Syngas: The Key to Unlocking the REcarbonization of Industry

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Hard-to-Electrify Industries Need Green Carbon

Some industries, such as aviation fuel and cement manufacturing, are very hard to electrify. In those cases, we need green carbon to replace fossil carbon.

Therefore, the fuels and chemicals industry needs to be REcarbonized...

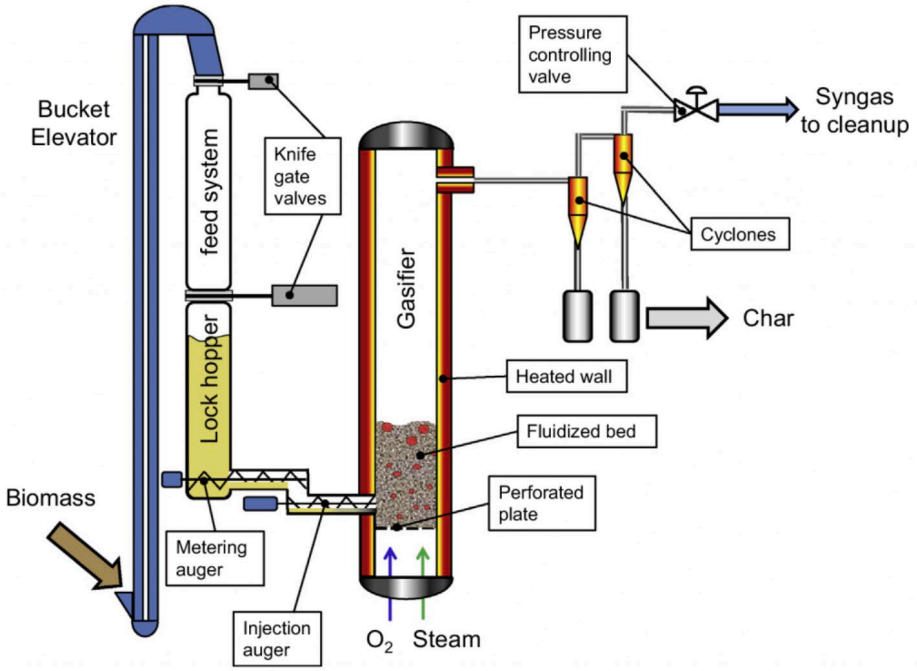
But where will the green carbon come from?

Image Source: EECO

Biomass Unlocks Sustainable Syngas for Carbon Replacement

- Green carbon from biomass can be utilized via green syngas through gasification and pyrolysis.
- Green syngas will become the platform chemical/intermediate, which presents a huge opportunity for biomass utilization.

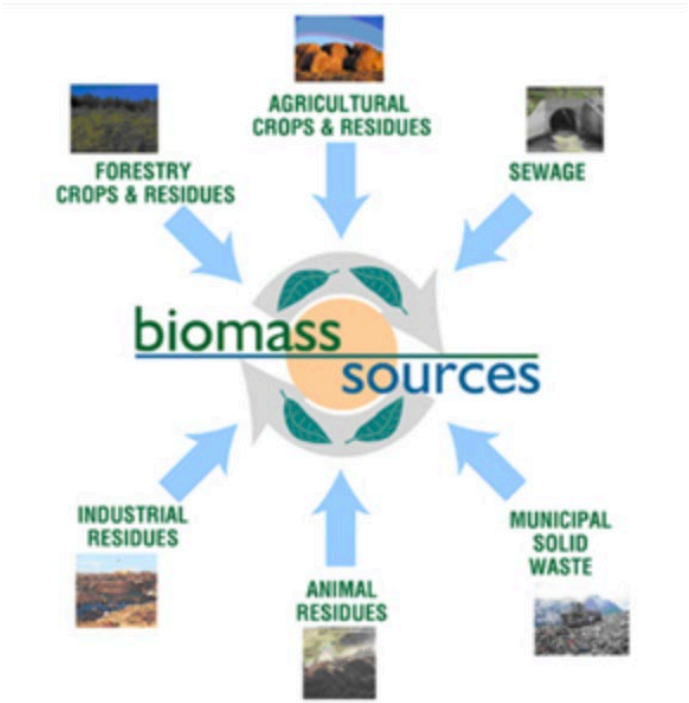
Example of biomass gasification process:

