Panel: Feedstock, Conversion and Innovation: Beyond 2030

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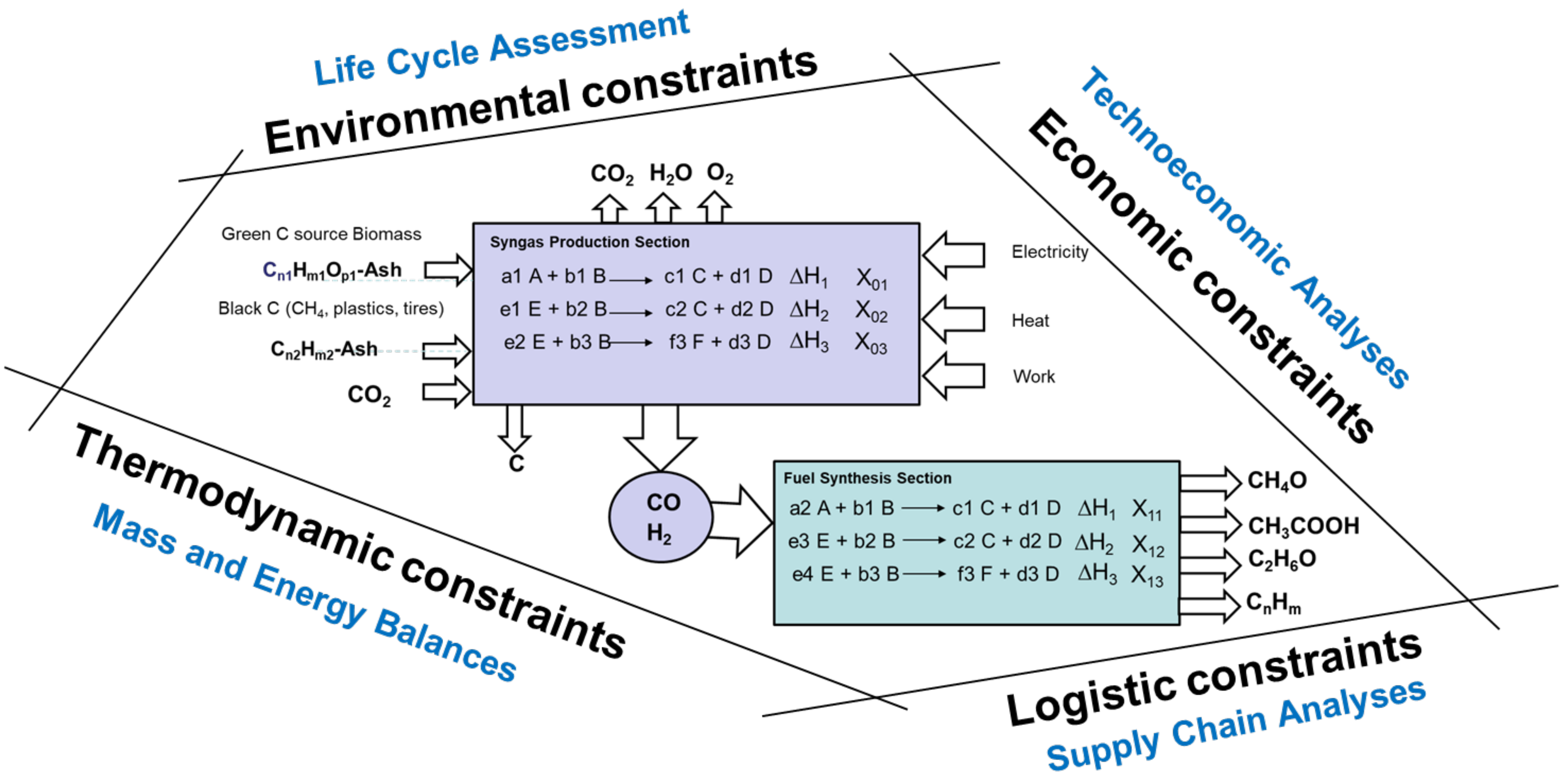
SAF Production: A Problem with Constrains



