THE UNIVERSITY OF ILLINOIS AT CHICAGO

High Octane Low Carbon Fuels: The Bridge to Improve Both Gasoline and Electric Vehicles

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Abstract

The present analysis compared the life cycle greenhouse emissions from combustion engines fueled with different ethanol-gasoline blends to electric vehicles charged on the marginal electricity mix. The marginal electricity mix was calculated using the EPA AVERT model and reflects the greenhouse gases emitted from the least cost generating units dispatched to meet incremental regional demand. We assert that the use of average emissions factors (e.g. eGrid) or emissions factors derived from optimized (but hard to implement) time-of-use and demand-side-management structures are less reflective of actual emissions incurred from EV charging. It is often argued that EVs will be charged during off-peak hours to alleviate load or during hours when renewable resources are online. However, in many areas coal and natural gas generating plants are on the margin during off-peak hours generating carbon intense electricity. To avoid one or the other hypothetical charging behavior assumption our approach, therefore, relied on marginal emissions factors determined by least-cost dispatch which researchers note is consistent with a consequential life cycle methodologies.

The present study finds that all EV and ethanol-gasoline blends provide substantial greenhouse gas reductions relative to gasoline-only vehicles. High octane fuel vehicles with ethanol provide very similar GHG savings compared to EVs (within 5 gCO_2e/MJ of each other) for many states. Importantly, E85 and HOF-plug-in hybrids are the lowest GHG emitting technology as these vehicles are both able to take advantage of the low carbon intensity of ethanol in their combustion engine and the low carbon intensity of the electricity grid in hybrid mode of operation. Ethanol at high blend levels can provide immediate GHG benefits while EV adoption increases. Long-term, due to the similar GHG savings of EVs, E85, and HOF, promoting these technology options towards the same adoption level across many Midwestern states will significantly increase the GHG emissions reductions that can be achieved by any one technology alone. Utilities in the Midwest face significant challenges when implementing load shaping and demand side measures to avoid EV charging on both peak load and during marginal coal/natural gas hours. E85, HOF and HOF-hybrids can provide the natural bridge and ensure the cleanest use of resources.

Building out an EV infrastructure will require substantial investment, incentives, and financial and environmental risks. The present study documents that EV's environmental benefits depend largely on electricity charging patterns and load management of the anticipated large vehicle fleet which are unknown today. Research into this topic should demand as much attention as direct and indirect land use life cycle emissions received for biofuels during the Renewable Fuels Standard Development. This will ensure a level playing field for different technology alternatives and to fairly evaluate options for more effective climate change policy while reducing the risks to the consumer.

Introduction

This analysis compares the greenhouse gas emissions (GHG) from electric vehicles (EV) to those from internal combustion engines fueled with a variety of ethanol-gasoline blends. When calculating the life cycle GHG emission of EVs many prominent US Government and NGO calculator tools correctly include upstream emissions but utilize average U.S. electricity emissions factors or regional, average electricity grid emissions factors.[1,2,3] Both the California and the proposed Midwest Low Carbon Fuel Standards are also using an average electricity mix. [4,5] This means that the GHG emissions from each generating resource's kilowatt produced in an interconnect region (or state, or other regional aggregation) are arithmetically averaged throughout a given year (often based on EPA's eGRID database). In reality, however, the large projected addition of EVs to the incumbent grids will constitute a marginal load addition in an environment of generation resource retirements and additions. A marginal generating resource is the lowest cost power plant that adapts its power generation capacity in response to a change in power demand.[6] The marginal electricity is the electricity generated by all the marginal generating plants. As EV populations grow, the long-run marginal generation resource will be the source of power. Economic dispatch modeling provides a basis for calculating which generation resources contribute marginal power.

Ryan et al. point to the lack of consensus what methodology to use when determining the GHG emissions factors from the electricity grid and they quantify the impact that, for example, the use of a marginal vs. average emissions factor can have on EV vehicle emissions assessments.[7] The authors recommend that for consequential life cycle analyses (LCA) of new loads marginal emissions factors are recommended while for attributional LCAs of existing load an average factor should be used. The announced large scale build-up of the EV fleet has consequential life cycle implications similar to the US

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[1] US Department of Energy. Alternative Fuels Data Center. "Emissions from Hybrid and Plug-In Electric Vehicles" https://afdc.energy.gov/vehicles/electric_emissions.html

[2] Union of Concerned Scientists. EV Emissions Tool FAQ. https://www.ucsusa.org/resources/ev-emissions-tool-faq?_ga=2.262193292.1441610942.1612809258-1305637195.1612809258

[3]US Department of Energy. Greenhouse Gas Emissions from Electric and Plug-In Hybrid Vehicles; Beyond Tailpipe Emissions Calculator https://www.fueleconomy.gov/feg/Find.do?action=bt2

[4] The LCFS originally used a marginal mix for new loads but changed to an average mix in response to lawsuits that claimed that the marginal approach was not consistently applied.

CARB (2009). "Detailed California-Modified GREET Pathway for California Average and Marginal Electricity. Version 2.1"; Stationary Source Division, California Air Resources Board: Sacramento, CA, 2009; available from http://www.arb.ca.gov/fuels/lcfs/ 022709lcfs_elec.pdf.

CARB (2015). "Calculating Life Cycle Carbon Intensity Value of Transportation Fuels in California"; Staff Report

[5] Great Plains Institute (2020). "A Clean Fuels Policy for the Midwest. A white paper from the Mid-Western Clean Fuels Policy Initiative." Quote: "States should publish an average electric grid carbon intensity
based on the most accurate state or regional value. The state or regional grid mix emissions factor should be available as a default value if a utility-specific value is not available."

[6] Thomas Dandres, Reza Farrahi Moghaddam, Kim Khoa Nguyen, Yves Lemieux, Réjean Samson, Mohamed Cheriet, "Consideration of marginal electricity in real-time minimization of distributed data centre emissions";
Journal of Cleaner Production, Volume 143, 2017

[7] Nicole A. Ryan, Jeremiah X. Johnson, and Gregory A. Keoleian, "Comparative Assessment of Models and Methods To Calculate Grid Electricity Emissions"; DOI: 10.1021/acs.est.5b05216; Environ. Sci. Technol. 2016, 50, 8937−8953
Nicole A. Ryan, Jeremiah X. Johnson, and Gregory A. Keoleian,

EPA's 2010 modeling of the renewable portfolio (RFS) standard. Across 10 different methods Ryan et al. found an up to 68% difference between marginal and average emissions factors for an individual charging station. For the US average they found that marginal emissions factors are 21% higher than average emissions factors. These findings were generally corroborated by others but the inverse can also occur.[8,9]

The marginal electricity mix shifts significantly with retirements and additions. In January 2021 the US Energy Information Administration (EIA) released the generating resources retirement projection for the year.[10] EIA states that over half of all generation retirements (5.1 GW) will come from nuclear retirements while "coal retirements will slow in 2021 […] after substantial retirements of coal-fired electric generating capacity over the past five years." EIA further states that "if all five reactors close as scheduled, 2021 will set a record for the most annual nuclear capacity retirements ever." It is widely published that nuclear resources will be mostly replaced by natural gas fired ones.[11,12,13] With coal retirements slowing[14] and nuclear power being replaced by higher carbon emitting natural gas fired power plants we see a potential at least in the short run for a deceleration in the decarbonization trend of the electric grid.

