

HONEYWELL UOP BIOCRUDE UPGRADING TECHNOLOGY

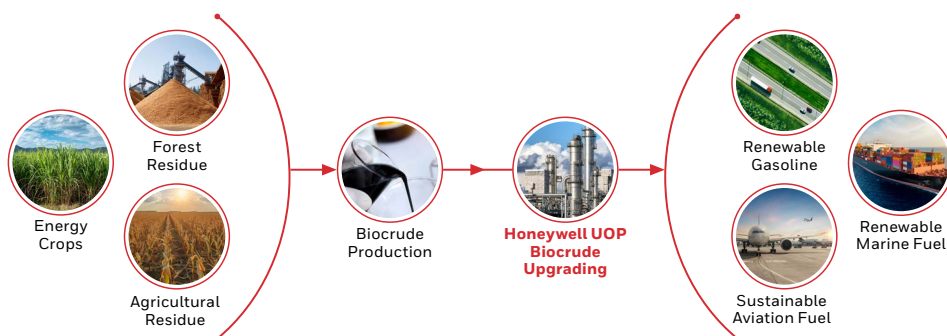
Honeywell's next generation renewable fuels processing technology produces drop-in renewable aviation, marine, and road transportation fuels from abundant and lower-cost biomass sources.



NEW TECHNOLOGY HELPS UNLOCK THE POTENTIAL OF BIOMASS

Global renewable fuel commitments from corporations and policy makers are already outpacing triglyceride feedstock capacity, requiring additional feedstocks and pathways to meet long-term demand. Waste wood and plant residues from agriculture, forestry, and other industries—also known as lignocellulosic biomass—can be an abundant and inexpensive renewable fuel feedstock, but its use has been limited due to processing challenges.

Honeywell UOP's Biocrude Upgrading technology can help unlock the potential of solid biomass by enabling an efficient conversion of historically challenging biocrude feeds into drop-in transportation fuels reliably and at scale. Biocrude Upgrading produces renewable marine fuel, sustainable aviation fuel (SAF), and renewable naphtha feed for gasoline, giving refiners and project developers multiple options to valorize solid biomass via biocrude intermediates.



PATHWAY BENEFITS

- Utilize abundant & inexpensive lignocellulosic biomass
- Higher liquid yields than once-through gasification or fermentation¹
- Bio-oil intermediates enable hub-and-spoke approach

WHAT SETS BIOCRUDE UPGRADING APART?

Biocrude Upgrading uses pyrolysis oil (pyoil) or hydrothermal liquefaction (HTL) oil as an intermediate between waste biomass and drop-in transportation fuels. Historically, converting highly oxygenated biocrudes to finished fuels, or blending them directly into transportation fuel streams, has posed challenges such as fouling and polymerization, catalyst deactivation, and blending compatibility. Honeywell UOP's Biocrude Upgrading addresses these challenges using an innovative reactor and catalyst system.

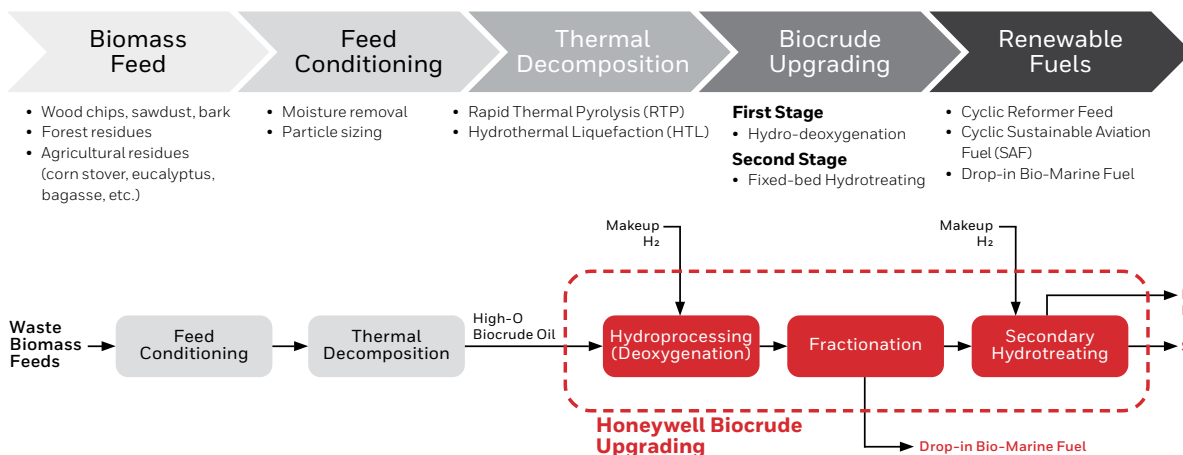
Biocrude is transportable and more energy-dense than lignocellulosic wastes, which reduces the need to co-locate fuel upgrading facilities near a biomass source. This offers more flexibility to refiners and project developers to use a hub-and-spoke project approach, where a single large Biocrude Upgrading unit is fed by multiple biocrude production units. This approach can also allow upgrading units to be optimally placed and help minimize biomass transportation distances, enabling lower logistical costs compared to fully distributed fuel production.

