TOYOTA

TOYOTA MOTOR NORTH AMERICA, INC.

Sustainability and Regulatory Affairs

325 Seventh Street, NW #1000 Washington, DC 20004

July 5, 2023

Michael S. Regan, Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Subject: **Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles [Docket ID EPA-HQ-OAR-2022-0829].**

Dear Administrator Regan:

Toyota Motor North America, Inc. (Toyota) appreciates the opportunity to provide comments on the Notice of Proposed Rulemaking (NPRM) referenced above (the Proposed Rule).

Toyota shares the administration's goal to decarbonize transportation and is committed to vehicle electrification to improve society and the lives of our customers. Our environmental track record speaks for itself. We have sold over 20 million electrified vehicles globally since the introduction of the Prius in 1997. These electrified vehicles have resulted in a cumulative reduction of 162 million tonnes of CO_2[1]. And Toyota has put more vehicles with electrified powertrains on the road in the U.S. than all other automakers combined. But we are not stopping there. We have much more planned:

- We announced on May 31, 2023, that an all-new, three-row battery electric SUV will be assembled at Toyota Motor Manufacturing Kentucky (TMMK) starting in 2025, using batteries from our Toyota Battery Manufacturing North Carolina (TBMNC) plant. We subsequently announced a $2.1 billion capacity expansion to support this new SUV, bringing the total investment in TBMNC to nearly $6 billion.
- We announced that we will launch 10 new BEVs globally by 2026, and that we aim sell 1.5 million battery-electric vehicles (BEVs) per year globally by the end of 2026.
- In line with the Paris Agreement, we aim to reduce average CO_2 emissions for new vehicles we sell worldwide by 33% by 2030 compared to 2019. We received validation and approval for this target from the Science Based Targets Initiative (SBTi) in September 2022. Furthermore, we aim to reduce new vehicle CO_2 emission by more than 50% by 2035.[2]
- We are fully committed to achieving carbon neutrality in 2050 over the entire life cycle of our vehicles.

We share the objective of reducing carbon as much as possible, as soon as possible. The Proposed Rule underestimates key challenges including the scarcity of minerals to make batteries, the fact that these minerals are not mined or refined in the U.S., the inadequate infrastructure, and the high cost of BEVs. The data shows a more effective approach to reduce more carbon sooner is to promote a multi-pathway strategy (PHEV, HEV, BEV and FCEV) that addresses these challenges, encourages innovation, and provides consumers with affordable choices that meet their needs.

[1] June 2023 Sustainability Data Book, available on https://global.toyota/en/sustainability

[2] See Science Based Targets Initiative, https://sciencebasedtargets.org

While our attached comments cover a range of issues for EPA's consideration, the five below summarize the most critical:

1. The proposed standards are expected to result in a new vehicle sales mix of 67% BEV by 32MY. Achieving such a high penetration is almost entirely dependent on factors outside our control. As discussed in more detail in our attached comments, hundreds of new mines are needed globally to produce enough critical minerals to support so many BEVs. The sources for those minerals are almost exclusively outside the U.S., as is most of the mineral processing to turn the ore into usable battery-grade material. And the charging infrastructure (both in-home and public) needed to support that level of electrification is far from where it needs to be. Recent legislation and incentives are directionally supportive but appear far short of what is needed. EPA should adjust the standards in the proposed rule to account for these major uncertainties over which automakers have little control, but for which we face significant compliance and brand/reputation ramifications should they not come to bear. Compliance cannot be based on factors over which we have no control.

2. The annual stringency increases in the first three years of the proposed rule are extreme and outside historical norms. EPA has historically recognized that technology penetration is slower in early stages of market development and increases more rapidly over time. The proposed early ramp rates run directly contrary to this reality. We are also concerned that this extreme rate may have a paradoxical effect on CO_2 emissions – lowering the volume of older, higher polluting vehicles replaced because artificial shortages will be created of low-carbon non-BEV vehicles that many customers prefer. Automakers need time to invest in EV and battery production capacity, for the charging infrastructure to develop across the country, and for the market to mature. To reduce carbon dioxide emissions as much as possible, as soon as possible, customers need choices that encourage replacement of high-CO_2 emitting vehicles with low- or zero- CO_2 emitting vehicles. EPA should smooth the early rates of increase in recognition of these factors.

3. The stringency of the criteria pollutant standards (i.e., tailpipe standards) exceed California's recently finalized LEV 4 standards with little technical or scientific justification. In fact, the proposed tailpipe standards serve as a de facto BEV mandate. EPA should adopt California's LEV4 standards – the most stringent ever put in place in the U.S. - and not go beyond these.

4. The proposed rule discriminates against plug-in hybrid electric vehicles (PHEVs) based on flawed data and analysis from an environmental NGO to arbitrarily lower the "Utility Factor" (UF). EPA's proposed UF slashes the compliance benefit of PHEVs by between 25% and 45% and discourages OEMs from pursuing this technology. EPA should retain the current Society of Automotive Engineers (SAE) method for assessing the UF. *PHEVs should be encouraged by this regulation, not discouraged* – they are an extremely efficient use of limited and expensive minerals, provide significant GHG reduction benefits, are more affordable than similar BEVs, and require less reliance on charging infrastructure.

5. We encourage EPA to consider a role for low-carbon liquid fuels (LCLFs) in future rulemaking. This is the only viable option to reduce GHG emissions from the existing U.S. fleet of 270 million vehicles. Regardless of how quickly the needed shift to electrification occurs, vehicles with internal combustion engines (ICEs) will be on U.S. roads in large numbers for decades to come. Failure to provide a GHG-reduction solution for this massive source of emissions would be missing an enormous opportunity.

Thank you for considering Toyota's input on this important rule. We hope that with modifications to the proposed rule, significant emissions reductions can be realized, and greater vehicle electrification can be supported while protecting consumer choice, maintaining a secure and reliable supply chain for critical minerals and battery production, and supports a vibrant automotive sector.

Should you have any questions about the attached comments, please contact Richard Gezelle, Senior Principal Engineer, Environmental Regulations, at rick.gezelle@toyota.com or (202) 463-6845.

Sincerely,

Tom Stricker
Group Vice President
Sustainability and Regulatory Affairs

Attachment 1

Comments of Toyota Motor North America, Inc.

Notice of Proposed Rulemaking: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles

Docket ID Number: EPA-HQ-OAR-2022-0829

July 5, 2023

Toyota Motor North America, Inc. (Toyota) appreciates the opportunity to provide comments on the above-referenced Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles. As a member of the Alliance for Automotive Innovation (AAI), Toyota supports and incorporates by reference the AAI's comments. Our comments on the proposal are organized as follows:

Table of Contents

List of Figures

List of Tables

1 Overview

When President Biden issued Executive Order 14037 in 2021 calling for 50% electrified vehicles (defined then as battery electrics (BEVs), plug-in hybrids (PHEVs) and fuel cell hybrid electrics (FCHVs), Toyota publicly committed to making every effort to achieve those targets. However, the Proposed Rule would force about 60% BEVs alone by 2030, and 67% by 2032. This significantly moves the goal line on electrification and is paramount to a BEV mandate on an incredibly aggressive timeline. Taken separately, the proposed GHG standards and the proposed tailpipe/criteria standards each attempts to steer the future toward a BEV-only vehicle market. Together they do that and impose significant costs on internal combustion engine (ICE) vehicles currently accounting for about 94% of the new vehicle market. Toyota shares the administration's goal to decarbonize transportation, but believes the Proposed Rule requires significant adjustments.

Data show that a portfolio approach to electrification which includes the technologies above plus hybrid electrics (HEVs), provides the same or greater carbon reductions as an approach that focuses exclusively on BEVs. A portfolio approach utilizing scarce critical minerals in the most effective manner to remove more traditional ICE vehicles from the road more quickly. It also provides consumers with more carbon-reducing options that fit their lifestyles and purchasing power.

The Proposed Rule also for the first time imposes standards on automakers for which compliance requires significant actions by third parties over which we (or EPA) have no control. First, achieving the level of BEVs required by the Proposed Rule will require massive new supplies of critical minerals, the mines to extract them, and the refining facilities to turn ore into battery-grade material. Currently, virtually the entire mineral and battery supply chain is outside the U.S. Second, it requires massive investments in home and public charging infrastructure, as well as upgrades to the electrical grid throughout the U.S. and an accelerated shift to renewable power generation. Various provisions of the IIJA and IRA directionally support some of these areas but fall significantly short of what will be needed for the expected level of electrification. And finally, the ultimate impact of these factors on vehicle costs and consumer demand are unclear, at best. The are few contingencies for automakers and our customers in the event any or all these factors stand in the way of complying with the Proposed Rule. Our comments below address these and other issues.

We are prepared to follow up with additional information beyond these comments. We look forward to collaborating toward a more workable Final Rule.

2 Critical Material Supply

Batteries account for largest cost associated with an electric vehicle. The global supply of battery critical minerals and the refining of those minerals will ultimately determine PEV costs as global demand increases nearly five-fold over the next decade[1]. Hundreds of new mines are needed globally to produce the critical minerals needed to support this demand. Currently, virtually all critical mineral extraction and processing are conducted outside the U.S.

The proposal outlines various incentives, tax credits, and other mechanisms in the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) aimed at speeding the development of a domestic supply chain, as well as efforts the Administration and private sector are taking to aid the electrification transition. The IIJA and IRA serve as a necessary down payment on what will be needed to achieve shared electrification goals but fall far short of what is needed to achieve the proposed standards. Further, the proposal lacks an actionable plan for translating funding and goals into specific projects in a manner that will enable automakers to sell the share of BEVs required to meet the preferred alternative standards.

Below is a summary of Toyota's understanding of the critical mineral landscape and supply-demand challenges over the period of the Proposed Rule, based on extensive collaboration with experts in the field. Please see Appendix A for a more detailed assessment and accompanying data.

[1] BMI Lithium Forecast, Q1 2023.

2.1 Lithium

The proposal identifies lithium as most likely to first constrain PEV production due to limited availability. EPA contends there will be ample supply of the other critical minerals through 2035 and/or there are known substitute minerals that make their availability less critical[2]. Therefore, the proposal's assessment of critical mineral availably is limited to a single mineral - lithium.

EPA's analysis concludes there will be sufficient lithium supply to support the 67 percent BEV share required by the Proposed Rule and that prices will stabilize mid-decade. However, it appears this conclusion is based on a *global lithium supply* that in many cases may not qualify for the 30D IRA tax credits that EPA applied to most every vehicle in the supporting analyses. The proposal notes "the Inflation Reduction Act incentivizes use of domestically sourced and processed mineral products, it only ties these products to availability of the related tax incentives (primarily the Clean Vehicle Credit under 30D) and does not prohibit use of imported mineral products by manufacturers that cannot secure domestic sources. Thus, it is the *global supply for lithium*, not only domestically sourced supply, that potentially constrains battery production."[3]

As described in more detail in Appendix A, the global supply of lithium is highly unlikely to satisfy the U.S. demand driven by the preferred alternative standards. Further, the supply-demand gap grows significantly when lithium sources are limited to U.S. and FTA countries that qualify for the IRA tax credits. Benchmark Mineral Intelligence (BMI) with partner RhoMotion conducted a forecast of global lithium supply versus demand through 2035.

The BMI study concludes 41% PEV penetration in 2030 is possible globally without consideration of available lithium under a business-as-usual base case scenario. When available global lithium supply is considered, the projected supply-demand gap constrains PEV penetration to 36% of new vehicles sold globally in 2030. A high-demand scenario incorporates the announced PEV targets for 41 leading OEMs and additional government policy aspirations which results in supply-

[2] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, Draft Regulatory Impact Analysis (DRIA), April 2023, page 3-23.
[3] Id. at 3-24

demand deficit starting today that would require U.S. manufacturers to compete on a global scale for limited lithium - creating many unknown supply bottlenecks.

The BMI/RhoMotion study included a PEV mix of 88 percent BEVs and 12 percent PHEVs for 2030 in contrast to EPA's assumption of 100 percent BEVs for the proposal. The supply-demand analysis would have concluded larger shortfalls that would have occurred sooner if BMI had assumed 100 percent BEVs. The data in these supply-demand figures is for calendar year rather than vehicle model year. For the sake of this evaluation, the calendar year will be used and assumed equivalent to the previous model year (ex. 2030 calendar year is the same as 2029 model year).

Projected U.S. refined lithium supply (larger than U.S. mined lithium supply) is far short of the demand needed to comply with the Proposed Rule -allowing for only a 15% PEV penetration in 2030 assuming a 100 kWh average battery size. Expanding the lithium supply to FTA countries that qualify for the IRA tax credits enables higher PEV penetrations. However, the study finds that the U.S. would need to consume an implausible 99% of U.S. and FTA lithium supply to attain a 60% PEV (80% BEV/20% PHEV) share in 2030 for an assumed battery size of 100 kWh. In the more realistic case where the aggregate demand from other FTA countries in addition to the U.S. is considered, a deficit occurs after 2028 in the base case demand scenario (41% PEV in 2030) and would occur sooner and grow faster if U.S. demand is increased to attain the 60% PEV penetration in 2030 being proposed. Supply from IRA-compliant U.S. and FTA countries would support only a 25% U.S. PEV penetration in 2030 for a 100 kWh average battery size if FTA countries meet their lithium demand first before providing excess refined lithium supply to existing U.S. domestic supply.

Mined lithium supply from Australia, an FTA country, could potentially satisfy U.S. demand driven by the proposed standards and make the proposal's assumptions about IRA cost savings more realistic. However, 96% of Australian supply is currently sold to and refined in China, a foreign entity of concern. Quickly relocating Australian supply to a US+FTA country faces significant hurdles given existing business partnerships and the effort to establish new partnerships with capital- and operational-intensive infrastructure.

