



Chemical Market Analytics'
World Chemical Forum
- Carbon Negative Ethylene -
Coming Soon to a Pipeline Near You

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U.S. Midwest agricultural production



U.S. Gulf Coast hydrocarbon processing



Agricultural production and hydrocarbon processing



The original intersection of agricultural production and hydrocarbon processing?





- **Headquarters:** Houston, Texas
- **Founded:** 2014
- **Equity sponsor:** Energy Capital Partners



- Portfolio company of ECP formed to capitalize on changing market dynamics in North American energy
- Highly specialized in energy infrastructure value chains
- Executive leadership team has more than 100 years of energy industry experience at leading midstream, petrochemical and fuel component producing companies
- Focus on the intersection of NGLs, petrochemicals, fuels, and renewables naturally suits management's expertise
- Backed by a substantial equity commitment from ECP, a leading private equity and credit investor in the energy sector with capital commitments in excess of \$25 billion

Company projects

Project Traveler

32,000 bpd ethylene-to-alkylate production facility

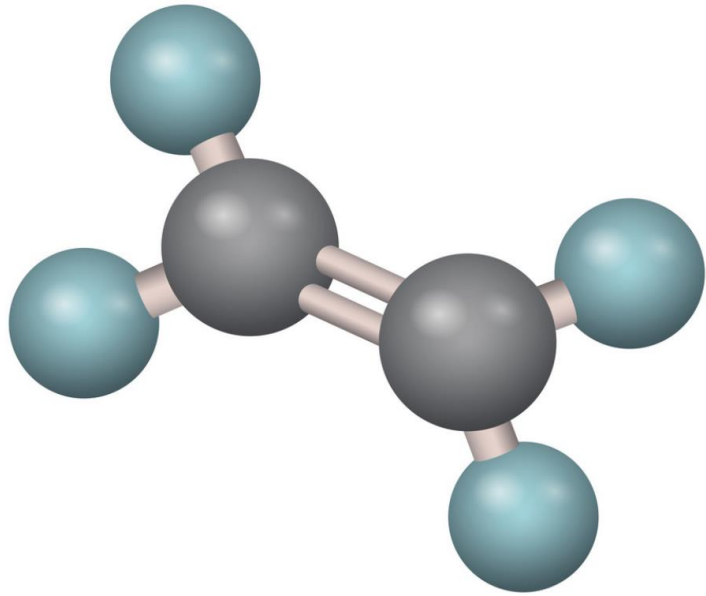
- FID Nov, 2019; commissioning at present
- 567 kTA (1,250 mmpy) ethylene consumption
- Produces ultra-high octane (96+), clean burning alkylate for gasoline blending
- Located adjacent to the Houston Ship Channel, with pipeline connectivity to Kinder Morgan and ITC blending terminals
- Can utilize ethylene, propylene, n-butylene, and isobutylene as feedstocks
- All product placed under long-term, toll-based contracts

Project Lightning

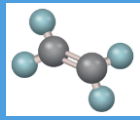
400 kTA ethanol-to-ethylene production facility

- Projecting FID in 1H 2024; start-up in 2027; permit in place
- 400 kTA (≈900 mmpy) ethylene production
- Produces bio-ethylene, renewable alkylate, and sustainable aviation fuel (SAF)
- Located at same Houston Ship Channel site as Project Traveler with pipeline connectivity to USGC ethylene pipeline grid for supply to industry
- Can utilize any type of ethanol as feedstock (denatured or non-denatured; corn or sugarcane; 1st, 2nd, or 3rd gen)
- Working long-term, toll-based contracting at present





- **Fossil** – NGLS, naphtha, gas oil
- **Circular** – recycled plastics
- **Bio-based** – crops, cellulosic, CO₂ utilization



