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Colorado's Low Emission Automobile Regulation (CLEAR): An Evaluation of the Initial Economic Impact Analysis

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Colorado's Quality Control Commission has approved new standards that adopt California's low emission vehicle standards (Colorado's Low Emission Automobile Regulations, CLEAR).[1] The Colorado government prepared an initial economic impact analysis (IEIA) of these regulations to inform a May 6, 2019 stakeholder meeting.[2] The IEIA concluded that the CLEAR regulations will, on net, create both economic and environmental benefits for Colorado.

As with most analyses that promise free lunches, the IEIA's conclusions warrant skepticism. This *Issue Brief* evaluates the IEIA analysis and raises serious questions regarding the reliability of the IEIA's conclusions.

The IEIA Is Not A Forecast

Fundamentally, the IEIA is not an analysis of the impacts Coloradans should expect from the CLEAR proposal because the analysis does not evaluate how consumers and producers will respond. Instead, as described in the IEIA, the results are a "compliance scenario", which means the IEIA

[1] (2018) "Air Quality Control Commission approves low emission vehicle standards" *Press Release: Colorado Department of Public Health & Environment* November 16; https://www.colorado.gov/pacific/cdphe/LEV-standards.

[2] "Initial Economic Impact Analysis Per C.R.S. 25-7-110.5(4)(c)(I) for Revisions to AQCC Regulation Number 20: Zero Emission Vehicle Program Request for Hearing" May 10, 2019.

calculates a scenario where the economic and physical dynamics are consistent with the desired results under the regulations.

Since the analysis is a compliance scenario, the claimed environmental benefits are not an assessment of the proposal's impact. They are simply the arithmetic result of the *assumed* emissions differences between EVs and gas-powered vehicles (ICE, or internal combustion engine) and the electric vehicle (EV) market shares necessary to reach the policy's goals.

Instead of creating a compliance scenario, the IEIA should perform alternative market analyses that account for current technological constraints, potential new technologies that could alter these constraints, and likely consumption and production responses. Further, several alternative scenarios should be performed to determine the sensitivity of the projected economic and environmental impacts to specific assumptions.

For example, how much would the results change if the EV were assumed to be most families' secondary vehicle versus their primary vehicle? Or, what would the impact on the results be if the fuel efficiency of ICE vehicles were assumed to increase at a faster rate? Without a comprehensive market analysis that addresses these types of questions, it is impossible to know whether the estimated scenario is realistic, or if the proposed standards are the most effective policy for achieving the stated goals.

The IEIA Did Not Consider Alternative Policy Options

The IEIA judges the emission reduction benefits of the CLEAR proposal without referring to the state's current emission trends. According to the state data collected by the U.S. Energy Information Administration, carbon dioxide emissions from fossil fuel consumption in Colorado peaked in 2007 and have been declining, on average, 1.2 percent per year ever since, see Figure 1.[3]

Figure 1 also projects out the impact on emissions should the current decline continue through 2030. Should the current trend continue, total emissions in 2030 will be 25.1 percent smaller than

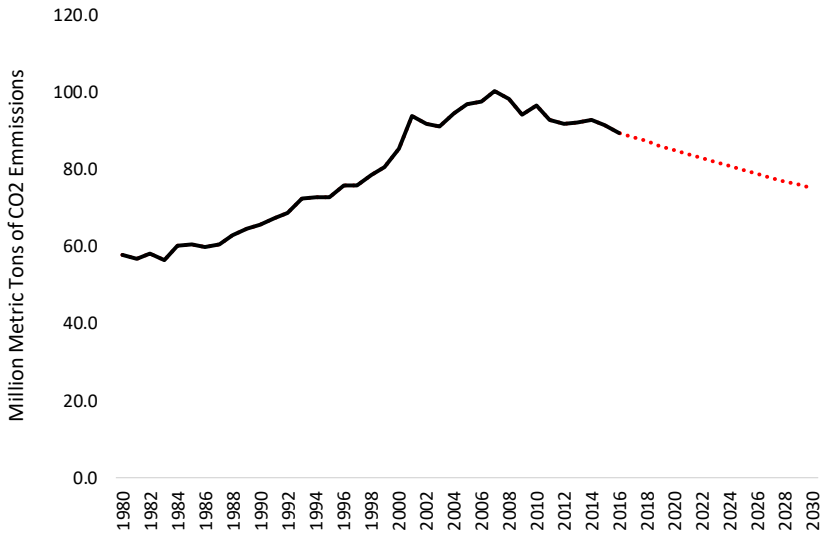
[3] See: "State Carbon Dioxide Emissions Data" *Energy Information Administration*, Release Date: October 31, 2018; https://www.eia.gov/environment/emissions/state/. Accessed July 3, 2019.