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Motivations and Background

- A sustainable fuel roadmap is a major goal of ASCENT
- Full TEAs represent years of specialized work
- Simpler production cost (PC) heuristics allow easier initial assessment

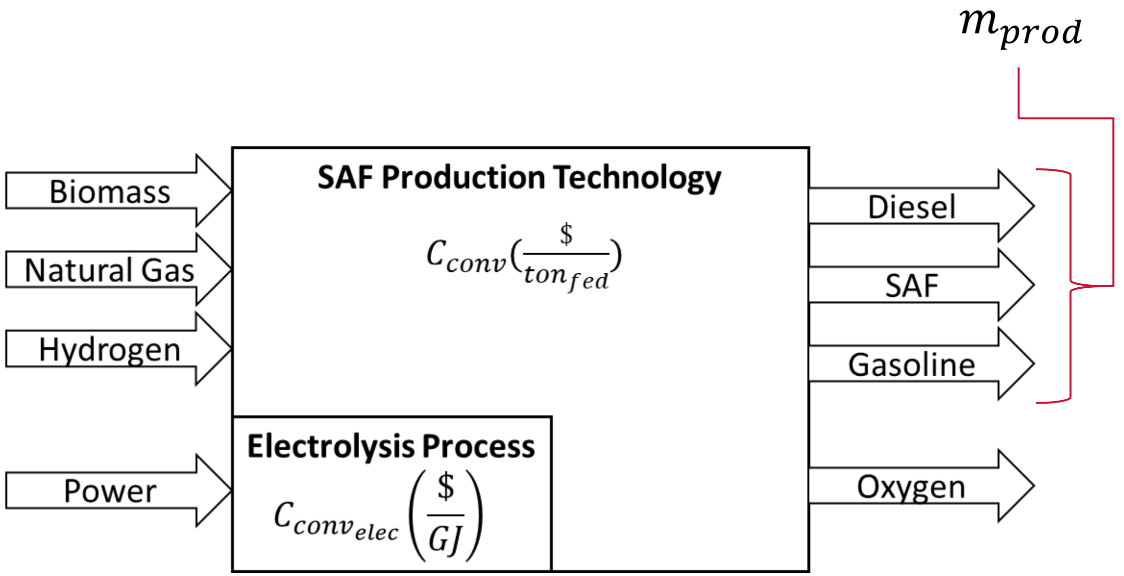
Lange has proposed simpler models:

$$C_{prod}\ \left(\$/_{ton}\right) \approx \frac{C_{feed} + C_{conv}}{yield}$$

- Conversion costs range from 100-400 $\left(\$/_{ton}\right)$
- Previous work explored further
  - Concluded minimum yield of 60% for profitability (Tanzil et al., 2020)
- Current lignocellulosic SAF C_{prod} range from 2000-5000 $/ton