Compare & contrast the benefits & challenges of

RECYCLE

Metals

■ Fossil

■ Circular

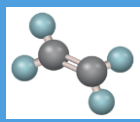
■ Bio-based

Waste

Change in

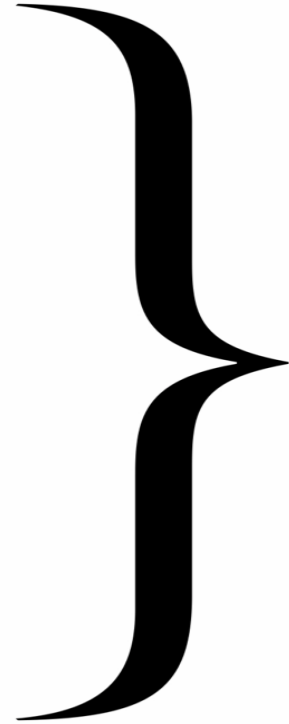
GREENHOUSE GAS

EMISSIONS/2000 Ocean



Compare & contrast the benefits & challenges of

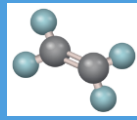
- Fossil
- Circular
- Bio-based



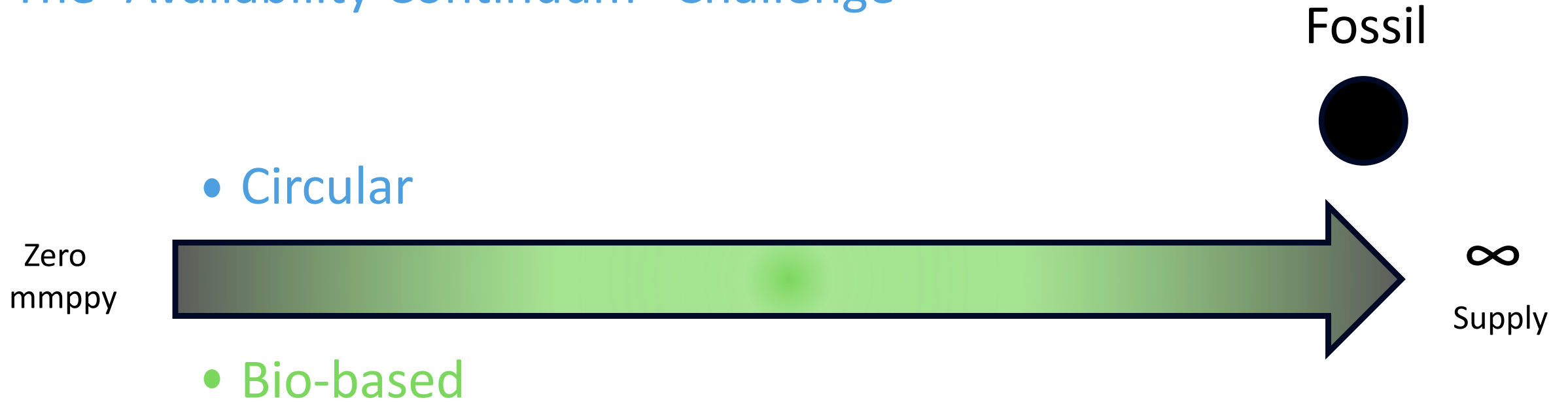
✓ *Cost*

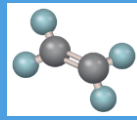
✓ *Availability*

✓ *Carbon Intensity (CI)*

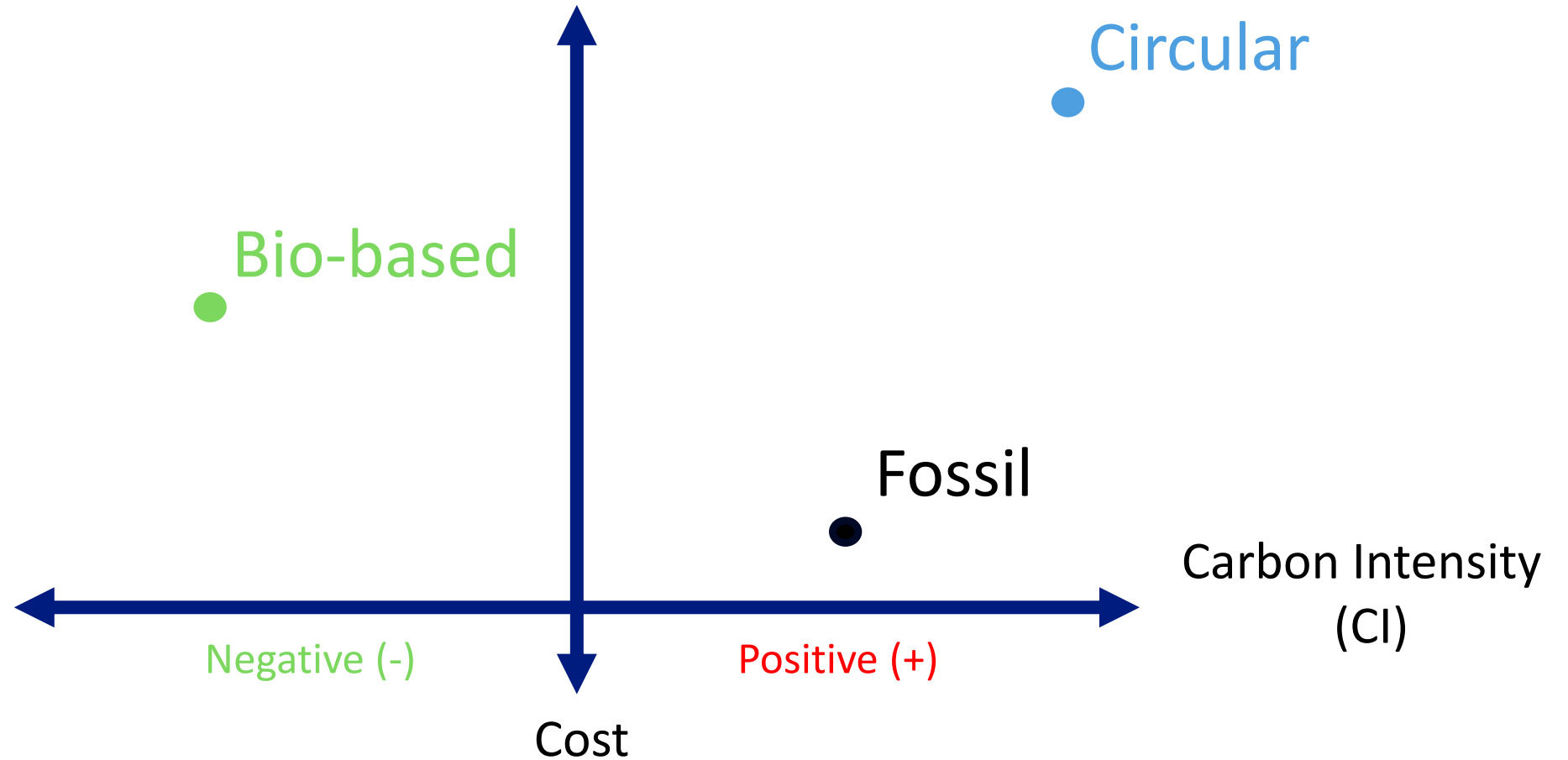


The “Availability Continuum” Challenge



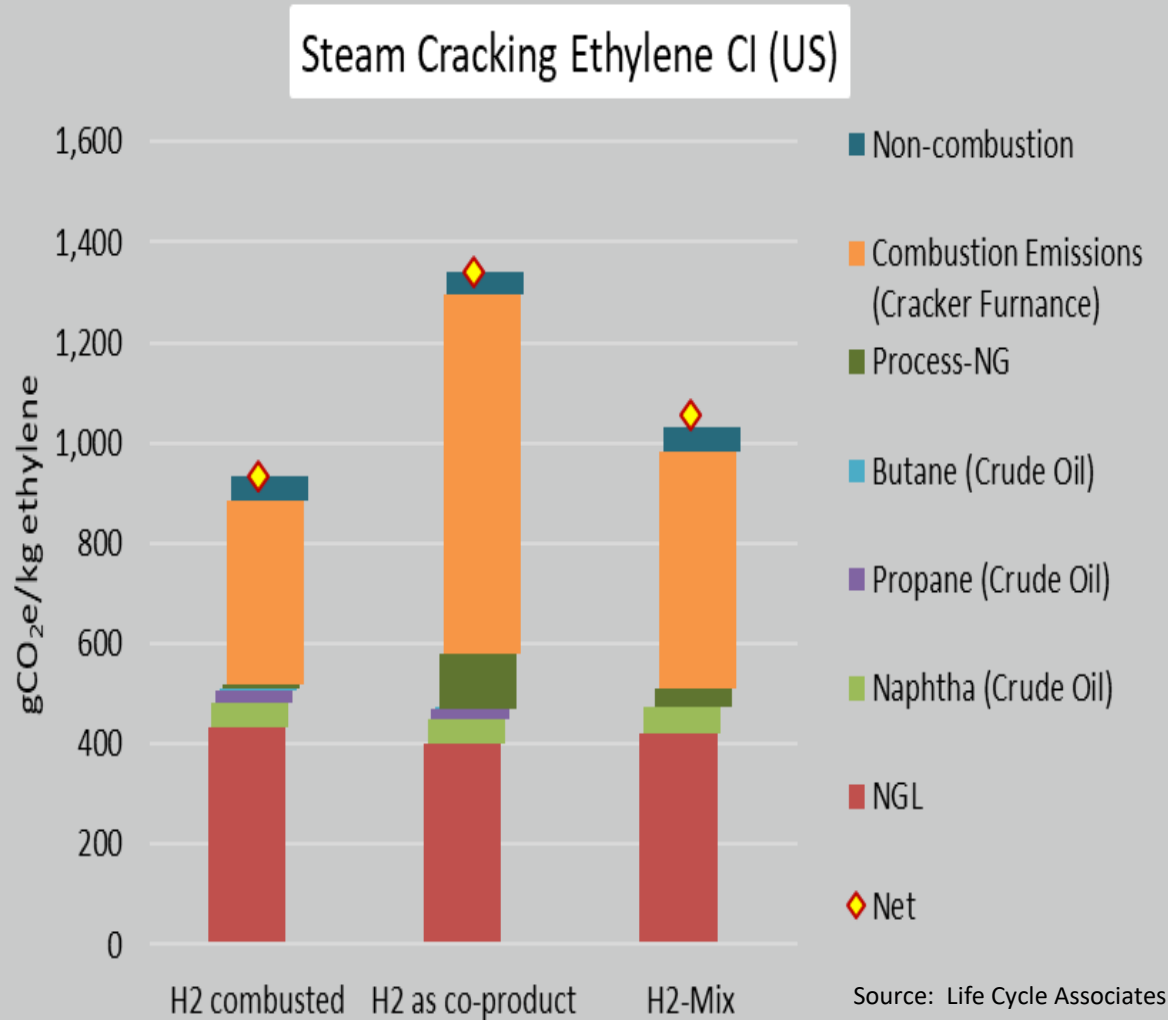


An unexpected result? *No!*



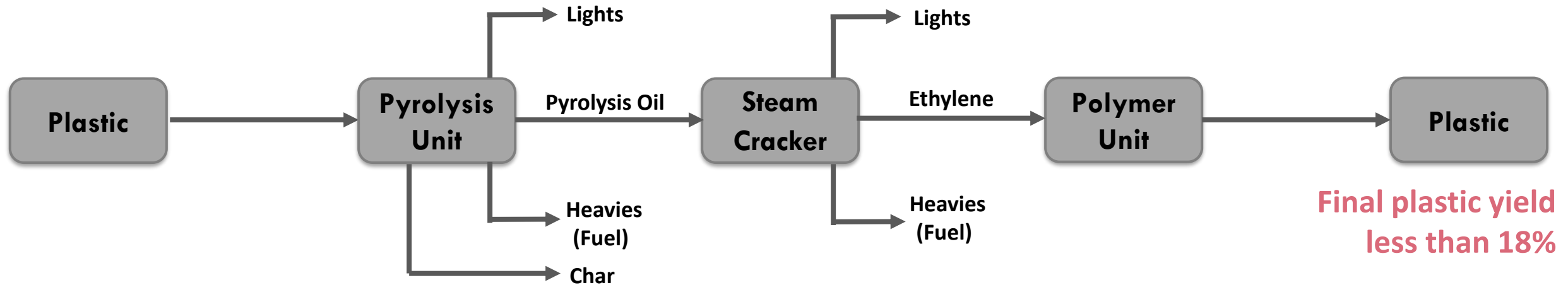
Source: NWEF, Life Cycle Associates

Carbon intensity (CI) of fossil ethylene



- Assumes average of US cracker feedslate (primarily ethane)