2007. The fact that emissions in Colorado are currently declining without the CLEAR proposal is an important consideration that should be incorporated into the IEIA.

Figure 1

Colorado Carbon Dioxide Emissions

1980 – 2016, Projections through 2030



Source: Author calculations based on data from the Energy Information Administration

The fact that emissions are declining illustrates that there are other policy actions that Colorado can take other than implementing the CLEAR policy. In fact, as illustrated in the Pacific Research Institute's recent publication *Legislating Energy Poverty*,[4] imposing low emission vehicle standards are not necessary for reducing overall GHG emissions. The net benefit from the CLEAR proposal cannot be ascertained, consequently, without comparing the costs and benefits of this policy to these other potential policy alternatives that could reduce GHG emissions relative to the current baseline.

It is possible that the CLEAR proposal is a more cost-effective alternative; it is also possible that the CLEAR proposal is a more costly alternative. Without an understanding of the policy

[4] Winegarden W. (2018) "Legislating Energy Poverty: A case study of how California's and New York's climate change policies are increasing energy costs and hurting the economy" *Pacific Research Institute*, December; https://www.pacificresearch.org/wp-content/uploads/2018/12/LegislatingEnergy_F_Web.pdf.

alternatives, which should include the expected results if the current baseline is followed, the actual net benefits of the CLEAR proposal is unknowable.

Greenhouse Gas Emission Reductions Are Based on Unrealistic and Incomplete Assumptions

The purpose of implementing the CLEAR proposal is to reduce overall GHG emissions. The IEIA measures the emissions benefit from EVs as the difference between the emissions released when EVs use electricity to charge their batteries compared to the emissions released from operating an ICE vehicle. Based on the average differences, the IEIA concludes that these regulations will reduce GHGs by 2.2 million metric tonnes between 2023 and 2030. However, this assessment fails to take a global view of GHG emissions.

Climate change is a global problem, so policies that simply shift emissions from one location (e.g. Colorado where EV vehicles will operate) to other locations (e.g. EV production facilities, often in China) do not reduce global emissions on net. This insight is important because currently, the production of EVs emits significantly more GHGs than the production of ICE vehicles – up to 74 percent more than the emissions emitted when producing an ICE vehicle.[5]

Since EV production generates larger emissions, EVs start from an emissions deficit compared to ICE vehicles. The lower emissions from operating an EV compared to an ICE vehicle will not reduce global GHG emissions, on net, until this deficit is closed. When compared to fuel efficient vehicles, it can take years for EVs to overcome this emissions deficit. In Germany, for instance, an electric vehicle "would take more than 10 years to break even" with the emissions from an efficient ICE vehicle.[6] And, this scenario assumes that no EVs would need to replace their batteries over this 10-year timeframe, which is likely to be an unrealistic assumption.

[5] Rolander N, Starn J, and Behrmann E (2018) "The Dirt on Clean Electric Cars: New research show some drivers might spew out less CO_2 with a diesel engine." *Bloomberg*, October 15; https://www.bloomberg.com/news/articles/2018-10-16/the-dirt-on-clean-electric-cars.

