Progress Toward Net-Zero:
Survey of RFA Members

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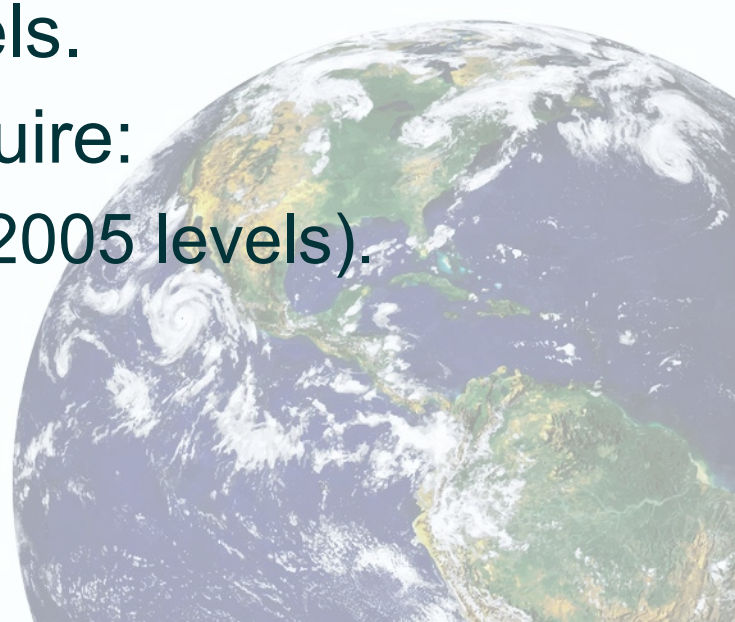
The “Energy Transition”

- Global energy sector is shifting from current fossil-based systems to lower-carbon sources, including renewables.
  - Driven by a convergence of government policies, changing corporate investment strategies (ESG), and consumer preferences.
- Paris Climate Agreement aims to limit global temperature increase to no more than 1.5° C above pre-industrial levels.
- According to the U.N., meeting this goal will require:
  - 45-50% GHG emissions reduction by 2030 (vs. 2005 levels).
  - **Net-zero GHG emissions by 2050.**



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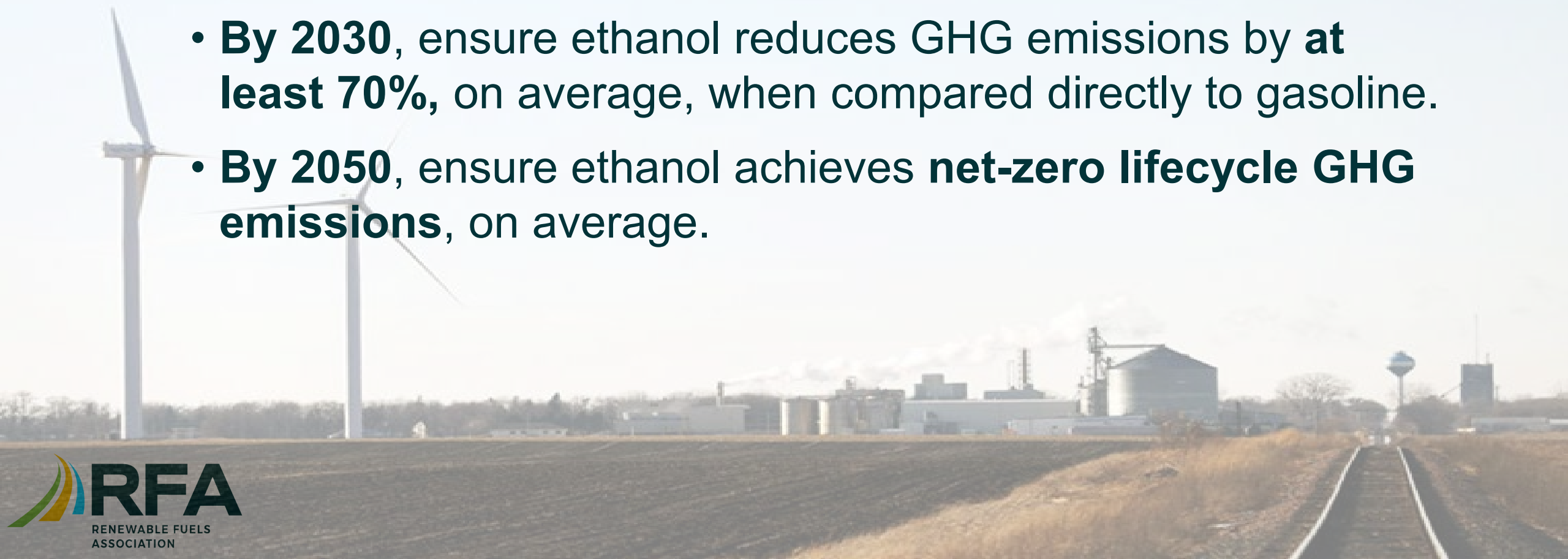
RFA's Net Zero Pledge

- In July 2021, RFA's renewable fuel producer members unanimously committed to certain carbon performance goals:
  - **By 2030**, ensure ethanol reduces GHG emissions by **at least 70%,** on average, when compared directly to gasoline.
  - **By 2050**, ensure ethanol achieves **net-zero lifecycle GHG emissions**, on average.