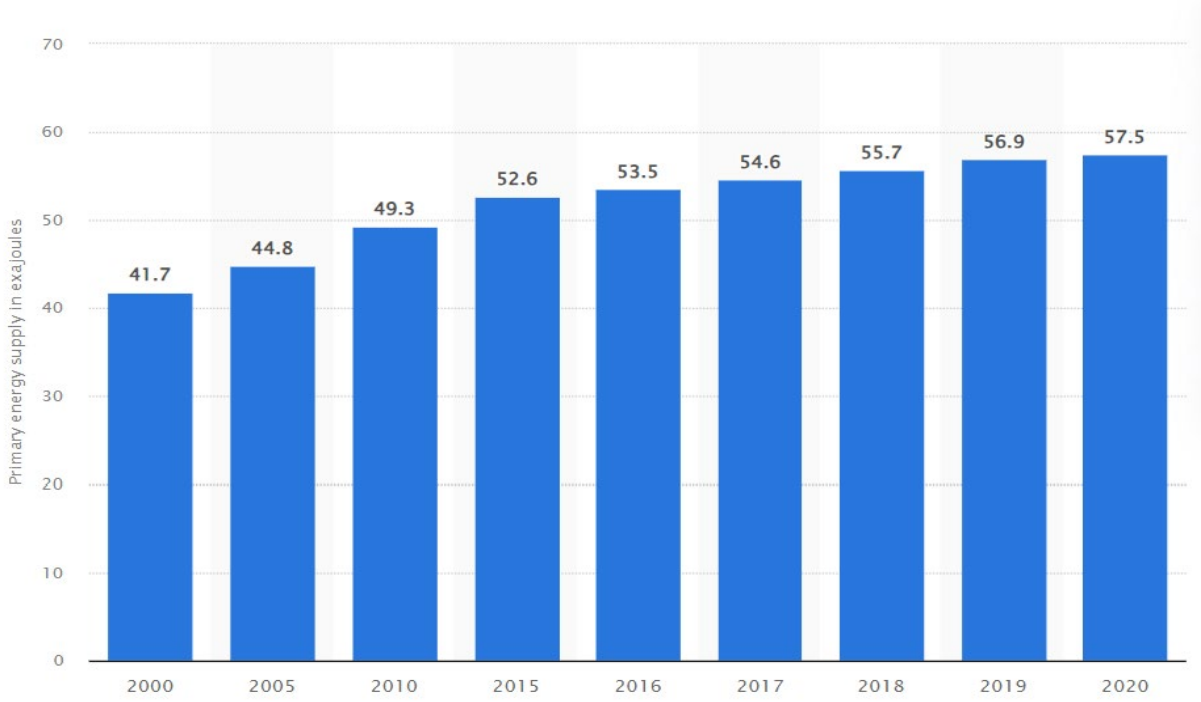


Source: Iowa State University

Biomass is Available Globally

Biomass comes from a variety of sources including forestry waste and agricultural residues. The amount of energy in global available biomass (2020) is the equivalent of 9.4B barrel of oil. **This is 3x greater than the oil produced by Saudi Arabia in 2024.**