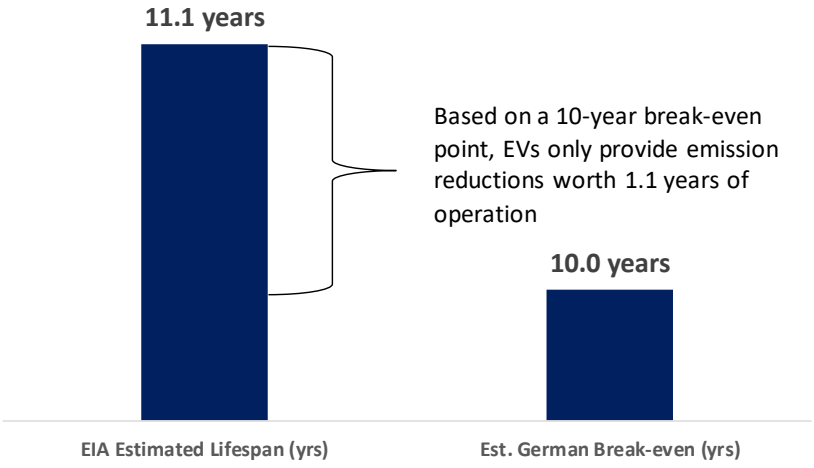
[6] Ibid.

The IEIA did not incorporate this net global emissions impact into its analysis, but it is imperative that Colorado fully accounts for the emission "break-even" timeframe before implementing the CLEAR proposal. Since the annual GHG emissions per electric vehicle in Colorado is higher than the national average according to the U.S. Department of Energy – 5,999 pounds in Colorado compared to 4,352 pounds for the nation overall – Colorado's GHG emission break-even timeframe will likely be longer than average for the U.S.[7]

To get a sense of the potential impact a global perspective can make, assume that the 10-year break-even point in Germany was applicable to Colorado. In order to determine the total GHG emission reduction, the IEIA assumed "a 150,000-mile useful vehicle life for all motor vehicles". According to the U.S. Department of Transportation, the average annual miles driven by age group is 13,476.[8] Applying the average annual miles driven to the assumed 150,000-mile useful life implies that the average car lifespan will be slightly longer than 11 years. If the emission break-even point for EVs is 10-years, then there is only a bit more than 1-year of emission reduction benefits from the regulations. Figure 2 visually illustrates this comparison.

Figure 2

Assumed EV Lifespan in Years Compared to a 10-year Break-even Timeframe



Source: Author calculations based on IEIA and Rolander (2018)

[7] "Emissions from Hybrid and Plug-in Electric Vehicles" *U.S. Department of Energy*; https://afdc.energy.gov/vehicles/electric_emissions.html. Accessed July 2, 2019.

[8] "Average Annual Miles per Driver by Age Group" *U.S. Department of Transportation Federal Highway Administration*, Page last modified March 29, 2018; https://www.fhwa.dot.gov/ohim/onh00/bar8.htm. Accessed July 2, 2019.

Compared to the annual GHG emissions of ICE vehicles (11,435 pounds of emissions),[9] and incorporating the impact from hybrid vehicles using the IEIA assumption that these vehicles accounted for 25 percent of total alternative vehicles, the annual emissions reduction from the CLEAR proposal would be 5,165 pounds per vehicle, or 2.34 metric tonnes per vehicle. Multiplied across the expected number of EV and hybrid vehicles, the expected reduction in GHG emissions would be significantly smaller than the 2.2 million metric tonnes estimated by the IEIA. These calculations illustrate that, once the impact on global emissions are considered, the expected amount of GHG emission reductions estimated in the IEIA may be a significant overstatement.

In addition to the need to account for the impact on global emissions, the IEIA made several other assumptions in order to estimate the reduction in GHG emissions that are unrealistic, or biased toward concluding that the policy creates large environmental benefits. The study also fails to provide evidence that minor changes to these assumptions will not meaningfully impact the estimated impact on GHG emissions.