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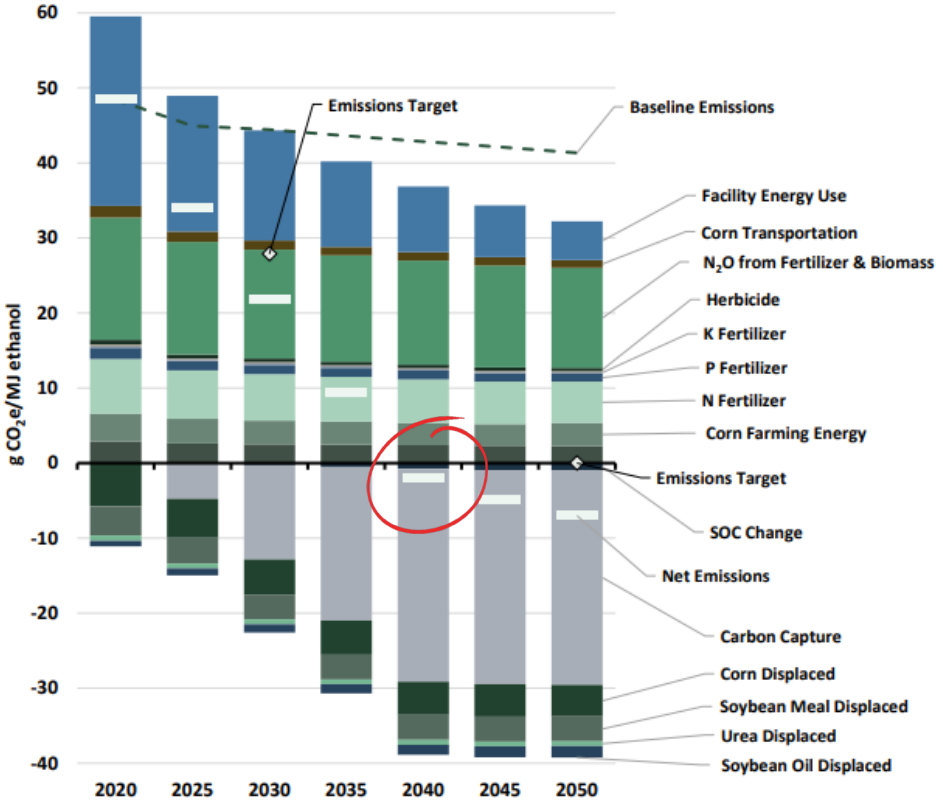
Pathways to Net Zero

- In February 2022, RFA released a study by Informed Sustainability Consulting examining various technology pathways for achieving net zero emissions. Key conclusions:
  - *"By investing in low-carbon process innovations and establishing a market for low-carbon agricultural products,* ***ethanol producers can achieve extremely low emissions and fill a critical need in tomorrow's zero-carbon economy****."*
  - *"…****the industry can achieve net-negative CI ethanol by adopting near-term technologies and expanding best practices in corn farming****."*



Under this combination of technologies and practices, ethanol reaches net zero by 2040

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Survey Results

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Survey: Progress Toward Net Zero

- In February/March 2023, RFA surveyed its ethanol producer members regarding initial progress toward reducing carbon intensity.
- Responses received from nearly all RFA member biorefinery facilities.
- Responses were received from both small and large facilities.
  - Range of annual production capacity = **35 MG to 150 MG.**
- Responses came from geographically diverse areas.
  - Responses from biorefineries operating in **12 different states.**
  - Inside and outside of “Corn Belt.”
- Biorefineries using the **dry mill process** accounted for all responses.
  - No responses from wet mills.

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What is the approximate carbon intensity (in grams CO2e per megajoule) of the ethanol produced today at this facility (using DOE Argonne GREET_2022)?

- Volume-weighted average[1] = **52.5 g/MJ**
  - Range = **47 to 70 g/MJ**
  - Median value = **52 g/MJ**
- Includes GREET "indirect land use change" emissions of **6.7 g/MJ**
- Volume-weighted average for direct emissions only = **45.8 g/MJ**
- For reference, gasoline has a carbon intensity of **93-102 g/MJ[2]**
  - Surveyed facilities produce ethanol that is **44-55%** less carbon intensive than gasoline on average

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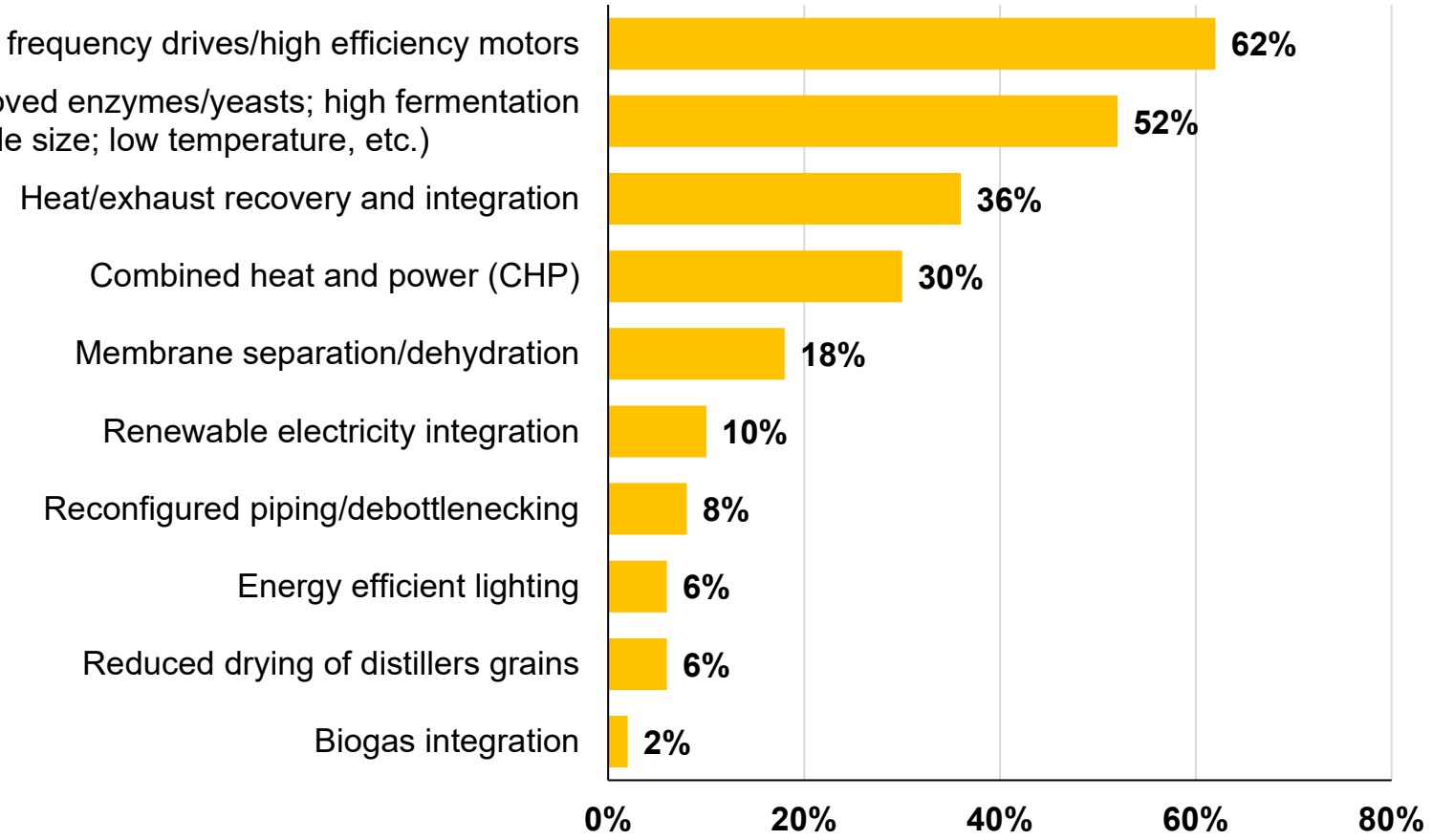
1) Based on normal operating capacity volume
2) 93 g/MJ from DOE Argonne GREET_2022; 102 g/MJ from CA Air Resources Board