In addition to the installed generation resources the marginal electricity mix varies significantly by month and time of day. A Swedish study showed that with large-scale use of EVs, the timing of charging loads becomes important. However, the authors state that "we don't really know much about what influences choice of when to charge and how policy can influence people's charging time." [15] Load-shaping programs can theoretically direct EVs to charge during peak solar and wind hours but utilities would need to comprehensively introduce time of use (TOU) charges where electricity rates are higher

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[8] McCarthy, R.; Yang, C. "Determining marginal electricity for near-term plug-in and fuel cell vehicle demands in California: Impacts on vehicle greenhouse gas emissions"; J. Power Sources 2010, 195 (7), 2099−2109.
[9] Graff Zivin, J. S.; Kotchen, M. J.; Mansur, E. T. "Spatial and temporal heterogeneity of marginal emissions: Implications for electric cars and other electricity-shifting policies"; J. Econ. Behav. Organ. 2014, 107 (PA), 248−268.
[10] US Energy Information Administration. "Nuclear and coal will account for majority of U.S. generating capacity retirements in 2021."
https://www.eia.gov/todayinenergy/detail.php?id=46436#:~:text=At%205.1%20GW%2C%20nuclear%20capacity,operating%20U.S.%20nuclear%20generating%20capacity.&text=Each%20of%20these%20plants%20has,combined%20capacity%20is%204.1%20GW.
[11] https://stateimpact.npr.org/pennsylvania/2018/04/27/as-nuclear-power-loses-ground-to-natural-gas-environmentalists-are-torn-are-the-risks-worth-saving-it-for-climates-sake/#:~:text=That's%20because%20the%20power%20currently,the%20carbon%20dioxide%20as%20coal.&text=Together%2C%20the%20four%20plants%20provide,to%20power%204%20million%20homes
[12] https://energypost.eu/carbon-emitting-gas-not-renewables-is-replacing-u-s-nuclear/
[13] https://www.forbes.com/sites/kensilverstein/2019/05/10/if-nuclear-energy-is-replaced-by-natural-gas-say-goodbye-to-climate-goals/?sh=a4215fe20169
[14] EE News. December 2020. "With mega-emitters closed, coal's 'cleaner fleet' persists";
Quote: "Emissions reductions from retirements have been supercharged in the last two years from the shutdown of some of America's largest coal plants. But that trend did not extend to 2020. […] Few super-emitters are slated to shut down in full between now and 2025."
https://www.eenews.net/stories/1063720241#:~:text=Coal%20closures%20could%20slow%20over,have%20been%20announced%20by%20utilities.
[15] Joram H.M. Langbroek, Joel P. Franklin, Yusak O. Susilo, "When do you charge your electric vehicle? A stated adaptation approach"; Energy Policy, Volume 108,2017,

during peak time; however, such load shifting could divert other power users to purchase fossil power in the near term. Problematically, some low carbon fuel policies allow for the assignment of renewable power to EV charging, thereby reallocating already existing clean resources to a new use without adding incremental renewable generation[16,17].

McKinsey in a recent report states that "if electric vehicles were charged at peak times; they would create a substantial burden on the electricity grid and necessitate capital investments."[18] McKinsey continues "a TOU-linked demand charge would help stimulate optimal charging behavior (such as charging overnight when demand is lowest) and smooth demand throughout the day." However, Maninder et al. show that in the Midwest "marginal emissions factors are higher-than-average during late night and early morning hours when electricity demand is lower […] and coal is the dominant marginal fuel at low demand hours."[19] In other words EVs should not be charged during daytime peak hours but also not at night in the Midwest when coal/natural gas is on the margin which will likely leave impossibly narrow charging windows. Despite the promise of TOU and demand side programs utilities face significant challenges when implementing these measures to accommodate both off-peak and clean charging for EVs. This reinforces our assertion to not rely for now on the carbon savings potential from these programs but revert to a least cost dispatch analysis.

In the present study we calculated the marginal emissions factors for a region using the latest version of EPA's AVoided Emissions and geneRation Tool (AVERT) model, which was released in September 2020.[20] As the user manual of AVERT states: "within each region across the country, system operators decide when, how, and in what order to dispatch generation from each power plant in response to customer demand for electricity in each moment and the variable cost of production at each plant." AVERT analyzes how hourly changes in demand change the output of fossil generators and with that their hourly generation, heat input, and emissions of $PM_{2.5}$, SO_2, NO_x, and CO_2. Based on the interconnection of the US electric grid AVERT utilizes regional files. The map of the regions is shown in Figure 1. For our study we used the Midwest, Central, and Mid-Atlantic regions. Note that metro-Chicago, for example, falls under the Mid-Atlantic region while rural Illinois is part of the Midwest region.

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[16] CARB (2020). "Application and Reporting Instructions for Smart Charging Lookup Table Pathway"; California Air Resource Board, Low Carbon Fuel Standard

[17] https://www.betterenergy.org/blog/electric-vehicles-in-a-midwestern-clean-fuels-policy/

[18] https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/solving-the-rate-puzzle-the-future-of-electricity-rate-design

[19] Maninder et al. ;"Marginal Emissions Factors for Electricity Generation in the Midcontinent"; ISO P. S. Thind, Environmental Science & Technology 2017 51 (24), 14445-14452
DOI: 10.1021/acs.est.7b03047