For example, even as the IEIA notes that the state is "well positioned to meet the 30 percent renewable statutory requirements in 2020", coal is still responsible for generating 47.1 percent of Colorado's electricity compared to the national average of 35.2 percent.[10] Since a large amount of Colorado's electricity is generated from coal, the emissions benefits from the mandate would require a fundamental transformation of the state's electricity infrastructure, as mentioned in the IEIA. The costs and difficulties associated with fundamentally transforming Colorado's electricity infrastructure cannot be understated. Should the transformation be unsuccessful (or less successful than anticipated), then the expected reduction in emissions will overstate the actual emissions reductions achieved.

Worsening this problem, the purpose of the CLEAR program is to encourage more EVs. EVs shift the power source for vehicles to the electric grid, which will create a significant increase in demand for electricity. As a result, Colorado's electricity transformation needs to not only ensure that current electricity demand projections are met, the transformation needs to ensure that an unknown

[9] "Emissions from Hybrid and Plug-in Electric Vehicles" *U.S. Department of Energy*; https://afdc.energy.gov/vehicles/electric_emissions.html. Accessed July 2, 2019.

[10] "Emissions from Hybrid and Plug-in Electric Vehicles" *U.S. Department of Energy*; https://afdc.energy.gov/vehicles/electric_emissions.html. Accessed July 2, 2019.

surge in demand is also met. Effectively meeting the power needs of the electric grid during such a transformation is an even more complicated task.

While unstated, the IEIA made other technology assumptions that are crucial to the outcome. Starting with ICE vehicles, according to the EPA,

> In model year 2017, the average estimated real-world CO2 emission rate for all new vehicles fell by 3 grams per mile (g/mi) to 357 g/mi, the lowest level ever measured. Fuel economy increased by 0.2 miles per gallon to 24.9 mpg, achieving a record high.
>
> Since 2004, CO2 emissions have decreased 23%, or 104 g/mi, and fuel economy has increased 29%, or 5.6 mpg. Over that time, CO2 emissions and fuel economy have improved in eleven out of thirteen years and have repeatedly achieved new records.[11]

Improvements to ICE fuel efficiencies will reduce the net GHG emissions benefit EVs create. Since there has been consistent improvement in the efficiency of ICE vehicles, it is essential that this dynamic be included in the analysis. It is unclear from the IEIA that such considerations were incorporated, however. Without accounting for potential efficiency gains of ICE vehicles, the analysis overstates the potential GHG emission reductions.

Similarly, the estimated emissions reduction depends on the lifespan of the EV's battery. Just like the lithium-ion battery in an i-Phone or Samsung Galaxy phone, an EV's "full-charge" will degrade over time. EV manufacturers do offer warranties against battery degradation. The warranty on a Tesla Model S is 8 years, with unlimited miles; a Nissan Leaf offers an 8-year warranty as well, but also imposes a mileage limit of 100,000 miles and with a 75 percent charge guarantee (e.g. the battery will charge up to 75 percent of its initial full battery charge).[12]

Current expectations are that technology improvements are forthcoming that will increase this lifespan, but by how much is an important assumption. If the battery life is assumed to significantly

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[11] (2019) "The 2018 EPA Automotive Trends Report" *Environmental Protection Agency*, March; https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100W3WO.pdf.

[12] (2019) "Electric vehicle battery life & warranties" *Energy Sage*, January 2; https://www.energysage.com/electric-vehicles/buyers-guide/battery-life-for-top-evs/.

improve, then the emission reduction benefits will be higher. Alternatively, more conservative assumptions regarding battery life improvements will lessen the emission reduction benefits.

The battery life assumption raises another concern that the IEIA fails to address as well – the GHG emissions break even time. Referring back to the German example, if an EV's effective battery life is only 8-years, but the break-even time frame is 10-years, then on net, the CLEAR proposal would lead to a net increase in GHG emissions. Due to the possibility of this outcome, it is imperative that the IEIA fully evaluate the potential risks should the battery life of the EVs become a binding constraint.