What technologies or practices have been adopted at this facility since 2015/16 that have led to reductions in the carbon intensity of the ethanol produced at this site? (list all that apply)

Share of surveyed facilities who have adopted certain technologies and practices since 2015/16



All facilities reported adopting at least one of these technologies since 2015/16.

Most facilities adopted more than one of these technologies and practices.

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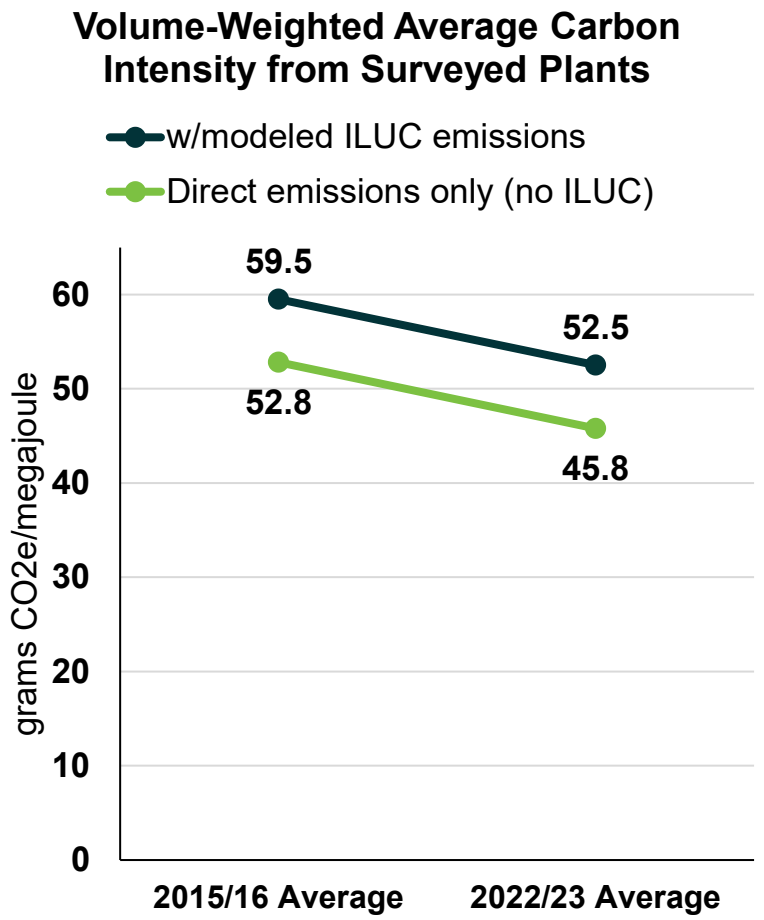
What impact have these improvements had on the carbon intensity of the ethanol produced at this facility? How much has the carbon intensity of your ethanol dropped since the 2015/2016 timeframe?

- Volume-weighted average reduction since 2015/16 = **7 g/MJ**
  - Range of reductions = **3 to 17 g/MJ**
  - Median value = **8 g/MJ**
- Equates to a **12% reduction** in average carbon intensity since 2015/16
  - Range = **4%** to **25%** reduction
  - Median value = **13%** reduction



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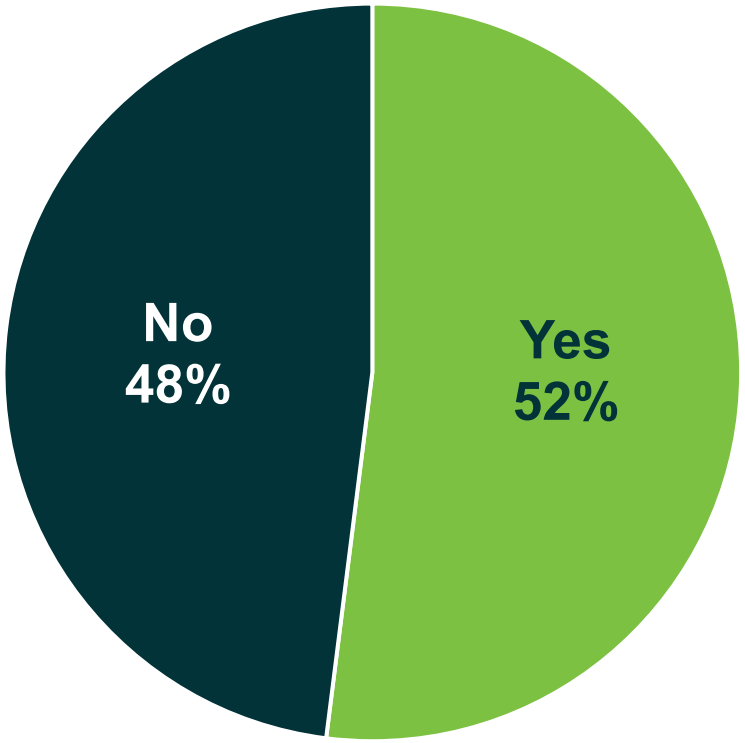
Does this facility produce cellulosic ethanol from corn kernel fiber or other biomass feedstocks?