[20] https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert

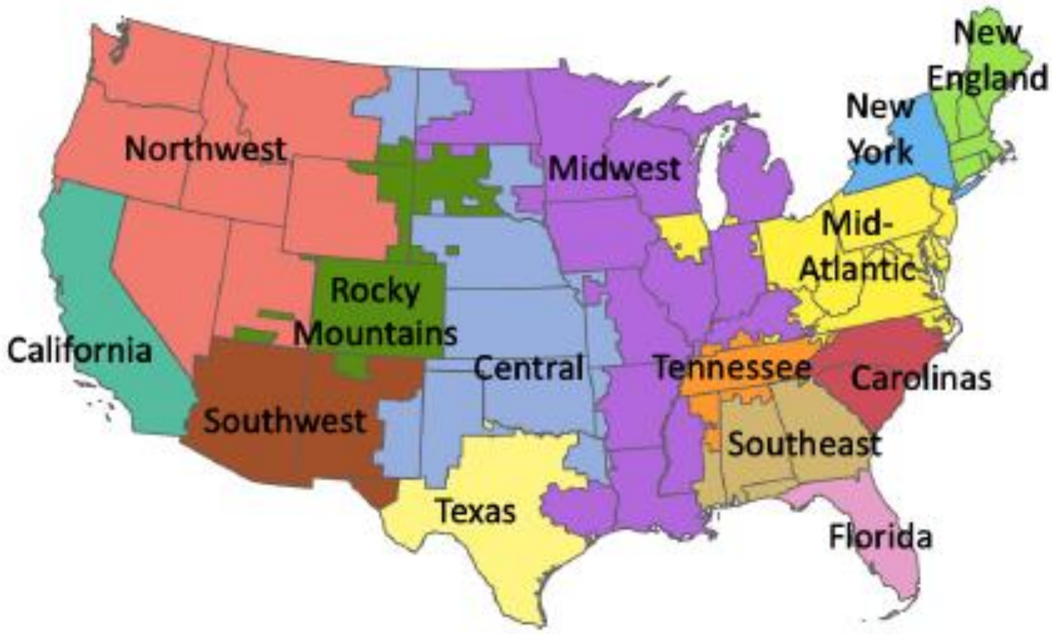

Figure 1: AVERT Regions

Analysis

Existing Published Model Data in AVERT

EPA has used AVERT to produce marginal emission factors for each AVERT region and a weighted average for the nation each year from 2007 to 2019 which we access for our initial analysis.[21] The AVERT factors are already adjusted for transmission losses while we adjusted the output-based eGRID factors upward to account the transmission losses that are provided separately in eGRID. The table below summarizes our results. As can be seen, the marginal factors are, for some states, significantly higher than the average emissions factors.

[21] https://www.epa.gov/statelocalenergy/avoided-emission-factors-generated-avert-0

Table 1: Marginal Avert Factors by Region (2019)

	AVERT Region	Avert 2019 lbs/MWh*	eGrid Region	eGRID 2018 lbs/MWh**	eGrid Transmission Loss %	eGRID with Transmission Loss	%Diff Marginal to eGrid Avg
Colorado	Rocky Mountain	1,904	RMPA	1,171	4.88%	1,231	55%
Illinois - Chicago	Mid-Atlantic	1,540	RFCW	1,174	4.88%	1,234	25%
Illinois - Rural	Midwest	1,860	SRMW	1,677	4.88%	1,763	6%
Indiana	Midwest	1,860	RFCW	1,174	4.88%	1,234	51%
Iowa	Midwest	1,860	MROW	1,249	4.88%	1,313	42%
Kansas	Central	1,800	SPNO	1,172	4.88%	1,232	46%
Kentucky	Midwest	1,800	SRTV	1,038	4.88%	1,091	65%
Michigan	Midwest	1,860	RFCM	1,321	4.88%	1,389	34%
Minnesota	Midwest	1,860	MROW	1,249	4.88%	1,313	42%
Missouri	Midwest	1,860	SRMW	1,677	4.88%	1,763	6%
Nebraska	Central	1,800	MROW	1,249	4.88%	1,313	37%
North Dakota	Midwest	1,860	MROW	1,249	4.88%	1,313	42%
Ohio	Mid Atlantic	1,540	RFCW	1,174	4.88%	1,234	25%
South Dakota	Midwest	1,800	MROW	1,249	4.88%	1,313	37%
Wisconsin	Midwest	1,860	RFCW,MROWE/MROW	1,420	4.88%	1,493	25%
*already adjusted for transmission loss			**eGrid Output factors not adjusted for transmission loss				

New AVERT Model Runs

In a second analysis we uploaded the Midwest and Mid-Atlantic regional database spreadsheets into AVERT and ran the Excel-based version of the model. This allowed us to calculate the marginal emissions factors on a finer temporal resolutions (variation by month throughout the year) as well as the state/county of interest. We then converted the marginal emissions from avert (in tons CO_2e per marginal megawatthour of load) into a gCO_2e/MJ value based on the energy economy ratio (EER). The EER is a ratio that compares the fuel economy of gasoline vehicles to the fuel economy of comparable vehicles operating on all other fuel types.[22] As a result the carbon intensity of EVs varied widely by our studied locations and by month and ranged between 55 gCO_2e/MJ to 95 gCO_2e/MJ. In total we calculated the carbon intensity for EVs charged on the marginal electricity mix for 15 states and regions across the Midwest including: Rural Illinois, Northern Illinois Chicago, Minnesota, Indiana, Missouri, St. Louis, Ohio, North Dakota, South Dakota, Wisconsin, Iowa, Kentucky, Nebraska, Kansas, Colorado.

[22] Unnasch, S., & Browning, L. (2000). "Fuel Cycle Energy Conversion Efficiency Analysis"; California Energy Commission and Air Resources Board, California, viewed, 11, 07-12 with follow in analysis in Unnasch, S. and Chan, M. (2007) Full Fuel Cycle Assessment Tank to Wheels Emissions and Energy Consumption. California Energy Commission Report CEC-600-2007-003-D.

We then compared these EV marginal emissions from AVERT to those of gasoline (E0), gasoline with 15 percent ethanol (E15), gasoline with 85 percent ethanol (E85)[23], high octane fuels with thirty percent ethanol (HOF), and HOF in a plug-in hybrid electric vehicle (HOF-Hybrid). The carbon intensity of gasoline differs based on region, crude supply, refining complexity and ranges from 93 to 100 gCO_2e/MJ. We used the US DOE average life cycle number of 95.3 gCO_2e/MJ. The carbon intensity of ethanol (47.5 gCO_2e/MJ) was derived from the "USDA Greenhouse Gas Balance of Corn Ethanol" publication.[24,25] This carbon intensity was recently confirmed by Scully et al.[26] When ethanol is blended into gasoline and adjusted by the energy fraction the carbon intensity of E15 is 90.2 gCO_2e/MJ and 79.8 gCO_2e/MJ for HOF E30. For the HOF-Hybrid we assumed a 50 percent operation on the marginal electricity mix.

Figure 2 below shows the results for Rural Illinois, which is connected to the Midwest AVERT Region. The light grey area represents the carbon intensity of EVs charged on the local, marginal electricity mix by month. The darker sections of the curve represent an additional penalty assigned to EVs for inefficiencies during winter charging.[27] It is obvious that all studied alternative vehicle technologies are generally cleaner than gasoline. However, during sever winter times when significant cabin heating is required EVs in rural Illinois will not be cleaner than gasoline (dark grey area graph approaches blue gasoline line in Figure 2). HOF vehicles provide very similar GHG savings compared to EVs on average (red line compared to grey area). Importantly, E85 and the HOF-Hybrid vehicles are the best options. The HOF Hybrid is able to take advantage of the low carbon intensity of ethanol in its combustion engine and the lower than gasoline carbon intensity of the electricity grid in its hybrid mode of operation.