2.2 Graphite and Nickel

As described in Appendix A, data indicate graphite will be more constraining than lithium. The U.S. currently does not produce any natural graphite and relies on imports mainly from China. The U.S. is projected to have a combined 22k tonnes of graphite refining capacity per year by 2030. USA+FTA countries are projected to reach 203k tonnes per year.[4] For an average BEV battery size of 70 kWh, the graphite produced from US+FTA countries would support 2.9 million BEVs per year in 2030 which would satisfy only 18% of the projected new vehicle sales in 2030. To comply with the 60% BEV share driven by the proposed standard in 2030, 66% of refined graphite would need to be procured from global supplies that are outside of US+FTA control and may not qualify for important IRA benefits to incentivize vehicle purchases.

Nickel is also experiencing tight supply with a focus on mining in a single country, Indonesia, which is projected to comprise over 50% of global mined nickel battery material in 2030. Growing geopolitical and environment concerns surrounding Ni mining in Indonesia are causing instability, and it is still not known whether Treasury Department guidance will consider Indonesia as an FTA country, although Indonesia has proposed such status recently.[5]

2.3 Mining

Over the next decade, projected critical mineral demand will require the development of over 300 new mines.[6] EPA's projections for new mines do not account for the significant risk of announced mines failing to reach the operational stage and the extensive lead times for the successful ventures to reach efficient operation. The proposal claims significant deposits of nickel, cobalt, lithium, and graphite in the U.S. remain undeveloped. The proposal notes DOE has identified 19 mines in addition to three mines from a December 2022 study and concludes these sources could likely advance lithium sufficiency well beyond 2028. When inherent risk factors are considered, only 18

[4] Cite BNEF "Metals Data Hub" online database, last updated Oct. 2022
[5] Citation: https://www.reuters.com/world/asia-pacific/violence-indonesia-nickel-smelter-protest-kills-2-dozens-detained-2023-01-16/
[6] Benchmark Source, More than 300 new mines required to meet battery demand by 2035 (Sep. 6, 2022); https://source.benchmarkminerals.com/ar�cle/more-than-300-new-mines-required-to-meet-batery-demand-by-2035.

out of 50 proposed or announced lithium mining projects in the U.S. are expected to be operational by 2035, according to BMI. For those mines that do reach the production stage, lead times can take 4-7 years without delays for lithium mining and 13-19 years for new nickel mining, according to IEA. Permitting and related environmental concerns add to lead time and are more extensive in the U.S. due to strict regulations and oversight - unlike mining operations in many parts of the world. Over 70% of mineral reserves are within 35 miles of tribal lands, which can further complicate the approval process with government authorities.

2.4 Price Volatility

The economics behind the forecasted tight global lithium supply are at odds with EPA's claim that "the price for Lithium is likely to stabilize at or near its historical levels by the mid-2020s".[7] In this fragile condition of tight supply, every step of complex and intertwined global operations must fall perfectly into place as planned to avoid price spikes. BMI suggests that lithium prices will stabilize, but there is ongoing risk of underestimating potential volatility resulting from future shocks to the system.

Clearly higher mineral prices affect PEV manufacturing costs and then have a commensurate effect on sales volumes. Mining operations have an incentive to minimize risk and thus err on the side of undersupply because excess supply causes prices to drop and profits to decline. According to numerous analysts, such a situation unfolded when a temporary "excess" of global supply spurred by an increase in lithium mining projects occurred at the same time PEV sales slowed in China because of expiring subsidies. These combined events resulted in the current lower lithium prices which are expected to remain through the 2026 timeframe but are not expected to hold, as mining and refining companies will adjust supply to avoid that less profitable scenario.[8]

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[7] 88 Fed. Reg. at 29313.
[8] https://internationalbanker.com/brokerage/why-are-lithium-prices-collapsing

2.5 Conclusion

A deeper analysis of global and IRA-compliant critical mineral supply and demand is needed to support the Final Rule. The proposal's cursory assessment results in erroneous conclusions that "critical battery mineral supply is likely to be adequate to meet anticipated demand, in some cases by a significant margin."[9] The proposal lacks the evidence to support this finding. Demand for critical minerals are higher today than in the years referenced in the proposal due to new government policies and automaker targets. Future demand growth for PEVs is unclear given the uncertain geo-political considerations and supply chain operations beyond the control of manufacturers and EPA. It is highly plausible the tight supply-demand for lithium and graphite will lead to volatile prices. The proposal fails to consider how this could suppress demand and annual PEV market share. The Final Rule must include a significantly more robust and clear-eyed analysis based on a boarder array of sources. It must also reconsider how the global supply chain for mineral mining, refining, cell production, and battery production are most likely to evolve in order to better understand the extent to which IRA or other financial incentive can be considered in the cost analysis supporting the rule.

3 Battery and Component Production

Toyota's assessment of production capacity aligns with DOE's projections referenced in the proposal where expected growth based on new plant announcements in North America is estimated to reach 838 GWh annual capacity by 2025 and 998 GWh by 2030. Just as with mining operations, there is lead time to establish a battery factory and then ramp up production. Constructing new facilities, scaling up operations, and training a new workforce is challenging and takes time. According to e-Source, it takes about 4 years to reach full scale battery production.

- Year 1: 75% for full year's production
- Year 2: 85% for full year's production

[9] DRIA at 3-23.

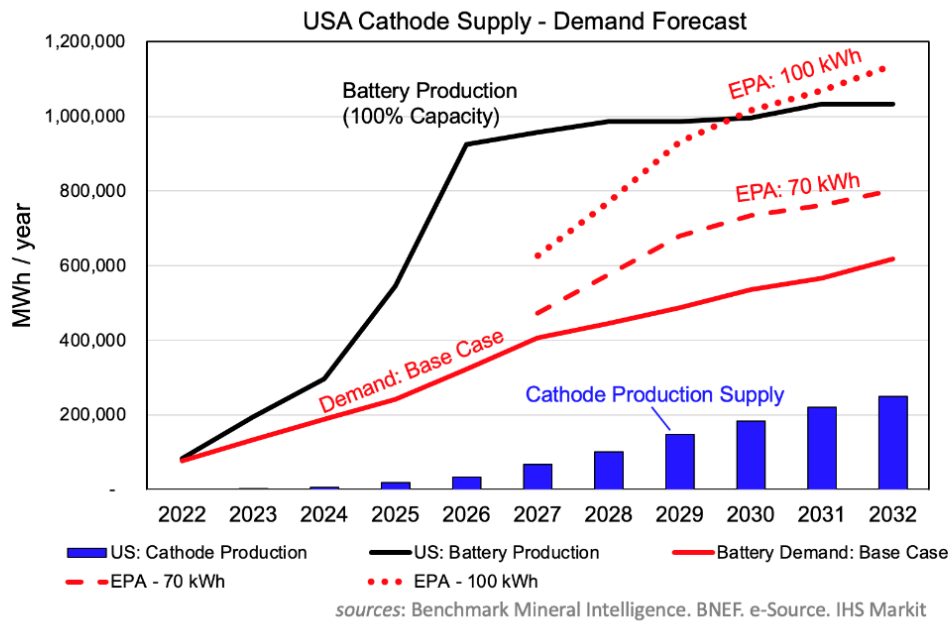
- Year 3: 87% (89.5% by end of the year)

3.1 Midstream Constraints

Battery manufacturing capacity is less a constraint to achieving future BEV adoption than the upstream supply chain steps for sourcing the minerals. The proposal notes preliminary projections prepared by Li-Bridge for DOE in November 2022 indicate that global supplies of cathode active material (CAM) and lithium chemical product are expected to be sufficient through 2035.[10] However, more recent assessments project shortfalls for upstream mining and the midstream processing and cathode/anode production capacity to supply the new battery factories with the necessary battery minerals.[11] Leveraging data from BMI, BNEF (Bloomberg New Energy Finance), e-Source and IHS Markit, we find that with U.S. battery manufacturing at 100 percent capacity is sufficient to meet EPA's proposed requirements at 70 kWh average battery size. However, the production of US cathode manufacturing is in severe deficit, even to achieve the previously discussed base case of 41% PEV penetration in 2030 (Figure 1).

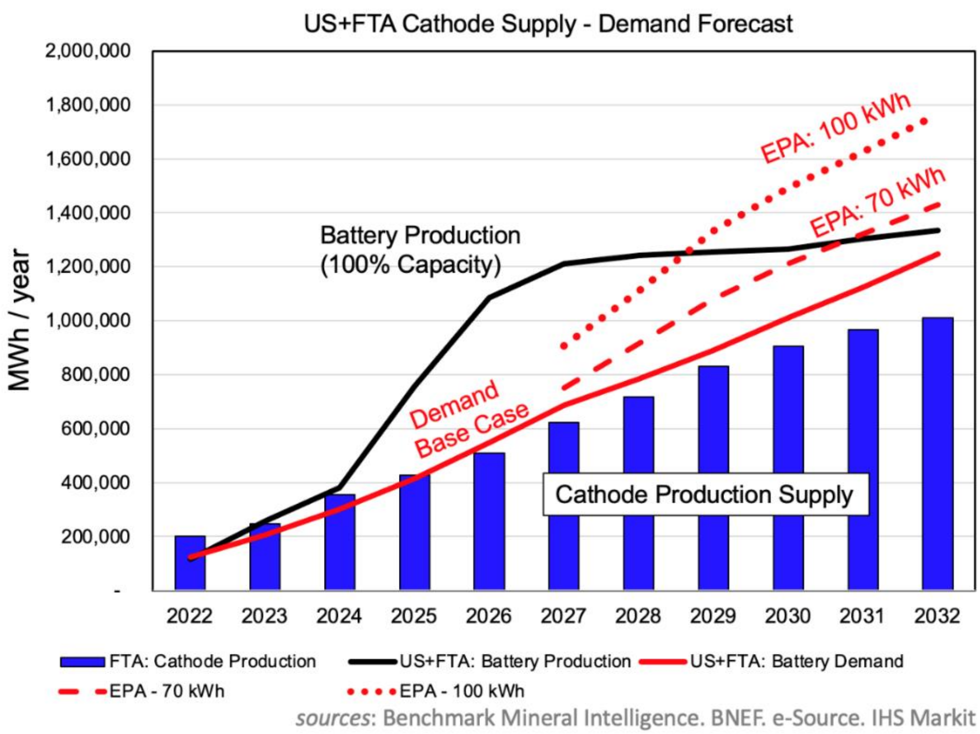
[10] 88 Fed. Reg. at 29319
[11] Benchmark Minerals, Report, Q1 2023

Figure 1 U.S. Cathode Supply-Demand Forecast



For this important mid-stream step of cathode manufacturing, a similar deficit of US+FTA sourced cathode material also occurs for a base case 41% BEV penetration rate in 2030. Again, production is not constrained by battery manufacturing capacity but rather by US+FTA cathode manufacturing capacity as illustrated in Figure 2. China makes up 83% of cathode manufacturing with Japan and S Korea at 15%, and the rest of the world at 2%. Because Japan and S. Korea are already included in US+FTA supply, a significant ramp up of new cathode manufacturing in IRA-compliant countries is needed to meet US base case demand and EPA proposed requirements.

Figure 2 U.S.-FTA Cathode Supply-Demand Forecast



3.2 Conclusion

Battery production is less of a constraint than the materials and midstream production that feed into that process. In addition to cell manufacturing, the assessment supporting the Final Rule needs include the capacity of cathode and anode active material manufacturing and the resulting impact on battery and ultimately PEV costs. The Final Rule needs to account for the lead time associated with establishing new facilities and ramping up production operations to full scale capacity. Finally, cost assessments supporting the Final Rule need to account for the share of production that will not qualify for the IRA benefits which could affect the modeled BEV penetrations.

4 Battery Costs Projections

EPA's assessment of future battery costs is highly optimistic and inconsistent with available sources. The assessment starts with an inaccurate baseline cost for 2022 and then uses an incomplete set of forecasts to develop two trajectories which rely on assumed mid-decade price stabilization of lithium. The assessment appears to ignore the risk for price spikes arising in a tight and geopolitically sensitive market for critical minerals. Please see Appendix A on mineral supply and potential price implications. Lastly, EPA applies tax credits from the IRA 45X provision in a confusing way that could go beyond the intent of the legislation.

4.1 Baseline Assumptions

To arrive at the 2022 baseline for direct manufacturing costs, EPA used ANL's BatPaC 5.0 to develop a sweep of expected costs ($/kWh) for varying battery sizes (gross kWh), at four different production rates as shown in Figure 3. EPA selected a 75kWh battery at 250,000 packs/year to arrive at $120/kWh to represent the baseline. EPA attempts to justify the baseline by comparing it to a Tesla 30-40 GWh capacity "gigafactory". The assumed production rates are overly optimistic and contrary to our comments above on the lead time and scale up of new battery production facilities. EPA must recognize battery plant sizes and capacities will vary greatly based on a host of factors ranging from site size to workforce availability, to logistical optimization in the vehicle production footprint, to battery mineral/cell/pack supply chains and sources, to capital availability, and so forth. EPA appears to have selected a large capacity facility to represent what it expects will be "typical". If EPA had data suggesting a 250,000 unit per year battery facility would be "average" then this approach might make sense. As it stands, such a large facility is more likely to be the exception and not the rule, and EPA should expect most battery production to align with the lower capacity curves in Figure 3. Painting the entire industry's manufacturing approaches with a single broad brush likely underestimates costs.