- Burning hydrogen for fuel, rather than recovering as a co-product, reduces carbon intensity (reduces carbon based fuel consumption)
- If 50% of hydrogen is burned for fuel, results in CI of 1.05 kg CO₂e per kg of ethylene produced

Chemical recycling gets rid of a lot of plastic...but doesn't enable much new plastic



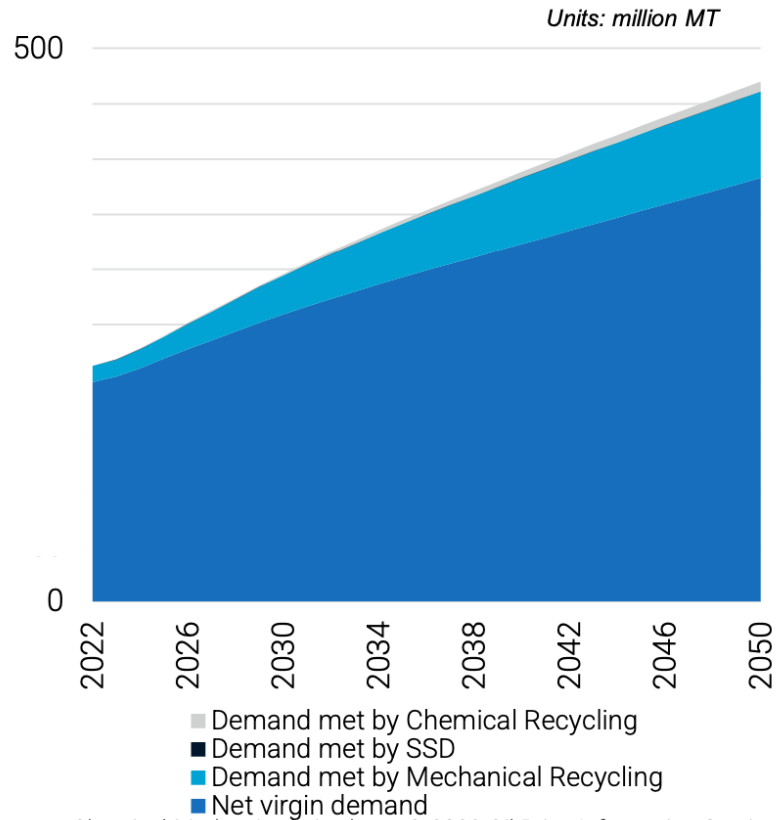
Steps not shown include aggregation, sorting, cleaning, and metals removal of waste plastic

Achieving a circular economy for plastics is not always aligned with Net Zero goals

Our world needs a source of renewable & sustainable ethylene for plastic production

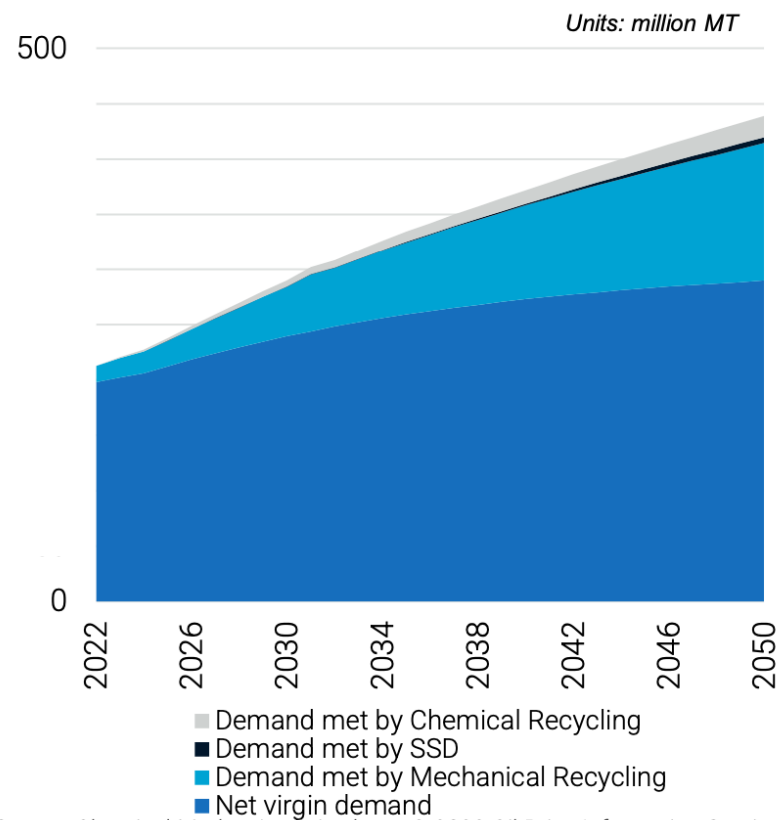
Circular plastics not projected to be a major source of needed ethylene

Base Case



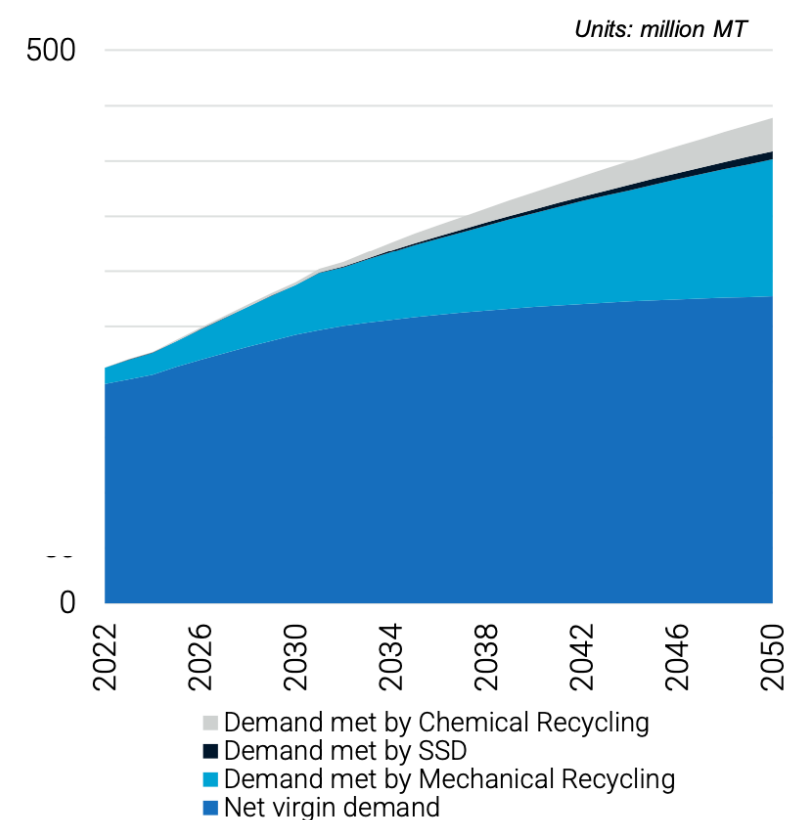
Source: Chemical Market Analytics by © 2023 Oil Price Information Service, OPIS LLC.