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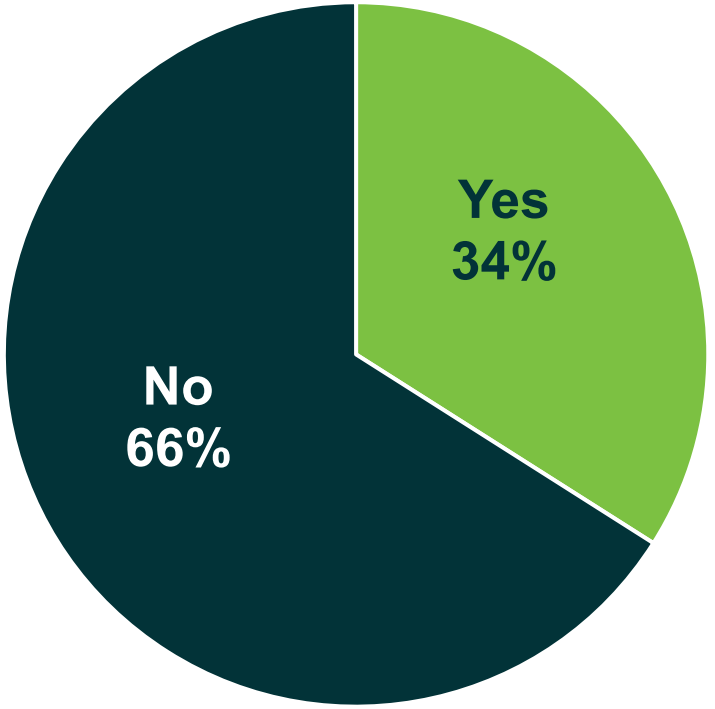
Does this facility currently recover CO2 from fermentation (e.g., for use in food/beverage processing)?



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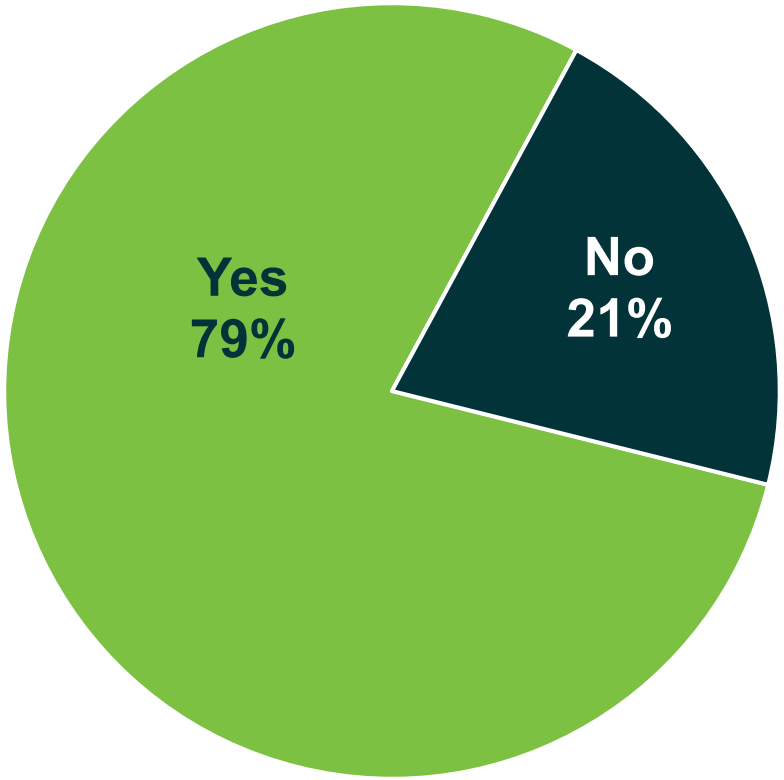
Is this facility intending to adopt carbon capture and geological sequestration (CCS) technology?



If not, why? (most common responses)

- ❑ No adjacent geology for sequestration.
- ❑ No reasonable access to proposed CCS pipelines.
- ❑ Long-term ROI is unclear without more low-carbon markets.

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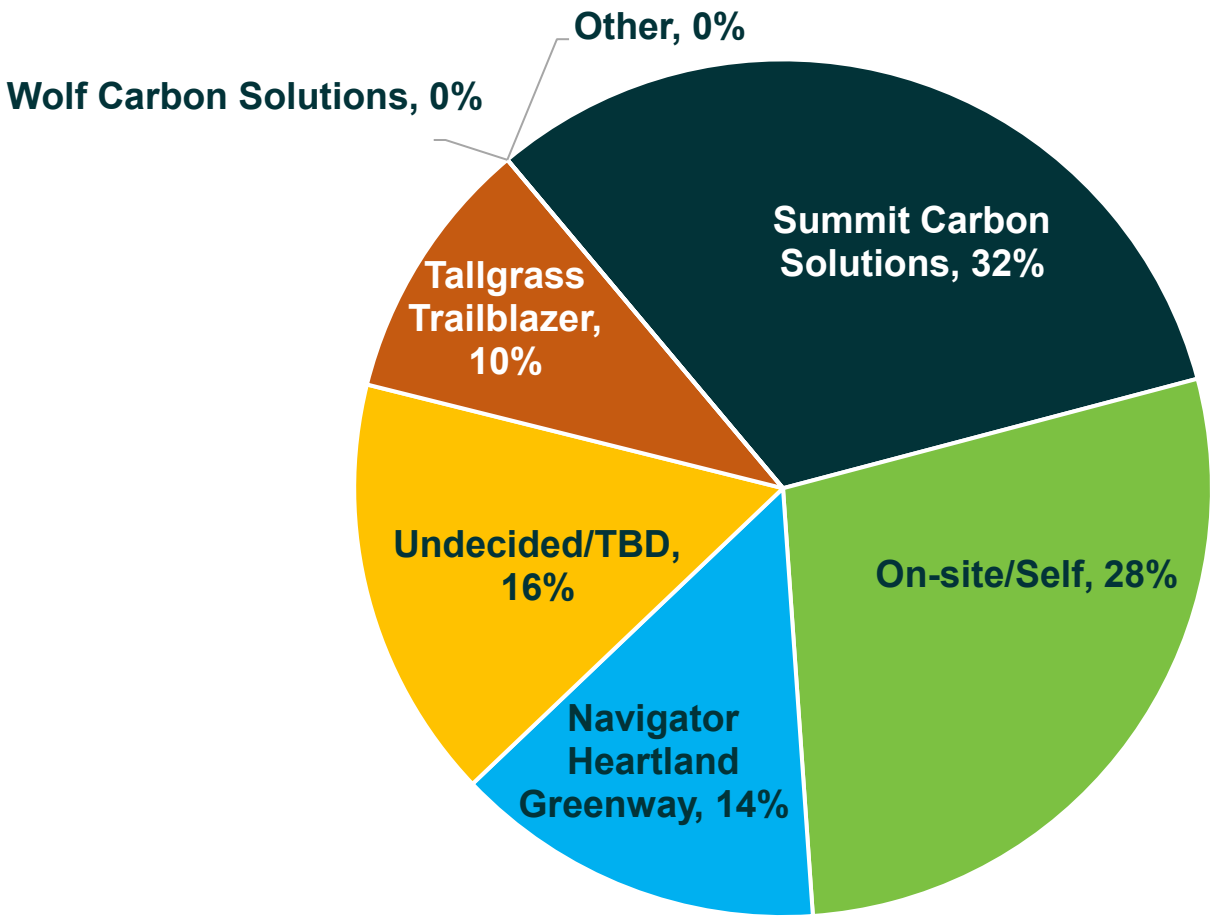
If this facility is pursuing carbon capture and geological sequestration, which provider is the facility planning to partner with?



