed design including datasheets, reactor and vessel design, equipment layout, site layout is ongoing
 - Civil, structural, and electrical design is underway and being performed by Stanley Consultants
 - Construction bid documents being developed:
 - Module fabrication
 - Site excavation and foundations
 - Field erection
 - Site electrical upgrades and distribution to modules
 - Site interviews of potential subcontractors and vendors

3 – Technical

Accomplishments/Progress/Results

- **Costing - Frontline will request quotes from multiple fabricators or service providers for**
 - Fabrication of the multiple modules that make up the gasifier and gas conditioning process
 - Control system integration including control system architecture design, procurement, and programming
 - Site development and concrete foundations
 - Field mechanical erection, pipe rack installation and piping interconnects, and final assembly
 - Field electrical installation including site upgrades and distribution to modules

4 - Relevance

- **This project readily fits the BETO MYPP goals by**
 - Producing drop-in, advanced biofuels using sustainable feedstocks
 - Reducing U.S. dependence on foreign oil by producing military spec diesel and jet fuel
 - Motivating growth of the bioenergy industry through use of non-food biomass such as wood, ag residues, and sorted waste
 - Integrating the processes of biomass gasification and FT synthesis to produce useable liquid fuel products

4 – Relevance - Continued

- **This project demonstrates advanced thermal gasification technology that substantially reduces “tars” in the syngas out of the gasifier reactor (i.e., reformation of tars in the gasifier reactor)**
 - Reduction of tars greatly simplifies downstream gas cleanup and conditioning
 - Reduction of tars essentially eliminates production of a hazardous waste and reduces the hazards associated with handling/management of that waste
 - Reformation of tars increases syngas yield and conversion efficiency

5 – Future Work

- **BP 1B – detailed design**
 - Identify firm costs for the fabrication, procurement, and construction of the pilot plant
 - Obtain a ‘Go’ decision from the DOE
- **BP 2 - construction**
 - Procurement – most procurement to be executed by Frontline
 - Fabrication and erection – module fabrication and craft field work
 - Control system – integrator for procurement and programming
 - Commissioning – loop checks, unit operation validation, emergency shutdown validation

5 – Future Work – Continued

- **BP 2 – operation**
 - Feed system, gasifier, and gas conditioning startup – confirm syngas quality
 - 1000 hrs of integrated operation for production of FT intermediates
 - Upgrade of FT intermediates to military spec F-76, JP-5, and JP-8
- **Explore future market opportunities**
 - Government
 - Federal
 - DOD
 - State and local agencies
 - Commercial
 - Private waste companies
 - Add partners for total solutions (waste-to-fuels)

Summary

- **Project aligned with BETO MYPP goals and objectives**
 - Use of renewable, non-food feedstocks
 - Production of military spec diesel and jet fuel
- **Demonstration of innovative thermal gasification technology for the production of low-tar syngas**
- **Integration with FT process for synthesis of hydrocarbon intermediates with subsequent upgrading to military spec fuel**
- **Working on detailed design – completion target this summer**
- **Begin BP-2, procurement/fabrication/construction/operation upon ‘Go’ decision’ from the DOE**



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Thank you!