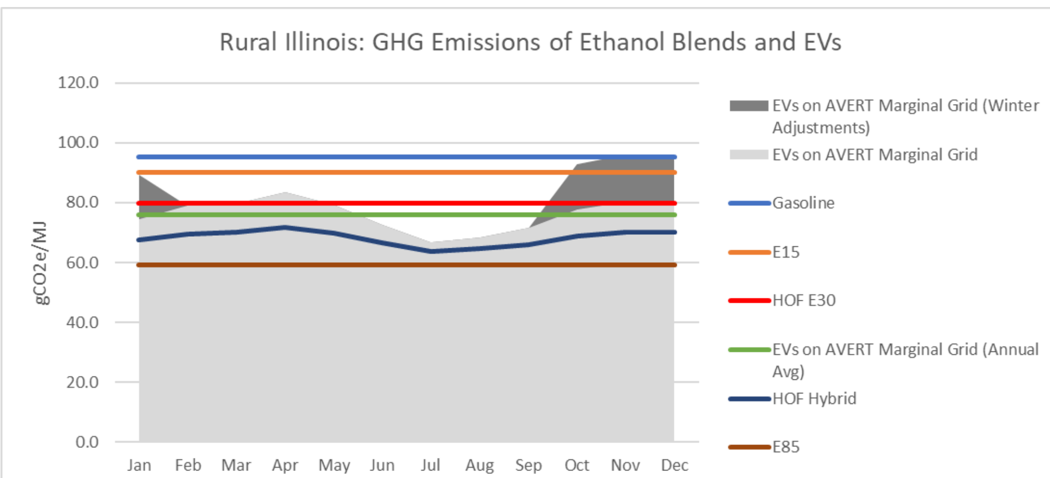

Figure 2: Rural Illinois

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[23] operating on 80% ethanol on average

[24] https://www.usda.gov/media/press-releases/2017/01/12/usda-releases-new-report-lifecycle-greenhouse-gas-balance-ethanol

[25] E30 also assumes a fuel economy improvement of 6% consistent with US DOE Co-optima study:
Sun, P., Elgowainy, A., & Wang, M. (2019). "Well-to-Wheels Energy and Greenhouse Gas Emission Analysis of Bio-Blended High-Octane Fuels for High-Efficiency Engines"; Argonne National Laboratory, https://www. energy. gov/sites/prod/files/2019/03/f60/USDRIVE_FWG_WTW_Analysis. pdf.

[26] Melissa J. Scully et al 2021 Environ. Res. Lett. in press https://doi.org/10.1088/1748-9326/abde08

[27] EER for wintertime operation is adjusted to reflect 1500 W of vehicle cabin heating.
https://forums.tesla.com/discussion/148278/how-many-watts-does-the-cabin-heater-consume

The situation is different for northern Illinois which includes the Chicago metro area. Northern Illinois connects to the less carbon intensive Mid-Atlantic AVERT region resulting in lower CI values for EVs. However, even in this region HOF vehicles are cleaner than EVs during some winter months and HOF Hybrids again provide the cleanest option.

The equivalent analysis for the remainder of the regions is shown in Appendix A. For many Midwestern States and regions such as North Dakota, South Dakota, Missouri St. Louis, Nebraska, Kansas, Iowa, Kentucky, Wisconsin HOF provides very similar GHG emissions benefits to EVs (red line overlaps with grey area in the graphs during many months of the year).

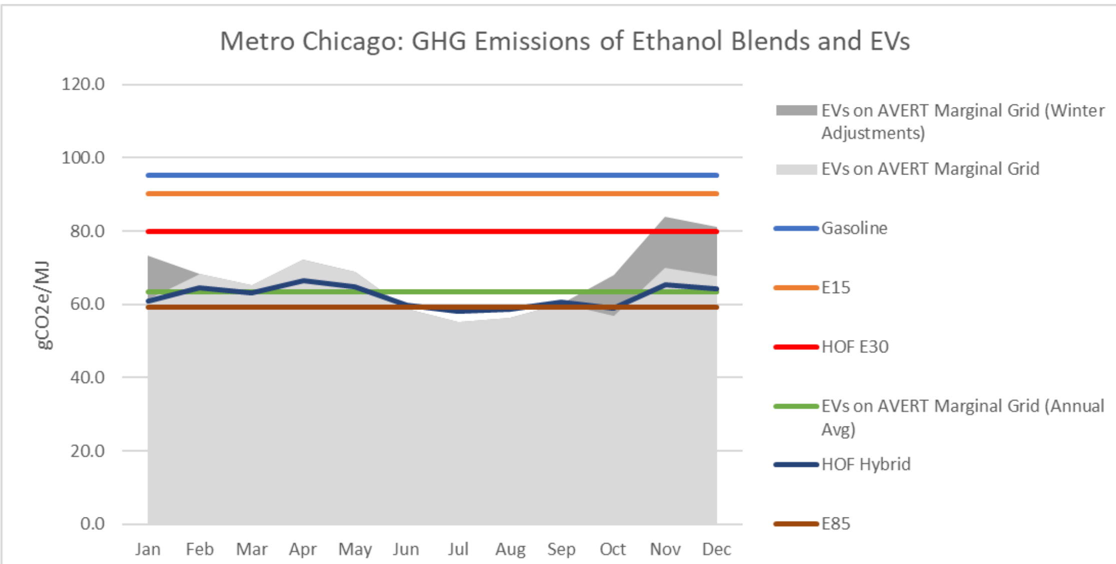
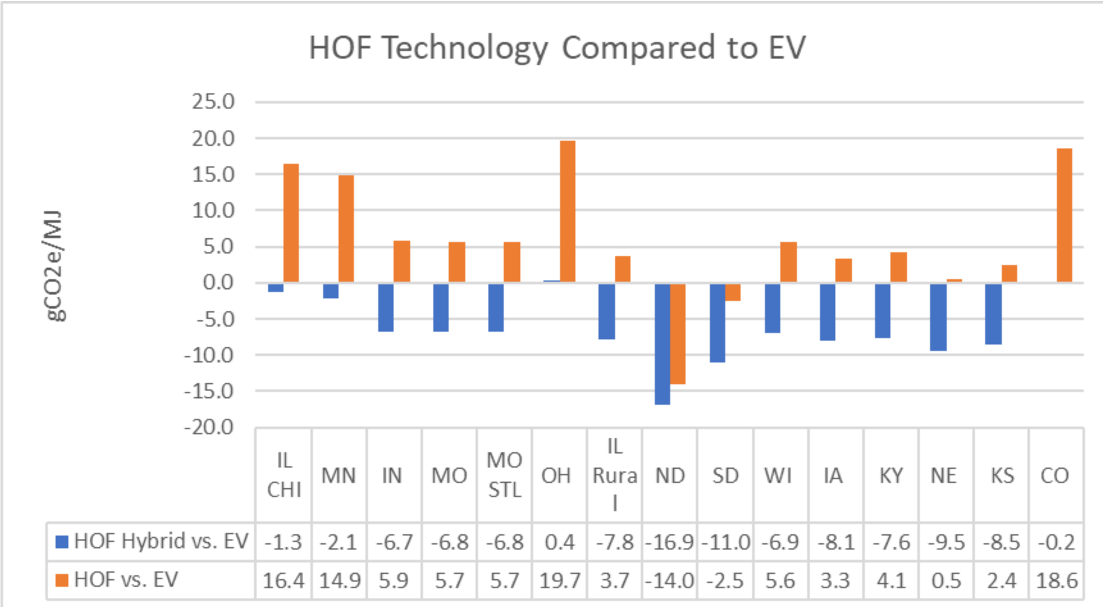