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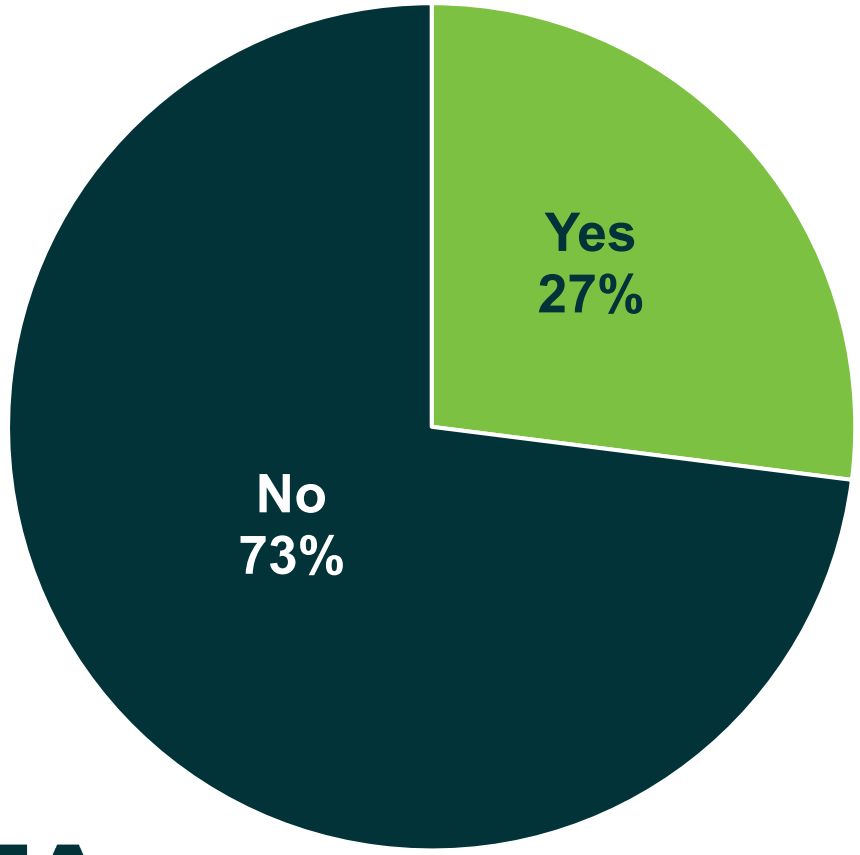
Is this facility working with feedstock suppliers/farmers to encourage or reward more carbon-efficient farming practices (e.g., reduced tillage, cover crops, etc.) to lower the carbon intensity of processed feedstocks?



If not, why? (most common responses)

- ❑ No clear policy incentive, reason, or requirement to do so.
- ❑ No way to monetize farm-level CI improvements.
- ❑ Currently no ROI for this. Policy must catch up first.
- ❑ We are evaluating opportunities and developing plans.

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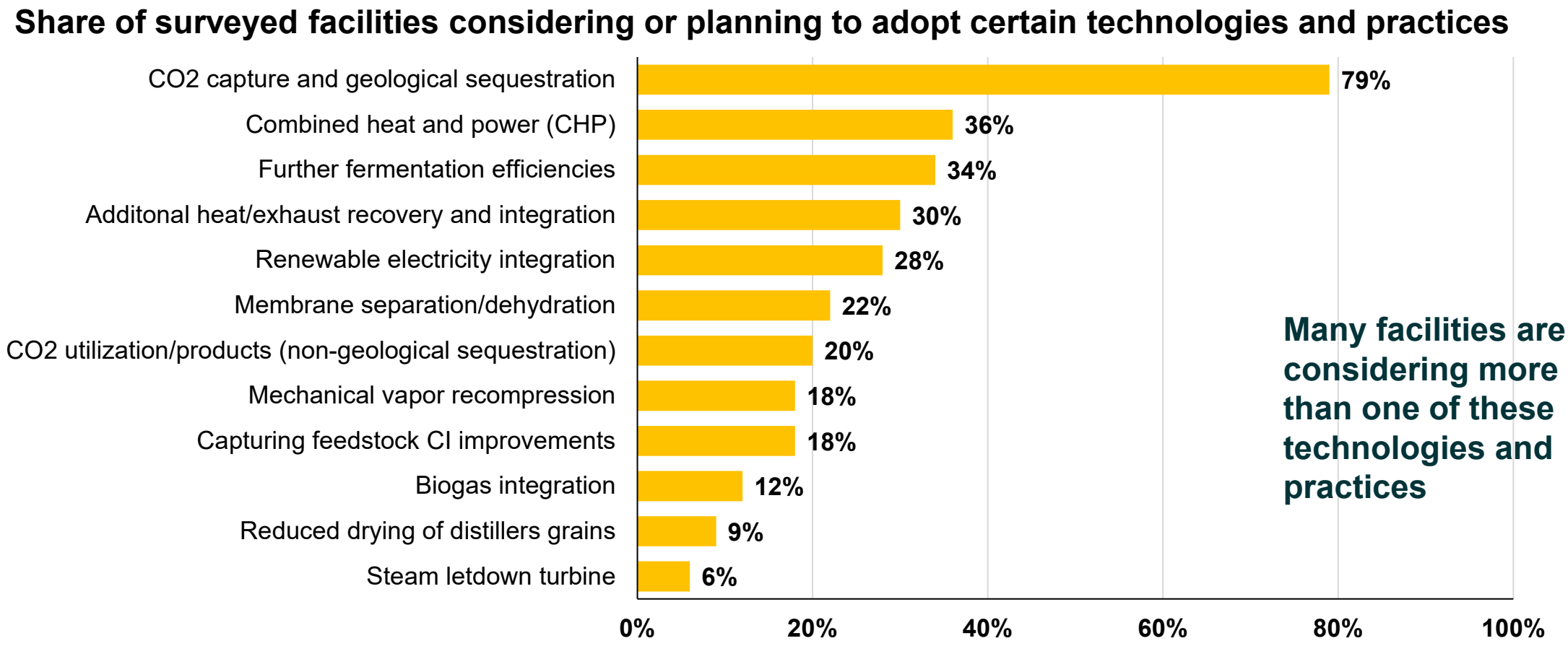
What other technologies or practices is the facility considering or planning to adopt to further reduce carbon intensity in the next 3-5 years? (list all that apply)



