Conference Summary

Life-Cycle Analysis for Transportation Symposium (LCATS)

Nov. 16-17, 2023, San Antonio, Texas

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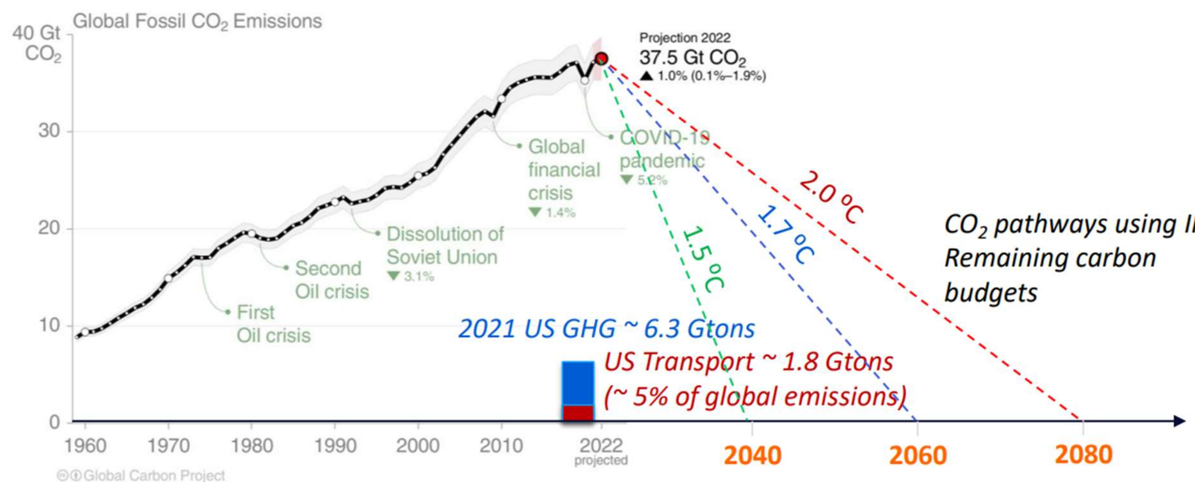
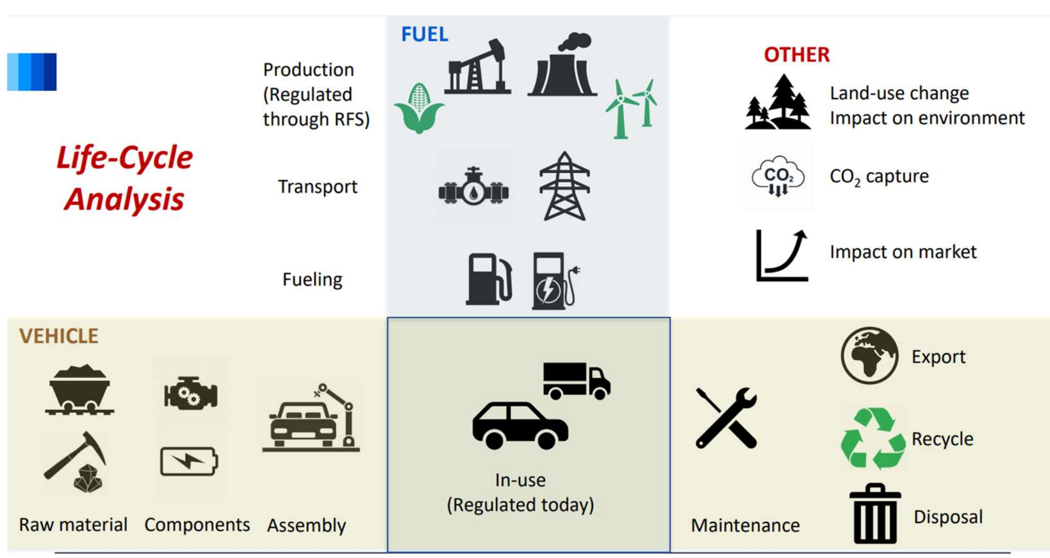
Setting the stage

Addressing climate change will require reversing the trend of increasing anthropogenic CO_2 emissions and achieving net zero CO2 emissions in the coming decades. Transport will play a key role given its significant share of global emissions. The LCA conference brought together experts from across the industry to share thoughts on the best pathways to tackle this problem. It is not an easy problem though – the entirety of US transportation emissions accounts for 5% of global emissions – that is the same as the reduction seen during Covid.