Figure 3 Proposed Rule Cost Estimates by Battery Size and Production Rates[12]

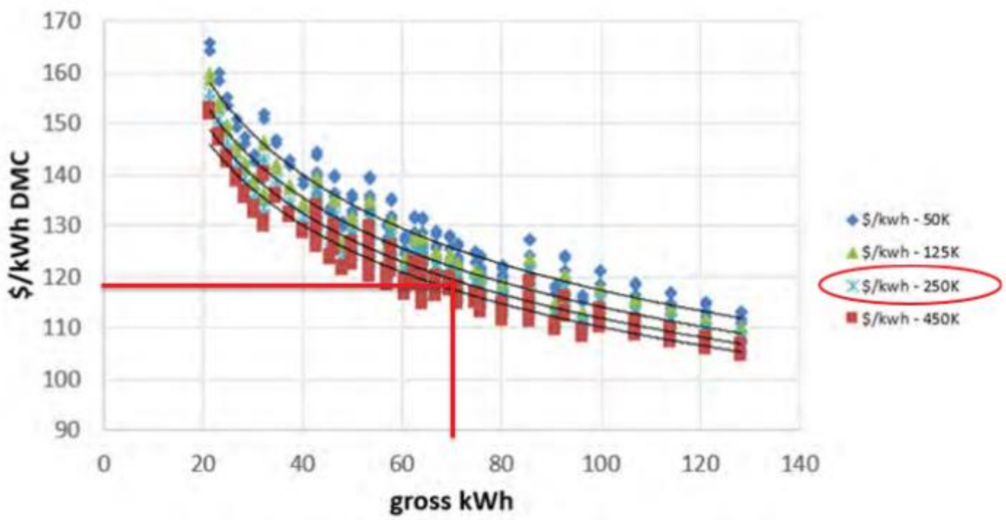


Figure 2-20. Direct manufacturing cost estimates for BEV packs at various annual production volumes for NMC811-G chemistry, base year 2022.

EPA also seeks to justify the baseline battery cost with a qualitative comparison to the summary of cost projections from EDF/ERM as seen in Figure 17.[13]

Toyota's assessment of available sources finds baseline battery costs significantly higher than $120/kWh. We considered three studies by e-Source, Mauler et. al., and BNEF and added them to EPA's DRIA Figure 2-24 (shown in Figure 4). For EPA's battery cost future projections, we added insights from two studies, Mauler et.al. again, and an MITEI study.

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[12] Figure 1 - EPA DRIA Figure 2-20 Plot of Base Year 2022 DMC estimates for different sized BEV battery packs at 4 different production rates

[13] Environmental Defense Fund, Electric Vehicle Market Update (Sep. 2022) at pg. 27. Available at https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2022/09/ERM-EDF-Electric-Vehicle-Market-Report_September2022.pdf.

Figure 4 EDF/ERM Batter Cost Survey form Proposal with Added Data

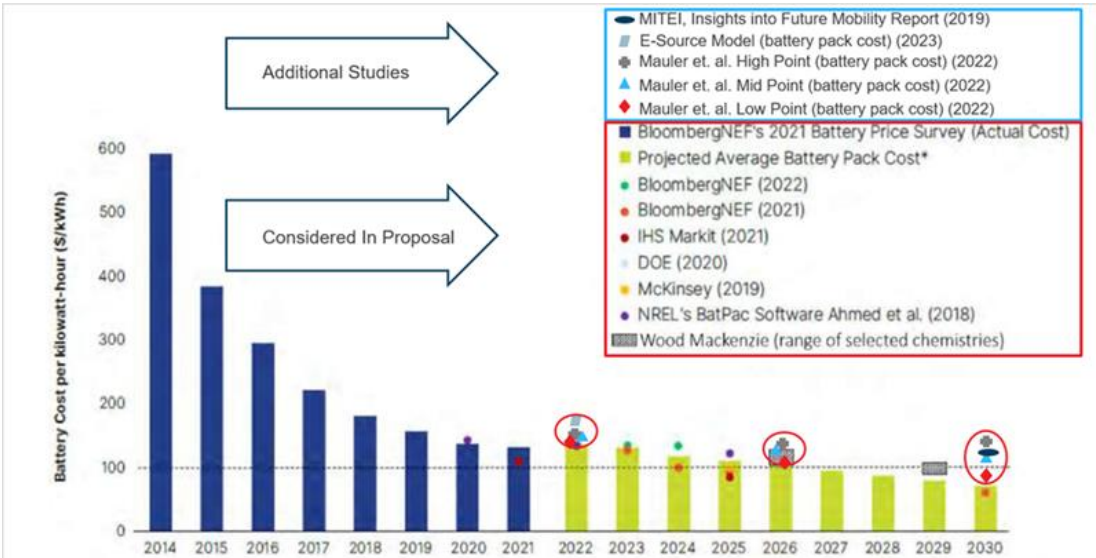

Figure 2-24 Projected battery pack costs from various sources summarized by EDF/ERM
Including E- Source, and Mauler et. al. Study battery pack cost findings from Toyota and AAI Analysis

A 2023 study from e-Source, which specializes in downstream battery supply chain analysis and manufacturing modeling,[14] concludes a cost of $158/kWh in 2022 for a 75-kWh NMC811 battery pack produced at US 100-GWh plant at 250,000 packs/year. This is significantly higher than the proposal's stated $120/kWh for 2022 – even at the high production capacity of 250,000 units.

The December 2022 updated annual battery price survey from BNEF observes average lithium-ion battery pack prices of $141 per kilowatt hour in 2021 increasing to $151 in 2022, representing the first increase since 2013 (Figure 5). This agrees with the e-Source study and is consistent with the price volatility in 2022 stemming from skyrocketing raw material prices, record-setting inflation, and geopolitical tensions with Russia. EPA appears to have used the 2022 BNEF data, however the 2022 data point is not included in Figure 4.

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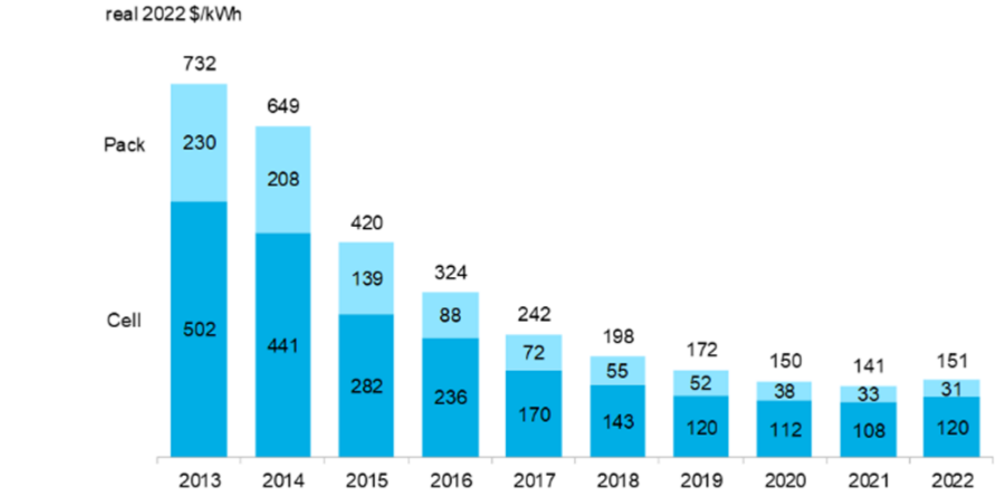
[14] Proprietary study by e-Source for USA cost per pack of NMC811, 75 kWh packs at 250,000 packs per year assumed.

Figure 5 BNEF Battery Pack and Cell Cost Projections



Source: BloombergNEF. All values in real 2022 dollars. Weighted average survey value includes 178 data points from passenger cars, buses, commercial vehicles and stationary storage.

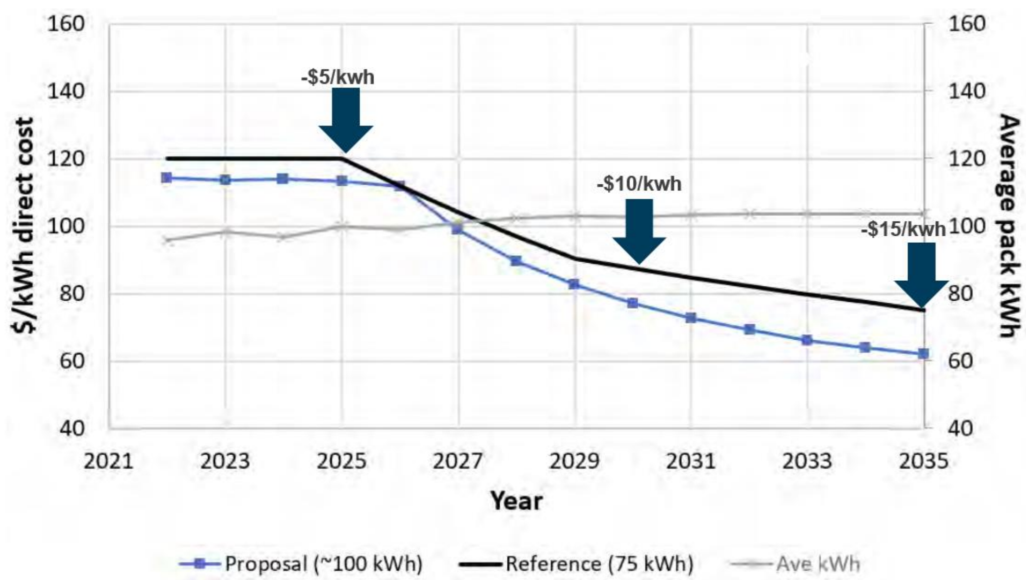
4.2 Forecasts

The EDF/ERM report referenced in Figure 4 is used to establish a cost trajectory that is anchored by the following data points: $120/kWh baseline for 2022, $110/kWh for 2026 and $90/kWh for 2030.

In Figure 6, direct manufacturer costs for a 75-kWh battery (black line) that decline over time are developed by applying assumed rates of learning to the "reference trajectory". The trajectory for a 100-kWh battery (blue line) was then generated in the OMEGA model.

The steepest reductions occur from 2025 to 2029 due to assumed stabilized lithium prices by the mid-2020s. The price for the 75-kWh battery falls to about $90/kWh in 2030 which implies 25% reduction in cost from 2022 baseline. The 100 kWh battery cost declines from the $115/kWh baseline to about $78/kWh in 2030 resulting in an 32% reduction, and to $61/kWh in 2035, a 21% cost reduction. The resulting costs seem implausible and would be considerably higher if upward pressure on prices cause by tight supply of were appropriately considered.

Figure 6 OMEGA Battery Pack Costs



Toyota's referenced sources indicate the cost of batteries is expected to decline in the future, but this decline could be slowed or even reversed if battery raw material prices rise. Technological innovation is expected to lead to significant cost reductions, but there is a significant risk that it may not be able to offset the rising cost of critical minerals. The Mauler *et.al*. study analyzed several battery forecast studies and found "the methods of technological learning, literature-based projection, bottom-up modeling, and expert elicitation…(and) technological advances... and economies of scale" [15] tend to neglect raw material price volatility. When rising material cost is added to the analysis as a main variable, even the slightest increase threatens to offset those production savings for battery costs. The study found the 2030 battery pack cost for low price case to be $96/kWh, and $130/kWh for the high price case, with a midpoint of $113/kWh. This is in stark contrast to EPA's 2030 battery pack cost projection of $78/kWh in 2030.

Finally, a 2019 study by MIT Energy Initiative (MITEI) finds that "Though battery costs have declined substantially, predictions about future price declines must be approached with caution as

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[15] Id.

they often fail to account for the cost of the raw materials used to make batteries."[16] MITEI projects the 2030 price of a Li Ion battery pack will be $124/kWh, despite a decline in costs. This aligns the fluctuating price of Li, Ni, Mn, Co and C found in the Mauler et. al. study, which was done independently and in 2022.

4.3 Application of IRA

Projected battery costs are further reduced in EPA's analysis by applying the IRA 45X cell and module tax credits. To do this, the direct manufacturing costs above are scaled up to their retail price equivalent (RPE) from which the IRA tax benefits are subtracted resulting the lower cost curve in Figure 7.

Figure 7 IRA 45X Cost Reductions

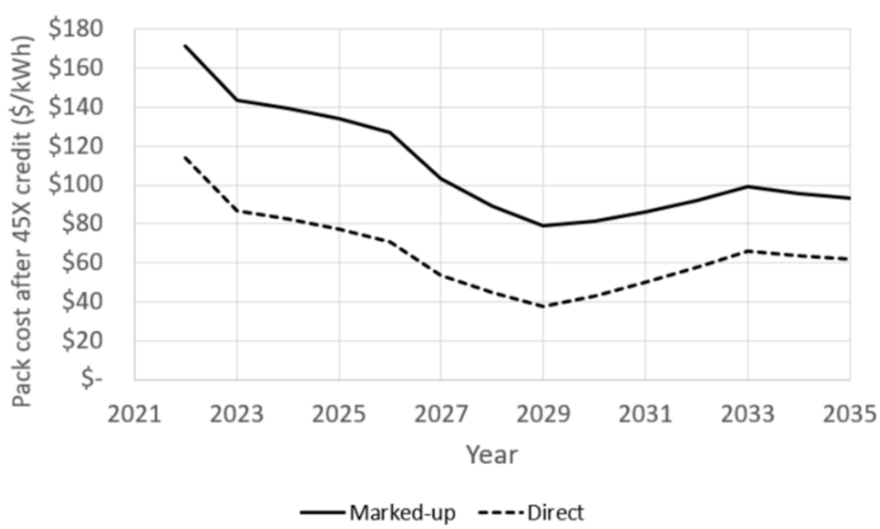

Figure 2-27: Volume weighted average pack direct manufacturing cost and marked-up cost per kWh after application of 45X credit

It is unclear as to how the IRA tax credits are applied to arrive at the lower curve. The RPE curve seems to be missing from Figure 7making it impossible to visualize the actual cost reductions due

[16] MIT Energy Initiative. Insights into Future Mobility. Cambridge, MA. (2019), 77-79. https://energy.mit.edu/wp-content/uploads/2019/11/Insights-into-Future-Mobility.pdf

to the IRA tax credits. Toyota recommends the Final Rule clearly describe and illustrate each step of the process and provide an accounting of the cumulative IRA tax credits applicable each year, as well as the marked-up (RPE) costs prior to the IRA tax credits being applied for comparison. Toyota believes EPA must reconsider how the IRA benefits are being applied to achieve battery cost savings for the proposed standards. The resulting battery costs seem implausible as total battery costs after the tax credit can be negative.