Figure 3: Metro Chicago

Figure 4 summarizes just HOF technologies compared to EVs. The graph shows the difference in gCO_2e/MJ between HOF and EVs. The blue bars show the CI advantage of HOF Hybrids over EVs. In every state HOF Hybrids provide lower CI scores than EVs (negative blue bars). But it also documents how in most states the non-hybrid HOF vehicles (orange bars) are either within 5 gCO_2/MJ or even cleaner than EVs.

We conclude that Ethanol at high blend levels can provide immediate GHG benefits while EV adoption increases. Long-term, due to the similar GHG savings of EVs, E85, and HOF, promoting these technology options towards the same adoption level across many Midwestern states should significantly increase the GHG emissions reductions that can be achieved by any one technology alone.

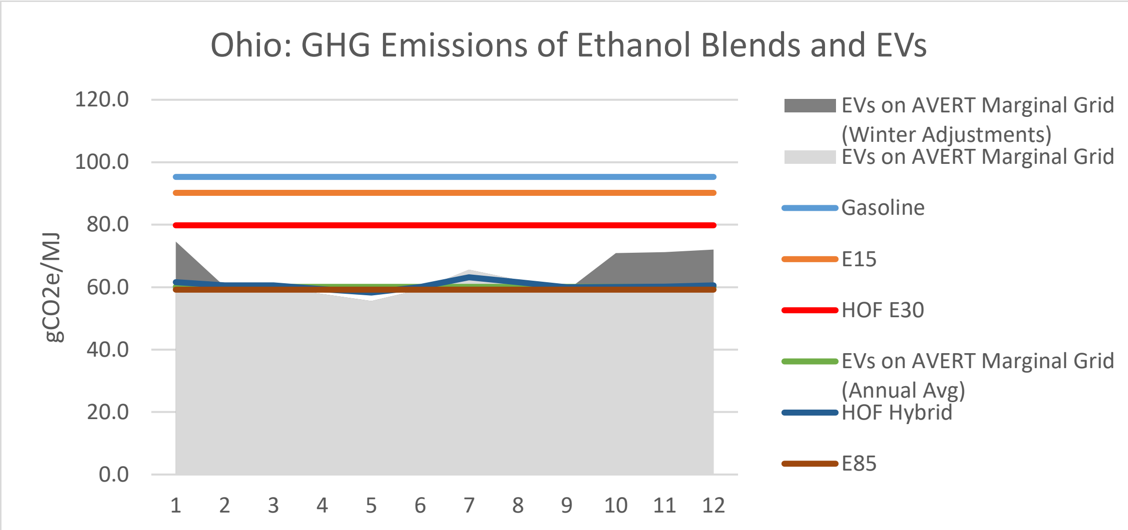
We also see the need for more research into each dispatch region's optimal daily and hourly charging window for EVs that avoids both taxing of on-peak resources and the use of marginal, dirtier generating facilities. We must also ensure that existing renewable resources are not diverted from current utility loads to serve EVs. This topic requires as much attention as direct and indirect land use life cycle emissions received for biofuels during the Renewable Fuels Standard Development.