Technology-Agnostic Framework

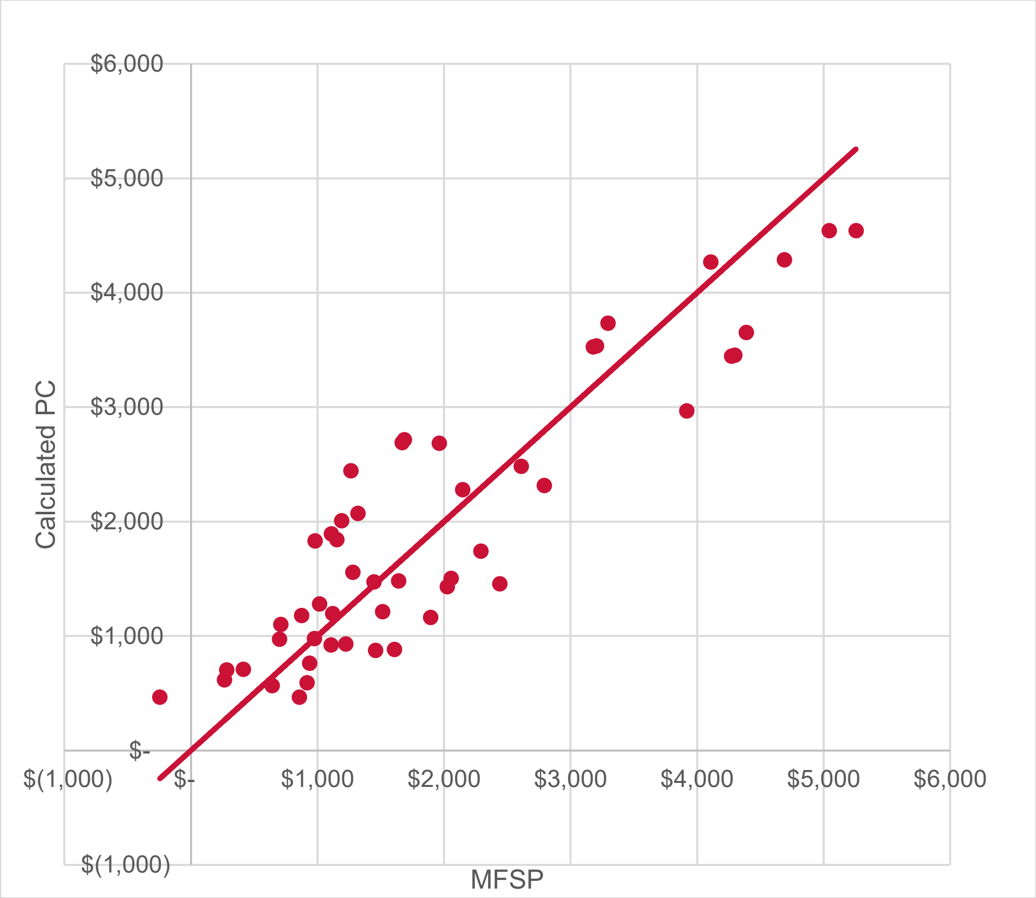
Resource Cost	Flowrate (tons)
C_b =70 \$/ton	m_b
C_{NG} = 193 \$/ton	m_{NG}
C_{H_2} = 4000 \$/ton	m_{H_2}
C_{power} = 21.1 \$/GJ	W_{elec}/m_{prod} $(\frac{GJ}{ton})$
C_{O_2} = 40 \$/ton	m_{O_2prod}
C_{prod} (\$/ton)	m_{prod}



$$C_{prod} = \frac{(C_b + C_{conv}) \cdot m_b + C_{NG} \cdot m_{NG} + C_{H_2} \cdot m_{H_2} - C_{O_2} \cdot m_{O_2prod}}{m_{prod}} + (C_{power} + C_{conv_{elec}}) \cdot \frac{W_{elec}}{m_{prod}}$$

Data Selection and Correlation

- 50 Datapoints from 8 studies
  - 28 used to fit base PC calculation
- Fermentation, gasification, pyrolysis, lipid hydrogenation, and electro-fuel processes included
- DAC, cellulosic biomass, lipids, and natural gas feedstocks
- Uncertainty of $615/ton
  - Reasonable for economic analysis – 30% error the norm



Fitted Model

$$C_{prod} = \frac{(C_b + \$317) \cdot m_b + C_{NG} \cdot m_{NG} + C_{H_2} \cdot m_{H_2} - C_{O_2} \cdot m_{O_2 prod}}{m_{prod}} + (C_{power} + 39) \cdot \frac{W_{elec}}{m_{prod}}$$

- $317/ton consistent with values in chemical industry (100-300 $/ton) (Lange, 2019)
- $39/GJ approximates the levelized cost of electrolysis
- All other variables obtained from cost data

