Ethanol: Climate & Land Considerations

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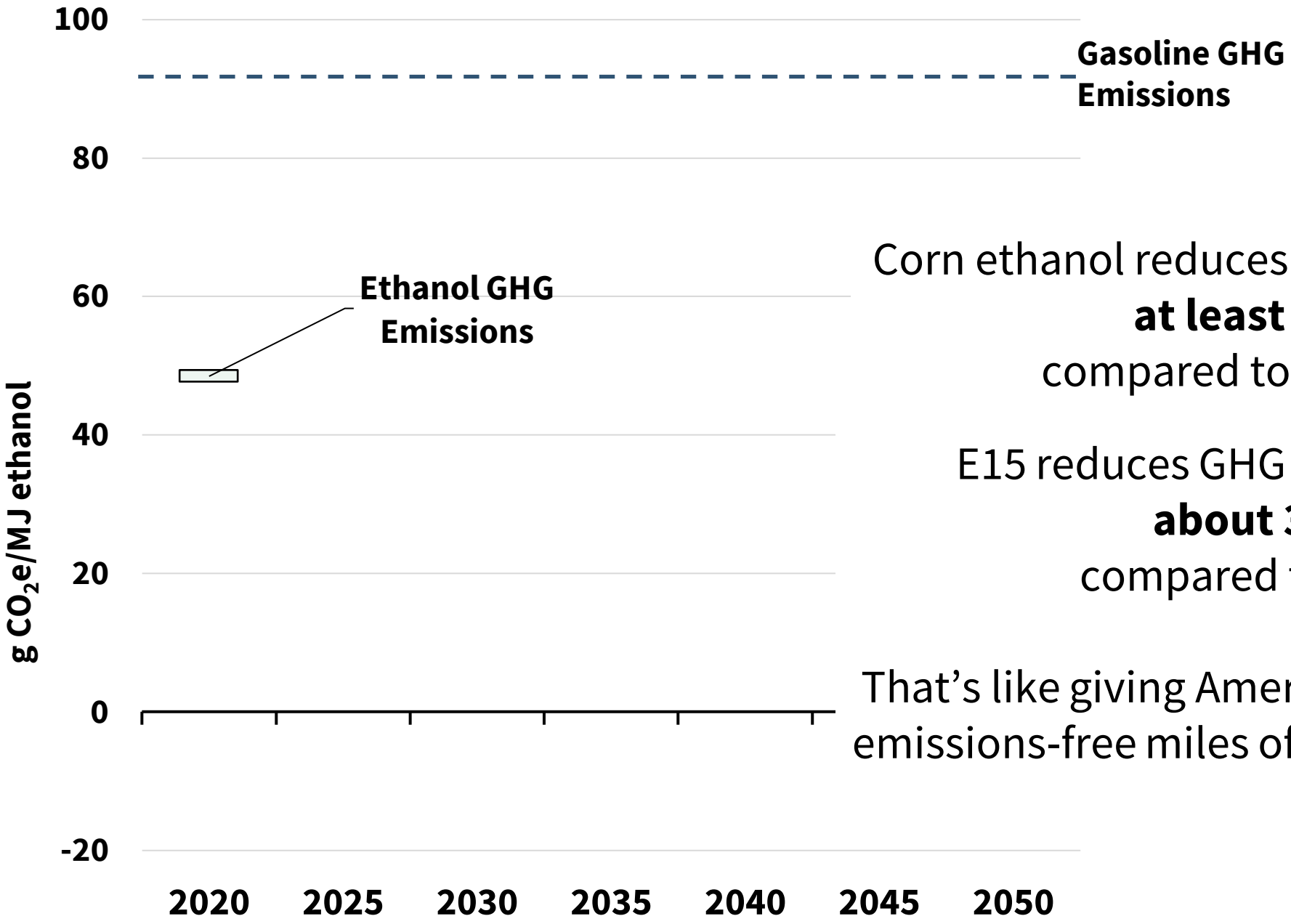
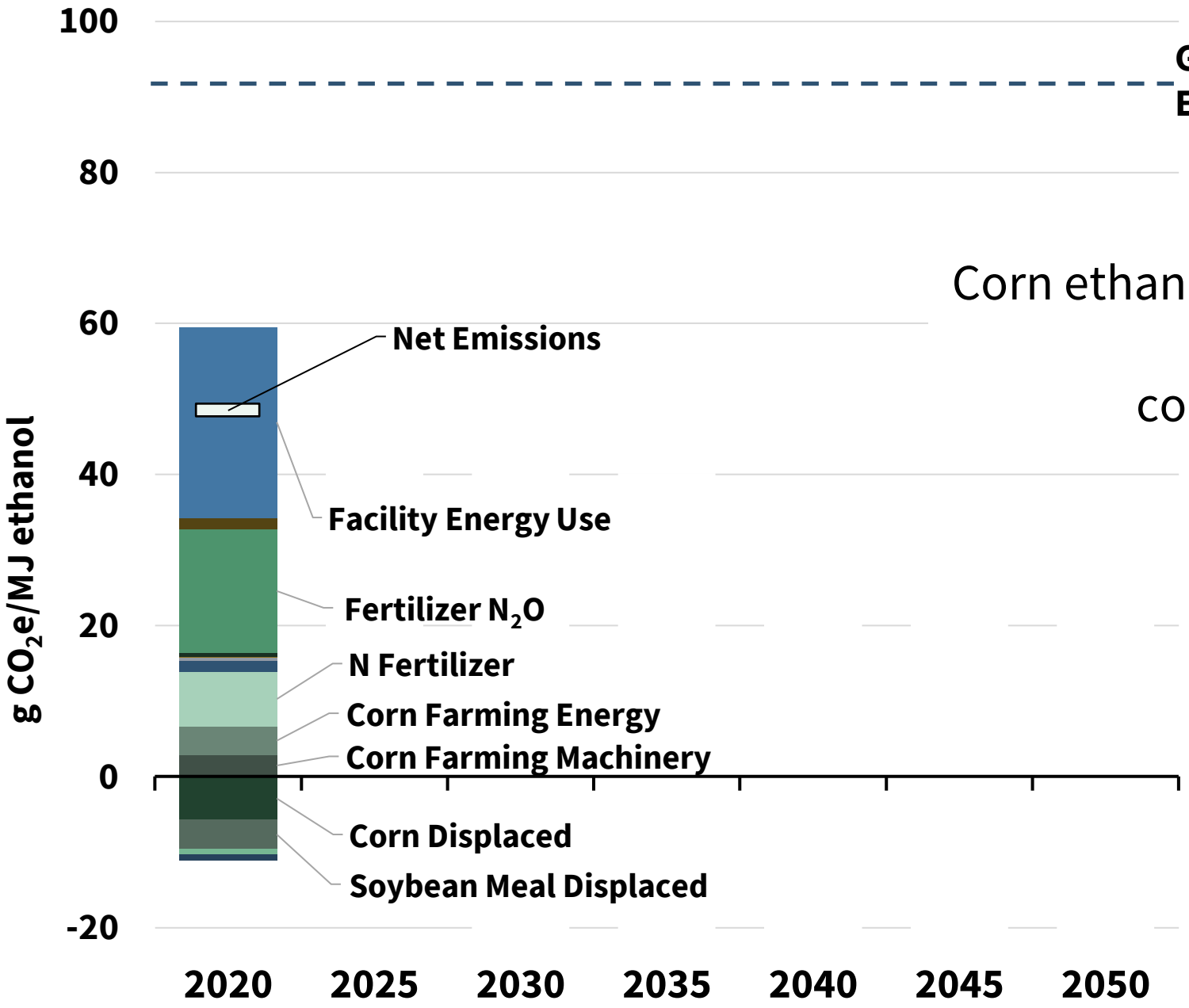