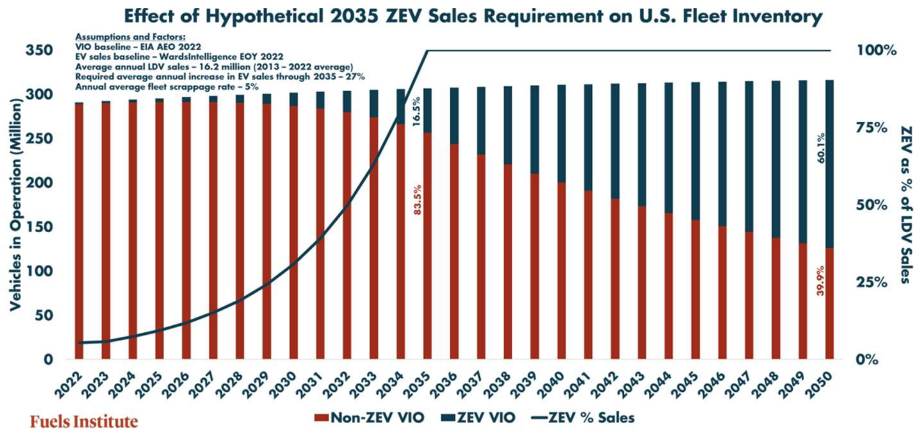


One thing is certain – what matters is the CO_2 entering the atmosphere, irrespective of the source (tailpipe or stack) and a full lifecycle analysis of transport GHG emissions is required to implement policies and technologies.

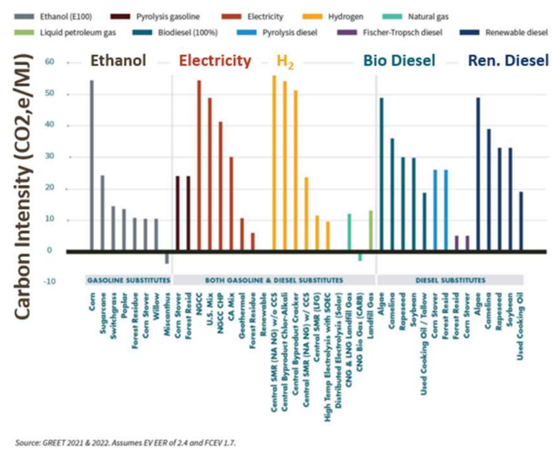


(Plots on this page taken from the keynote by the author – A. Joshi, ClearFlame Engines)

While policies are pushing transportation towards rapid electrification, even achieving 100% electric sales is not going to eliminate all ICEs anytime soon. The **Transportation Energy Institute** showed that even 100% plug-in sales by 2035 would translate to ~ 266 million ICE vehicles on the road in that year. Even in 2050, the legacy fleet will be ~ 40% ICE powered. Reduced carbon intensity of fuel is the only option to decarbonize these vehicles.

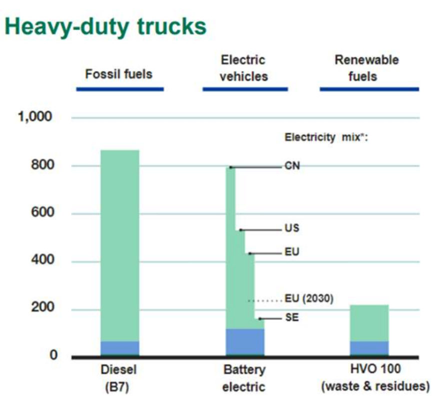


Renewable Fuels + ICE



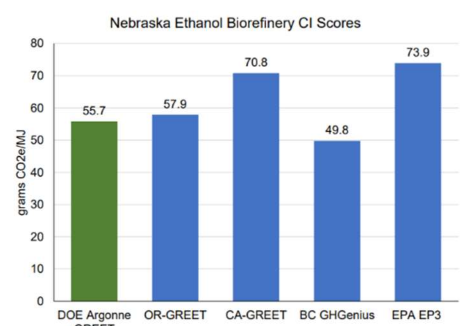
Stillwater Associates analyzed various decarbonization pathways of transportation and concluded that the use of existing low carbon intensity fuels provides a more rapid reduction in GHG emissions compared to electrification. Moreover, the carbon intensity of these fuels can be further lowered depending on the feedstock, processing, and use of carbon sequestration.

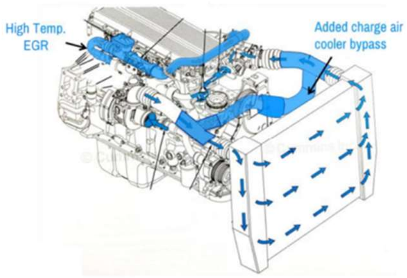
Several fuels are being produced in significant quantities today, and new ones being commercialized. **Chevron** discussed their work being done on renewable gasoline, emphasizing that while there is much discussion about renewable diesels, bulk of the US personal transportation still relies on gasoline. The renewable gasoline has been demonstrated on road earlier this year.