Many facilities are considering more than one of these technologies and practices

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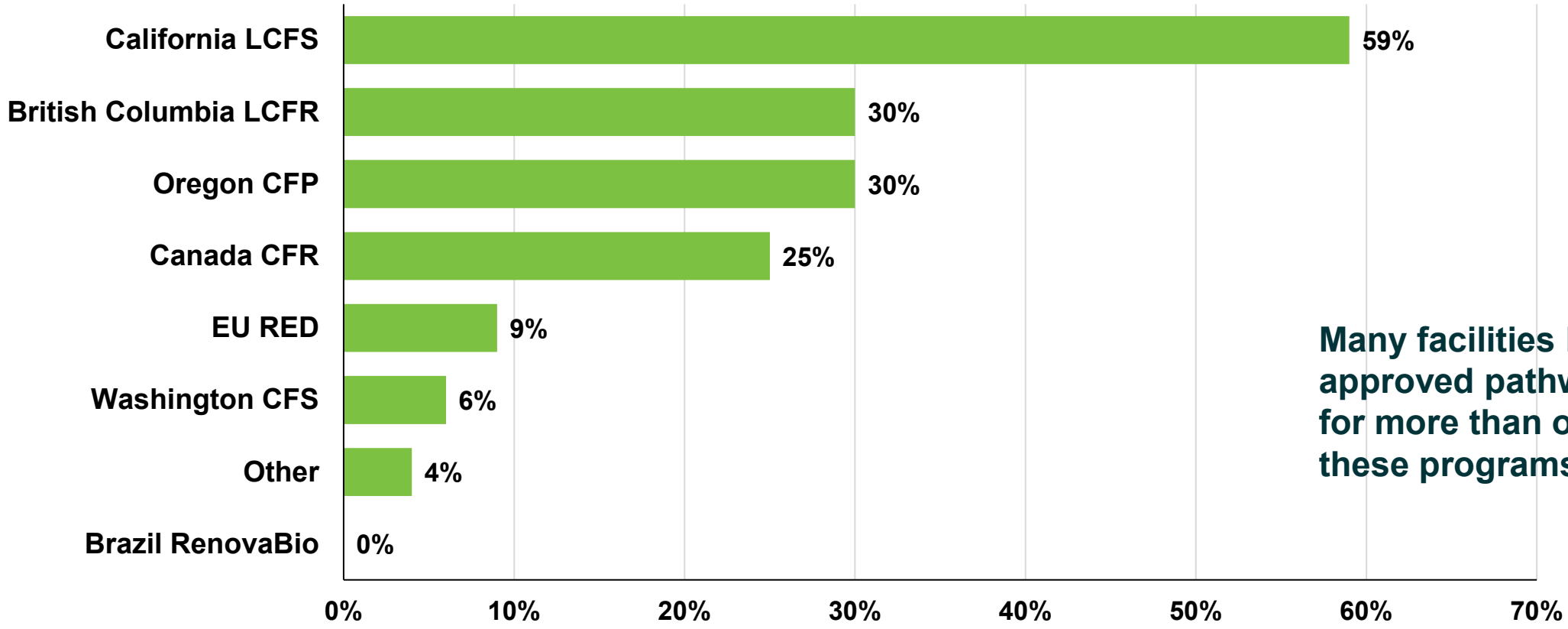
Does this facility have approved pathways for the following low carbon fuel regulations? (select all that apply)



Many facilities have approved pathways for more than one of these programs

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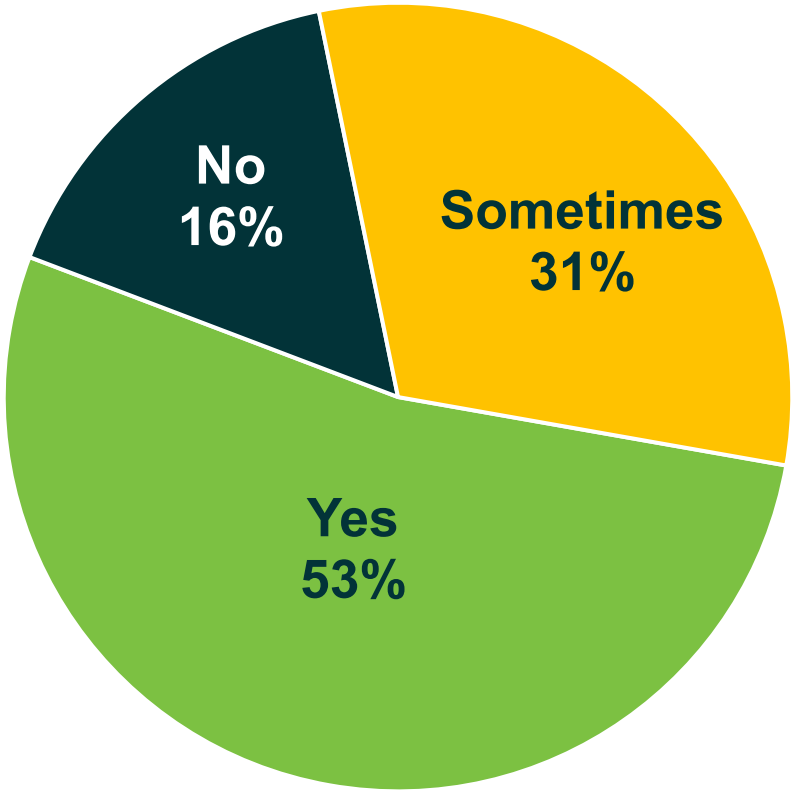
Have you received a premium value for renewable fuels sold into these low-carbon markets?