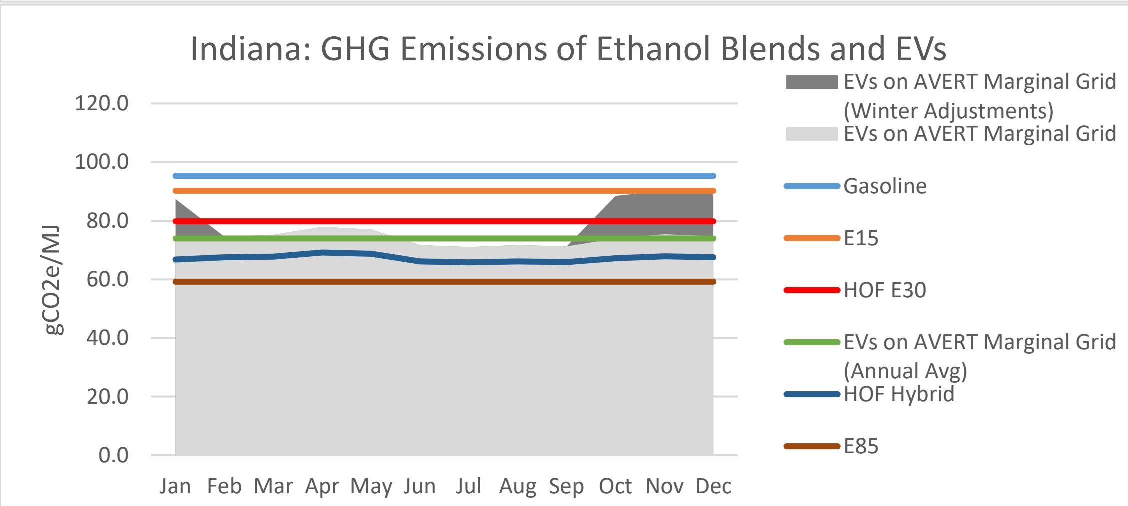


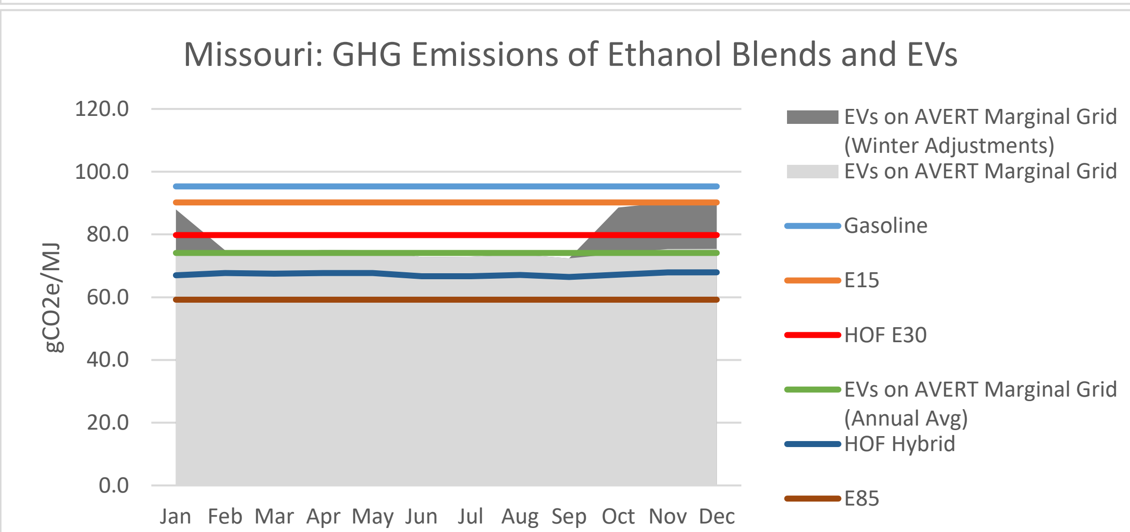
	IL CHI	MN	IN	MO	MO STL	OH	IL Rural	ND	SD	WI	IA	KY	NE	KS	CO
HOF Hybrid vs. EV	-1.3	-2.1	-6.7	-6.8	-6.8	0.4	-7.8	-16.9	-11.0	-6.9	-8.1	-7.6	-9.5	-8.5	-0.2
HOF vs. EV	16.4	14.9	5.9	5.7	5.7	19.7	3.7	-14.0	-2.5	5.6	3.3	4.1	0.5	2.4	18.6

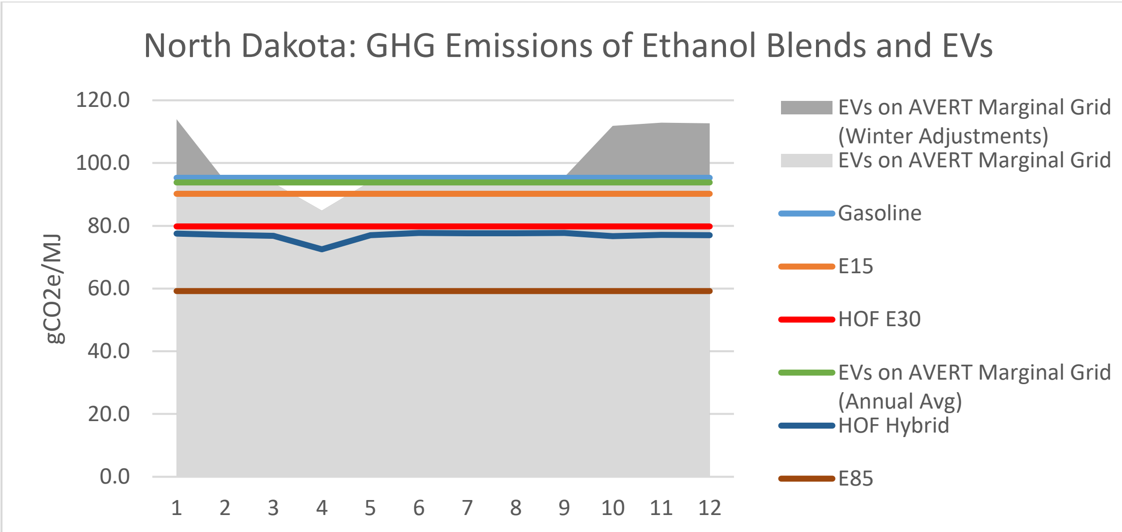
Figure 4: HOF Technologies Compared to EVs

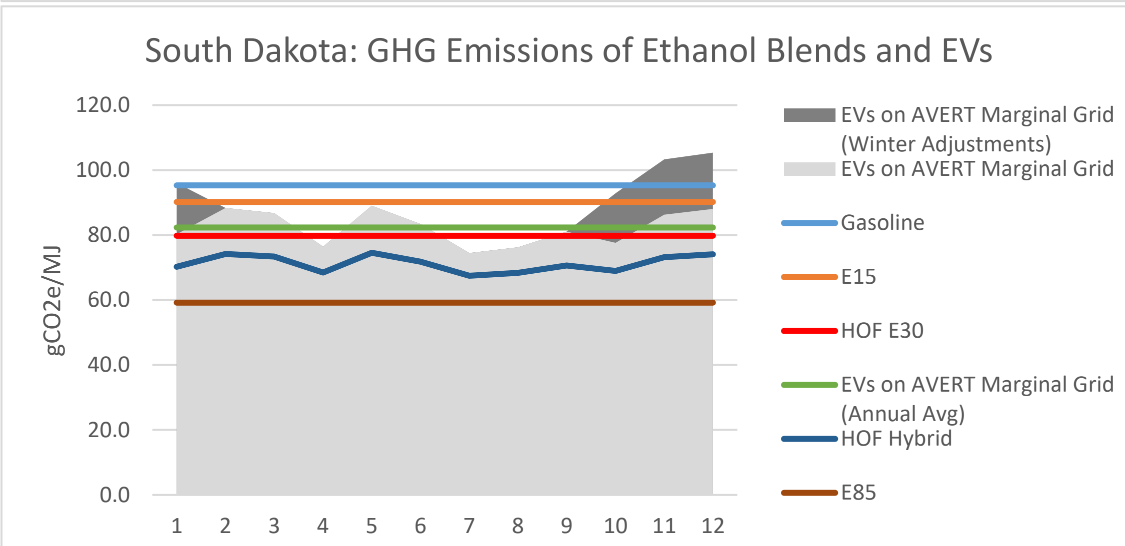
Appendix A: State by State Analysis








North Dakota: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
E15
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