Frontline BioEnergy, LLC

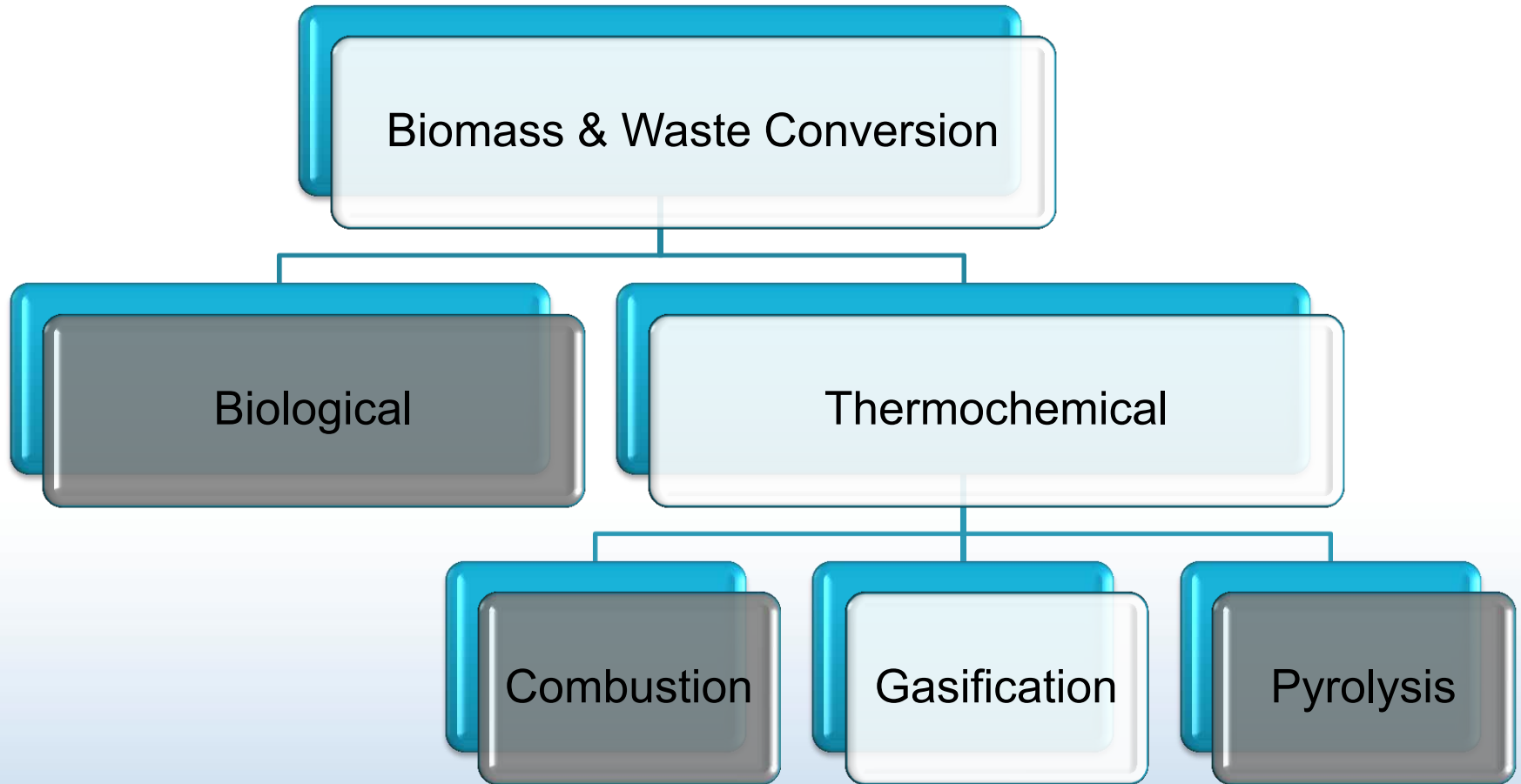
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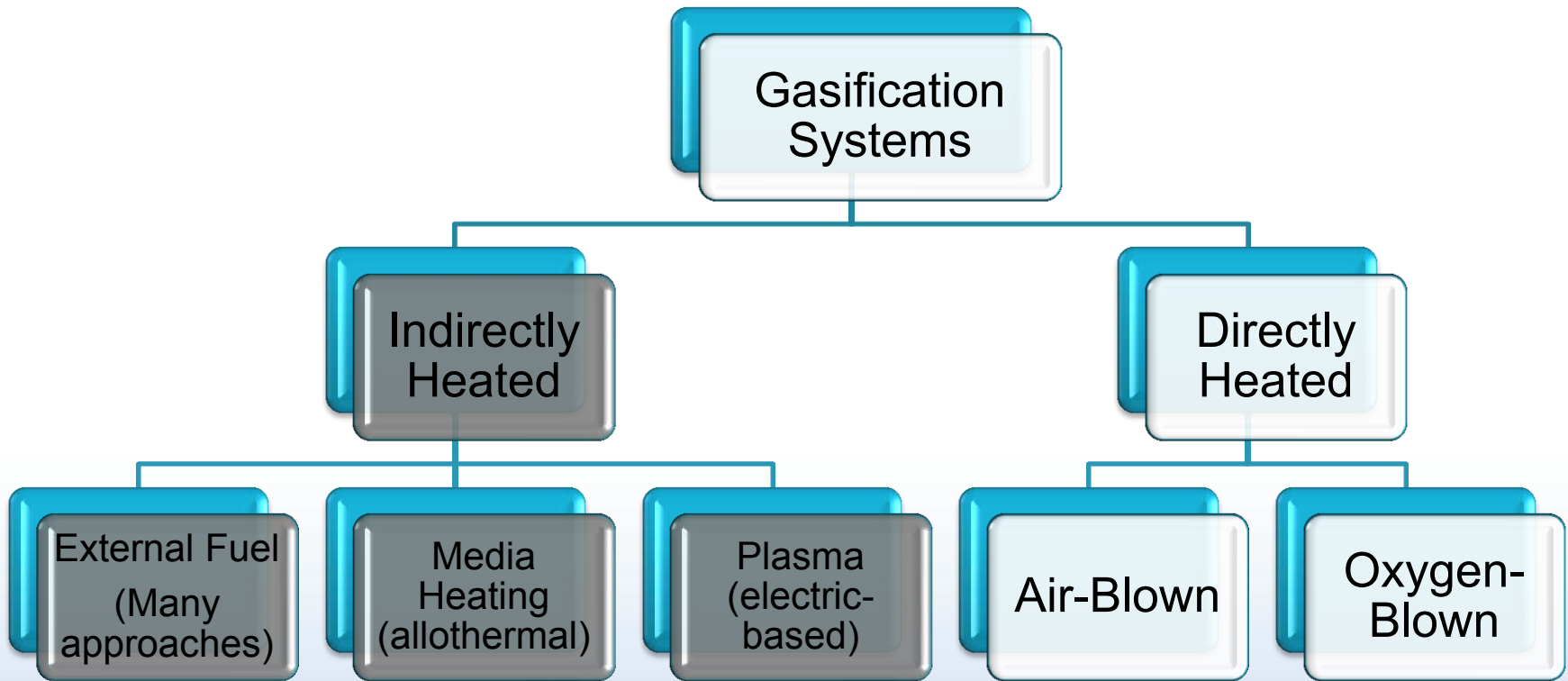
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Types of Conversion Systems



Types of Gasification Systems



Direct Gasification Reactors