Green Case



Source: Chemical Market Analytics by © 2023 Oil Price Information Service, OPIS LLC.

Circular Plastics - 2050

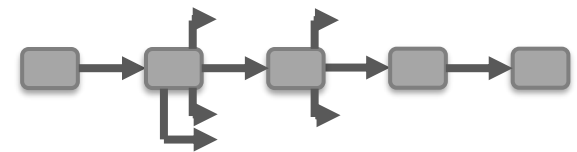
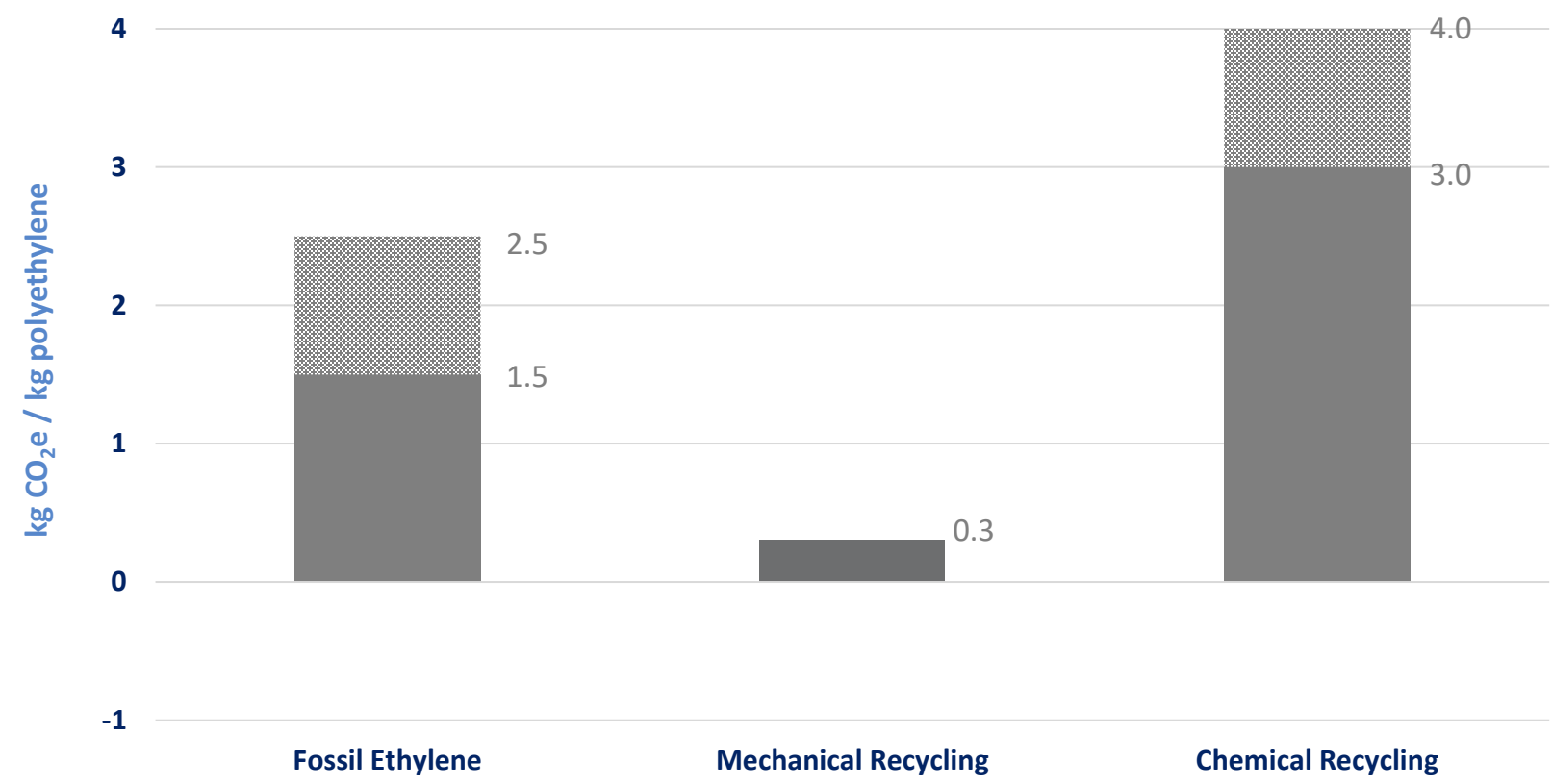


Source: Chemical Market Analytics by © 2023 Oil Price Information Service, OPIS LLC.

- Eliminating plastics waste to landfill and incineration does not equate to eliminating fossil-based production
- Due to yield losses in converting waste to plastics, chemical recycling accounts only for 6-8% of total plastics demand

Chemically recycling plastic increases its carbon intensity

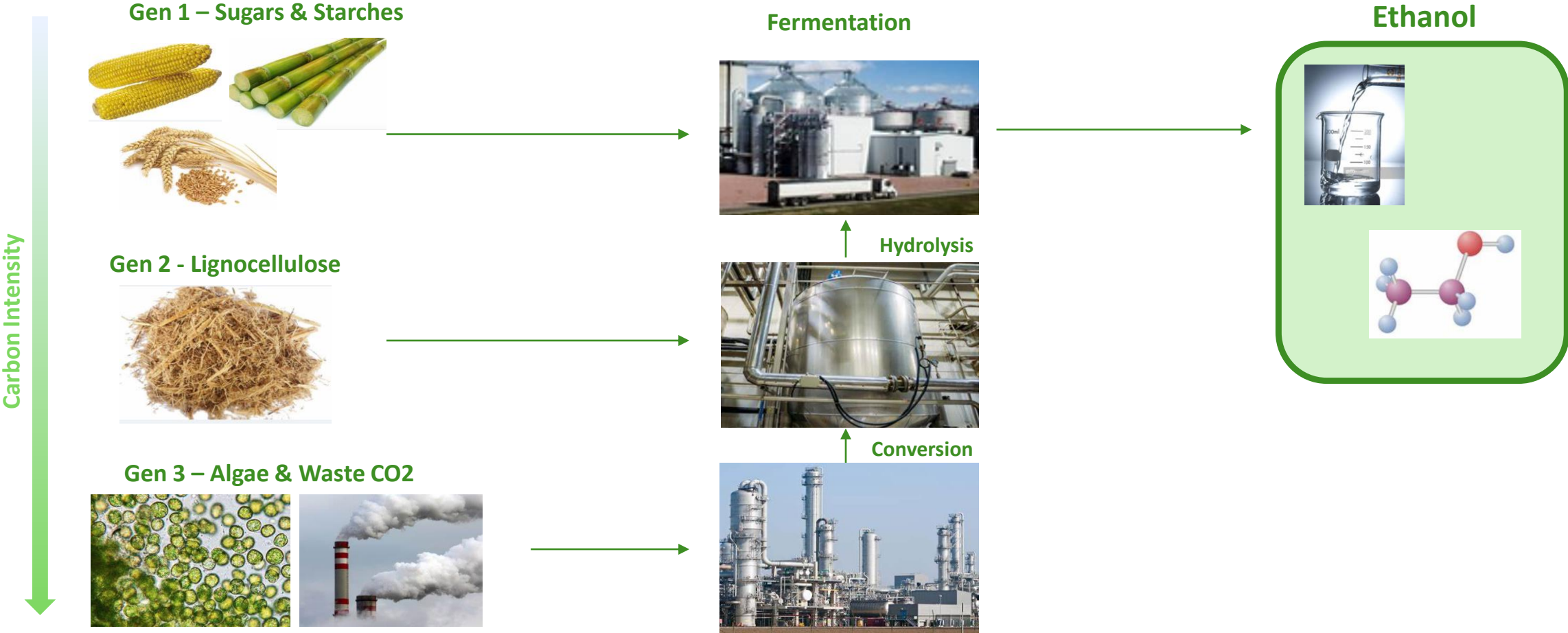
Relative Comparison of Scope 1 & 2 Carbon Emissions for Various Polyethylene Production Methods