EPA assumes that starting in 27MY virtually every battery produced on the path to hitting the 67% BEV target in 32MY will be produced in the U.S. and earning the 45X credit. This is unrealistic and not supported by the U.S. Department of Energy or any other projections. EPA's own analysis of this scenario would put the cost of the 45X credit related to the proposed rule at around $160 billion between 2027 and 2032 - nearly six times the total CBO score of $30.6B.

Further, EPA assumes that starting in 27MY, every BEV sold in the US will receive part of the combined 30D+45W Clean Vehicle Credits, up to a maximum of $6,000 per BEV in 32MY. EPA's own analysis of this scenario would put the total cost of the 30D+45W Clean Vehicle Credits related to the proposed rule at around $270 billion between 2027 and 2032 – nearly twenty-five times the total CBO score of $11 billion ($7.5 billion for 30D and $3.5 billion for 45W).

4.4 Conclusions

The battery cost projections in the proposal are not realistic because they do not sufficiently consider the dynamic external variables creating tight supply which increase the risk of supply chain disruptions and volatile raw material prices. Nor does EPA's assessment account for the time it takes to establish and ramp up battery production. The Final Rule must take a broader view of available expert sources and reconsider the applicability cost reductions through IRA. The result should be revised the battery cost projections.

5 GHG Program

The Proposed Rule fails to demonstrate the penetration of BEVs assumed for compliance with the proposed standards is feasible. The proposal notes "While emission standards set by the EPA under CAA section 202(a)(1) generally do not mandate use of particular technologies, they are technology-based, as the levels chosen must be premised on a finding of technological feasibility."[17] CAA section 202(a)(1) states "Any regulation prescribed under paragraph (1) of this subsection (and any revision thereof) shall take effect after such period as the Administrator finds necessary to permit the development and application of the requisite technology, giving appropriate consideration to the cost of compliance within such period."[18]

The aggressive ramp up of BEVs (see Table 1) required to comply forces a rapid transformation of how vehicles are manufactured, driven, fueled, and serviced. As such, "leadtime and requisite technology" must extend to the availability of critical minerals, the readiness of a sustainable battery supply chain and fueling infrastructure, as well as other market-related factors that will affect the price and consumer demand of BEVs.

Table 1 Annual BEV Penetration Assume for Compliance w/ Proposed Standards

MY	2027	2028	2029	2030	2031	2032
BEV Share	36	45	55	60	63	67

Today's PEV support system clearly cannot meet the needs of the future envisioned by the proposal. Our comments explain why the proposal lacks a clear justification for how the support system will be in place over the period of the proposed standards. Neither EPA nor auto manufactures can control the timing or outcomes of these essential support measures.

Therefore, it is disappointing that EPA removed the e-RIN proposal from the RFS set rule as it is one of the few measures for which EPA has direct authority to provide at least some level of assistance in supporting the EV shares required in the GHG proposal. After a muti-year

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[17] 88 Fed. Reg at 29232.
[18] 42 U.S.C. § 7521(a)(2).

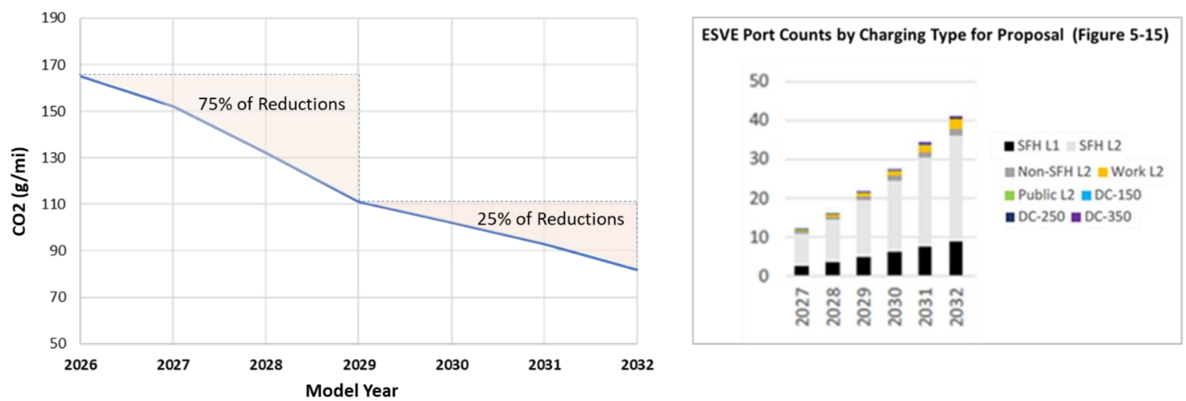
collaboration with the auto industry, a valuable policy tool for establishing PEV markets and promoting clean energy has been lost.

Finally, EPA has taken a more measured view of technology risk and uncertainty in past vehicle emissions rulemakings in which technology costs were lower and automakers had significantly more direct control over managing their technology development, deployment, and sales mix to comply. In this Proposed Rule, EPA appears to be taking a much more cavalier approach to risk, lead time, and ensuring the "requisite technology" is available, despite the high cost of BEVs, the massive uncertainty around mineral supplies, the significant investment needed in charging infrastructure and the power grid, and the uncertain market demand for BEVs. The standards in the Final Rule should be adjusted to better account for market uncertainties.

5.1 Annual Stringency Increase

The greatest rate of emissions reductions is required over the first three years of the proposed standards with annual rates of improvement is as high as 16% (compared to a maximum of 12% annual rate over the final three years) (see Figure 8). This front-loaded stringency runs contrary to the longstanding recognition that technology penetration is slower in early stages of market development and accelerates with continuous refinements and growing consumer awareness and acceptance. The situation is made worse by the BEV-forcing nature of the proposal and the requisite need to establish battery supply chains, production capacity, and charging infrastructure.

Figure 8 Required PEV Growth Versus Infrastructure Ramp Up



EPA requests comment on whether the standards should extend beyond the 2032 model year. Toyota is concerned that the proposal has not adequately addressed the market uncertainty surrounding the proposed standards through 2032 model year. Therefore, we believe it would be inappropriate to extend the standards beyond 2032.

5.2 Limited Compliance Paths

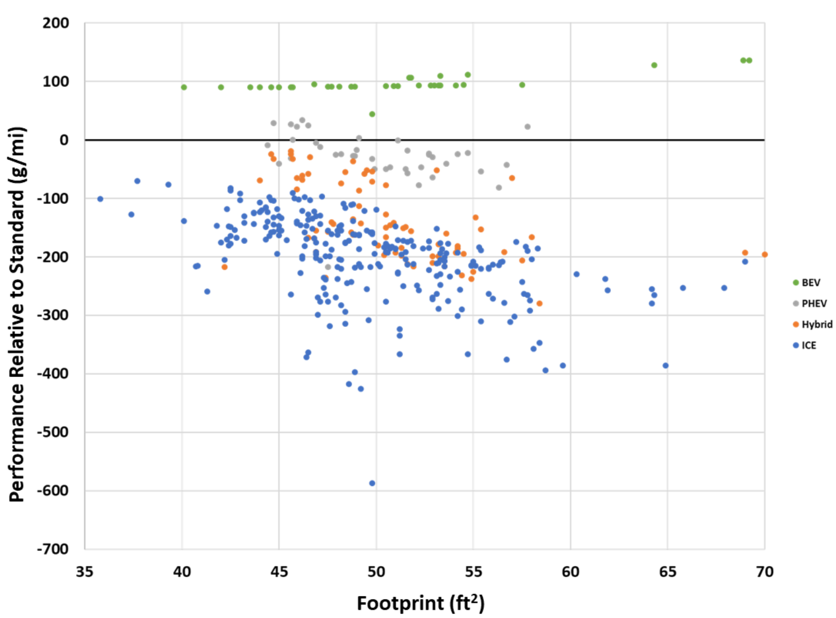
EPA suggests that manufacturers have the flexibility to pursue alternative paths that require less BEVs than assumed in the preferred alternative. In practice, standards based on 60 to 70 percent of the fleet performing at zero grams per mile severely constrain the ability of non-ZEV technologies to displace the assumed BEV penetration and still comply with the combined fleet target of 102 g/mi standard in 2030 model year and 82 g/mi in 2032 model year. Based on data from the OMEGA model for the 2027 model year, the projected combined-fleet performance for conventional ICE and strong hybrid vehicles, on average, cannot attain the proposed combined-fleet standards for that model year (Table 2). The performance gap of these technologies relative to the standards widens with each following model year. This does not mean every ICE vehicle and hybrid will no longer comply with its footprint target in 2027 model year but increasingly these vehicles will need to be offset with larger and larger shares of BEVs and PHEVs for compliance with the fleet standards.

Table 2 2027 Model Year Combined Fleet Performance Relative to the 2027 Model Year Standard

Standard (g/mi)	CO2 (g/mi) Performance		Comply
	HEV	ICE	
152	192	240	No

In Figure 9, the performance of every 2022 model year vehicle is compared to its respective footprint target proposed for the 2030 model year. Vehicles are distinguished by powertrain technology type with strong and mild hybrids lumped together. BEVs are the only technology for which every vehicle can meet the proposed 2030 standard. This further illustrates that 2030 standards are essentially a BEV mandate.

Figure 9 U.S. Combined Fleet 2022MY Performance Relative to 2030 Footprint Targets



This poses significant risks to consumers, automakers, and the environment. Should the BEV market not mature at the rate EPA expects due to any of the myriad factors already described, consumers may be unable to find suitable non-BEVs that meet their needs as automakers would likely have cut back investment in these products. The result could be that consumers hold on to older, higher-emitting vehicles longer. Such a scenario is not beneficial for consumers or the environment. If automakers can somehow "backfill" weak BEV demand with other vehicles and technologies, they could face compliance challenges. The simple technology market share analysis using combine fleet emissions values (Table 3) shows several scenarios for "USA Motors" in which industry-wide BEV sales fall short of EPA's expected 60% in 2030 and are "backfilled" by other technologies such as ICE, HEV, and PHEV. While these scenarios would be good for consumers, it would clearly place automakers in a difficult compliance situation based on factors outside their control. We expect the GHG credit market would not be equipped to resolve this magnitude of compliance shortfall, especially with off-cycle credits proposed to be eliminated.

Table 3 U.S. Combine Fleet Recovery Scenarios for Less Than 60% BEV in 2030 MY

Technologies to Comply (CO2 Performance*)	Mix for Assumed 60% BEV Penetration	Mix for Actual 45% BEV Penetration	
		PHEV/HEV Recovery	ICE Recovery
ICE (259 g/mi)	37%	30%	51%
HEV (197 g/mi)	3%	15%	4%
PHEV (89 g/mi)	0%	10%	0%
BEV (0 g/mi)	60%	45%	45%
Fleet Performance	102 g/mi	115 g/mi	140 g/mi

*Includes 6 g/mi AC Efficiency Credits for ICEs

The ability to pivot on technology strategies and product plans is already severely limited by the resource shift to electrification and becomes more impractical the longer it takes for unresolvable market problems to surface. The only remedy in such a scenario is to revise the standards, which consumes time and complicates automakers' planning and investments.

6 Role of PHEVs and HEVs

Diversity is the antidote for uncertainty. The Final Rule must be more inclusive of PHEVs and HEVs to hedge compliance and environmental risks in the event the BEV market is slower to develop because of the previously mentioned market uncertainties. Unfortunately, PHEVs are excluded from the compliance modeling used to demonstrate feasibility of the standards; and HEVs are relegated to a subset of ICEs never exceeding 3 percent combined-fleet penetration when the technology is in 7 percent of all vehicles sold today.[19]

The proposal acknowledges "PHEVs can provide significant reductions in GHG emissions and a bridge for consumers that may not be ready to adopt a fully electric vehicle."[20] Toyota is seeking carbon reductions as quickly as possible by providing our customers with a range of low carbon solutions that best fit their incomes, needs, and lifestyles. From that perspective, BEVs, PHVs, and HEVs have a role to play in displacing conventional petroleum vehicles from the road. During the transition to electrification, PHEVs and HEVs offer a broader spectrum of more accessible low carbon options to consumers.

6.1 PHEV Architectures and Applications

This modeling deficiency seems temporary in the case of PHEVs as EPA seeks comment and recommendations on the types of PHEV architectures that should be considered for the analysis supporting the Final Rule. Toyota recommends that modeling for Final Rule include the more capable strong-PHEV designs being introduced to meet US06 high power cold starts as well as the range-extending architecture EPA mentions being studied at Southwest Research Institute. We agree PHEV architectures can provide pickup trucks expanded utility and power in addition to all-electric miles, but believe the technology is viable for the entire spectrum of vehicle classes including sedans, CUVs, SUVs, minivans, and pickup trucks as evidenced by the Prius Prime and RAV 4 Prime. Compliance modeling to support the Final Rule should incorporate the technology into all light-duty vehicle classes.

