The Energy Transition – How RFA Members Are Driving Progress Toward Net-Zero Carbon Emissions

June 12, 2023

RFA member producers and companies continue to show their commitment to a net-zero future by implementing more efficient technologies and GHG-reducing processes. Moving forward, the renewable fuels and products industries are uniquely positioned to increase their contributions towards the net-zero energy transition. These actions and commitments will ensure our industry is poised to lead the world in its goals for a greener future.

Background

Globally, the energy and product sectors are shifting from current fossil-based systems to lower-carbon sources. This shift is driven by a convergence of government policy, changing corporate environmental and social governance initiatives, and changing consumer taste and preferences.

This energy transition can be characterized and rooted in globally accepted initiatives focused on reduction of GHG emissions and overall reductions in lifecycle CO2 production.

The 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 a 45-50% GHG emissions reduction by 2030 (vs. 2005 levels), then progressing to an economy-wide Net-zero GHG emission model by 2050.

In July 2021, RFA's renewable fuel producer members unanimously committed to certain carbon performance goals:

- By 2030, ensure ethanol reduces average GHG emissions by at least 70% when compared to traditional fossil-based gasoline.

- By 2050, ensure ethanol achieves an average net-zero lifecycle GHG emission.

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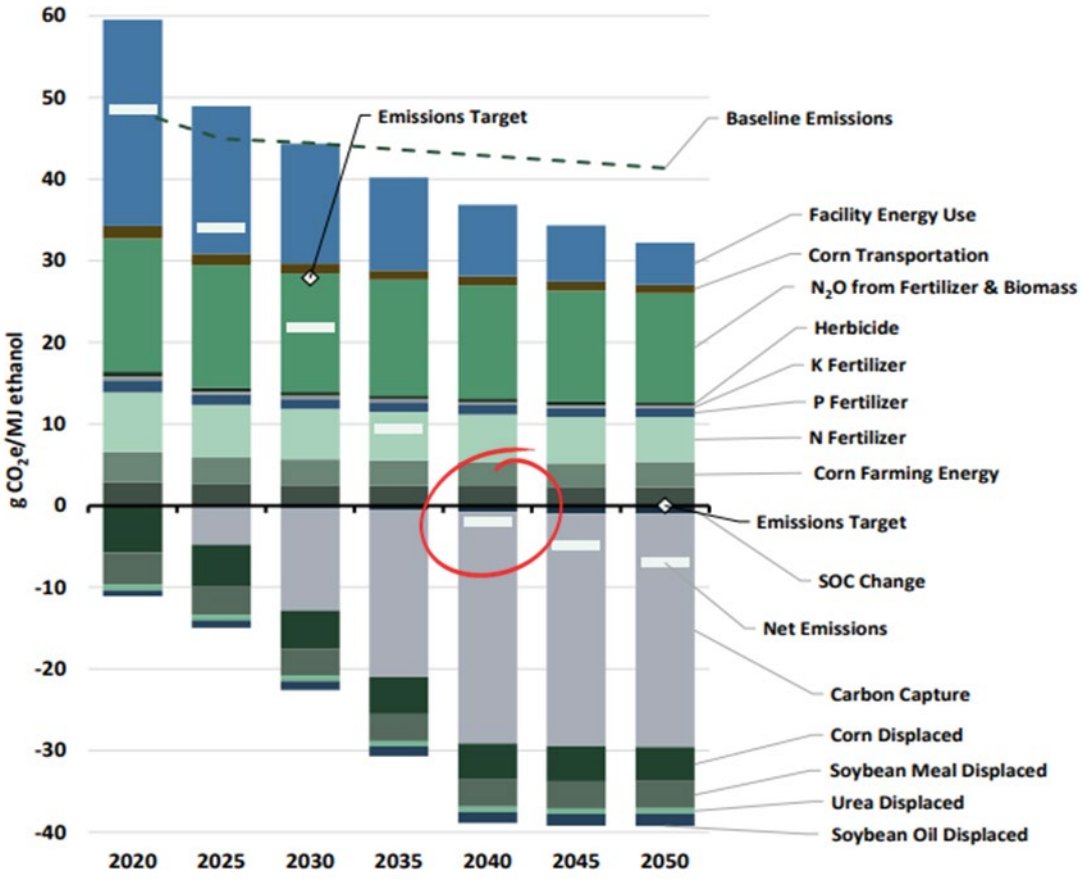
How We Get To Net-Zero Emissions

In February 2022, RFA released a study by Informed Sustainability Consulting examining various technology pathways and practices for achieving net-zero emissions. Key conclusions found that, *"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."*

In addition to traditional technology adoption solutions that drive down individual plant energy consumption rates, we are seeing increasing interest and adoption of new technologies such as carbon capture and sequestration/utilization (CCUS) as well as more efficient agricultural best practices that can further drive down lifecycle carbon scores.