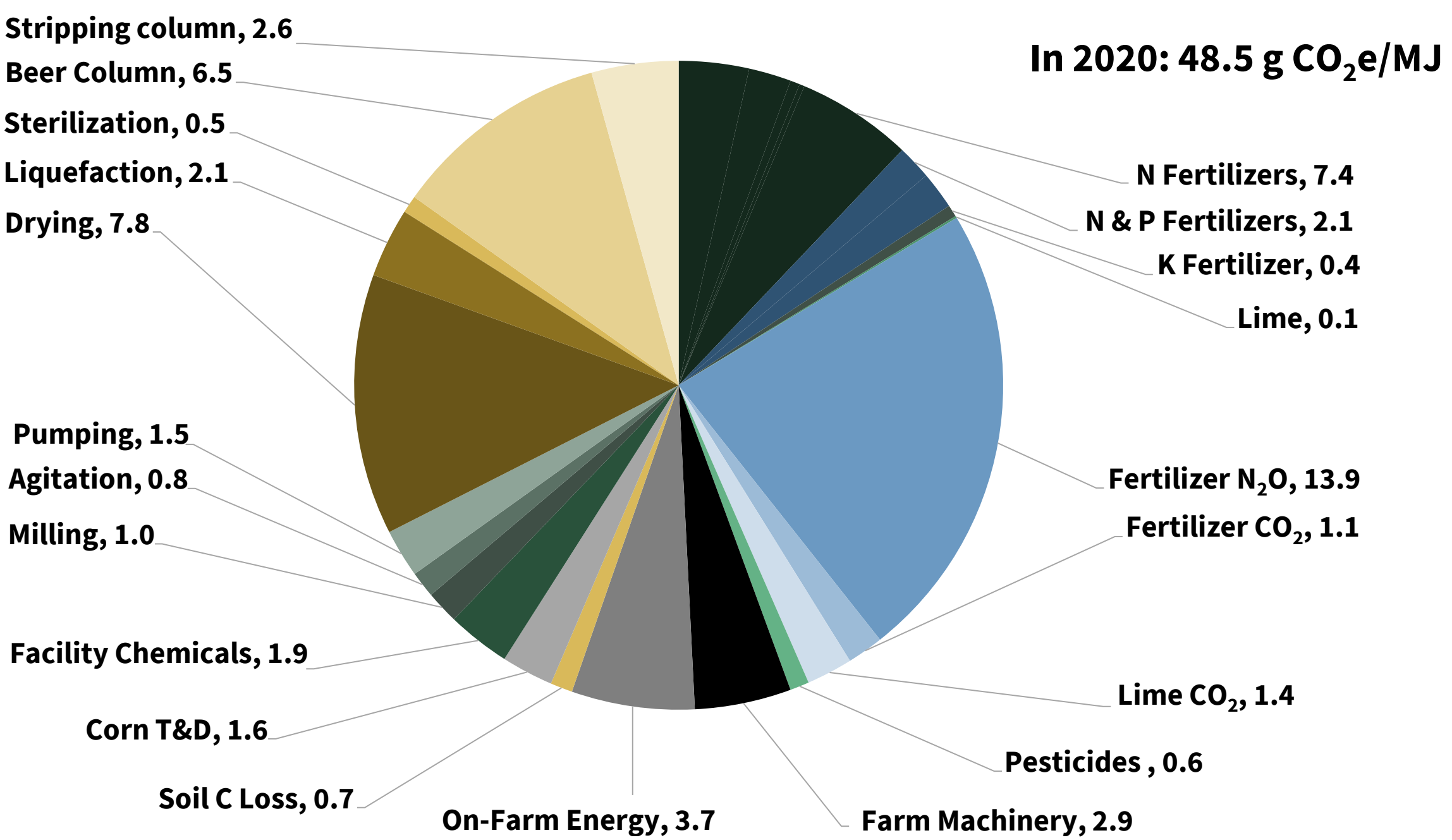
Corn ethanol reduces GHG emissions by
at least 40%
compared to gasoline.