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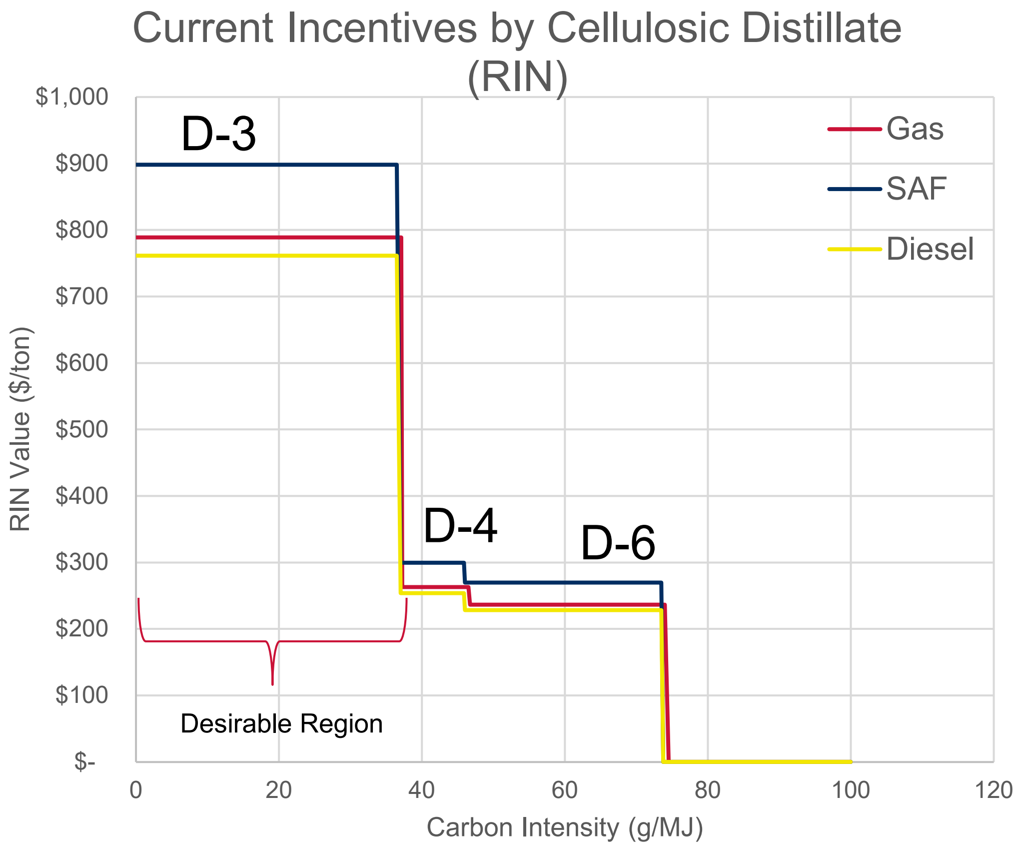
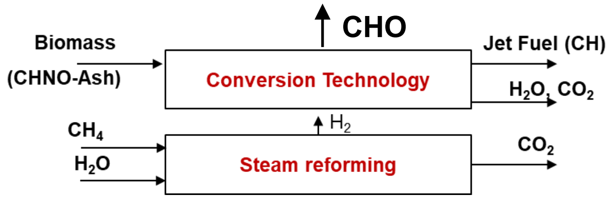
Incentives

- Highly volatile
- Incentives can total over 100% of the fuel price
- Best approached as a sensitivity analysis
- By developing conversion constants, the effect of incentives on fuel price can be predicted despite the lack of fixed incentives



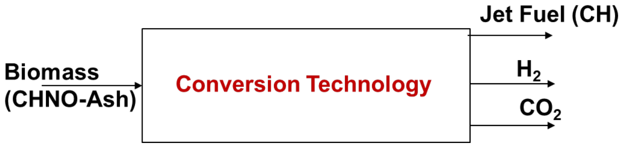
Application: Purely Stoichiometric Models

Current Commercial Technologies



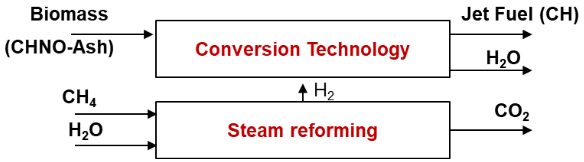
Yield = 0.09 – 0.23
MFSP = $2050-5190/ton

All O removed as CO_2



Yield = 0.34
PC = $1,195/ton
CI = 3.2 gCO2/MJ
RIN Effect = $605/ton
SPC = $590/ton

All O removed as H_2O with external H_2

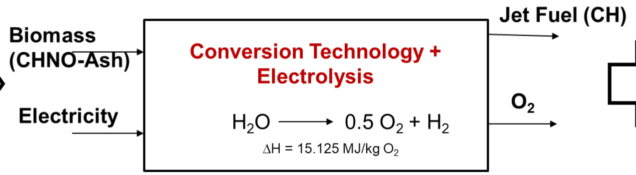


Yield = 0.55
PC = $762/ton
CI = 25 gCO2/MJ
RIN Effect = $393/ton
SPC = $369/ton ←