Regional and unique combinations of carbon saving technology adoptions will lead to a renewable fuels industry that can achieve an average net zero carbon score by 2040 with the goal of net-negative thereafter.

Pathways to Net Zero



Sources: Pathways to Net Zero, Informed Sustainability Consulting

Under these combinations of technologies and practices, ethanol reaches net zero by 2040

RFA Member Survey of Technology Adoption

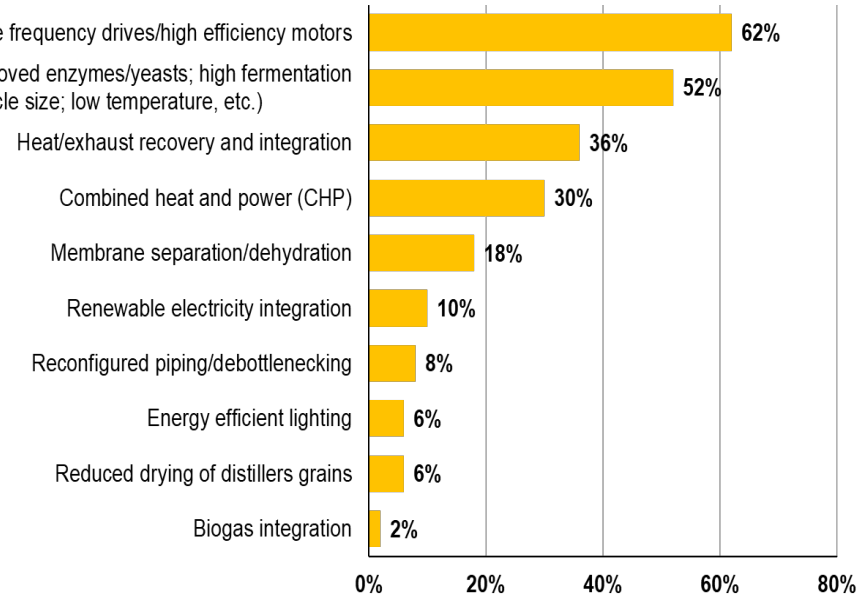
In March 2023, RFA surveyed its producer members regarding initial progress towards reducing carbon emissions. Facilities included both large and small biorefineries in geographically diverse areas. Feedback from these producer members highlights the forward-thinking nature of our industry membership, with virtually all members involved in currently incorporating carbon reduction technology platforms, and with many investigating multiple carbon reduction solutions simultaneously.

RFA members have already achieved a volume-weighted Carbon Intensity (CI) average of **52.5g CO^2e/MJ**. According to DOE Argonne GREET and CA Air Resources Board, traditional gasoline has a CI of 93-102g/MJ. This leads to RFA membership producing ethanol at **44-55%** less carbon intensity than gasoline on average.

Surveyed facilities who have adopted 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.



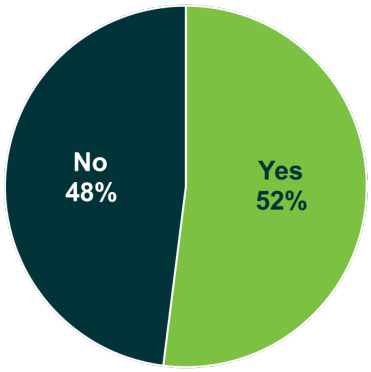
Source: RFA survey of member producers

As plant equipment enters end of life, members sited their implementation of more efficient motors, drives and efficient lighting that are leading to overall plant specific energy savings**.** Supporting industries have also had a favorable impact on carbon reduction. Increases in speed of biotech integration due to high-throughput screening practices have allowed producers to run higher gravity fermentations resulting in more efficient processing of feedstocks and production outputs.

Additional energy saving plant integrations such as reconfiguration and debottlenecking, combined heat and power (CHP), implementation of renewable energy sources and membrane separation and dehydration of ethanol are enabling further efficiencies.

Commitment to efficient operations and overall reduction in energy use, RFA members are reducing overall carbon intensity of final products but are also capturing added value in beneficial markets worldwide. More efficient uses of corn feedstock are also captured by RFA Members, with over 50% citing participation in the production of ethanol from corn kernel fiber. This further increases fleet efficiencies by capturing more value from every input unit.