South Dakota: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
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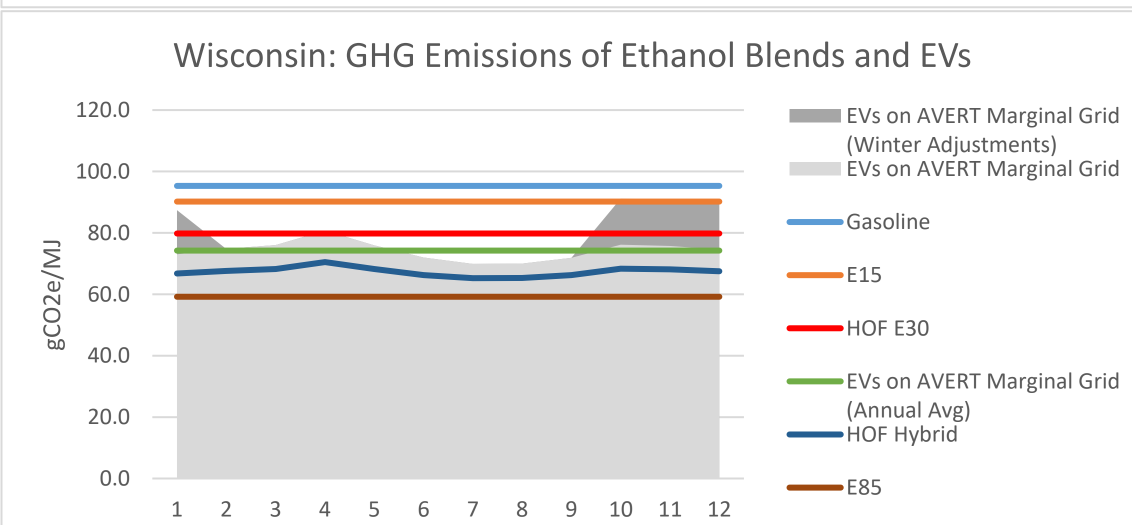
EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
E15
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


Wisconsin: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
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EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
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HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
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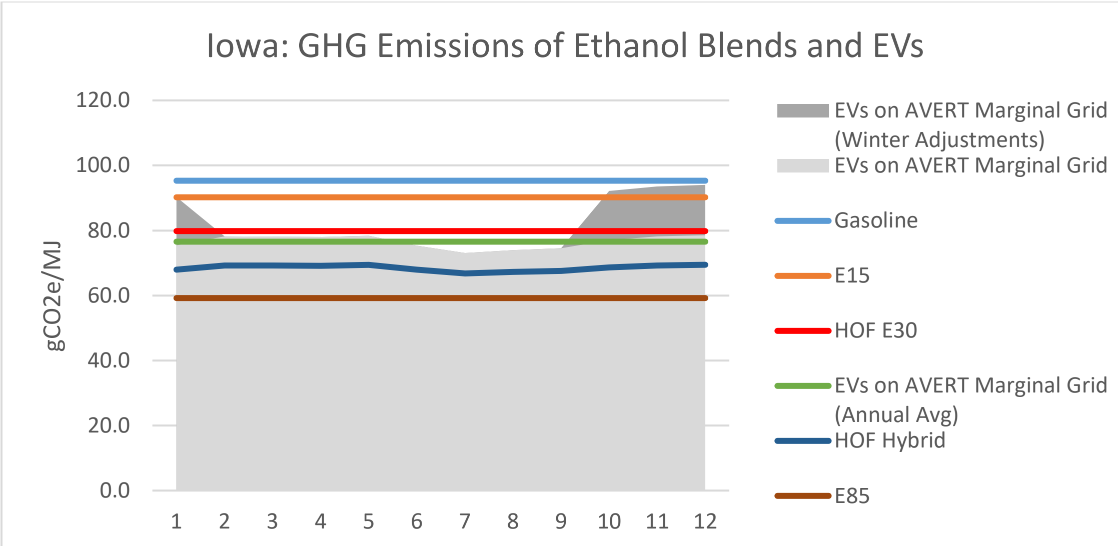
Iowa: GHG Emissions of Ethanol Blends and EVs
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EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
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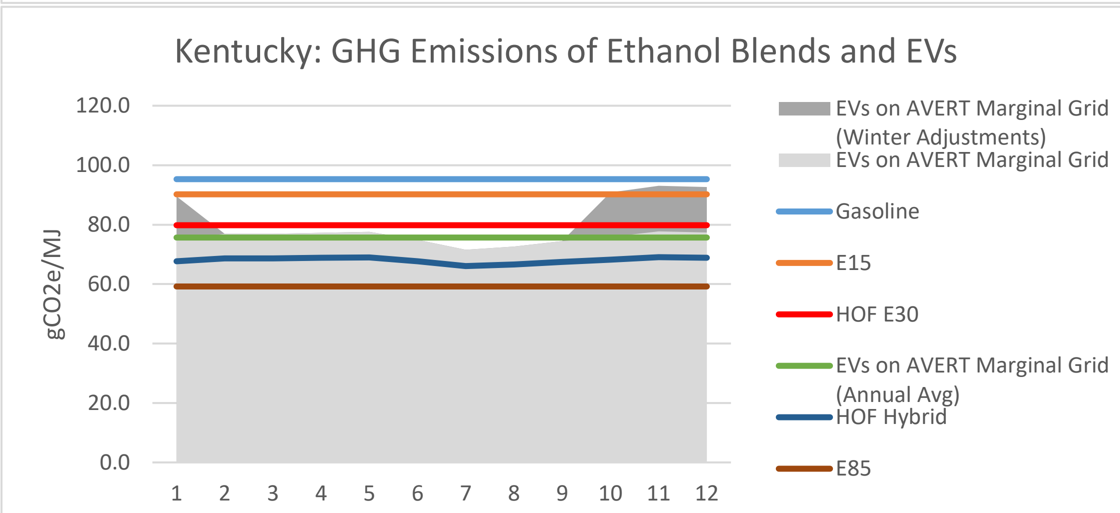
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


Kentucky: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
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EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
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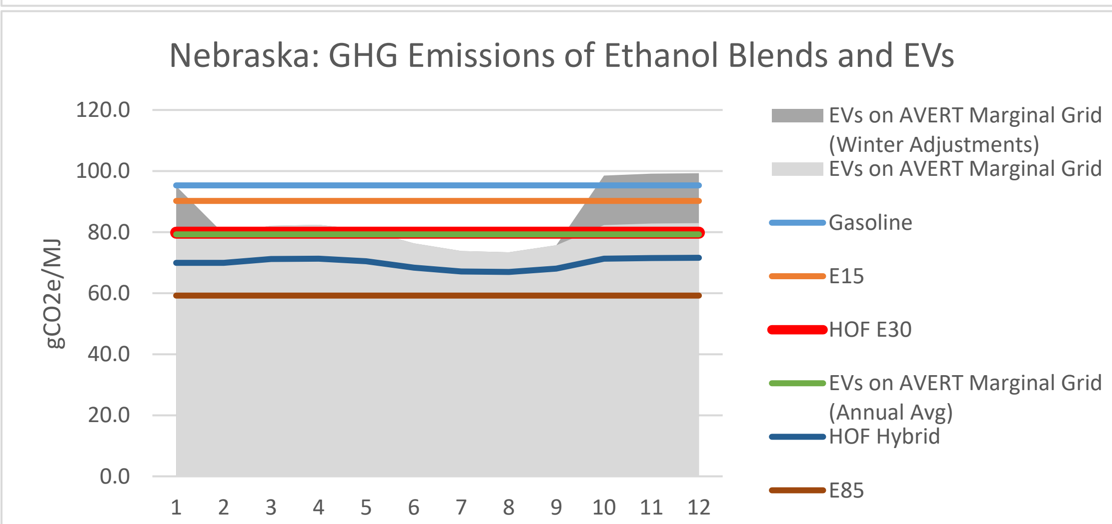
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