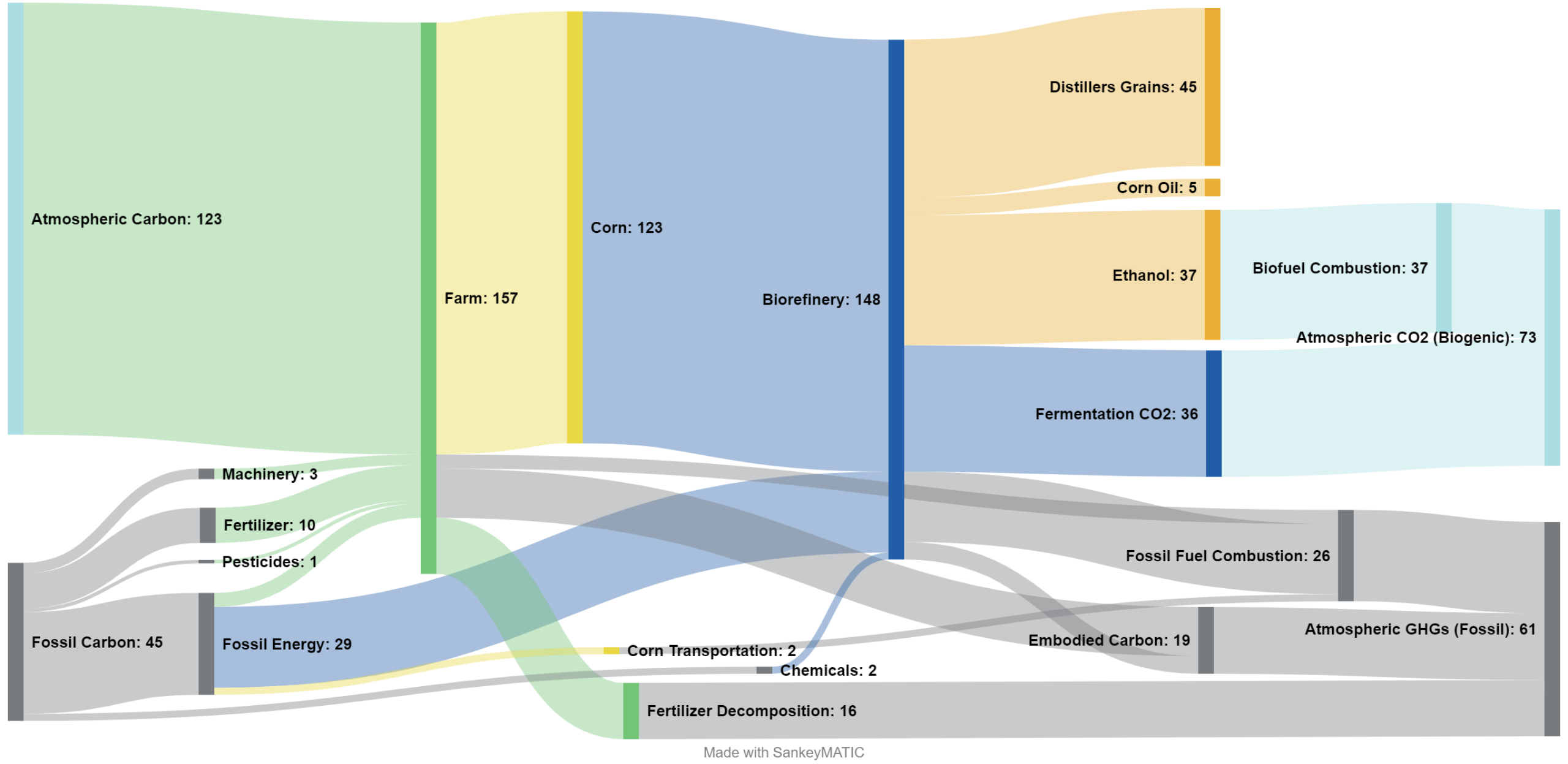
E15 reduces GHG emissions by
about 3%
compared to E10.