The process builds on Honeywell's experience producing pyrolysis oil via Rapid Thermal Processing (RTP) and upgrading it via FCC Co-Processing. The innovative technology uses a specialized hydrotreating process to efficiently convert biomass into drop-in renewable marine fuel, (SAF), and renewable naphtha for gasoline production. The thermal decomposition pathway for biomass upgrading can potentially offer higher carbon yield to renewable fuels than a once-through gasification process.¹

TECHNOLOGY BENEFITS

- Robust reactor & catalyst system to process highly oxygenated bio-oils
- Flexible product slate with ability to maximize SAF or marine fuel
- True **drop-in renewable marine fuel** product with a lower CI² and lower cost of production³
- **SAF product** properties create potential for a Jet-A replacement >50% in the future by blending with other types of SAF⁴
- Naphtha product fraction is an excellent reforming feed for **high-octane renewable gasoline** production
- Modular RTP and Biocrude Upgrading solutions available, can help in reducing project schedule and risk

BIOCRUDE UPGRADING PATHWAY & PROCESS OVERVIEW



BIOCRUDE UPGRADING FUEL PRODUCTS

Biocrude Upgrading is an efficient fuel production process to help enable lifecycle emissions reduction in several sectors.



Renewable Marine Fuel

- Drop-in replacement for conventional engines and infrastructure
- Lower-cost of lifecycle emissions reduction³



Sustainable Aviation Fuel

- Potential for a Jet-A replacement >50% in the future by blending with other types of SAF⁴
- Similar production cost to HEFA using lignocellulosic feedstock⁵



Renewable Road Fuel

- Excellent feed for high octane gasoline
- No blending limitations for gasoline production

OPENING THE MARINE SECTOR TO RENEWABLE FUELS

Maritime fleet operators are seeking alternatives with lower carbon intensity (CI) than conventional heavy fuel oils (HFO), to meet evolving policy requirements in the maritime sector.⁶ This is expected to drive a significant increase in adoption of lower-CI marine fuels by the end of the decade, creating market opportunity for refiners to supply those fuels.

HONEYWELL UOP EXPERIENCE

- Honeywell UOP's Biocrude Upgrading process has been extensively demonstrated in pilot scale facilities with over 8,000 hours of cumulative pilot plant data. Individual continuous run lengths of over 3,600 hours have been achieved without reactor plugging or fouling.
- Honeywell UOP has over a decade of experience upgrading and characterizing biogenic feedstocks, beginning with the launch of the Ecofining[®] process in 2013, developed in collaboration with Eni SpA. This experience has given Honeywell expertise in understanding and managing the specific risks associated with biogenic feedstocks and products.
- Honeywell UOP is a leader in the thermal conversion of biomass to liquid fuels. Our RTP technology offers the largest available single-train capacity for biomass thermal decomposition, at 400 metric tonnes per day of dry biomass feed.⁸
- Honeywell UOP has experience processing pyoil and other challenging feeds using its FCC Co-Processing and Uniflex[®] technologies. This experience has now been leveraged for the development of the Biocrude Upgrading process.
- Honeywell UOP has 70+ years of hydroprocessing experience (hydrotreating and hydrocracking).

¹ Yield is measured in weight % conversion of biomass feedstock to hydrocarbon liquid fuel.

² Carbon intensity is compared to HFO or LNG used as fuel in the maritime sector.

³ Cost of lifecycle emissions reduction refers to \$/CO₂ avoided for marine fuel production via Biocrude Upgrading compared to other alternative fuels proposed to displace HFO in the maritime sector.

⁴ A blend rate greater than 50% would require approval through ASTM D7566.

⁵ SAF production costs refer to total production cost in \$/MT of liquid product.

⁶ Policies like the EU's Emissions Trading System and FuelEU Maritime Mandate have set targets to reduce maritime greenhouse gas emissions by up to 80% by 2050.

⁷ Assuming a maximum 20-30% CI reduction from LNG compared to MGO. Energy Reports, "A review of cleaner alternative fuels for maritime transportation," Al-Enazi et al. April 15, 2021 [Accessed August 14, 2025]

⁸ The largest commercially-demonstrated pyrolysis unit has a single-train capacity of <150 Mtpd, and the largest commercially-demonstrated HTL unit has a single-train capacity of <50 Mtpd.

For more information
<https://uop.honeywell.com>

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