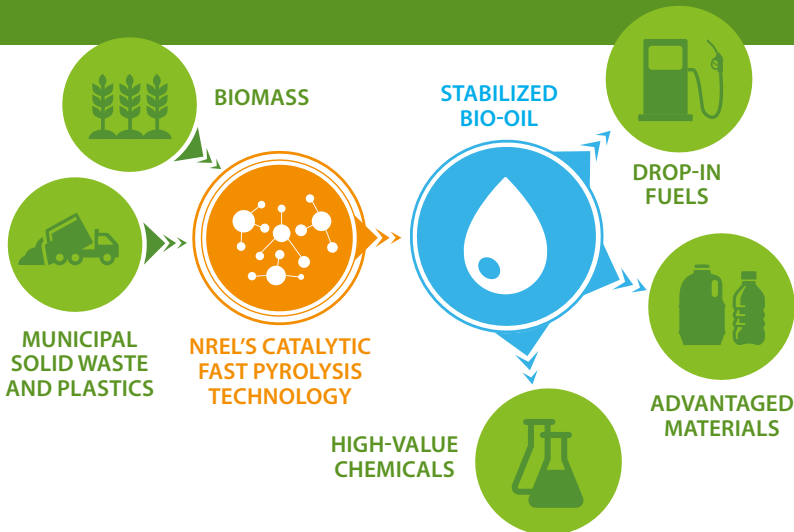


LOW-COST PRODUCTION OF VERSATILE BIO-OIL

ADVANTAGES OF OUR CATALYTIC FAST PYROLYSIS (CFP) TECHNOLOGY

- 1 Direct liquefaction** of biomass with **high carbon efficiency (>40%)**
- 2 Improved bio-oil stability, reduced oxygen content and acidity** compared to raw pyrolysis oil
- 3 Bio-oil readily fractionated** using conventional petrochemical approaches
- 4 Versatile downstream bio-oil utilization enabled by tunable composition:** feedstock for refinery co-processing; low-cost hydrotreating to gasoline, diesel, and jet fuel blendstocks and oxygenated compounds for material and chemical production
- 5 Reduced greenhouse gas emissions** and pathway to cellulosic fuel (D3) Renewable Identification Numbers (RINs)

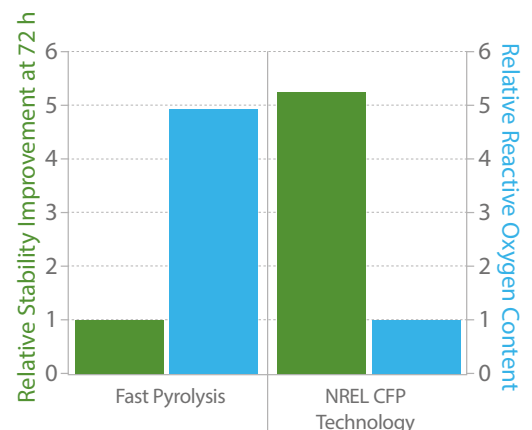
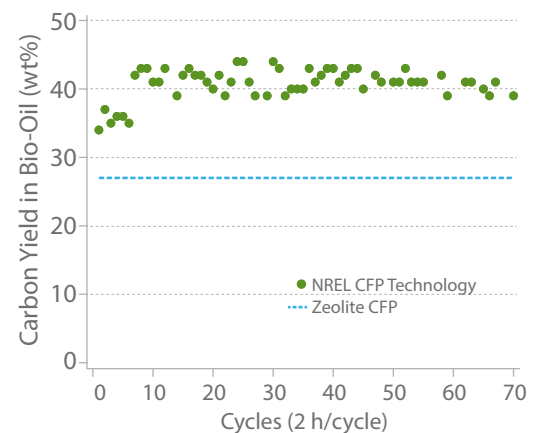


VALUE PROPOSITION AND DIFFERENTIATORS

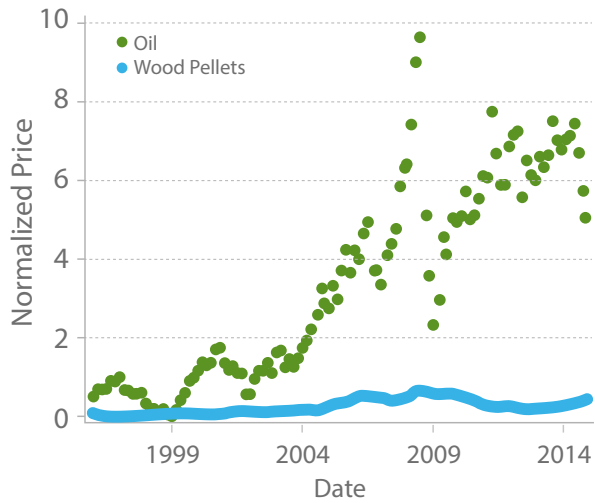
NREL's partners can generate both cost-competitive renewable fuels at yields greater than 70 gallons per ton of biomass and high-value chemicals and materials from a versatile bio-oil intermediate to meet regulatory mandates and public demand:

- **Greater than 60% reduction** in greenhouse gas emissions compared to petroleum-sourced fuels
- Stabilized, refinery-compatible bio-oil **reduces downstream hydrotreating and separations costs**
- **Oxygenated products** for novel polymer synthesis
- Woody feedstock **cost decoupled from petroleum.**

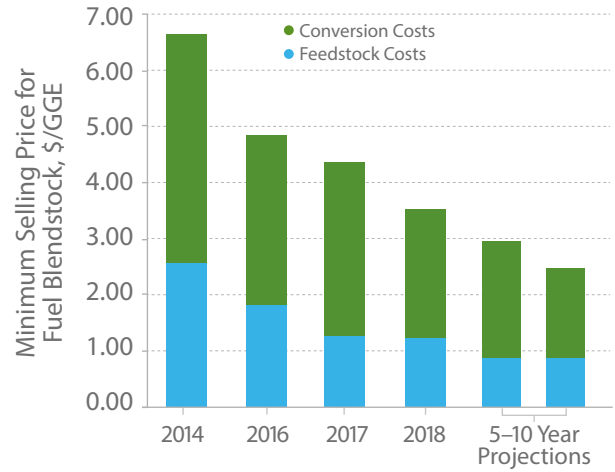
Increased Yield and Improved Stability



Market Considerations: Reduced Volatility and Cost



Sources: FutureMetrics, Pellet Price Database; U.S. Energy Information Administration, Petroleum & Other Liquids



Cost reductions through targeted R&D combined with renewable fuel policy incentives* can reduce commercialization risk.

* Renewable Fuel Standard (RFS) and Low Carbon Fuel Standard incentives are market-based and may fluctuate over time.

WE ARE SEEKING STRATEGIC PARTNERSHIPS AND COOPERATIVE RESEARCH AND DEVELOPMENT

- Feedstock suppliers (forest and agriculture) looking to generate additional revenue through **bioproducts and biofuels, taking advantage of available RINs**
- Farms, orchards, and agricultural entities seeking improved sustainability and profits by **converting their waste and residues into bioproducts**
- Refiners looking to meet regulatory mandates California Air Resources Board and RFS programs through **bio-oil co-processing**, and those seeking routes to **renewable chemicals**
- Airlines in search of **renewable jet fuel blendstocks** to comply with international policy
- States, cities, and municipalities targeting a **versatile platform to commoditize renewable feedstocks**
- Catalyst manufacturers and technology providers seeking to **expand product offerings into renewable fuels and chemicals markets**
- Polymer manufacturers seeking **cost-effective renewable feedstocks** with potential performance advantages.



CONTACT US to discuss how our technology can address your needs

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