That's like giving Americans 200,000,000 emissions-free miles of driving every day.

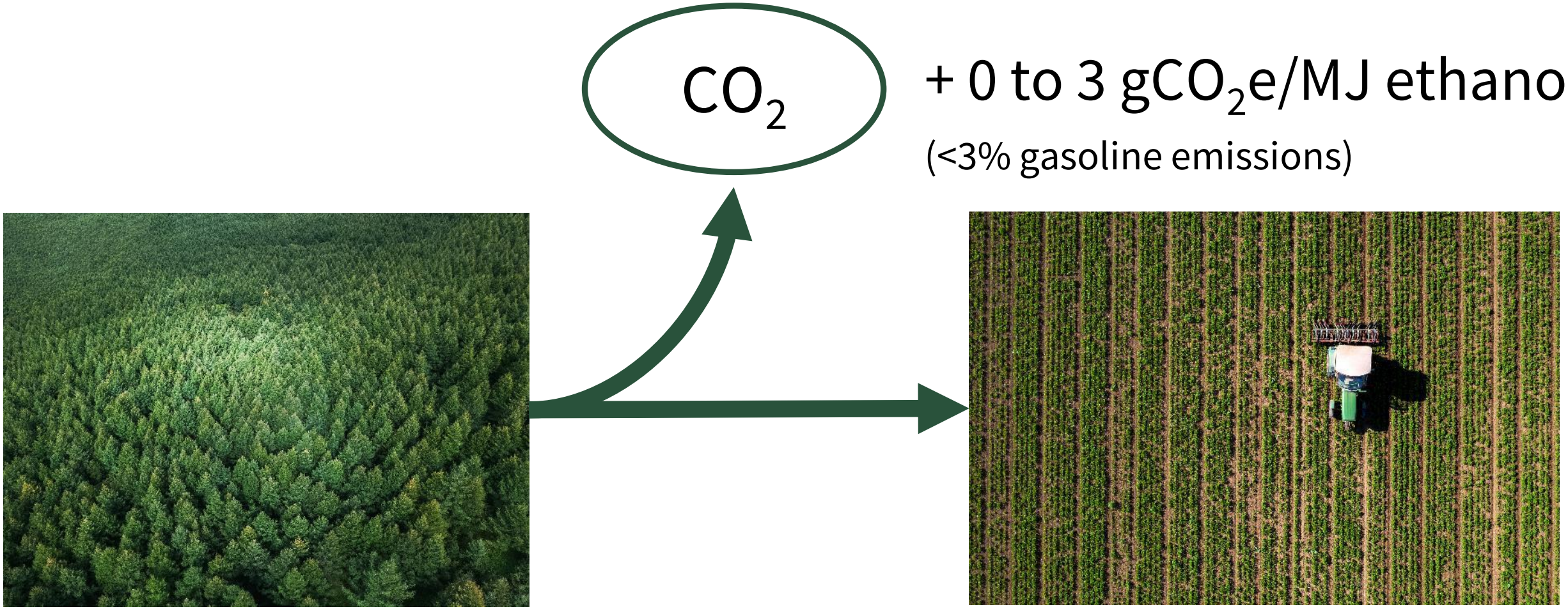


Corn ethanol reduces GHG emissions by **at least 40%** compared to gasoline.