A circular economy for plastics is not necessarily aligned with Net Zero carbon intensity goals

Source: Chemical Market Analytics by OPIS

Ethanol can be produced from a variety of feedstocks and is widely available



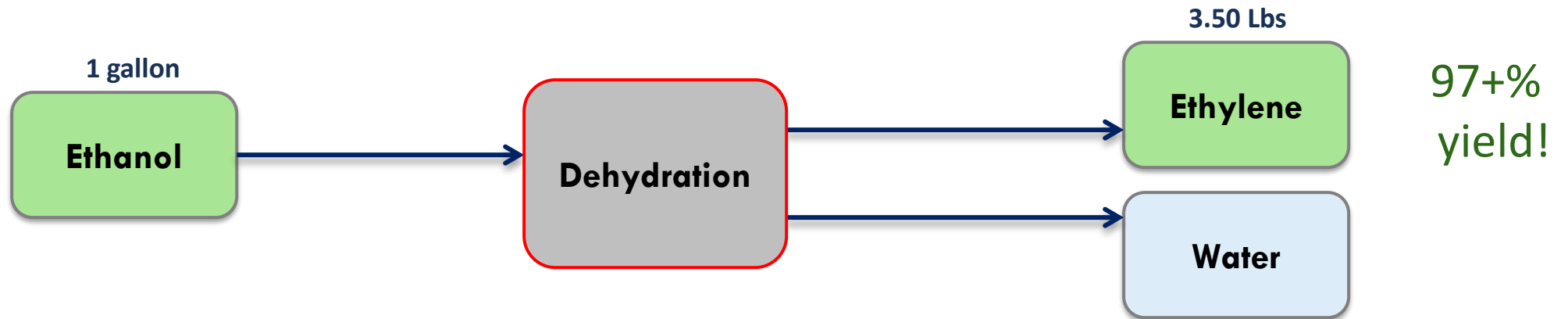
We support utilization of the lowest carbon intensity feedstock sources possible.

Ethanol is simply renewable and sustainable ETHYLENE that is chemically bonded to water

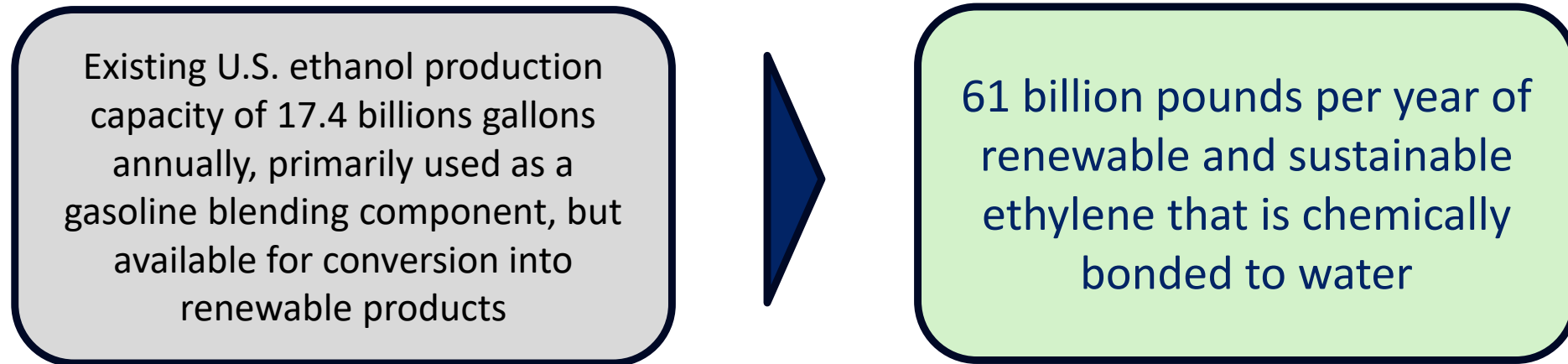


Technology is commercially proven many times over; operating today at multiple facilities around the world that total to over a century of operation

Utilized since 1960s, typically to produce antifreeze and plastics in locations with no ethylene source



The US is the largest ethanol producer in the world, with over 55% of global production capacity

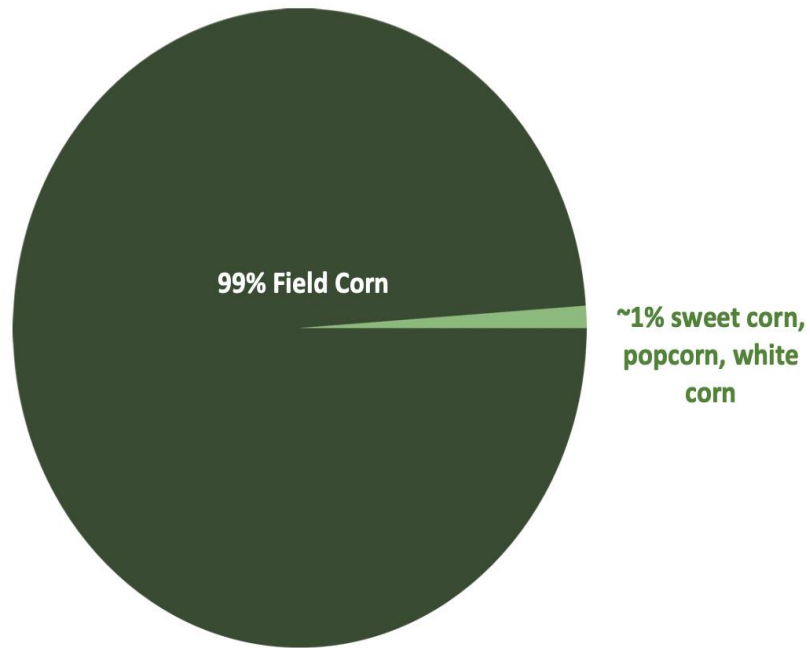


We have enough operating ethanol production to produce over 60% of total US ethylene needs TODAY

Source: Renewable Fuels Association, NWEF

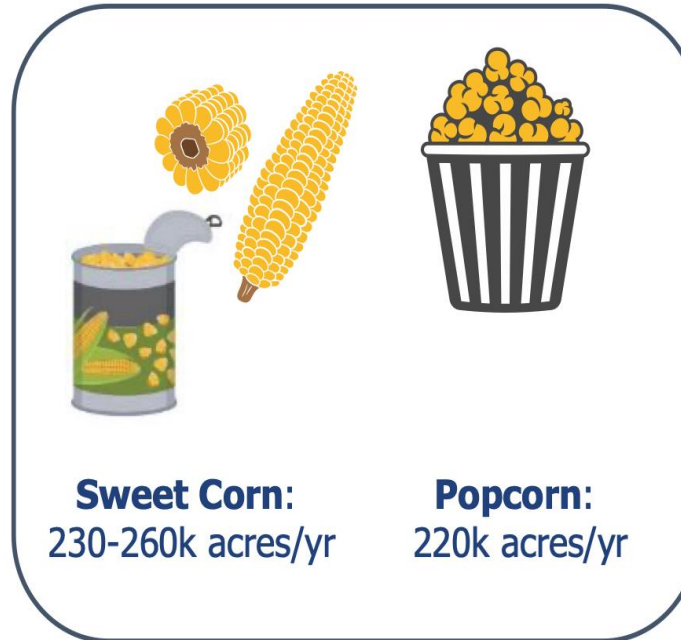
But wait, isn't this food versus...petrochemicals?