This concern is particularly relevant for Colorado, where different parts of the state will experience extreme cold in the winter, and extreme heat in the summer. In Denver, for instance, the average low is 16 degrees in January.[13] "New research from AAA reveals that when the mercury dips to 20 degrees Fahrenheit, the average driving range of an electric car decreases by 41 percent."[14] And, it is not just the cold weather. "Extreme heat is also a drag on electric vehicles. When outside temperatures heat up to 95 degrees Fahrenheit and air conditioning is used inside the vehicle, driving ranges can decrease by 17 percent, AAA reports."[15] In Las Animas, Colorado the average high temperature in July is 95 degrees.[16] Consequently, depending on where families live, Colorado's wide temperature variations raise additional concerns regarding EV battery efficiency. These concerns will impact the expected net emissions reduction from the CLEAR proposal.

The IEIA's Estimated Net Economic Benefit Relies on Questionable Assumptions

Beyond the concerns regarding the IEIA's environmental conclusions, there are also questions regarding whether the CLEAR proposal will provide a net economic benefit. In our publication *Legislating Energy Poverty* we illustrated why "widespread adoption of the CA-NY approach

[13] https://www.denver.org/about-denver/denver-resources/weather/

[14] Hawkins AJ (2019) "Extreme weather is sucking the life from your electric car" *The Verge*, February 10; https://www.theverge.com/2019/2/10/18217041/electric-car-ev-extreme-weather-polar-vortex.

[15] Ibid.

[16] https://www.usclimatedata.com/climate/las-animas/colorado/united-states/usco0233.

[including California's electric vehicle mandate] will impose large economic costs on the country while not necessarily leading to larger reductions in greenhouse gas (GHG) emissions."[17] These findings are applicable to Colorado as the state considers adopting CLEAR.

For example, California has one of the highest retail electricity prices in the U.S., and the highest gas prices, due in large part to its energy policies. Compared to Colorado, California's electricity prices were 60.8 percent higher in 2017 according to the Energy Information Administration (the latest data available); California's gas prices as of July 2, 2019 were 38.8 percent higher.[18] High energy costs dampen economic growth and impose larger burdens on lower-income families. Should Colorado adopt the California approach, it should expect energy costs in the state to rise, to the detriment of economic growth and lower-income families. The IEIA should fully consider these impacts in its assessment.

There are also questions regarding the net economic costs of operating an EV compared to an ICE. According to the IEIA, the average cost of an ICE in 2023 will be $27,916. The average cost of an EV was assumed to be $34,219, it is unclear, however, whether this is a subsidized price. The IEIA assumes that the price difference between the EV and ICE ($6,303) is the relevant cost difference, which effectively assumes that the average family will purchase their cars with cash and not have to finance any portion of the costs. This assumption is likely to be inapplicable to most car buyers.

Assuming that purchasers put 20 percent down, and based on the current average interest rate on a 60-month new auto loan of 5.24 percent,[19] the total purchase costs of the EV would be $7,003 higher than the total purchase costs of the ICE vehicle, see Table 1. These large up-front costs will likely be an obstacle for many families.

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[17] Winegarden W. (2018) "Legislating Energy Poverty: A case study of how California's and New York's climate change policies are increasing energy costs and hurting the economy" *Pacific Research Institute*, December; https://www.pacificresearch.org/wp-content/uploads/2018/12/LegislatingEnergy_F_Web.pdf.

[18] Electricity prices are from the U.S. Energy Information Administration, Electricity Detailed State Data; https://www.eia.gov/electricity/data/state/. Accessed July 2, 2019. Gas prices are from AAA; https://gasprices.aaa.com/state-gas-price-averages/. Accessed July 2, 2019.

[19] "Finance Rate on Consumer Installment Loans at Commercial Banks, New Autos 60 Month Loan" https://fred.stlouisfed.org/series/RIFLPBCIANM60NM. The rate is as of February 2019.

Table 1

Total Purchase Costs of ICE Vehicle Compared to EV in 2023

Based on IEIA Price Data

	ICE	EV	Net ICE Costs/Savings
Down payment	$5,583	$6,844	$1,261
Total Loan Repayment	$25,434	$31,177	$5,743
Total Car Purchase Costs	***$31,018***	***$38,021***	***$7,003***
Annual Operating Costs	$1,115	$454	-$661

Source: Author calculations based on data from: St. Louis Fed (FRED), Initial Economic Impact Analysis of Colorado's Zero Emission Vehicle Program, and Sivak and Schoettle (2018)

Numbers may not add due to rounding.