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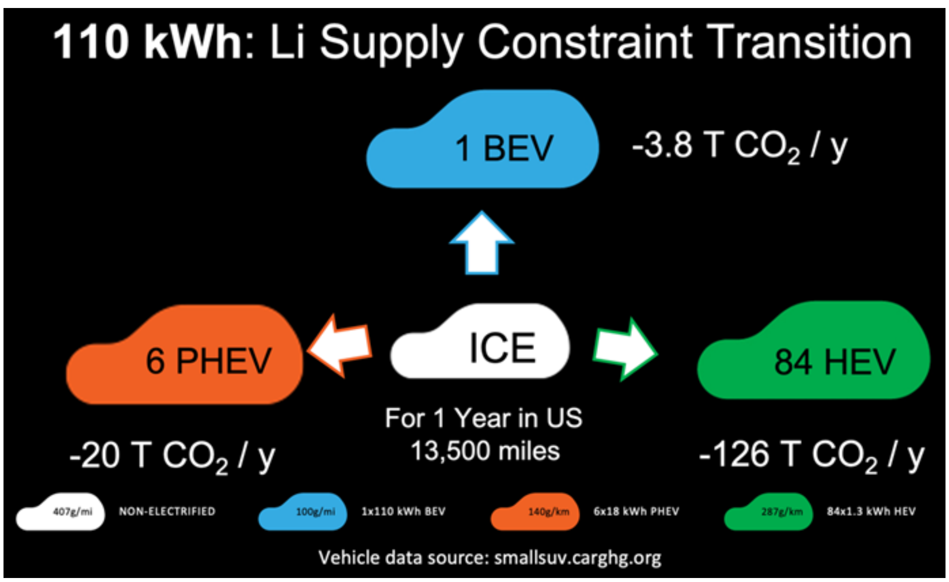
[19] S&P Global Catalyst for Insight – Data As of April 30, 2023.
[20] 88 Fed. Reg. at 29298.

6.2 Technology Assessments Should Incorporate Critical Mineral Supply and Lifecycle Emissions

The modeling should also include a sensitivity analysis of BEV/PHEV mix on critical mineral usage for any assumed overall PEV penetration. PHEVs can make the most efficient use of the limited battery supply and constrained infrastructure network forecast through the period of the rulemaking. The below example compares different vehicle powertrain emissions for a mid-size SUV using peer-reviewed data from carghg.com. The same amount of lithium in the battery of one 300-mile plus BEV can be used for up to six PHEVs –or more than eighty conventional hybrids. See Figure 10 for the CO_2 saved from replacing a mid-sized SUV powered by a conventional gasoline engine with electrified alternatives under a constrained lithium supply. This analysis assumes average US electric grid emissions for BEVs and the electric operation of PHEVs.

Figure 10 CO_2 Saving from Replacing ICEs Under Constrained Mineral Supply



PHEVs can rival the emissions performance of BEVs under many real-world operating conditions. PHEVs are not always the best-performing option but can have as good or better lifecycle performance because of lower manufacturing emissions for smaller batteries and lower well-to-tank emissions while still covering a significant fraction of daily trips in electric drive. Given most average daily trips are under 50 miles, this results in a significant portion of all-electric miles like a BEV.

Toyota supports EPA's proposal to permanently codify the zero g/mile treatment of tailpipe emissions for BEVs, FCEVs, and the all-electric driving portion of PHEVs. We have long opposed auto manufacturers being held responsible for upstream emissions beyond our control. That said, we do believe vehicle technology assessments supporting GHG rulemakings should account for life-cycle emissions under real-world operating conditions when evaluating the relative benefits of competing technologies. Limiting technology assessments to tailpipe emissions ignores factors such as geography, weather, and power sources which can mischaracterize the true relative performance and value of electrified powertrains, missing opportunities for further GHG emissions reductions.

6.3 Next Steps Toward Final Rule

EPA requests any relevant performance or utility data that may help inform their analyses for the Final Rule. We appreciate the opportunity to share data which will help elevate the role PHEVs in the Final Rule to be an important part of a sustainable transition to electrification. We plan to share such PHEV data outside of the comment period, possibly, including confidential information. For now, we request EPA consider the data we have provided that suggests PHEVs should be considered be an important contributor in whatever assumed PEV sales mix.

The proposal notes "that the inclusion of PHEVs could potentially increase the combined ZEV share projection beyond the BEV penetration levels shown."[21] For all the reasons covered to this point in our comments, Toyota strongly believes that PHEVs must be considered a PEV-alternative to BEVs, consistent with President Biden's Executive Order 14037. PHEV buyers seek price, utility, and total driving range that a BEV may not offer. PHEVs must be considered a substitute for BEVs and not ICEs or a way to increase total PEV share beyond 60% in 2030 and 67 percent in 2032.

[21] 88 Fed. Reg. at 29329

6.4 PHEV Utility Factor

The proposed revisions to the SAE vehicle Fleet Utility Factor (FUF) curve would significantly diminish PHEV compliance benefits and challenge the technology's market viability at a time when consumers and the proposed standards need more plug-in electric vehicle (PEV) options available. Toyota believes the FUF should remain unchanged as the proposal offers insufficient evidence to support such a consequential test procedure change for which there has been minimal industry engagement.

6.4.1 Supporting Studies Lack Peer Review

EPA contends available real-world data suggests the current PHEV compliance methodology which incorporates the SAE J2841 FUF curve significantly underestimates PHEV CO_2 emissions. The proposal references the authors of several studies that have questioned the efficacy of the SAE UF for PHEVs in Europe. These studies are not relevant to PHEV operation in the U.S. It is well documented that the real-world data in Europe is skewed by less capable PHEVs that were provided by companies to employees with free gasoline as a perk, but not free electricity. Further, tax policy in Europe incentivizes PHEV purchases but charging opportunities are often limited for multifamily dwellings which are common. Not surprisingly, PHEVs in the Europe-focused studies were primarily driven as conventional hybrids on gasoline. Finally, the potential for discrepancies in label versus real-world all-electric PHEV range is greater in Europe where the values resulting from the labeling procedure are significantly more optimistic than those in the U.S.

As seen in Table 4, several studies or articles are referenced in support of the proposed revision to the SAE FUF, only one of which has been peer reviewed by a neutral third-party, i.e. not chosen by the authoring organization. The proposal excludes several relevant peer-reviewed publications, including papers by Toyota[22] and UC Davis[23] that provide counter-balancing arguments to the claims that the SAE UF is no longer appropriate. Toyota's paper was peer-reviewed using a double-

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[22] Hamza, K., Laberteaux, K. and Chu, K.C. "On inferred real-world fuel consumption of past decade plug-in hybrid electric vehicles in the US," Environ. Res. Lett. 17 (2022) 104053.

[23] Raghavan, S. and Tal, G. "Plug-in hybrid electric vehicle observed utility factor: why the observed electrification performance differ from expectations." Int. J. Sustain. Transp. (2020) 16: 105-136.

blind process managed by the editors of the journal Environmental Research Letters. This paper directly rebuts the Fraunhofer/International Council on Clean Transportation (ICCT) paper and was published in the same journal as that Fraunhofer/ICCT paper, and after the Fraunhofer/ICCT appeared.

Table 4 Supporting References for Revision to J2841 FUF Curve

Reference Number in EPA NPRM	Primary Authoring Organization	Type of Article	Geographic Area of Focus	Publication Year	Peer Reviewed[1]?
472	T&E	Report	Europe/World	2020	No
473	ICCT	White paper	World	2020	No
474	ICCT	White paper	Europe	2022	No
475	Fraunhofer/ICCT	Journal Paper	World	2021	**Yes**
481	Fraunhofer	Report	Europe	2021	No
482	T&E	Report	Europe	2022	No
483	ICCT	White paper	US	2022	No

Instead, the proposed FUF change relies on the analyses of two error-filled datasets to depict real-world PHEV operation in the U.S. ICCT first presented the Fuelly and California BAR datasets in a December 2022 whitepaper.[24] Both the data and the analyses lack the scientific rigor required to support revising the SAE FUF curve.

6.4.2 Fuelly Web Application Dataset

The Fuelly website application is designed for gasoline vehicle users to input miles driven, refuel amount, and fuel price to calculate fuel economy and the operating costs incurred.[25] The input parameters do not allow charge-depleting (CD) and charge-sustaining (CS) driving miles to be calculated. The web application lacks separate inputs for electricity and gasoline consumption. Instead, there is a single input field labeled "Fuel" used to calculate the cost of fuel consumption which is the primary purpose of the web application.

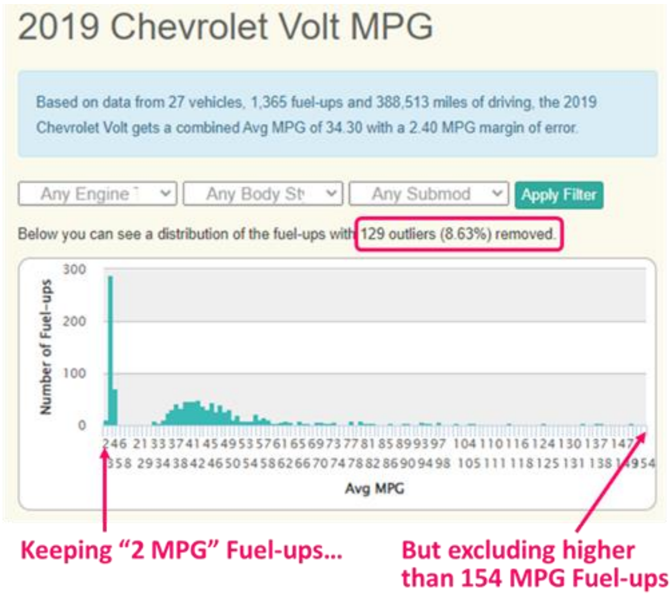
[24] "Real world usage of plug-in hybrid vehicles in the United States." Aaron Isenstadt, Zifei Yang, Stephanie Searle, John German, ICCT Report, December 2022.
[25] Fuelly is also available as a mobile phone application.

Inspecting the data in the Fuelly application has confirmed the lack of a dedicated interface for electricity consumption leads to data input errors. For example, samples of certain Tesla battery electric vehicles have values labeled as "miles per gallon" (MPG) entered in the "Fuel" input field instead of the appropriate "miles per kilowatt-hour" (kWh) units. This results in extremely low mile-per-gallon numbers being reported, significantly lower than expected for comparable- class gasoline vehicles. We believe that when owners attempt to track their electricity cost with the Fuelly interface, the application's back-end code treated the entered kilowatt-hour values as gasoline miles per gallon values, as suggested by Figure 11. This error significantly increases the inferred fleet-wide fuel usage and decreases the utility factor for PHEVs.

Figure 11 Selected Fuelly Data Entries for Tesla Model S (screen shot)

At the opposite end of the error spectrum, refueling events for PHEVs with an accurately high charging frequency and utility factor have been excluded as outliers by the Fuelly application solely because of their superior fuel economy. For example, it is not uncommon for a regularly charged Chevrolet Volt to attain 200+ MPG which can be filtered by from the distribution of re-fuel events because the value lies beyond Fuelly's 3-sigma screening limit that is applied to fleet average MPG (see Figure 12 below). These omissions further mischaracterize PHEV real-world fleet performance.

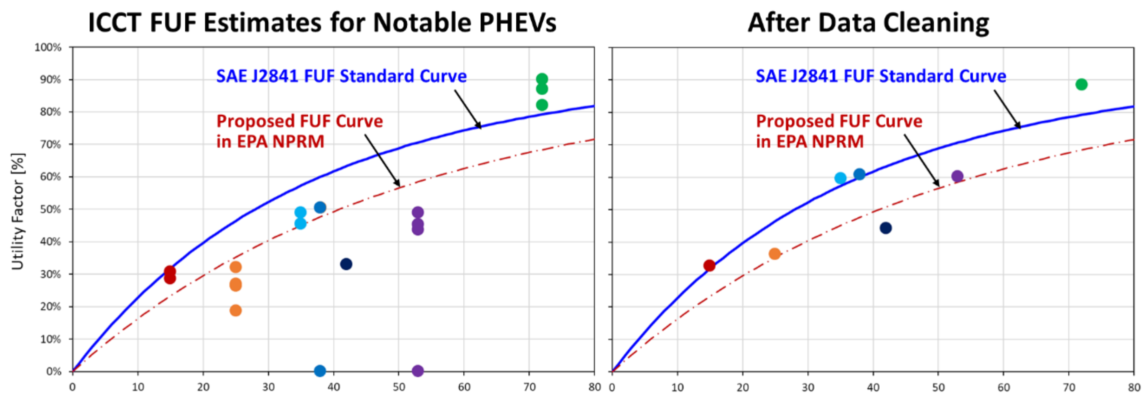
Figure 12 Fuelly Results for 2019 Chevrolet Volt



The left side of Figure 13 compares for selected PHEVs the UFs that ICCT inferred from the Fuelly data to both the SAE and EPA proposed UF curves. Though tedious, it is possible to correct or "clean" the Fuelly data for every refuel event of the selected PHEVs. The right side of Figure 13 shows that Toyota's cleaning of those selected data points results in the corrected Fuelly data curve being much closer to the SAE curve.[26] It is also important to note that, using the methodology ICCT used, and Toyota repeated (after appropriately cleaning the data), if the charge sustaining (CS) fuel-economy (in MPG) is lower than the EPA label CS fuel-economy (in MPG), then the calculated values, shown below, only represent lower bounds of UF on the on-road.[27]

[27] See Appendix B for a description of the data cleaning process.

Figure 13 Impact of Correcting Erroneous Data on Fleet Utility Factor (FUF)



Prior to the proposal being issued, Toyota met with EPA to raise concerns about the efficacy of ICCT's attempt to infer a real-world PHEV UF from the Fuelly web application. We reviewed a slide deck that deconstructed ICCT's methodology and identified examples of uncorrected data entry errors that directly impact the conclusions reached in ICCT's whitepaper.[28] Our efforts to replicate the Fuelly-based calculations described by ICCT in the 2022 Whitepaper and this proposal strongly suggest such cleaning of the data errors still has not happened.