Additional comments

- ❑ West Coast low carbon markets are now saturated. No premiums available.
- ❑ The price premiums from several years ago are gone.
- ❑ Freight to West Coast has always offset any premiums from our area.
- ❑ We still see modest premium value in low carbon markets, especially for corn kernel fiber ethanol.

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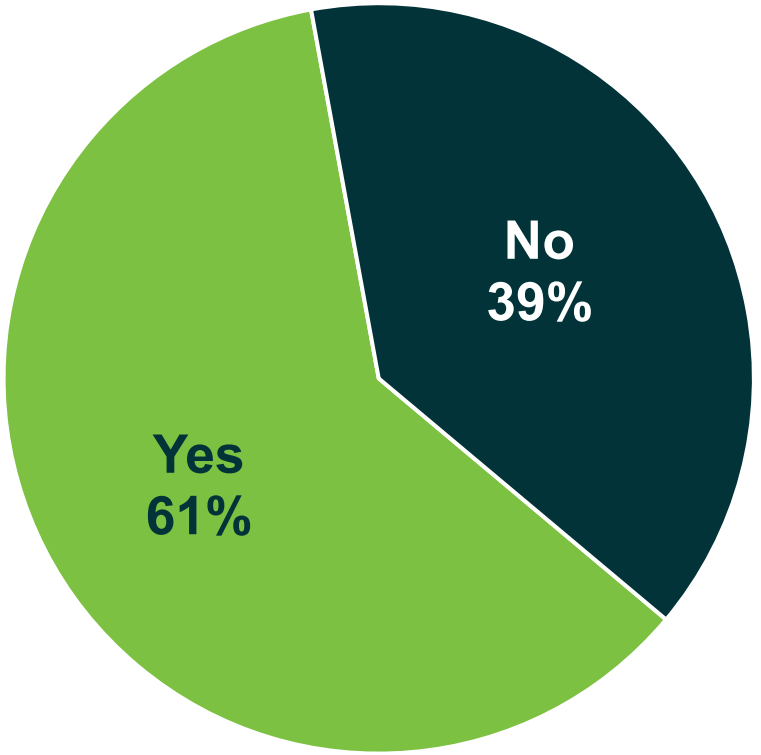
Does this facility have an approved Efficient Producer Pathway under the Renewable Fuel Standard?



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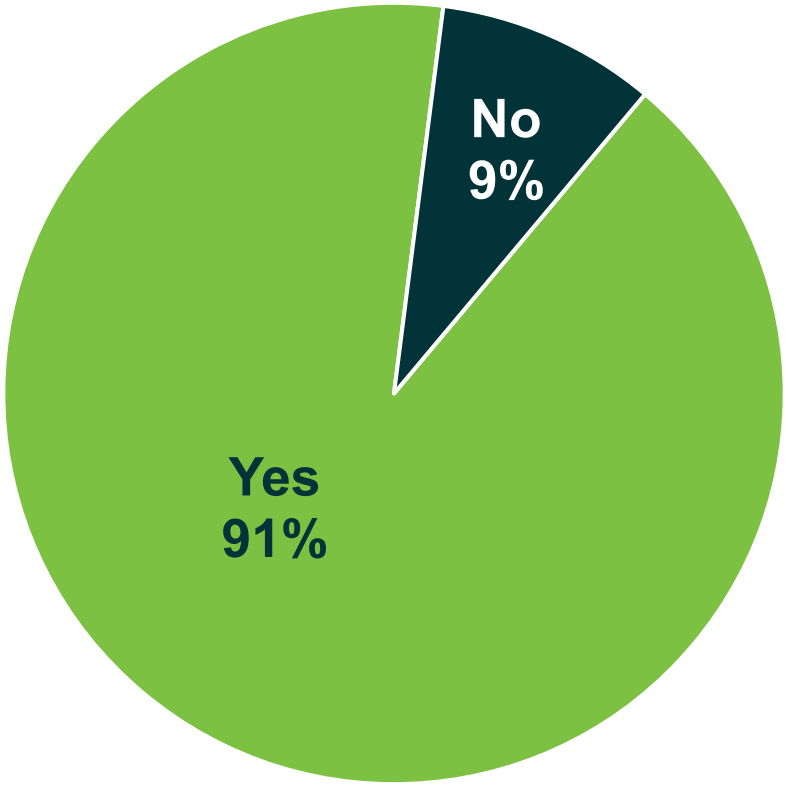
Has this facility adopted technologies/practices in recent years to reduce water use?



Additional comments

- Consumptive water use has dramatically dropped. Many plants are zero-discharge.
- Current membrane dehydration project will reduce water use considerably.
- Better cycling of boiler, cooling tower, and softener has decreased blowdown and water consumption.
- Enzyme advancements have helped reduce water use.

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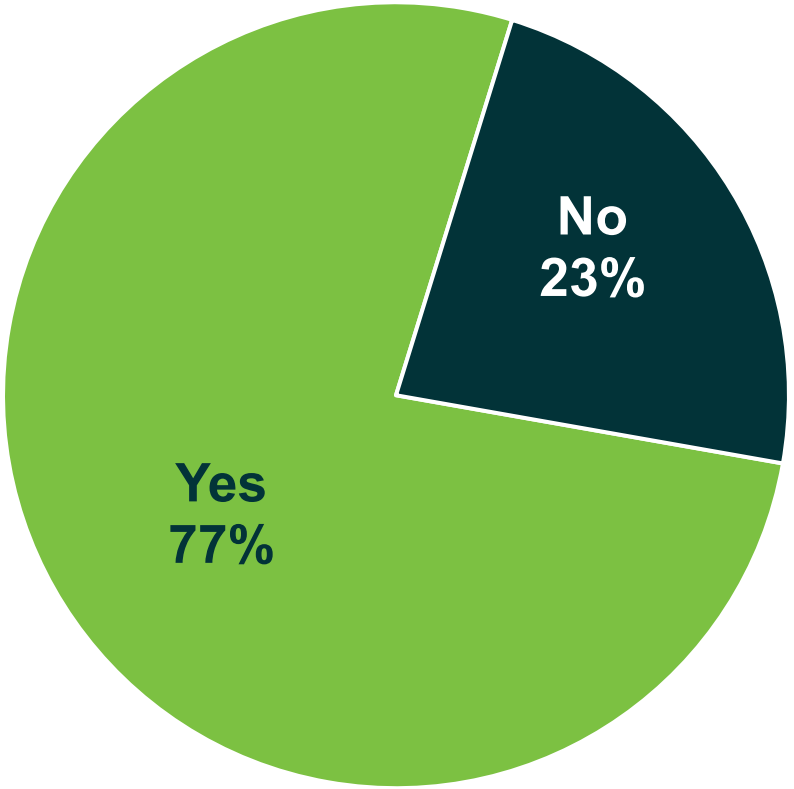
Is the facility on track to produce ethanol with net-zero carbon intensity by 2050 or sooner?