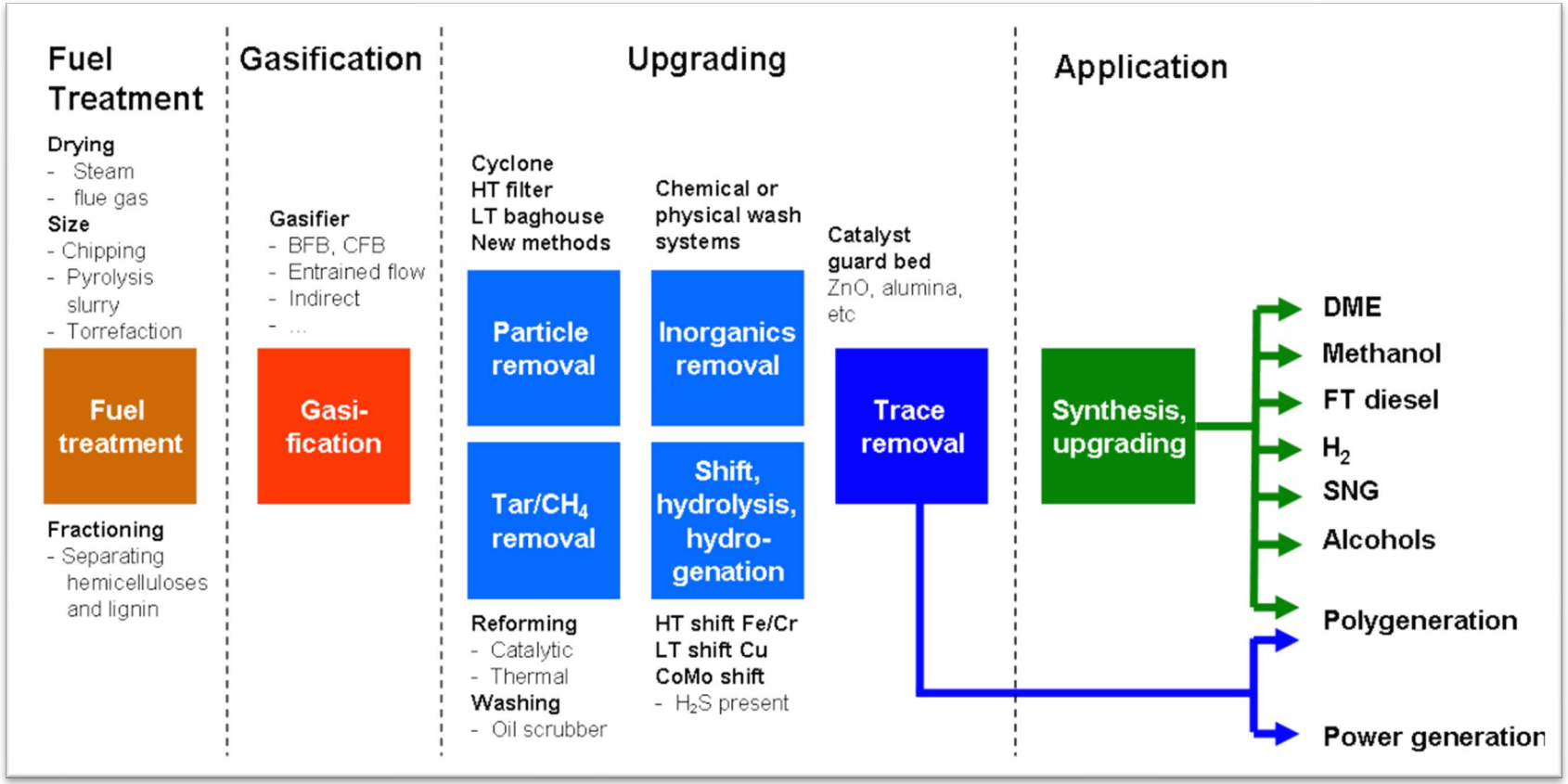




Source: Statista, 2024

Biomass Enables Green Fuels and Chemicals

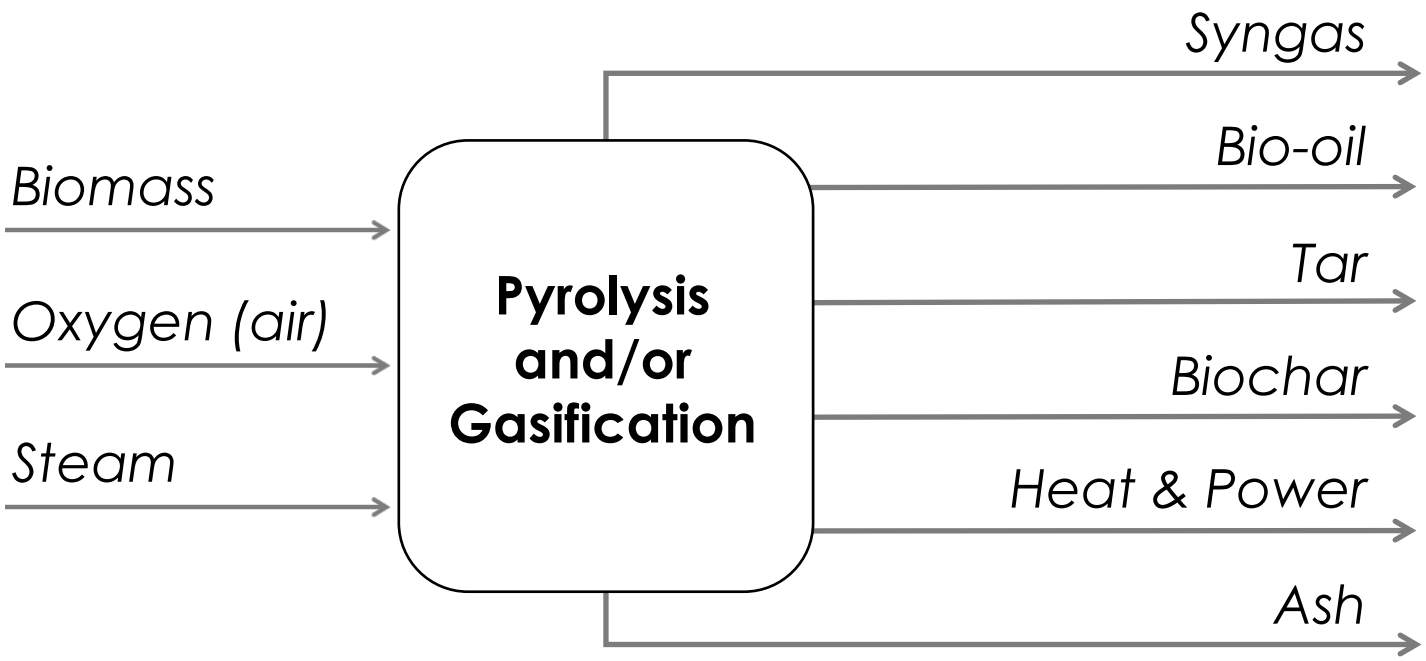
Thermochemical Conversion is the process that transforms renewable biomass into valuable energy carriers.