All O removed as H_2O with internal H_2 production

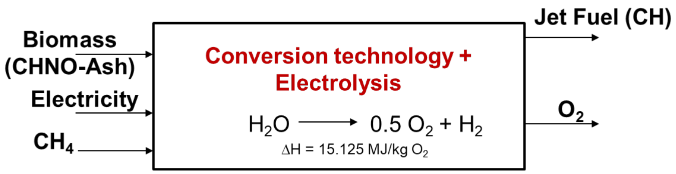
Yield = 1.22
PC = $434/ton
CI = 49 gCO2/MJ
RIN Effect = $64/ton
SPC = $370/ton ←

All O removed as O_2 via electrolysis



Yield = 0.53
PC = $1,523/ton
CI = 11 gCO2/MJ
RIN Effect = $605/ton
SPC = $918/ton

All O removed as O_2 via electrolysis + CH_4 addition



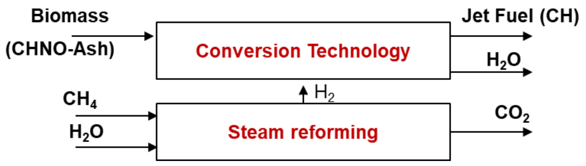
Yield = 0.76
PC = $1,177/ton
CI = 29 g CO2/MJ
RIN Effect = $393/ton
SPC = $784/ton

[1]Yields Defined on biomass basis (tons distillate/tons biomass)
[2]CI calculated using WA average grid footprint (27 g/MJ)

PC: Production Cost
SPC: Subsidized production cost

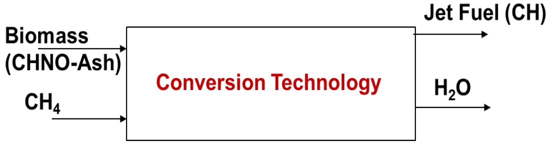
Application: Purely Stoichiometric Models

All O removed as H_2O with external H_2



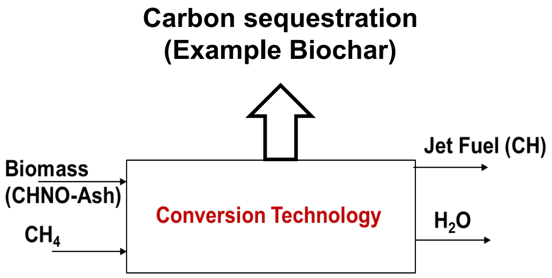
Yield = 0.55 ton fuel/ton biomass
PC = $762/ton
CI = 25 gCO2/MJ
RIN Effect = $393/ton
SPC = $369/ton

All O removed as H_2O with internal H_2 production



Yield = 1.22 ton fuel/ton biomass
PC = $434/ton
CI = 49 gCO2/MJ
RIN Effect = $64/ton
SPC = $370/ton

All O removed as H_2O with internal H_2 production + C sequestration



Yield = 0.56 ton fuel/ton biomass
Char commercialized at $ 300/ton
PC = $667/ton
CI = 11 gCO2/MJ
RIN Effect = $300/ton
SPC = $366/ton

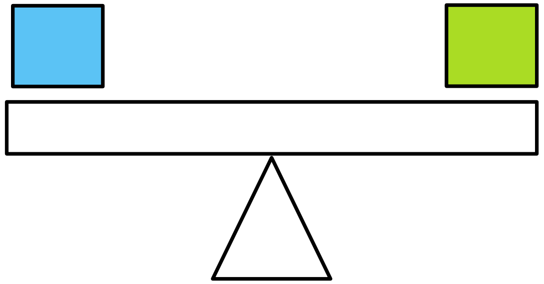
There are several technological solutions that could be viable depending on the trade-off between Economic Advantages (strongly associated with Fuel Yield) and Environmental Advantages (strongly linked with Carbon Intensity).