If not, why? (most common responses)

- ❑ Not enough policy certainty to make investments to get to net-zero.
- ❑ Can't achieve net-zero without access to geological CCS.
- ❑ Won't get to net-zero without mechanism for farm-level CI credit.
- ❑ If it is economically feasible and there is ROI, we will achieve net-zero. Today, feasibility is not clear.

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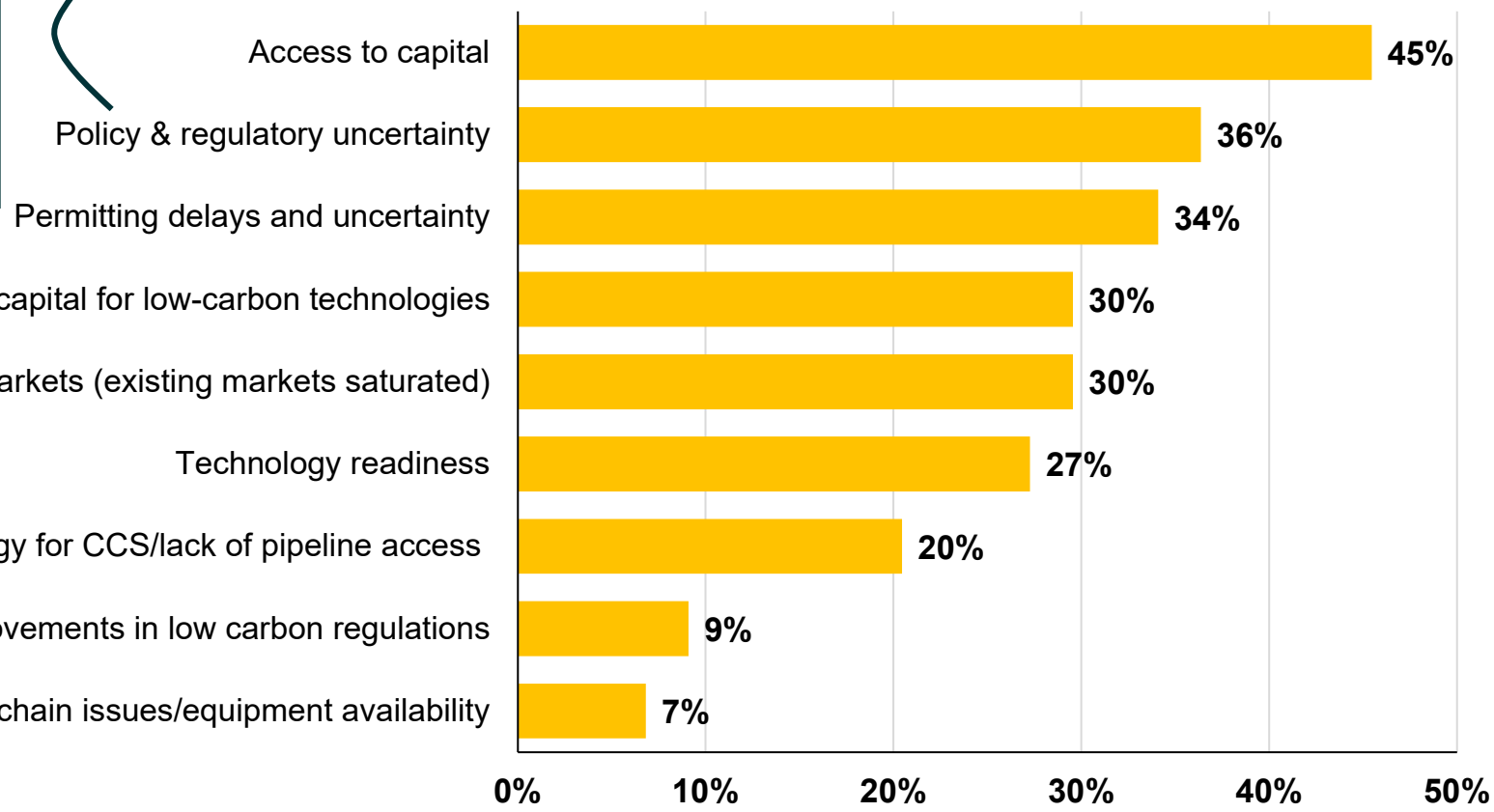
What are the most significant barriers to the adoption of technologies and practices that reduce carbon intensity at this facility? (list all that apply)

Policy & regulatory uncertainty (common examples cited)

- ❑ **Inaccurate GHG modeling**
- ❑ **Availability/eligibility for tax credits**
- ❑ **Legislative reform/repeal of IRA, RFS**
- ❑ **EV mandates/ICE bans**



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Conclusions

- New technology adoption has lowered ethanol's carbon intensity by 12%, on average, since 2015/16.
- Roughly one-third of surveyed facilities already capture CO2 (e.g., for food/beverage) and more than half already produce cellulosic ethanol from corn kernel fiber.
- Four out of five facilities intend to adopt carbon capture and geological sequestration. Pipeline access/geology remains a barrier for some producers.
- CCUS, CHP, fermentation efficiencies, waste heat integration, and renewable electricity are the top five technologies and practices under consideration for future adoption.
- Most facilities (3 out of 4) do not currently see a way to monetize farm-level (feedstock) CI reductions.
- Most facilities (3 out of 4) have approved pathways for at least one existing state or international low-carbon fuel program. Nearly two-thirds have RFS2 Efficient Producer Pathways.
- Nearly all (9 out of 10) facilities have adopted technology and practices to reduce water use.
- **Nearly 8 out of 10 facilities are on track to achieve net zero GHG by 2050 or sooner…**
- **…but access to capital; policy and regulatory uncertainty; permitting challenges; and a lack of clear ROI were cited as the top barriers to getting there.**

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