Source: Brandin et. al, 2017

Lignocellulosic Biomass can be Upgraded via Gasification or Pyrolysis

Dried biomass is fed into a gasifier along without oxygen and steam to produce syngas and other products. Pyrolysis is decomposition of the organic matter without steam or oxygen.



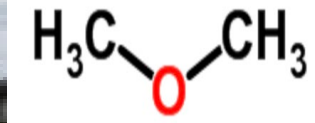
Multiple Types of Gasification Technology Exist

Type	Pressure Range	Temp. Range	Carbon Conversion	Products	TRL
Fluidized Bed	1 – 20 bar	600-1200 C	Up to 90%	Syngas, Bio-oil, Biochar	9
Entrained Flow	1 – 80 bar	1200 – 1600 C	Up to 99%	Syngas only	9
Plasma Assisted	1 bar	3000 C	Complete conversion	Syngas only	7-8
Fixed Bed	1 – 30 bar	600 – 1600 C	Up to 99%	Syngas, Bio-oil, Biochar	9

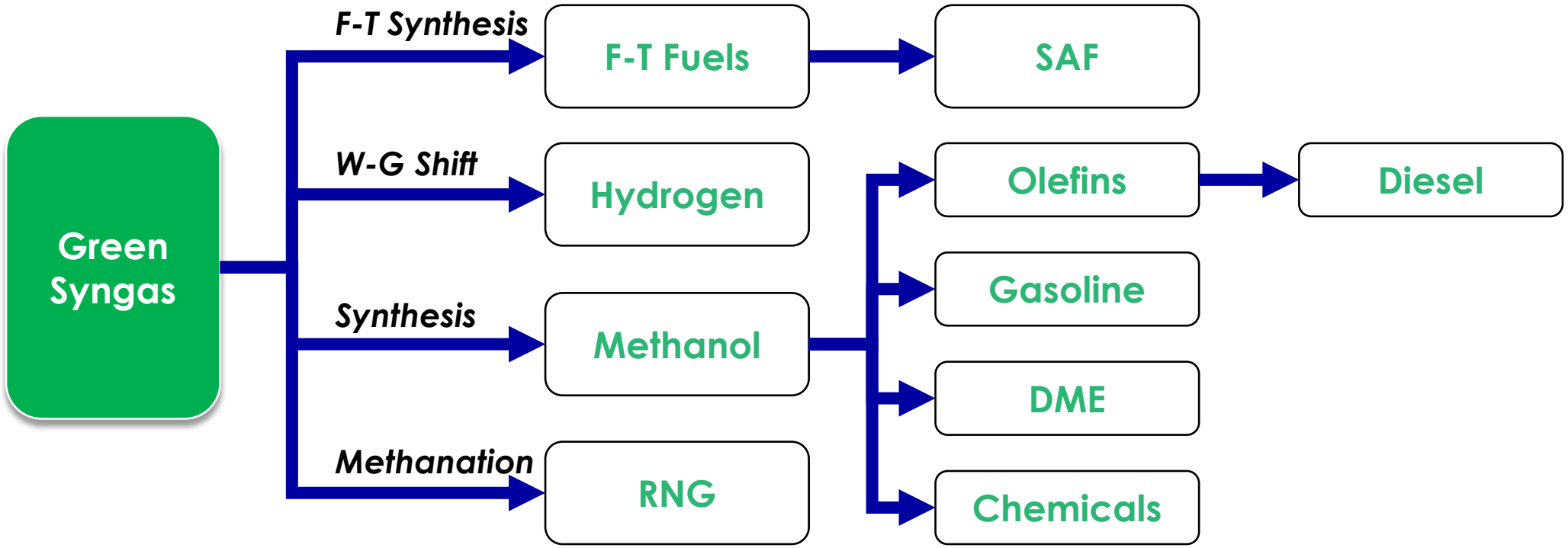
Commercial Pyrolysis Technologies Exist – Flash Pyrolysis Shows Promise