Total US Corn Production



2022 Field Corn:
79.2 MM acres harvested

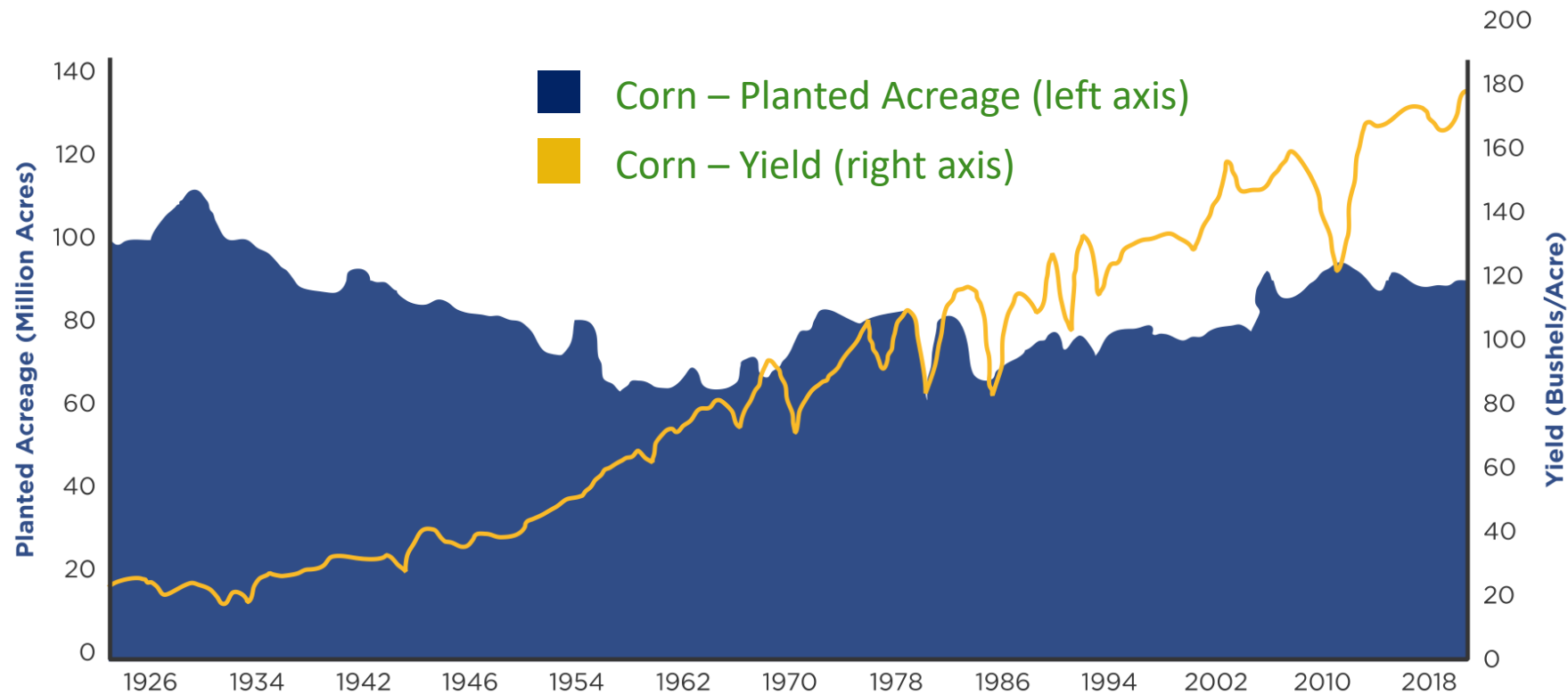
NOT Used



- The corn used for ethanol isn't the kind that humans eat
- Field corn is primarily used for animal feed
- Only the starch from corn is used to produce ethanol
- All contained protein and fat in the corn still go to the animal feed market

Source: Gevo, Nebraska Corn Board, USDA

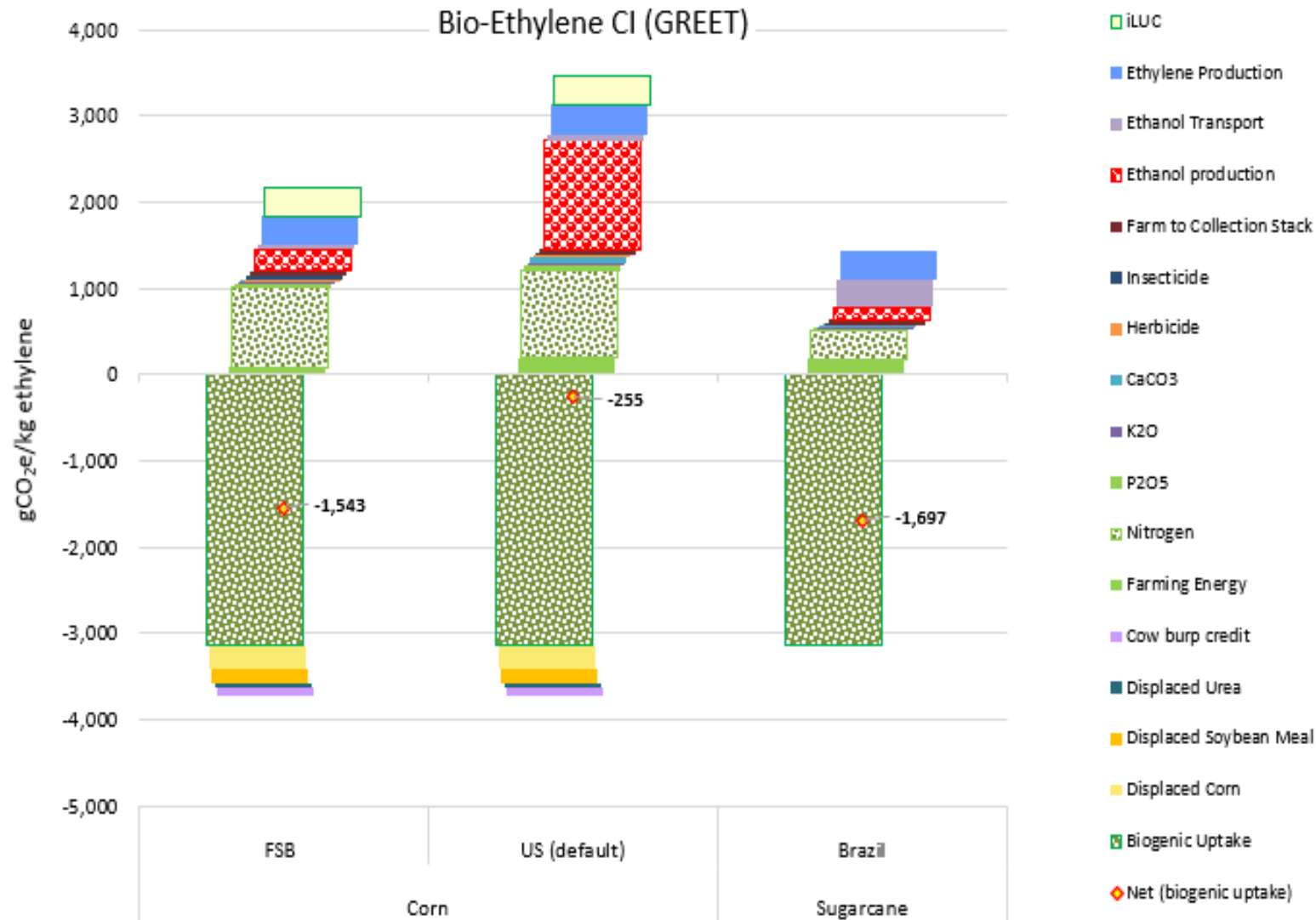
What about land use change?