The financial draw of an EV is its lower operating costs. Based on a University of Michigan analysis, the average annual cost of driving a typical ICE vehicle in Colorado is $1,115 compared to $454 for an EV, these values are presented in Table 1.[20] The annual average savings from driving an EV compared to an ICE vehicle are, consequently, $661. Without accounting for the time value of money, a family must own an EV car for nearly 11 years for the annual operating savings to exceed the expected $7,000 in extra costs to purchase an EV in 2023. Accounting for the time value of money, and the time it takes to recoup the initial cost premium of an EV exceeds any reasonable life expectancy of the EV battery.

These calculations illustrate that financially, EVs are not currently cheaper than ICE's from a lifetime use perspective, nor are they going to become cheaper within a 5-year time horizon. While those consumers who value the attributes of an EV more than the higher lifetime costs will choose to purchase them, these calculations illustrate that as of 2023, EVs impose higher lifetime use costs on consumers.

In terms of the CLEAR proposal creating a net economic benefit for Colorado, the key assumption is what will happen to the price of EVs over time. The IEIA assumes that the price of EVs will decline, as is assumed by many industry analysts, due to expected efficiency gains in the production of the battery technology. The IEIA further assumes that the price of ICE vehicles will continue to

[20] Sivak M and Schoettle B (2018) "Relative Costs of Driving Electric and Gasoline Vehicles in the Individual U.S. States" *University of Michigan*; http://umich.edu/~umtriswt/PDF/SWT-2018-1.pdf.

rise, as they have done in the past. The combination of these trends closes the gap in total purchase costs, leading to a net economic benefit for Colorado. While such a scenario is possible, there are other plausible scenarios as well. Perhaps the hoped-for efficiencies will not occur. Perhaps ICE prices will break their historical pattern due to stiffer competition from EVs. Perhaps other low-emission vehicles will be introduced.

To have confidence that the assumptions underlying the IEIA's compliance scenario are a reliable estimate for the future, it is necessary to evaluate how much the net economic benefit from the CLEAR proposal will change in response to changes in these assumptions. Without this analysis, the reliability of the reported economic impacts is questionable. This conclusion is strengthened given the negative economic consequences Californians bear from imposing the exact same policy.

Conclusion

Ultimately, the environmental and economic impacts from the CLEAR proposal depends on whether:

- EV technologies develop as the IEIA expects
- A robust EV support infrastructure (e.g. charging stations) can develop in Colorado
- Colorado can successfully transform its electricity infrastructure, and
- ICE fuel-efficiency innovations continue that reduce emissions from ICE vehicles.

There are sound reasons to suspect that accounting for these considerations, the CLEAR proposal will impose net economic costs on Colorado without significant environmental benefits. It is, consequently, imperative that the economic analyses used to evaluate the efficiency mandates incorporate robust assessments of these impacts. Without a clear understanding of these issues, the economic and environmental assessments of the CLEAR proposal are unreliable as a policy guide.

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Wayne H. Winegarden, Ph.D. is a Senior Fellow in Business and Economics at the Pacific Research Institute and director of PRI's Center for Medical Economics and Innovation. He is also the Principal of Capitol Economic Advisors.

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Dr. Winegarden's columns have been published in the Wall Street Journal, Chicago Tribune, Investor's Business Daily, Forbes.com, and Townhall.com. He was previously economics faculty at Marymount University, has testified before the U.S. Congress, has been interviewed and quoted in such media as CNN and Bloomberg Radio, and is asked to present his research findings at policy conferences and meetings. Previously, Dr. Winegarden worked as a business economist in Hong Kong and New York City; and a policy economist for policy and trade associations in Washington D.C. Dr. Winegarden received his Ph.D. in Economics from George Mason University.

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