Type	Temperature Range	Residence Time	Products	TRL
Slow Pyrolysis	400-600 C	10 sec – 30 min	Biochar with Bio-oil	9
Fast Pyrolysis	600-1000 C	0.5 – 10 sec	Bio-oil with Biochar	9
Flash Pyrolysis	800-1000 C	< 0.5 sec	Syngas is main product	5-8

Syngas Products



Syngas Enables Four Critical Decarbonization Pathways



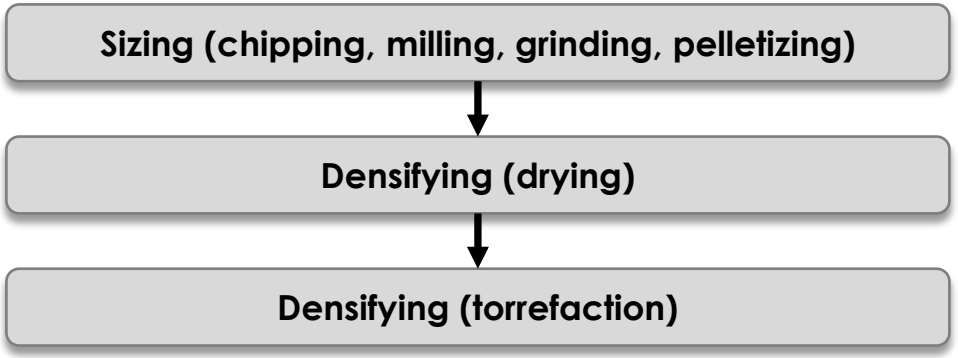
Syngas Products Have Challenges and Opportunities

Product	Status	Challenge	Opportunity
SAF	Demo	Scale up to commercial	Woody biomass greatly expands feedstock options
Methanol	Scaling	High CAPEX	Maritime demand, e.g. Maersk
Hydrogen	Piloted	Competes with Electrolysis	Biomass + WGS is a viable route

Technical Challenges Exist for Conversion Technologies

- Biomass Pre-Treatment
- Syngas Cleanup

Biomass Pretreatment is a Required, Complex Process



Challenges Include:

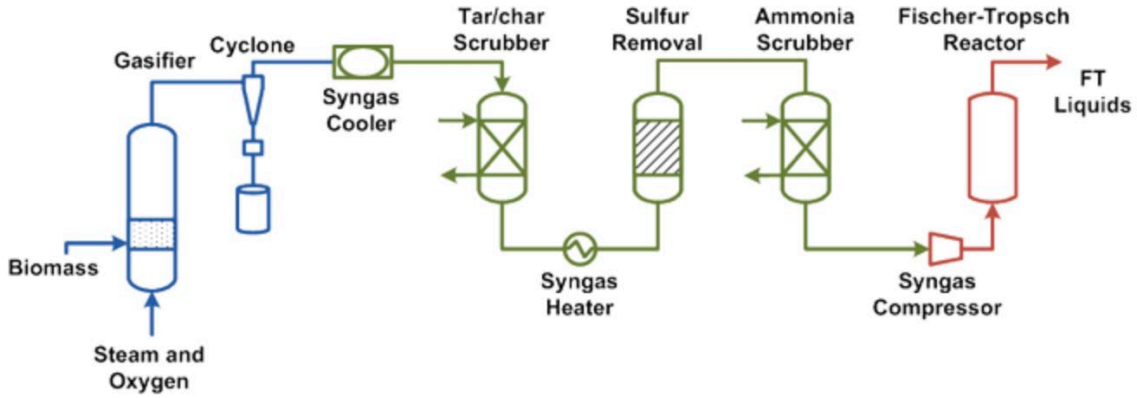
- Transportation and storage
- High CAPEX and energy consumption
- Property variations- moisture content, particle size
- Scalability of cost-effective, robust technologies