Neste showed lifecycle analysis done for passenger car and heavy-duty trucks which shows that renewable diesel can provide higher GHG reductions compared to battery electric vehicles for most of the grid carbon intensities today.

That lower carbon intensity fuels can help decarbonize transportation is clear. Quantifying the reductions and performing lifecycle analyses is far from easy, however. It depends on accurate inputs, baseline values for gasoline or diesel, and agreed upon methodologies. There can be significant discrepancies based on the variabilities in each of these. The **Renewable Fuels Association** showed an example of ethanol produced at a single biorefinery being assessed at 5 difference carbon intensities based on the LCA methodology. This points to the critical need for harmonization of LCA approaches.



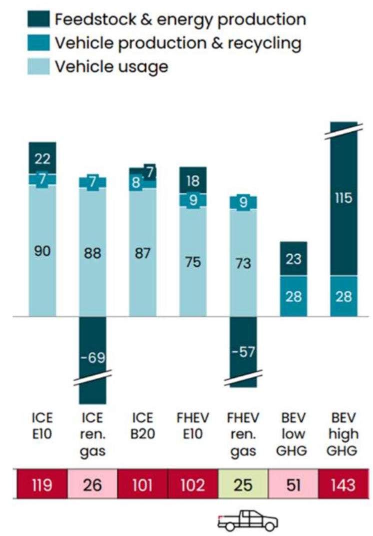


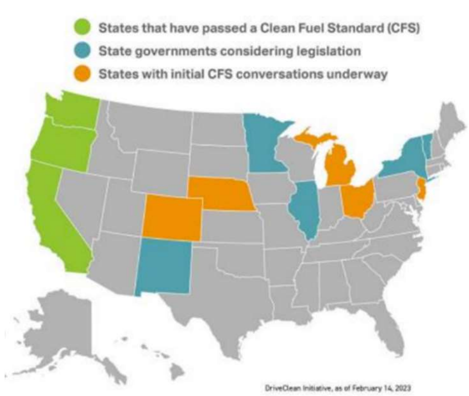
Ultimately, reducing GHG emissions from transportation will require pairing these renewable fuels with innovated and improved ICE technologies to take advantage of these fuels. **ClearFlame Engines** showed one pathway for heavy-duty vehicles. Combustion of near 100% ethanol in a diesel-like compression ignition engine results in ~ 45% GHG reduction on a well-to-wheel basis. Successful on-highway demonstrations have proved not only these emission reductions but also significant operational cost savings due to the lower fuel cost compared to diesel. The cleaner fuel also results in lower criteria pollutants.

Lifecycle studies

FEV presented a cradle-to-grave analysis of GHG emissions and total cost of ownership for a range of light-duty vehicles. An example for pickup trucks is shown here. It is seen that pairing an ICE or hybrid with renewable gasoline is found to deliver the deepest GHG reductions (up to 78%), while BEVs can offer up to 57% GHG reductions if fueled by a low carbon grid (not defined).

These are estimates for technologies today and will change with advances in the coming years. Also, plug-in hybrids were not included in the presentation. Still, the results show the importance of considering all pathways and the role of upstream fuel carbon intensity.





Beyond GHG reduction, there is also the question of effective utilization of scarce mineral resources. Hybridization provides a path for GHG reductions with much smaller batteries (relative to EVs). **MECA** presented a comprehensive LCA study of sedans, SUVs, and pickups. The analysis found that in 2030, except for states on the western and north-eastern grids, hybrids offer similar magnitude GHG reductions compared to electric vehicles (the advantage again being existing fueling infrastructure and smaller batteries and reduced dependence on critical minerals). The combination of hybridization and renewable fuels can deliver deep CO_2 reductions. Some states have adopted clean fuel standards and several more are considering legislation.

To the point above, plug-in hybrids can offer a good balance between reducing CO_2 emissions while using a smaller battery. **Toyota** discussed a tool – CarGHG – to evaluate the real-world GHG and total cost of ownership for ICE, PHEV and BEV options. We need to move beyond the certification procedures of evaluating GHG emissions at tailpipe only under idealized driving conditions, and rather consider real-world inputs, including consumer charging behavior and incentives, to derive GHG emissions and cost of ownership over the lifetime of vehicles. Further, it was shown that "there is no one-size fits all answer" and that the optimum choice really depends on the fuel carbon intensity and cost, which is changing with time and also with location.

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