In 2020: 48.5 g CO_2e/MJ
Stripping column, 2.6
Beer Column, 6.5
Sterilization, 0.5
Liquefaction, 2.1
Drying, 7.8
Pumping, 1.5
Agitation, 0.8
Milling, 1.0
Facility Chemicals, 1.9
Corn T&D, 1.6
Soil C Loss, 0.7
On-Farm Energy, 3.7
Farm Machinery, 2.9
Pesticides , 0.6
Lime CO_2, 1.4
Fertilizer CO_2, 1.1
Fertilizer N_2O, 13.9
Lime, 0.1
K Fertilizer, 0.4
N & P Fertilizers, 2.1
N Fertilizers, 7.4


Atmospheric Carbon: 123
Fossil Carbon: 45
Machinery: 3
Fertilizer: 10
Pesticides: 1
Fossil Energy: 29
Farm: 157
Corn: 123
Corn Transportation: 2
Chemicals: 2
Biorefinery: 148
Distillers Grains: 45
Corn Oil: 5
Ethanol: 37
Fermentation CO2: 36
Biofuel Combustion: 37
Atmospheric CO2 (Biogenic): 73
Fossil Fuel Combustion: 26
Embodied Carbon: 19
Atmospheric GHGs (Fossil): 61
Fertilizer Decomposition: 16
Made with SankeyMATIC