Nebraska: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
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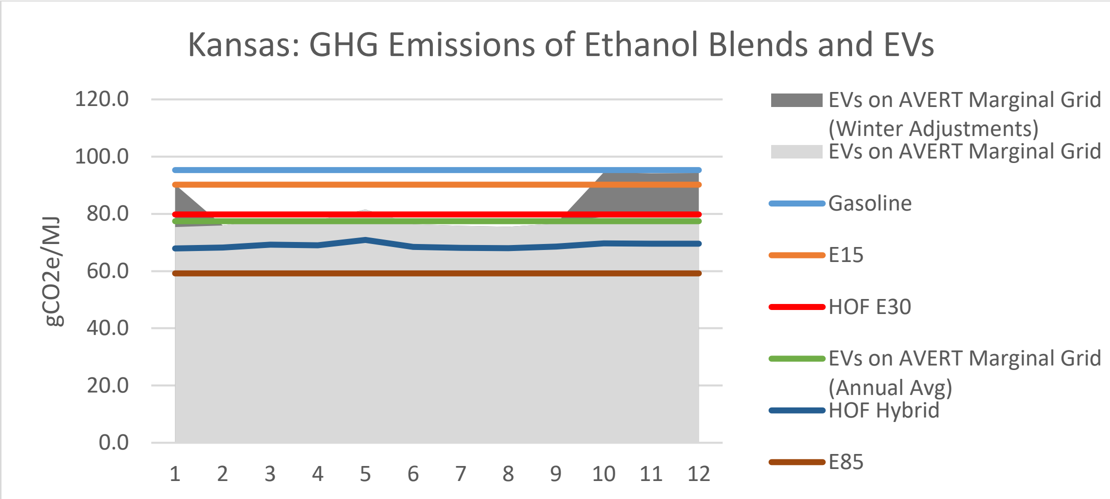
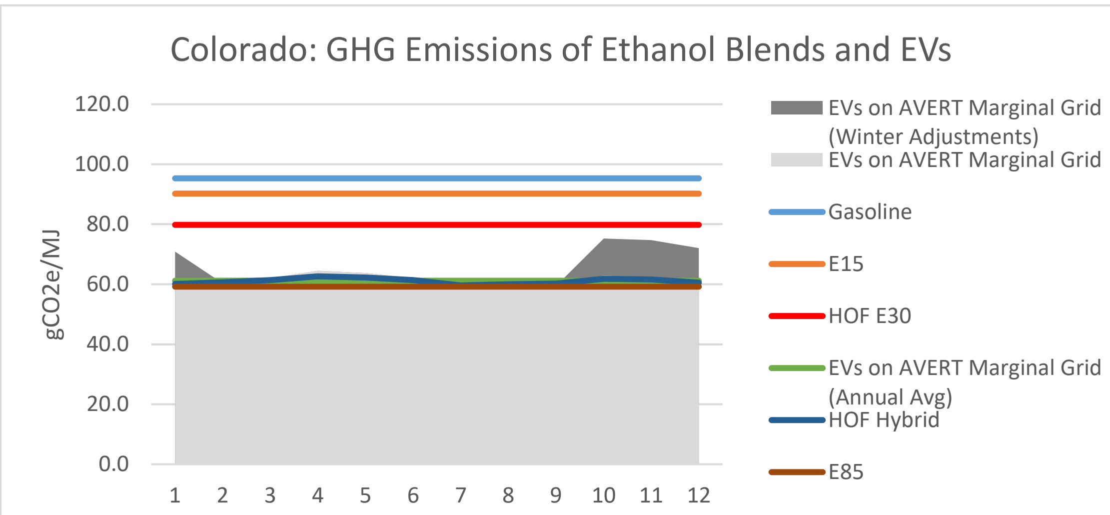
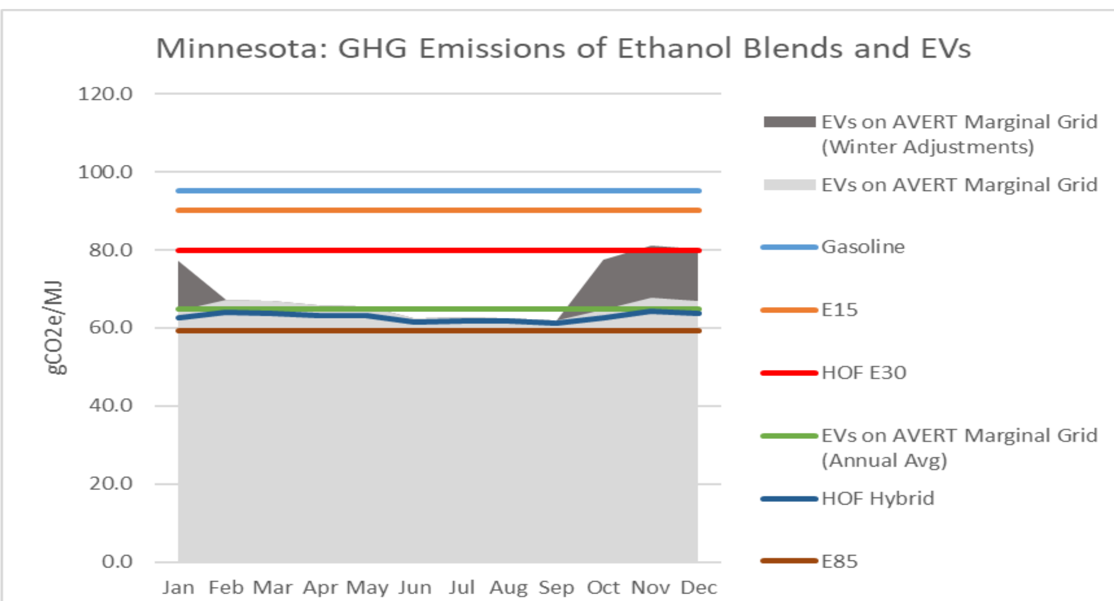
EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
E15
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


Kansas: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
E15
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


Colorado: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
E15
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85


Minnesota: GHG Emissions of Ethanol Blends and EVs
gCO2e/MJ
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
EVs on AVERT Marginal Grid (Winter Adjustments)
EVs on AVERT Marginal Grid
Gasoline
E15
HOF E30
EVs on AVERT Marginal Grid (Annual Avg)
HOF Hybrid
E85