6.4.3 BAR OBD Dataset

The OBD data obtained from the California Bureau of Automotive Repair (BAR) program does provide the vehicle parameters necessary to calculate an in-situ Utility Factor such as charge-depleting distance, charge-sustaining distance, and total distance traveled. However, as the proposal notes, there are limitations with the available data which Toyota believes make it unfit for depicting normal PHEV usage patterns. The BAR Smog Check program, which periodically collects the abovementioned parameters, is required in California for vehicles:

- 8-years or older,
- 4 model-years or older that change ownership, or
- Registered in California after moving from another state.

[28] The slide deck from the March 13, 2023 meeting is included as Appendix C.

The PHEV data tracking requirement in the BAR program started with 2019 model year but did not fully phase in until 2021 model year. The most recent vehicles in the cited BAR dataset used to support the proposal are from the 2022 model year, so none of the PHEVs in the sample were obligated to participate due to the age criteria referenced above. Considering a California Smog Test requires some effort and money from the vehicle owner, it is reasonable to conclude that few vehicle owners are going to pursue a test if it is not required. Therefore, the BAR OBD data evaluated for this proposal is dominated by recently registered 2019-2022 model year PHEVs that underwent the mandatory smog check, because they were recently registered in CA from another state. It is reasonable to assume that many of those moves to California involved a long-distance trip, and possibly relocation arrangements that at least temporarily limited access to charging. The recorded OBD data for vehicles that move between states is likely to include hundreds or thousands of recent miles accumulated primarily in CS mode, even if the owner regularly charges before and after the relocation. These unique circumstances suggest that cited BAR data will significantly underestimate typical, real-world FUF for PHEVs.

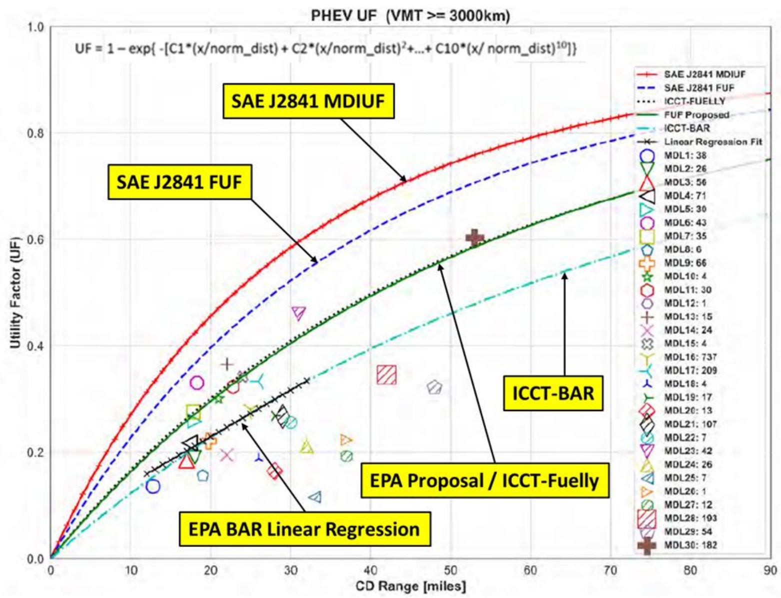
EPA's attempts to manage the rampant errors in the BAR dataset renders it statistically insignificant for an analysis of normal PHEV usage. The proposal explains that despite relaxing the data quality criteria to accept up to 20 percent mileage error[29] and vehicles with as low as 1,865 lifetime miles, only 2,060 out of more than 8,000 vehicles were retained from the BAR dataset. As a result, many of the PHEV variants studied by EPA have a sample size of 30 vehicles or less as seen in the legend on the right in Figure 14 below. The cleaned BAR dataset Excel file shared by EPA in the docket also confirms the inadequate sample size.[30] Because EPA accepted very low-mileage PHEVs for their supporting analysis, even a few hundred miles without charging can bias the results to a lower Utility Factor.

[29] The mileage error is in the discrepancy between odometer reading and vehicle lifetime miles reported from the OBD system.
[30] Docket Number EPA-HQ-OAR-2022-0829-0408.

As mentioned previously, most PHEVs in the cited BAR dataset underwent the smog check in 2020 through 2022 calendar years. The data collection through the 2020 calendar year includes the period when transportation was significantly impacted by the COVID-19 pandemic. Impacts included unusual fluctuations in gasoline prices including a 10-year low in 2020 making for both unusual driving patterns and less motivation to charge. We expect real-world FUF trends will increase post-pandemic.

During the March 2023 meeting with EPA, Toyota raised general concerns that the collection limitations and the necessary error filtering of the BAR dataset make it statistically insignificant and unrepresentative of typical PHEV usage patterns. We were unable to conduct a quantitative analysis of the data until it was placed in the docket after the proposal was issued. After evaluating the BAR dataset, our concerns are now bolstered by findings that long distance moving trips and the anomaly of COVID impacts bias the observed driving patterns and charging behaviors making the BAR data unfit for assessing the appropriateness of the SAE J2841 FUF curves. According to the proposal, EPA analyzed a filtered subset of the BAR OBD data results to address the data quality challenges and developed the "EPA BAR Linear Regression" curve listed in Figure 14 which also contains the two ICCT UF curves labeled as "ICCT-BAR" and "ICCT-FUELLY/EPA Proposal". EPA points out their linear regression fit of the BAR data subset lies on top of the "ICCT-BAR" curve fit from the full OBD dataset, implying good agreement between the two separate analyses of the BAR data.

Figure 14 PHEV Utility Factor Curves Considered in the Proposal[31]



Just how EPA developed the linear regression fit from the BAR OBD data is unclear. Given the scatter in the data, an exponential regression seems more appropriate if the aim is to infer a Utility Factor curve. The linear regression happens to match the ICCT analysis but provides no scientifically significant information unless EPA intends to propose linear UF curves.

6.4.4 Proposed UF Based on EPA's Analysis

The proposed FUF curve that results from EPA's analysis is calculated as the average of the SAE J2841 FUF curve and the ICCT-BAR curve which happens to match the curve fit of the problematic Fuelly data. The proposed curve shares the same weighting coefficients as the SAE curve under scrutiny. As seen in Table 5, the only difference between the SAE curve and the proposed curve is the Normalized Distance (ND) increasing from 399.9 miles to 583 miles. All other terms in the proposed revised equation to the right of Table are the same.

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[31] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, DRIA, April 2023, Fig. 3-29, pg. 3-79.

Table 5 Comparison of Proposed and Existing SAE FUF Terms

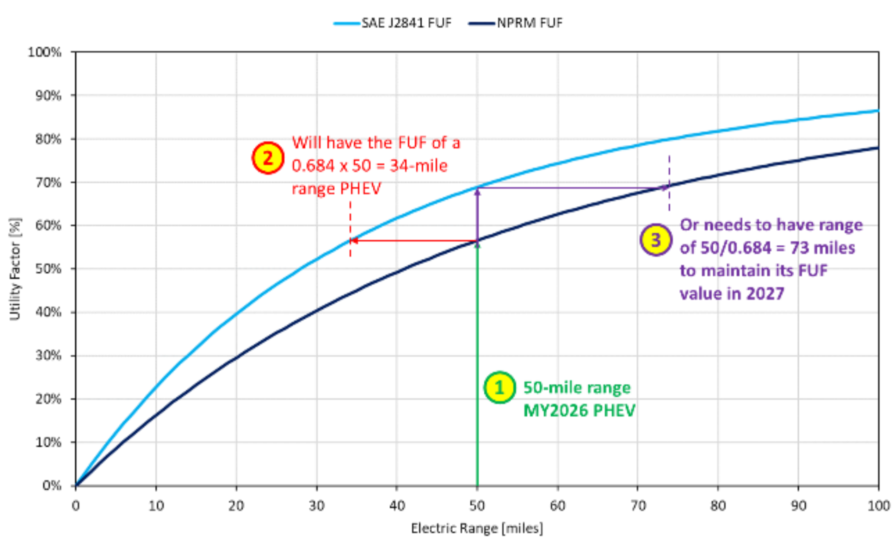
FUF / Terms	ND (Norm. Distance)	Curve Fit Coefficients					
		C1	C2	C3	C4	C5	C6
SAE J2841	399.9	10.52	-7.28	-26.37	79.08	-77.36	26.07
EPA Proposed	583	10.52	-7.28	-26.37	79.08	-77.36	26.07

$$UF_i = 1 - \left[\exp\left(-\sum_{j=1}^{k}\left(\left(\frac{d_i}{ND}\right)^j \times C_j\right)\right)\right] - \sum_{l=1}^{n} UF_{l-1}$$

UF_i = the utility factor for phase i. Let $UF_0 = 0$.
J = a counter to identify the appropriate term in the summation
K = the number of terms in the equation
d_i = the distance driven in phase i.
ND = the normalized distance.

The proposed ND adjustment amounts to discounting the advertised electric range of every PHEV by about 32 percent for compliance calculations because increasing the normalized distance has the same effect as lowering the CD range (see Figure 15).

Figure 15 Revised Normalized Distance Derates All-Electric Range for Compliance



The Draft Regulatory Impact Analysis explains that EPA "used the latest NHTS data (2017) and executed the utility factor code that is in SAE J2841, Appendix C, and found that the latest NHTS data did not significantly change the utility factor curves."[32] We are therefore confused over the basis for revising the normalized distance if overall driving distances have not changed. EPA's

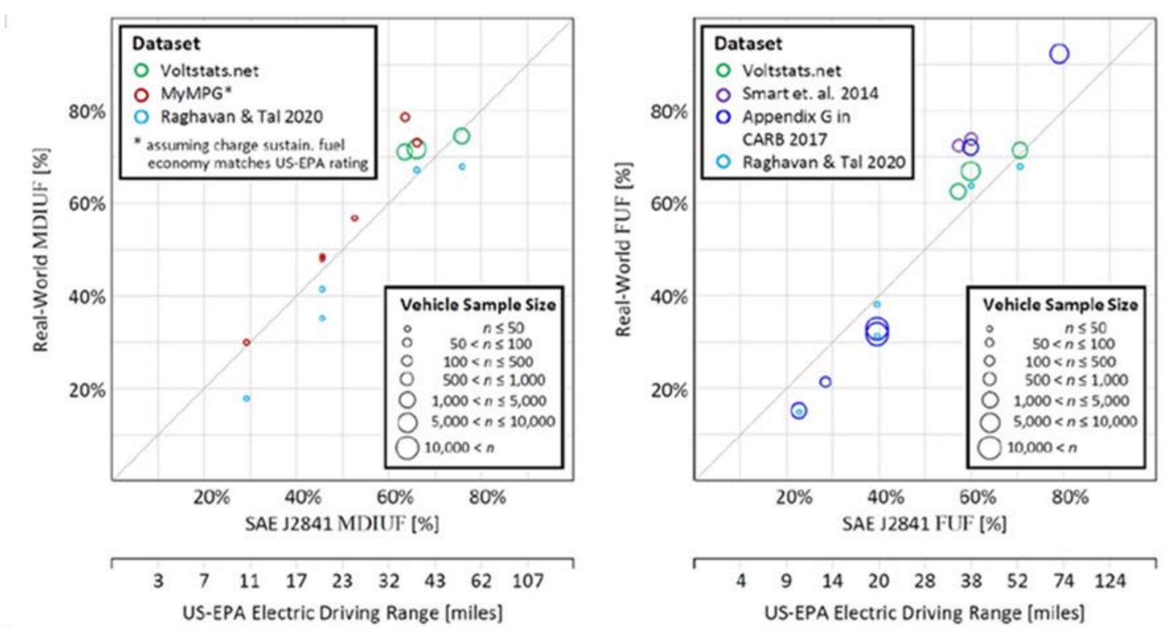
[32] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, DRIA, April 2023, Footnote 35, pg. 3-74.

analysis suggests the normalized distance should remain unchanged. Toyota opposes the normalized distance being changed based on the existing data.

6.4.5 EPA's Analysis and Conclusions Misaligned with Available Data

The previously mentioned Toyota and UC Davis work conclude that the real-world performance of previous-decade PHEVs in the US approximate the SAE UF curves reasonably well as seen in Figure 16. This is especially the case with more capable, longer-range PHEVs, a trend the problematic Fuelly and BAR datasets also support. However, EPA's linear curve fit that anchors the proposed UF curve revision is weighted toward vehicles with a range below 30 miles (see legend to right of Figure 14) whereas modern PHEVs with higher range and motor power outperform the vehicles used for EPA's analysis.