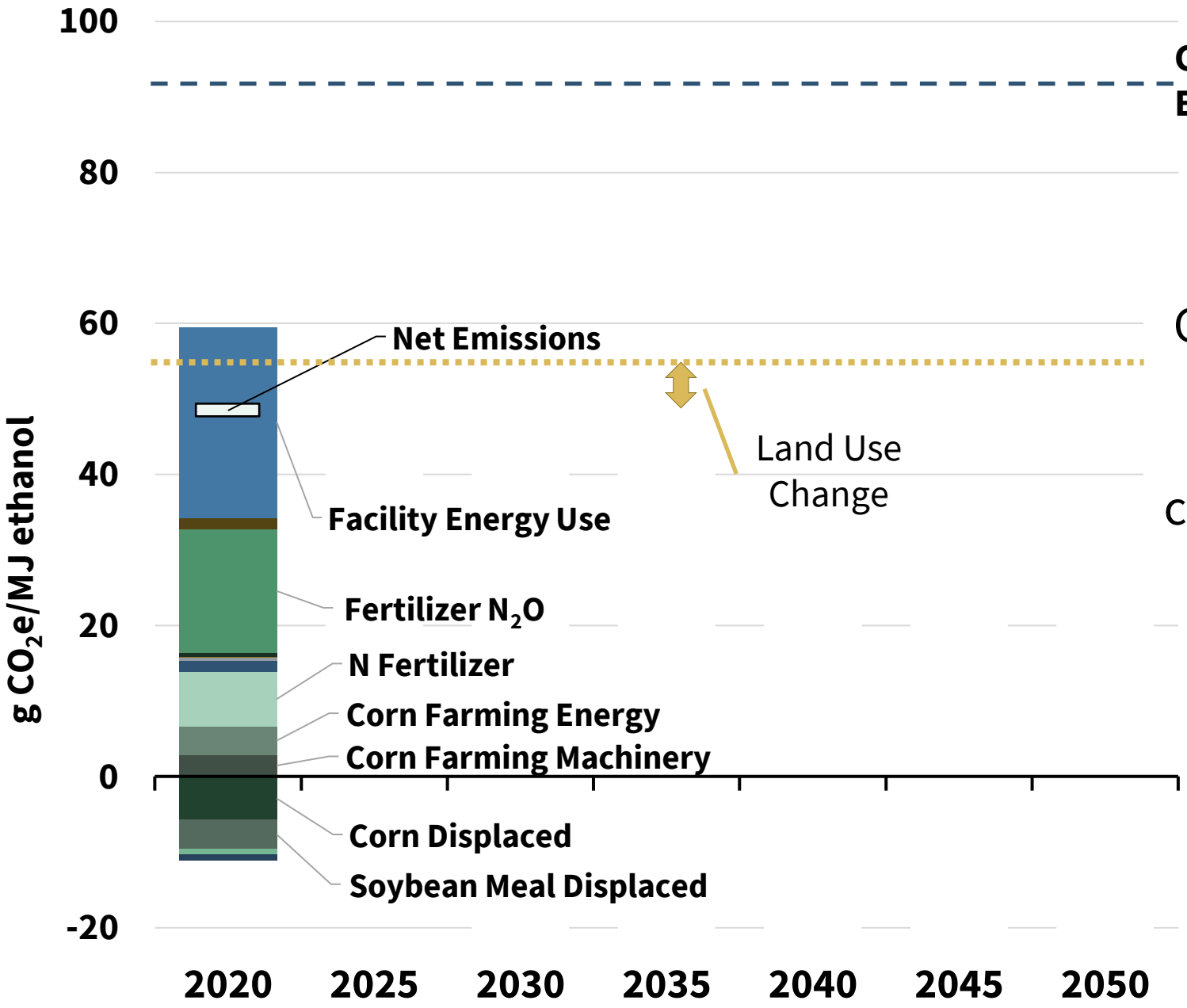
Land-use Change



Indirect Land-use Change

+ ~5 gCO_2e/MJ ethanol

(~5% gasoline emissions)



Corn ethanol reduces GHG emissions by **at least 40%** compared to gasoline.

Is land use change really that minor? Yes*

Major flaws in the Lark study published in PNAS:

The authors claimed to show very high greenhouse gas emissions from corn ethanol due to land use change. But…