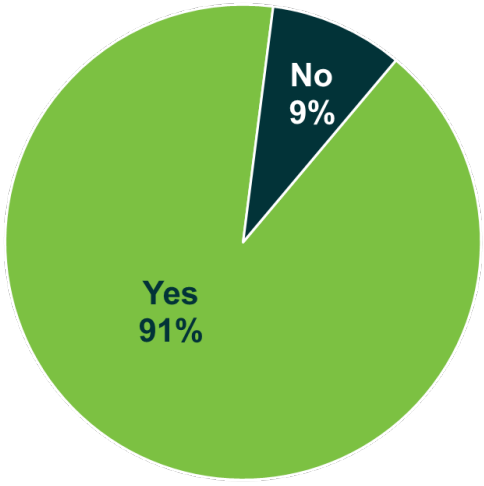
RFA Members producing corn kernel fiber derived cellulosic ethanol



Source: RFA survey of member producers

To further increase overall industry sustainability, RFA producer members have committed to greatly reducing facility water usage. 9 out of 10 plants have adopted methods, such as total water recovery and zero discharge technologies and practices to meet this goal.

Facility Adoptions of Technologies and Practices to Reduce Water Use



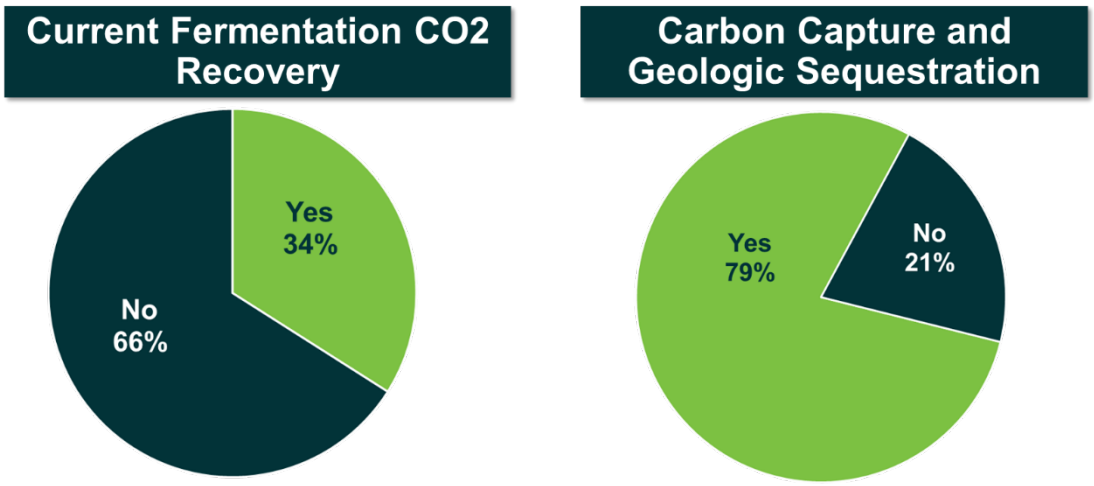
Additional comments

- ❑ **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.**

Source: RFA survey of member producers

When producer members were asked directly if they currently recover fermentation CO^2, one-third responded favorably. Currently, this biogenically produced CO^2 is utilized in food and beverage processing. Transport of CO^2 is somewhat logistically constrained to about a 300-mile radius around the point of origin. Further work in the utilization of fermentation gases could enable more ethanol producers to take advantage of onsite capture and utilization of these coproducts. This could have further implications for logistically isolated plants when a large portion of CO^2 exits markets as pipelines and sequestration projects ramp in the coming years.

Facility Adoption of CO^2 Recovery and Geologic Sequestration Plans



Source: RFA survey of member producers

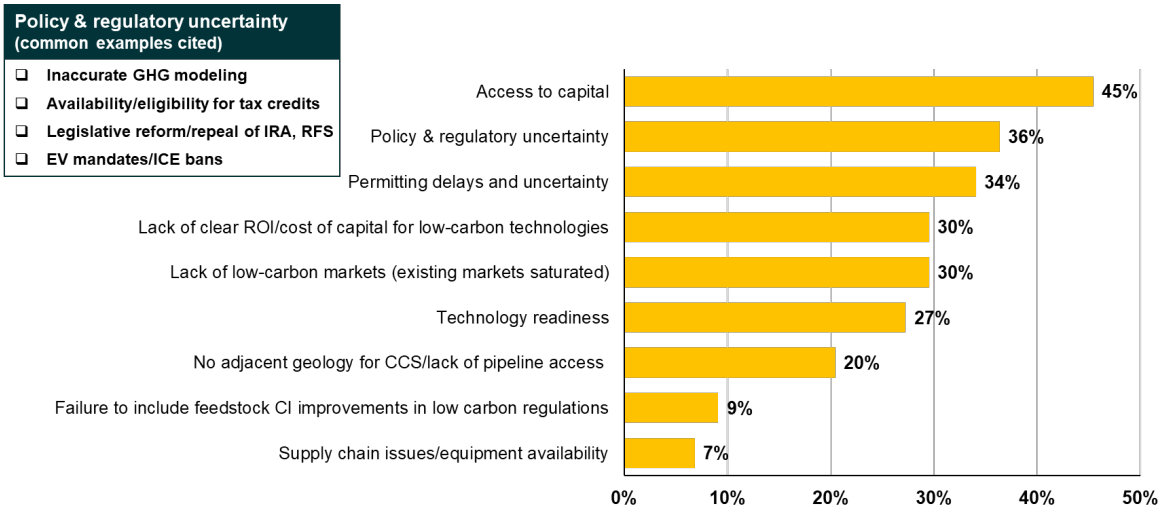
Overwhelmingly, members stated that a CO^2 geological sequestration opportunity was part of their carbon intensity reduction plans. Roughly 50% of geologic positive responses expecting to, or have already, announced partnerships with current proposed pipeline projects. More surprisingly, one-third of geologic respondents cited self-implemented CCS projects by taking advantage of favorable local geology.