Figure 16 Estimated Real World Utility Factor for U.S. Datasets Versus SAE J28

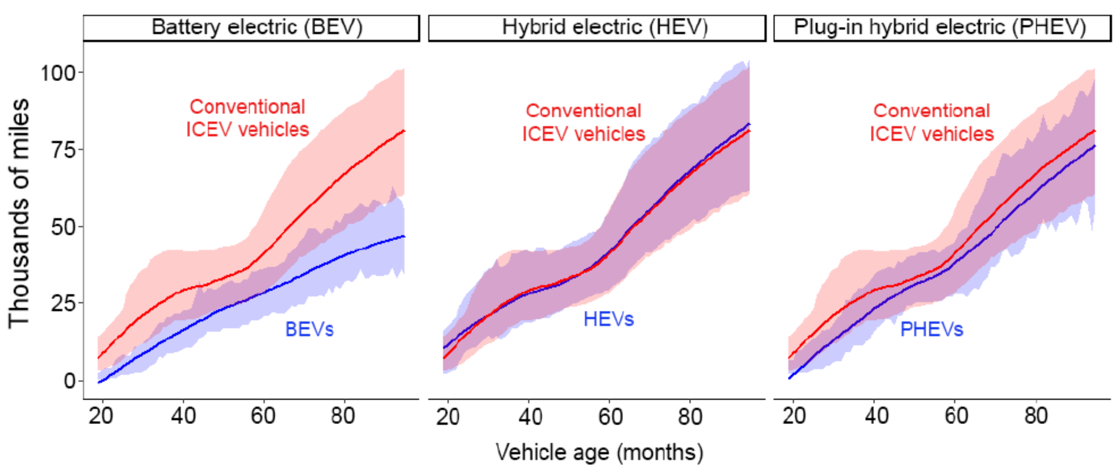


6.4.6 Treat Potential Discrepancies Between Real-World and Laboratory Evenly

Concerns over differences between real-world and laboratory performance, particularly those due to driving behaviors, have traditionally been resolved through post-compliance data adjustments aimed at consumer awareness and occasionally by expanding test cycle requirements. Not by revising the calculations used to determine compliance with the standards. The compliance benefit of internal combustion powertrains has never been penalized when studies have found on-road driving is more aggressive or fuel consuming than the test cycles indicate. Instead, lab results for CO_2 emissions and fuel economy are adjusted on the fuel economy label to better reflect real-world performance, and consumers are educated on how their mileage may vary based on their driving conditions.

PHEVs should be treated no differently than BEVs. Both technologies are still evolving, maturing and need support towards mainstream market adoption. The proposal appropriately does not scrutinize the advertised range, efficiency, and emissions performance of BEVs under real-world conditions. A BEV not attaining its advertised range can result in more ICE miles driven. One recent vehicle usage study concluded the average BEV is driven 29% less than the average non-BEV.[33] Figure 17 comes from another academic study that found that battery electric vehicles (BEVs) are driven on average 2,700 fewer miles annually compared to their conventional counterparts.[34]

Figure 17 Mileage Accumulation by Powertrain Type



[33] https://www.iseecars.com/most-driven-evs-study

[34] A. Zhao, E. Costigliolo, J. Helveston, L. Roberson, E. Ottinger, L. Zhao, J. Dunckley, "Coming of Age: Understanding Electric Vehicle (EV) Use Over Time via Used Vehicle Market Data", Electric Vehicles Symposium, 2023, Sacramento, CA)

The proposal heavily relies on the BEV technology improvements and charging infrastructure expansion to justify the standards. Those same improvements will also benefit PHEVs, since home charging, consumers awareness, and technology advancements will drive PHEV utilization closer to that of pure BEVs as consumers place greater emphasis on achieving advertised range and have greater desire and means to achieve it.

Existing regulation will also help spread the deployment of more capable PHEV designs that perform closer to their advertised all-electric range. The California ACC2 provisions will drive more capable architectures by requiring PHEVs to have a minimum all-electric range of 40 miles over the aggressive US06 test cycle that eventually increases to 50 miles, and a minimum of 70 mile range over the combined city/highway test cycle. Further, EPA's proposed PHEV high-power cold-start requirement will necessitate more all-electric capability.

6.4.7 Suggested Approach Moving Forward

Toyota is interested in ensuring PHEVs achieve their assumed emissions benefits. However, a proper science-based data collection and assessment of PHEV performance needs to inform real-world PHEV usage patterns and the resulting emissions. An analysis of a small sample of two error-filled datasets is not an appropriate basis from which to draw conclusions about PHEV all-electric range during real-world operation. An unprecedented revision of the Utility Factor curve based on the data in the proposal would be arbitrary and capricious.

We recommend EPA request SAE establish a consortium of auto companies, DOE, DOT, and other stakeholders to evaluate PHEV usage trends by architecture and performance capability. A first order of business should be determining a consensus method for measuring real-world EV range. The output of this effort should be a report that EPA would use to consider adjustments to the UF curve, alternative metrics such as PHEV design criteria, and/or improved information for consumer purchase decisions.

If proven necessary, PHEV electric range on the consumer-facing label could be adjusted. In such a scenario, increased knowledge about all-electric range could stoke competition in a growing market and motivate continued investment to refine and improve PHEV performance. Penalizing PHEV compliance with the proposed revision to the Utility Factor curve would only stifle investment and hamper deployment of new PHEVs leaving consumers less choice to reduce CO_2 emissions at a suitable price.

7 Off-Cycle Technology Credits

From the start of the GHG program effective with 2012 model year vehicles, off-cycles credits[35] have collectively motivated the introduction of technologies that would not been launched otherwise because they often provide no perceivable benefit for customers. However, these technologies net immediate real-world emissions reductions and should be viewed no differently than emissions reductions achieved over the Federal Test Procedure. Off-cycle credits encourage the continued use of these technologies with commensurate benefits to consumers, the environment and further innovation.

Toyota has invested billions of dollars in off-cycle technologies which have saved over approximately 100 million tons of CO_2 emissions from our products and avoided high GWP refrigerants from entering the environment. Off-cycle credits have become pivotal in Toyota's compliance planning and longer-term technology strategy affecting future products over the next several years that could potentially include PEVs.

The proposal:

- Eliminates AC refrigerant credits as well as the 5-cycle and alternative credit methods
- Phases out the off-cycle credit menu, and
- Excludes BEV and the electric operation of PHEVs from the remaining available credits.

Toyota has invested in and will deploy technologies that have been approved under the 5-cycle and Alternative test methods. We request all previously approved credits be added to the off-cycle credit menu and the cap increased by the amount of those added credits.

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[35] Which includes A/C refrigerant leakage credits and A/C efficiency credits for these comments.

Toyota also requests BEVs and PHEVs be fully eligible for the remainder of the off-cycle credit program. The efficiency of PEVs can be improved with off-cycle technologies. For example, solar panels and solar thermal control technologies conserve battery energy improving PEV driving range and reducing electricity consumption. Improved PEV HVAC system efficiency can produce similar benefits. In a March 2022 meeting with AAI that explored potential approaches for 2027 model year and later GHG standards, EPA mentioned the possibility of incentivizing increased PEV efficiency and range. Market factors alone will motivate improved efficiency and range over time, but off-cycle credits could help accelerate advancements as PEV technologies continue to evolve and mature. EPA and the auto industry could collaborate on appropriate credit values and how to avoid negative fleet emissions if PEV penetration eventually were to reach such a threshold market share.

8 Low Carbon Fuels

EPA needs to return to treating fuels and vehicles as a holistic system to capture the benefits of low carbon fuels. Low carbon liquid fuels are (1) technically feasible today, (2) the only viable decarbonization solution for the legacy vehicle fleet, (3) an important complement to vehicle electrification over a long transition, and (4) factor for a range of consumers whose needs or budgets require different solutions.

Toyota has been working with fuels industry partners to demonstrate the technical feasibility of low carbon fuels today. In April 2023, Toyota announced work with ExxonMobil to test research fuels in Toyota's advanced engines and vehicles. ExxonMobil reports their innovative fuels have potential to reduce greenhouse gas emissions up to 75% compared to conventional fuels available today.[36] During that same month, Toyota and Chevron demonstrated a real-world use-case of Chevron's Renewable Gasoline Blend (RGB). Toyota and Chevron drove three Toyota vehicles almost 1,000 miles across parts of Mississippi, Louisiana, and Texas. Chevron reports a 40% lower

[36] Reductions in Carbon Intensity (CI) estimates are based on the lifecycle greenhouse gas emission of the fuels tested at Toyota's Research Center, compared to petroleum gasoline. Estimated CI values are based on either GREET 2021 estimates, or feedstock Proof of Sustainability documents. Actual results may vary.

carbon intensity for Chevron RGB compared to traditional gasoline on a lifecycle basis. These low carbon liquid fuels are compatible with the existing vehicle fleet and existing infrastructure and are technically feasible today. The US ethanol industry continues to make great strides in reducing carbon the carbon intensity of their product. In a 2021 study, researchers from Harvard, Tufts, and EH&E estimated corn ethanol was 46% lower carbon intensity compared to average gasoline.[37] The Renewable Fuels Association reports their fuel producing members aim to reduce their lifecycle ethanol GHG by at least 70% on average compared to gasoline by 2030, and achieve net-zero lifecycle GHG by 2050.[38] Since the vast majority of the 280 million vehicles on US roads today have an internal combustion engine, decarbonizing liquid fuels on a well-to-wheel basis would yield immediate benefits for lowering the carbon intensity of transportation energy.

Low carbon fuels are an additional pathway for reducing transportation GHG. This pathway offers a hedge against uncertainties that could affect the pace of electrification, such as critical mineral supply and charging infrastructure development. The combination of low carbon fuels with hybrids and PHEVs shows excellent overall GHG performance while optimizing usage of potentially scarce critical minerals. In this way, low carbon fuels would be complementary to vehicle electrification and future GHG goals during the long energy transition.

Low carbon fuels preserve consumer choice on vehicles while still supporting decarbonization of transportation energy. Proposed regulations should factor for a range of consumers whose needs or budgets require different solutions. Vehicle electrification will proceed at different paces in different regions. Full vehicle electrification could take longer in rural areas or other locations lacking sufficient charging infrastructure. If forecasts for future battery costs prove inaccurate, it would have disparate impact on different socioeconomic levels. A diverse set of solutions offers more certainty of both emissions reductions and affordability, which is consistent with

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[37] Melissa J Scully et al 2021 Environ. Res. Lett. 16 043001

[38] Renewable Fuels Association. (2021, July 27). *RFA Pledge to President: Ethanol to Achieve Net Zero Emissions by 2050 or Sooner Link:* https://ethanolrfa.org/media-and-news/category/news-releases/article/2021/07/rfa-pledge-to-president-ethanol-to-achieve-net-zero-emissions-by-2050-or-sooner

environmental justice objectives. Low carbon liquid fuels are an important part of enabling all vehicle owners/users to play a role in reducing emissions.

9 Tier 4 Program

Toyota supports the comments by the Alliance for Automotive Innovation by reference. The comments here are to add emphasis or additional perspective to those items.

9.1 Overall comments

Toyota believes that the focus of OEM's efforts should be on electrifying the fleet and that additional and unnecessary provisions with minimal impact on air quality should be reconsidered by the EPA. We believe that the California Air Resources Board (CARB), with their long, collaborative process with all stakeholders, has done a good job of balancing the need to protect human health and with the structure and additional provisions in their LEV IV regulation. Since conventional vehicles will remain in the sales mix though and beyond the timeframe of this Proposed Rule, the unnecessary stringency of certain Tier 4 provisions does not promote more electrification, but rather reduced Toyota's ability to assign resources from conventional engines and hinders EPA's goal of alignment with President Biden's electrification goals. Therefore, we highly recommend that EPA harmonize with the regulatory structure and stringency of the California LEV IV regulation.

APPENDIX A Detailed Critical Minerals Assessment

Table of Contents

List of Figures

According to Benchmark Minerals Intelligence (BMI), battery demand in North America is forecast to grow nearly five-fold between 2022 and 2030 and with that the demand for the finite supply of critical minerals such as lithium, cobalt, nickel, and graphite that go into producing batteries.

The proposed rule identifies lithium as the material most likely to first constrain PEV production due to limited availability. EPA believes there will be ample supply of the other critical minerals through 2035 and/or there are known substitute minerals that make their availability less critical.[1] Therefore, the proposal's assessment of critical mineral availably is limited to a single mineral - lithium.

Toyota agrees lithium availability is likely to constrain global PEV production and put upward pressure on lithium pricing, but is also concerned about graphite supplies. Both minerals will be in tight supply sooner and for longer than projected by EPA's outdated sources[2], which do not reflect the current market dynamics for battery demand and material supply in a rapidly changing market landscape. At a minimum, the final rule must use updated data to reflect current battery and non-battery demand, mined supply, and battery plant announcements with pragmatic supply forecasts which show that not every announcement will lead to production.

Further, the analyses of critical material supply must distinguish the country of origin because it determines whether the IRA benefits used to justify aggressive BEV cost reductions apply. The IRA-qualifying supply of lithium, graphite, nickel, and cobalt and deserve a deeper evaluation to support the final rule. For example, nickel is also experiencing tight supply with a focus on mining in a single country, Indonesia, which is projected to comprise over 50% of global mined nickel battery material in 2030. Growing geopolitical and environment concerns surrounding Ni mining in Indonesia are causing instability, and it is still unknown whether Treasury will consider Indonesia as an FTA country as it requested.[3]

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[1] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, Draft Regulatory Impact Analysis (DRIA), April 2023, page 3-23.
[2] Ibid pages 29319 to 29323 for examples.
[3] Citation: https://www.reuters.com/world/asia-pacific/violence-indonesia-nickel-smelter-protest-kills-2-dozens-detained-2023-01-16/.