https://ag.purdue.edu/commercialag/home/wp-content/uploads/2022/05/Comments-on-Environmental-Outcomes-of-the-U.S.-Renewable-Fuel-Standard.pdf

Comments on "Environmental Outcomes of the US Renewable Fuel Standard"

Farzad Taheripour[1], Steffen Mueller[2], Hoyoung Kwon[3], Madhu Khanna[4], Isaac Emery[5], Ken Copenhaver[6], Michael Wang[3]

Comments on "Environmental Outcomes of the US Renewable Fuel Standard"

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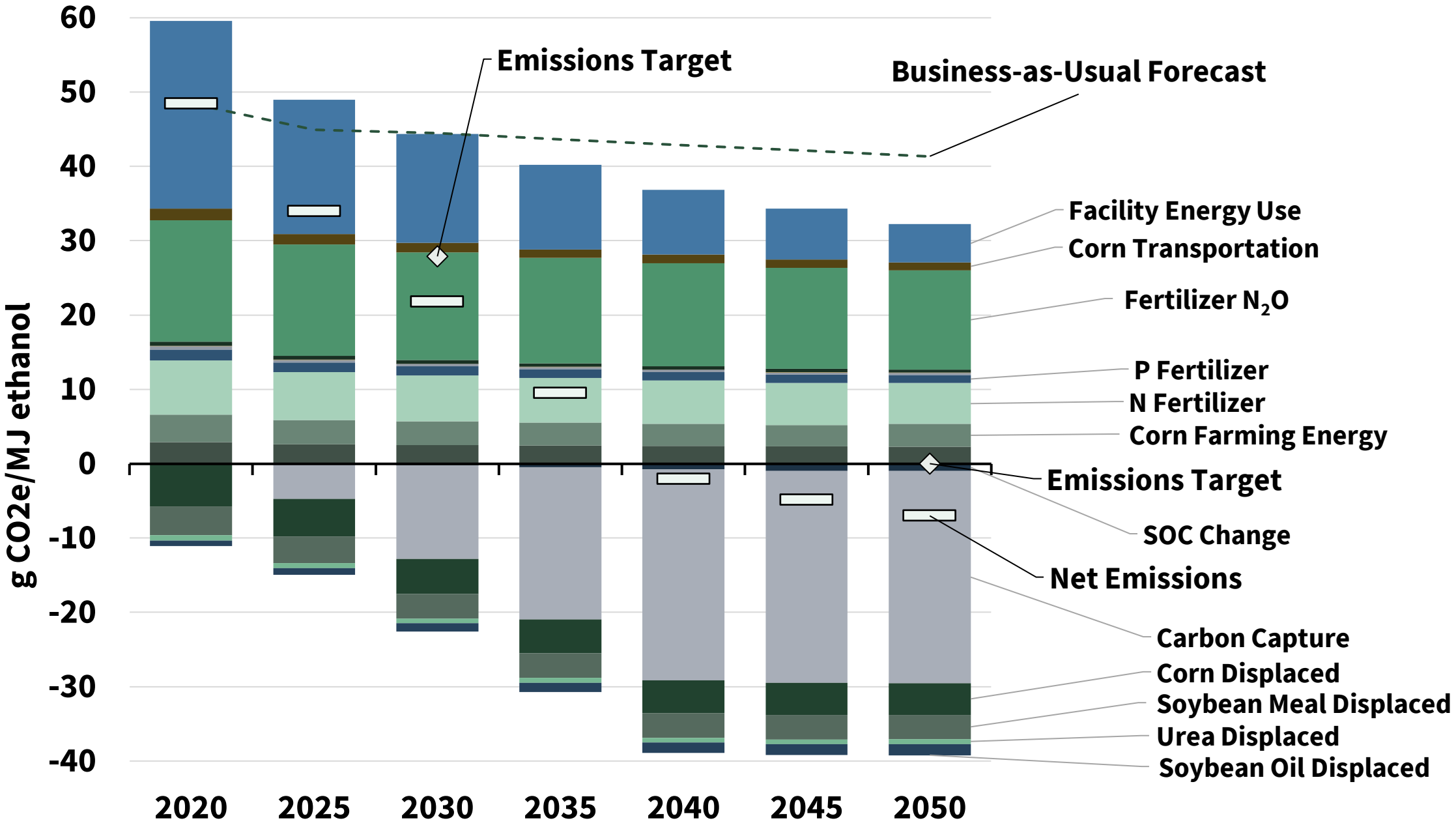
Major flaws in the Lark study published in PNAS:

- Some "land use change" was from fallow or idle cropland, not grassland or forest
- Used wrong soil carbon change data
- Double-counted fertilizer emissions
- Assumed corn prices drive CRP enrollment (actually set by Congress)
- Chose a time period when crop production & prices were driven by drought and other economic drivers, not renewable fuel policy

https://ag.purdue.edu/commercialag/home/wp-content/uploads/2022/05/Comments-on-Environmental-Outcomes-of-the-U.S.-Renewable-Fuel-Standard.pdf


g CO2e/MJ ethanol
60
50
40
30
20
10
0
-10
-20
-30
-40
2020
2025
2030
2035
2040
2045
2050
Emissions Target
Business-as-Usual Forecast
Facility Energy Use
Corn Transportation
Fertilizer N2O
P Fertilizer
N Fertilizer
Corn Farming Energy
Emissions Target
SOC Change
Net Emissions
Carbon Capture
Corn Displaced
Soybean Meal Displaced
Urea Displaced
Soybean Oil Displaced

Industry Pathway to Net Zero

BY 2030…

- ‘Better-than-BAU’ biorefinery efficiency & yields
- Renewable electricity at 50% of biorefineries
- Corn kernel fiber fermentation at 20% of dry mills
- Carbon capture & sequestration at 40% of biorefineries
- Bio-methane at 28% of biorefineries
- Renewable electricity at 25% of corn farms & elevators
- Reduced tillage at 7.5% of corn farms

BY 2050…

… continued ‘Better-than-BAU’

… 90% of biorefineries

… 50% of dry mills

… 90% of biorefineries

… 78% of biorefineries

… 90% of corn farms & elevators

… 30% of corn farms

Conclusions

- YES, corn ethanol reduces GHG emissions from gasoline
  - Land use change is a small part of GHG emissions from American ethanol (about 8% or less of gasoline's emissions)
- E15 reduces GHG emissions compared to E10
  - Up to 90,000 tons of CO_2 per day
- The Lark study published in PNAS has major flaws that misrepresent ethanol's carbon footprint
  - Wrongly identified land used for corn
  - Used inaccurate estimates of soil carbon change
  - Double-counted fertilizer's carbon footprint
  - Wrongly assumed prices drove CRP enrollment