For those that are currently unable to geologically sequester, it is expected that unique regional cooperations between producers could emerge. This allows for expanded industry participation in areas near, but not on top of geologic storage locations. A well head placed in a mutually beneficial location with favorable logistically adjacent geological formations could allow multiple ethanol producers to logistically transport fermentation products for final sequestration operations and 45Q program participation.

Net-Zero Constraints and Barriers

Members also took time to highlight a few constraints standing in the way of steady progress towards net zero emissions. Respondents highlighted lack of working capital and policy certainty surrounding net-zero goals and commitments.

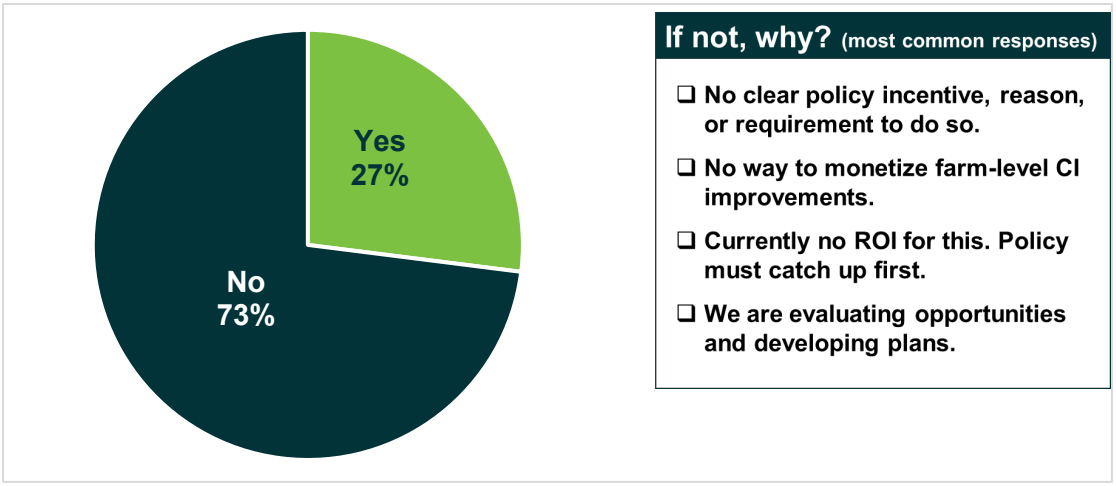
Survey results citing current barriers to carbon intensity reduction measures



Source: RFA survey of member producers

While access to capital may be more related to current economic conditions, inaccurate GHG modeling, lack of inclusion of farm level feedstock CI improvements and policy/regulatory uncertainty remain significant thoughts in producer's minds.

Facilities Working on Farm-level Feedstock Carbon Reduction Practices



Source: RFA survey of member producers

Conclusion

We are very pleased with our members' current and future plans regarding more efficient operational practices, significant reductions in water use, and new technology adoptions. It's this strong commitment to provide lower carbon renewable fuels and products making our industry more efficient while reducing cradle to grave carbon emissions of fuels and products.

However, the race for net-zero GHG emissions could be hindered without continued work on current regulatory and policy hurdles clearing the way for increased carbon emission technology adoption with clear and present ROI for producers. Two of the most impactful programs for ethanol CI reductions are CO^2 sequestration and farm-level carbon accounting reductions. 21% of our members attested that they are unable to sequester because they cannot directly access pipelines or favorable geology. 73% of members say they are not currently working on farm-level CI programs because there is currently no incentive to do so.

With continued and focused commitment to policy solutions that support implementation of carbon-reducing technology, the renewable fuels industry is well-positioned to achieve future net zero emissions goals for global transportation networks and renewable product spaces.