- Land use for farming has stayed relatively the same over the past 100 years
- Yield, however, has improved by 600+%
- Corn planting covers only 4.4% of the land mass of the US

Source: Gevo, USDA Feed Grains Yearbook Tables, Our World In Data, Nutrient Data Laboratory

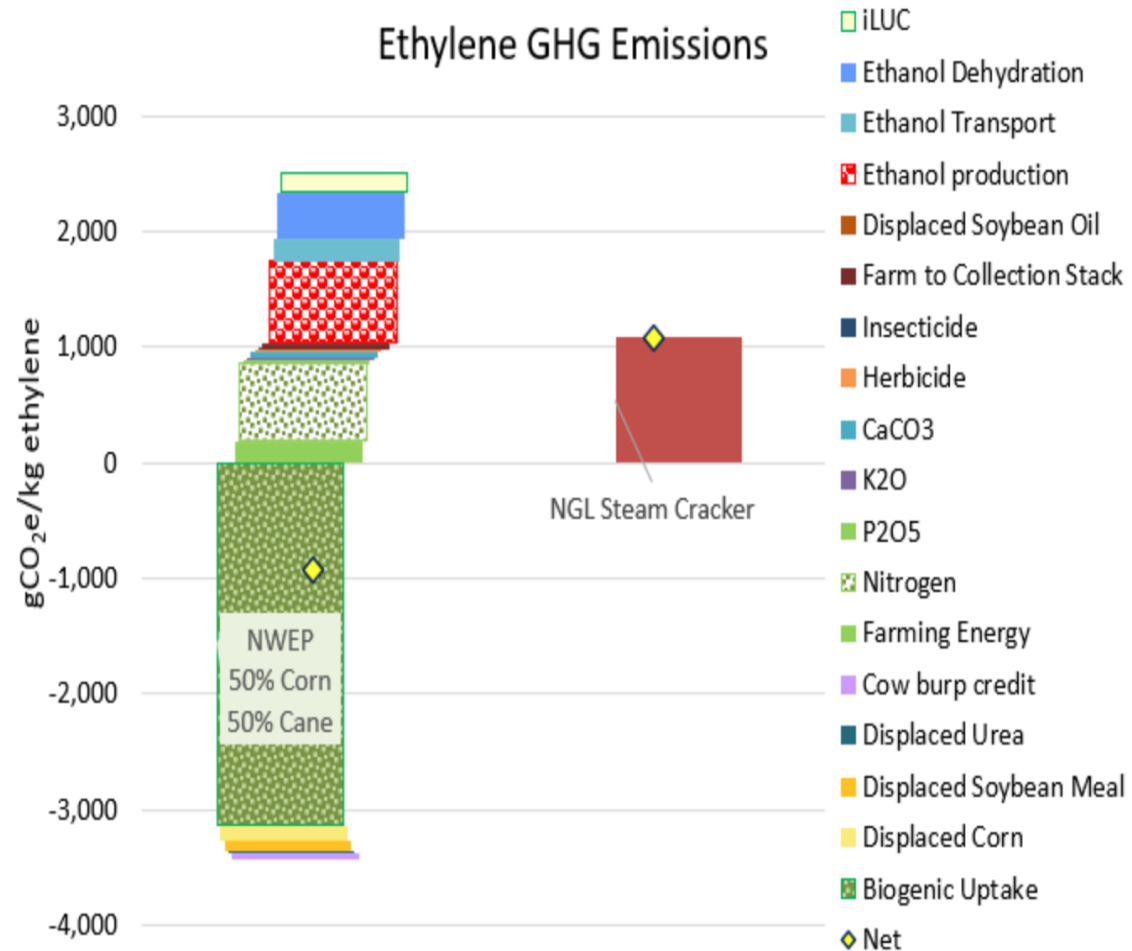
Carbon intensity (CI) of bio-ethylene



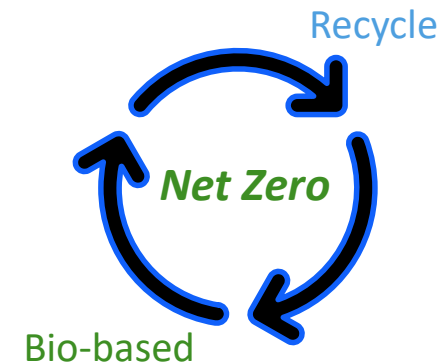
- Bio-ethylene from corn ethanol has negative CI using the NWEF process, **TODAY**
- Existing US corn-based ethanol has a -0.25 kg CO₂e per kg ethylene CI using the GREET model (and -0.60 kg CO₂e per kg ethylene CI on an ISCC basis)
- Brazilian sugarcane-based ethanol has a -1.70 kg CO₂e per kg ethylene CI using the GREET model (and -1.91 CO₂e per kg ethylene CI on an ISCC basis)

Source: Life Cycle Associates

Carbon intensity (CI) of bio-ethylene (continued)



- A blend of bio-ethylene with fossil ethylene provides **Net Zero** feedstock for any ethylene derivative process as a drop-in feedstock
- NWEP's Phase 2 project is estimated to save approximately **1,000,000 tons per year of GHG emissions** as compared to fossil-based ethylene production