Torrefaction Type	Characteristics
Rotary Drum	Robust, scalable Indirect heating inefficient
Screw Conveyor	Controlled contact time Capacity Limitations
Moving bed/Fluid bed/Torbed	Energy efficient Flue gas cleaning required
Multiple Hearth Furnaces	Promising technology Less mature

Syngas Cleanup is also Required

- More impurities present in syngas compared to conventional feedstocks: tars, S, N, Cl, As, etc.
- Solids are removed first, by physical separations such as cyclone, filtration, etc.
- Tar exists if gasification/pyrolysis temperature is below 1200 C. Best tar removal process is high temperatures.
- Absorption dominates the removal of gaseous impurities: chemical (Sulfinol); physical (Selexol, Rectisol); or hybrid absorptions (Sulfinol, Amisol).

Sample syngas cleanup process to FT Liquids



Source: Iowa State University

Conclusions

- The global energy transition is decarbonizing fossil fuel and feedstocks, resulting in carbon deficiency
- We need to REcarbonize industry
- Lignocellulosic biomass exists in sufficient quantity as a sustainable source of carbon
- Production of green carbon from biomass via green syngas by gasification and pyrolysis is achievable
- Syngas will be the platform chemical for multiple applications like methanol, SAF, and H2
- Huge challenges and opportunities for syngas generation and utilization technologies in the coming years

About the Author

Qi Chen, Ph.D. is a consultant for LEC Partners in the energy, oil & gas, and chemicals space. Specifically focused on hydrogen and syngas, he has previously worked in R&D, demonstration, and deployment of process technologies, as well project conceptualization, development and execution.

Qi's previous experience includes the University of Eindhoven, Technip, and Shell, where he led gasification initiatives in the Asia Pacific Region.

Qi a specialist in industrial gasification (POX) and pyrolysis for manufacturing of syngas, hydrogen, and olefins. He holds a Ph.D. in Chemical Engineering from University of Ghent (Belgium) and a BE from the East China University of Science and Technology in Shanghai.

About the Author

Pete Rocha. is Practice Lead for Low Carbon Hydrogen and Project Director for LEC Partners in the energy and biofuels space. Specifically focused on hydrogen and its derivatives, Pete has previously founded a hydrogen technology company focused on solid-oxide cell technology and is a commercial advisor to a start-up hydrogen storage company, in addition to leading many projects for LEC.

Pete's previous experience includes the Chevron-Renewable Energy Group, where he led growth initiatives on the U.S. West Coast.

Pete has deep experience in Strategy, Mergers and Acquisitions, Commercial Partnerships and Project Development. He holds an MBA with a concentration in Finance from the University of Chicago's Booth School of Business.

Appendix

Sustainable Aviation Fuel (SAF)

- Multiple regulations and incentives for SAF usage exist, e.g. EU "fit-for 55", US SAF Grand challenge, CORSIA
- Two primary routes for SAF exist: agricultural products (corn, sugar cane) and oils (soy, rapeseed)
- Limited feedstock availability
- Competition with food
- Woody biomass via syngas and the Fischer-Tropsch (FT) route would enhance the availability of sustainable fuels
- FT technologies are well proven at large scale
- FT SAF via green syngas needs to be proven at scale – technically and economically

Green Methanol from Biomass

- Subsidies and incentives under the Renewable Energy Directive (RED II) in EU, but less concrete than SAF
- Maritime market lead by Maersk: strong demand growth forecasted
- Syngas from biomass, followed by catalytic synthesis
- Methanol synthesis is well-established and proven
- SAF and sustainable gasoline can also be produced from methanol
- Projects focusing on supply to Maersk, e.g., European Energy
- China has many planned projects, totaling 26 million MT/yr
- High CAPEX is a challenge

The Laura Maersk.
The world's first container ship to be powered by a methanol-fuel engine.

Green Hydrogen from Biomass

- Subsidies and incentives for clean hydrogen under the RED II, US IRA, California LCFS
- Syngas from biomass, water-gas shift reaction for generation of H2
- PSA and membrane purification of H2
- WGS and PSA technology is well-established and proven
- Haffner Energy has successfully commissioned the world's first plant producing H2 from biomass at their Marolles site in France
- However, H2 from biomass needs to be proven economically

Thank You!

Ready to get started? Have any questions?
Let’s schedule a call to learn how we can help you.

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