New models are possible

Economic advantages

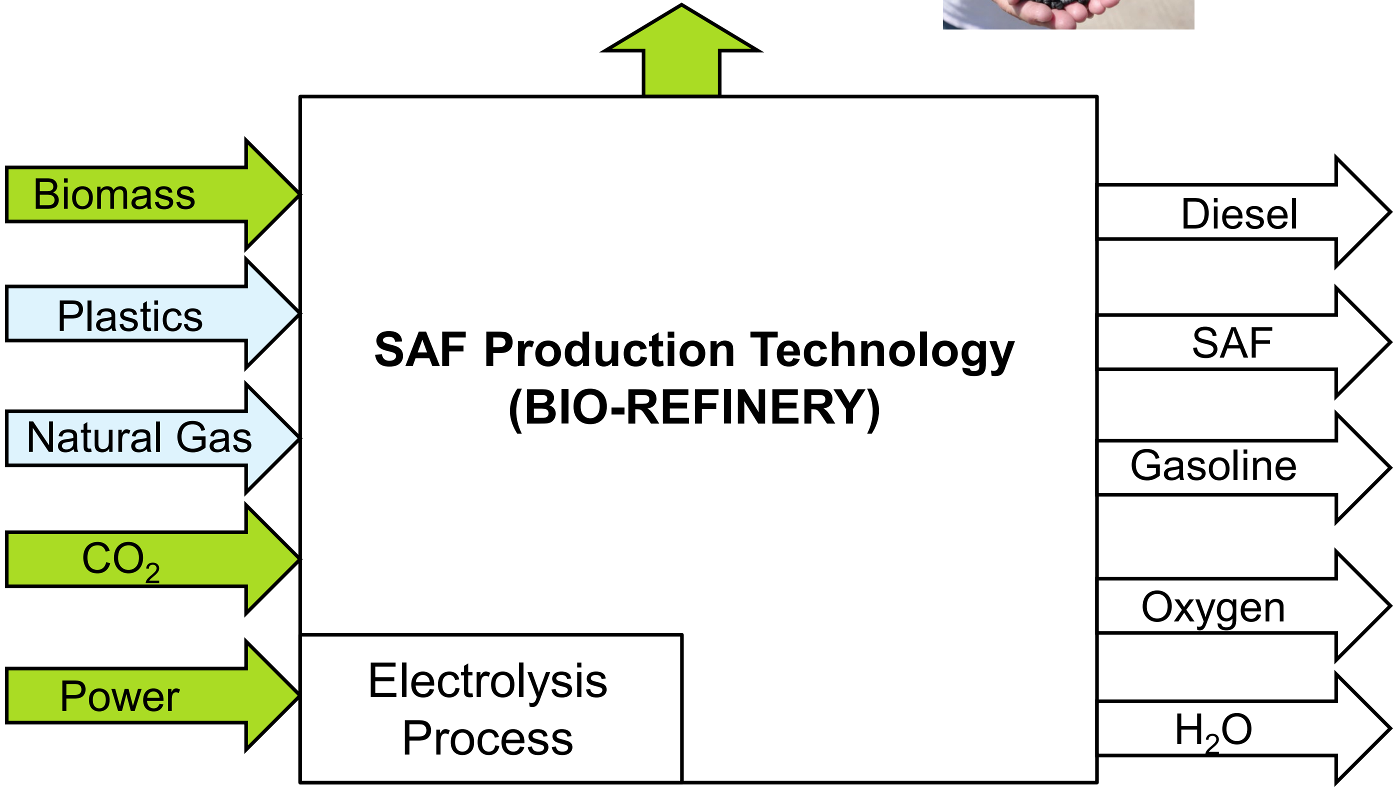
Environmental advantages

Right Balance between Economic and Environmental competitive advantages?



Balance will depend **on regulatory frame + incentive levels**

Carbon sequestration (Example Biochar)



FUTURE WORK: TO STUDY THE IMPACT OF CHEAP NON-RENEWABLE SOURCES OF C (SUCH AS PLASTICS) TOGETHER WITH CO_2 UTILIZATION AND CARBON SEQUESTRATION ON THE OVERALL VIABILITY OF SAF TECHNOLOGIES AND THE IMPACT OF INCENTIVE LEVELS!

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Thank you very much!

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