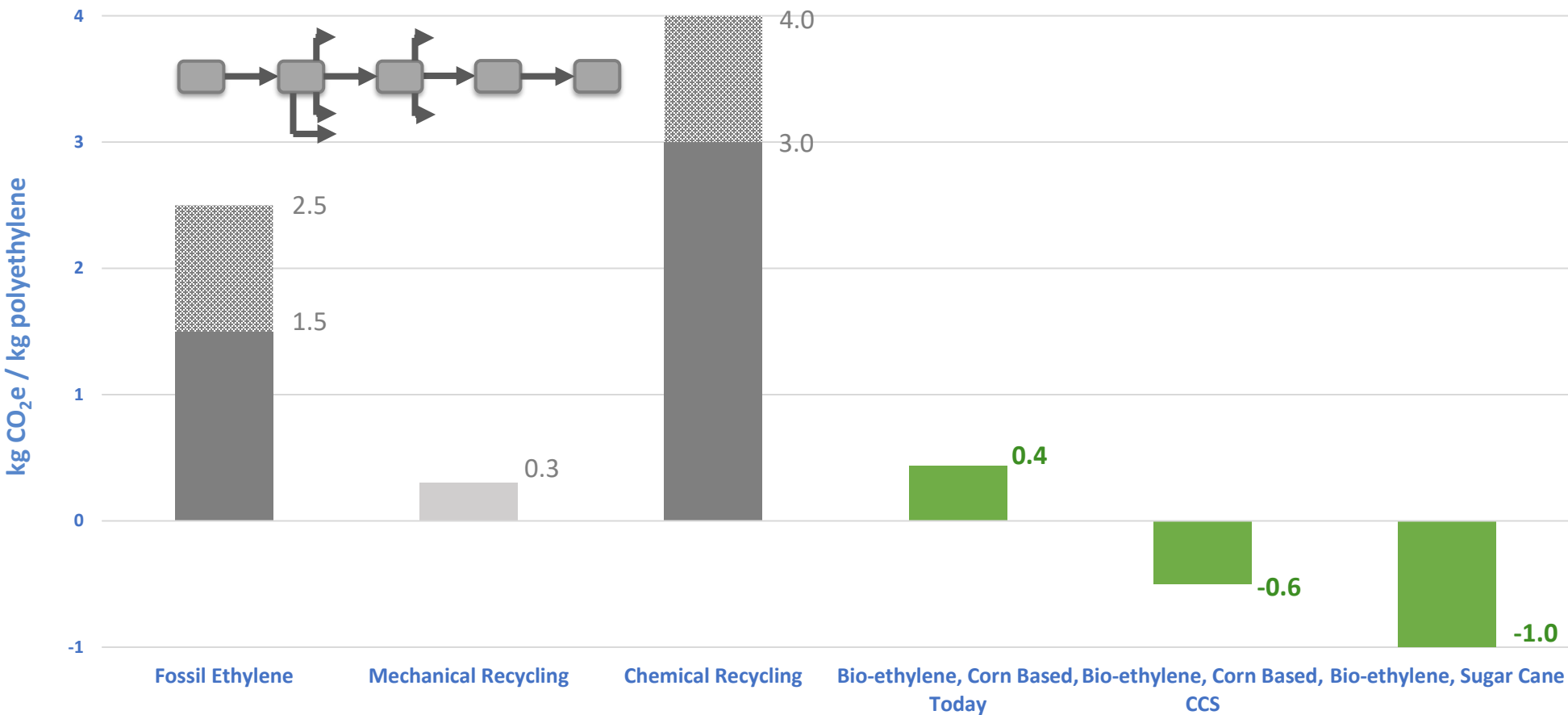


Plastics should be both bio-based and circular to achieve Net Zero!

Source: Life Cycle Associates, NWEP

Carbon intensity of polyethylene

Relative Comparison of Scope 1 & 2 Carbon Emissions for Various Polyethylene Production Methods

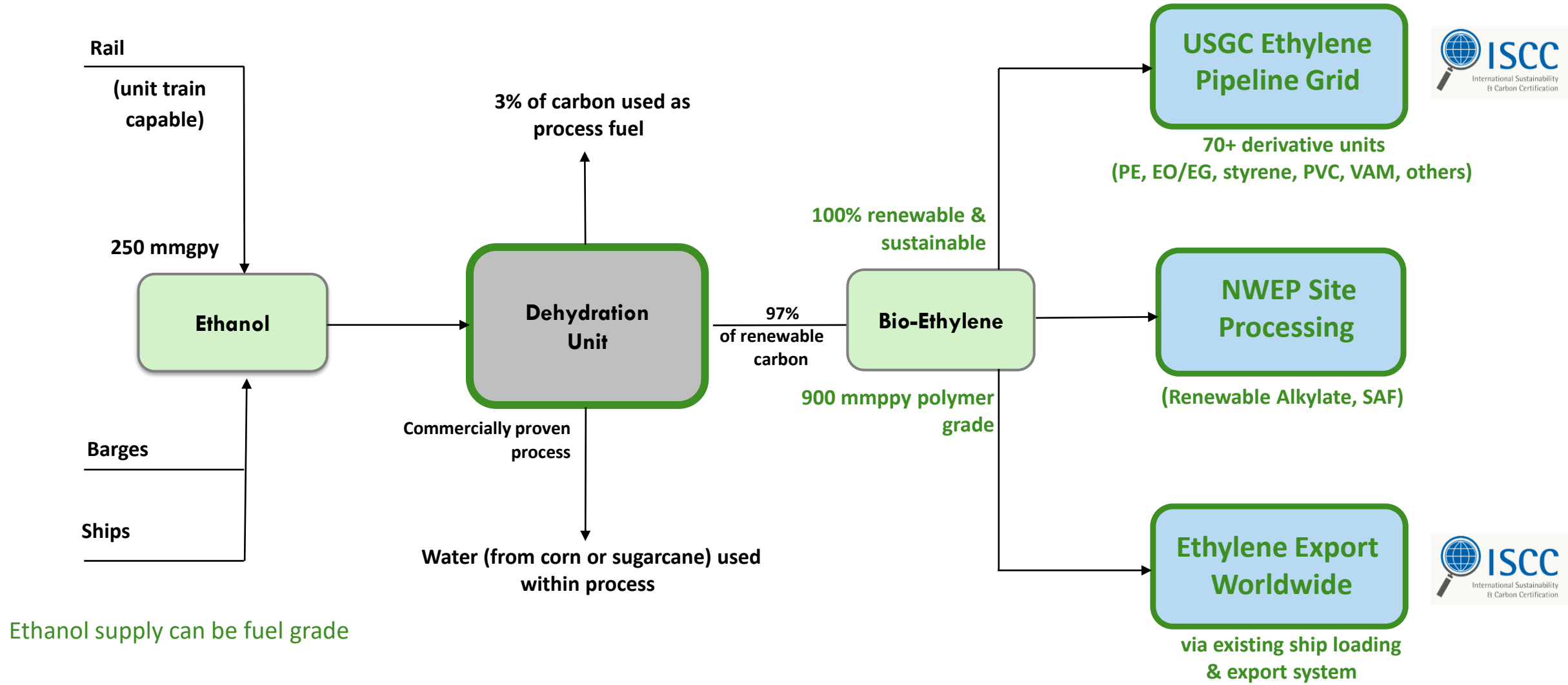


A circular economy for plastics is not necessarily aligned with Net Zero carbon intensity goals

Source: NWEF, Chemical Market Analytics by OPIS (gray bars), Life Cycle Associates (green bars)

Bio-ethylene provides the lowest carbon intensity of all sources for plastic production

NWEP bio-ethylene distribution

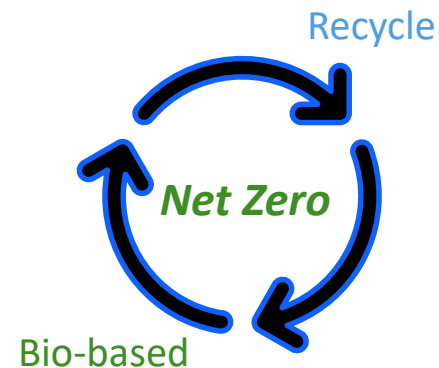


Summary

- Fossil ethylene remains low cost but a poor choice for our planet
- Circular ethylene is effective at removing plastic from the environment, but does so at a high carbon intensity and high cost
- Bio-ethylene, with a negative carbon intensity, allows a "drop-in" solution to achieve Net Zero goals of derivative producers
- Both bio-ethylene and circular ethylene are necessary to achieve Net Zero; we cannot simply "recycle our way there"

Feedstock required for one pound of ethylene:

- 0.42 gallons of ethane, or
- 5.7 pounds of waste plastic, or
- 0.35 gallons of ethanol





Thank you!