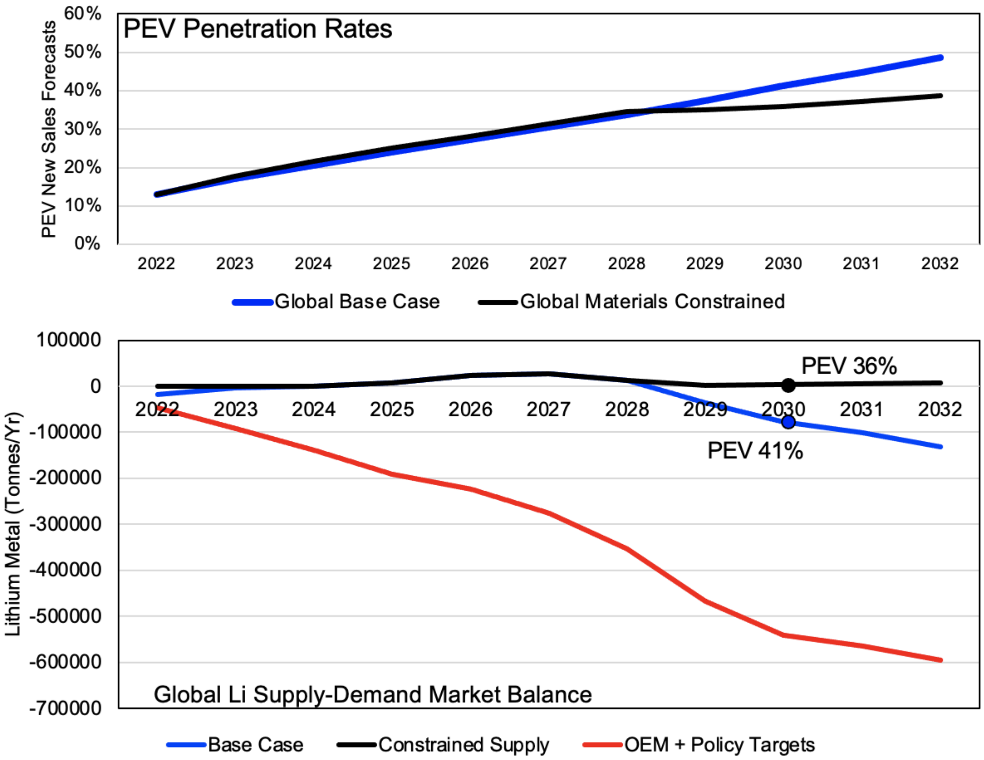
1 Lithium Constrained PEV Penetration – Global

Toyota's assessment of global lithium supply and demand is more aligned with the projections of IEA and BNEF studies that project lithium mine production may not meet end-use demand after 2028[4]. Benchmark Mineral Intelligence (BMI), leveraging transportation demand-side market data from their partner RhoMotion, forecasts global lithium supply versus demand through 2035. Figure 1 below forecasts a business-as-usual base case[5] global PEV penetration at 41% in 2030 with an average battery size of 68 kWh. This assumes an unconstrained lithium supply. Taking forecast global lithium supply into account results in supply-demand a gap emerging around 2028. This widening deficit in supply leads to a constrained PEV penetration of 36% new sales in 2030.

It is important to acknowledge two things. One, the supply shown in these comments utilizes the original source's (e.g. BMI, BNEF) de-risked supply scenario, meaning not 100% capacity, unless otherwise stated. Second, increased demand will motivate an increase in future supply project announcements. The challenge is how quickly the announced sources become operational and produce the quantities needed for compliance with the proposed standards. These operational challenges are discussed later in this section of our comments. Figure 1 shows the global PEV penetration rates in the base case as provided by BMI/RhoMotion, which includes incentives stemming from the Inflation Reduction Act (IRA).

[4] 88 Fed. Reg 29184 (May 5, 2023) at 29321.
[5] For the base case, BMI "subsegments each demand market by end application, [and] considers government intervention that can impact adoption/use of application, OEM strategies and technology roadmaps, historical trends to understand consumer behaviour, economics and material availability/capacity build out to determine forecasted adoption of each application. This then amalgamates into [an] overall demand for each market by chemistry and region." The BMI analysis considers lithium demand for battery and non-battery sources (including heavy duty vehicles).

Figure 1 Global Lithium Supply-Demand Forecast



source: Benchmark Mineral Intelligence, Li Forecast Q1 2023. RhoMotion

With the proposed rule essentially forcing ~60% BEVs in 2030, the global lithium gap would increase with heterogenous effects of supply-demand balance in the US and different countries, which is described further for the U.S.

The BMI study included a PEV mix of 88 percent BEVs and 12 percent PHEVs for 2030 in contrast to EPA's assumption of 100 percent BEVs for the proposal. The supply-demand analysis would have concluded larger shortfalls that would have occurred sooner if BMI had assumed 100 percent BEVs. The data in these supply-demand figures is for calendar year rather than vehicle model year. For the sake of this evaluation, the calendar year will be used and assumed equivalent to the previous model year (ex. 2030 calendar year is the same as 2029 model year).

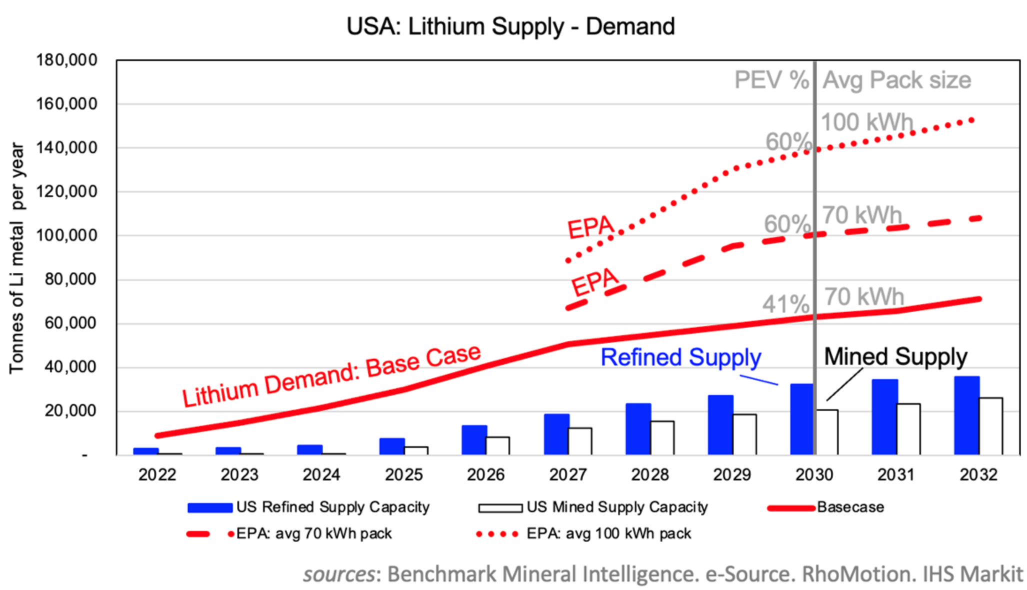
BMI and RhoMotion have also developed a global forecast for a high-demand scenario shown in 1 which incorporates the announced PEV targets for 41 leading OEMs and additional government policy aspirations. In this scenario, the lithium supply-demand balance immediately goes into deficit. This materiality limitation demonstrates how the attainment of ambitious OEM PEV targets and government policy aspirations in aggregate, which are insufficiently considered in the proposed standards, would require US manufacturers to compete on a global scale for limited lithium creating many unknown supply bottlenecks. Lithium supply constraints are next discussed in terms of domestic US supply and then US and Free Trade Agreement (FTA) country supply.

2 Lithium Constrained PEV Penetration – IRA Compliant

2.1 US Domestic Supply

First and not surprisingly, the forecast clearly shows that the U.S.-based lithium mined capacity and refined capacity (de-risked supply) is able to supply only 33% and 51%, respectively, of the lithium needed for base case U.S. demand at 41% PEV penetration in 2030, with an average pack size of 70 kWh.

Figure 2 U.S. Domestic Lithium Supply-Demand Forecast

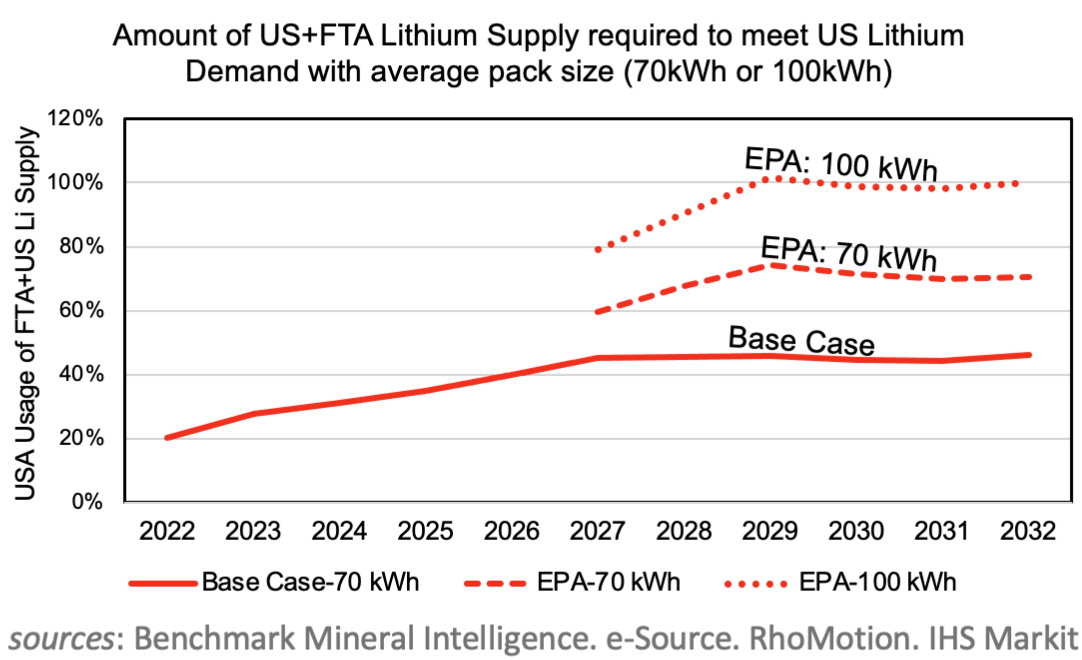


Thus, to meet base case demand requires sourcing the remaining lithium from outside of the U.S. both for mining and refining purposes. Figure 2 shows this in more detail. Domestic supply shrinks to only 32% of required lithium supply needed to satisfy a 60% PEV share for an assumed average battery size of 70 kWk (red dashed line) and only 23% the required lithium for an average 100 kWh battery (red dotted line) that is referenced in the proposal. This means for a 100 kWh battery, U.S. lithium supply could meet demand for approximately 15% PEV penetration in 2030, 45% less than 60% BEV penetration EPA is seeking through the proposal.

2.2 US +FTA Supply

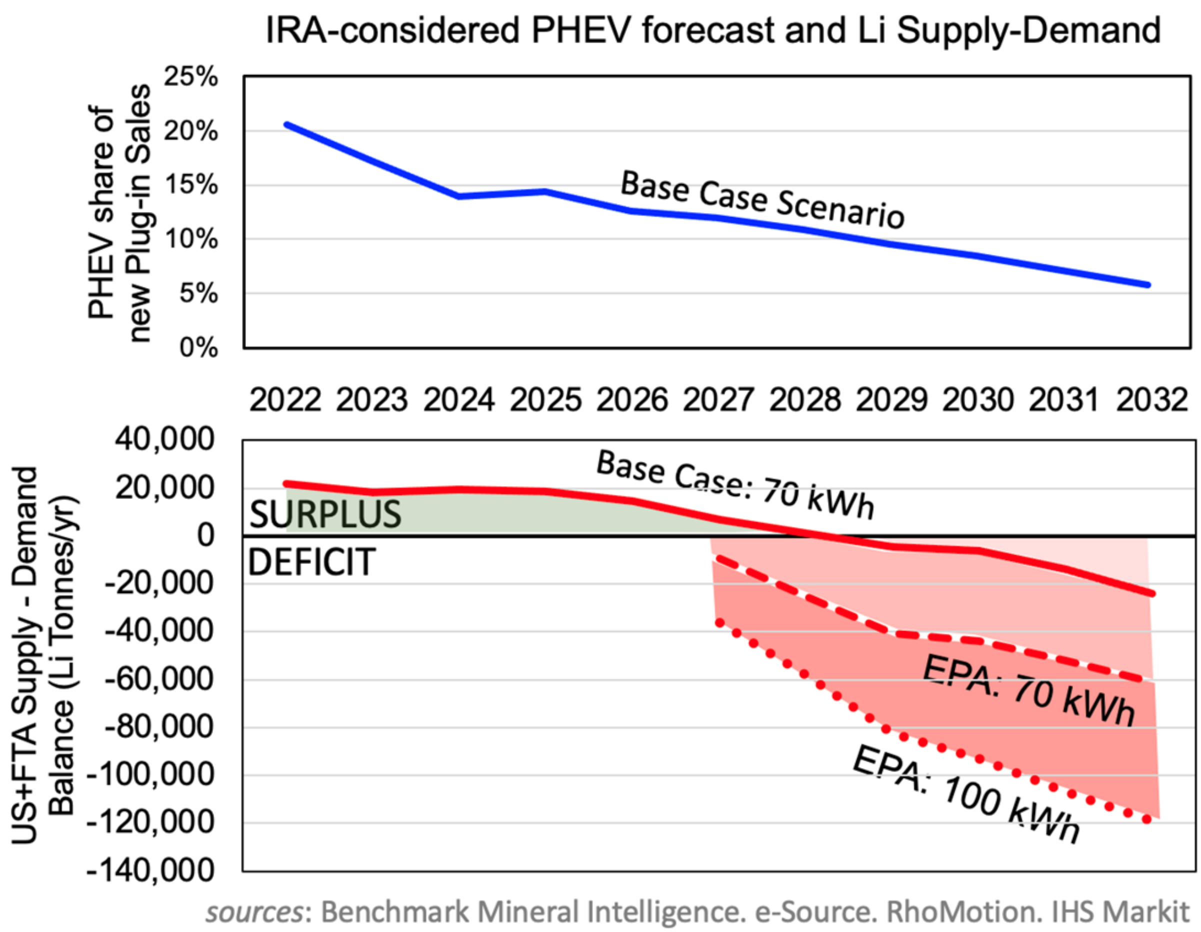
The lithium supply-demand gap narrows but continues when sourcing is extended to the Free Trade Agreement (FTA) countries that qualify for IRA tax credits. Data from BMI, RhoMotion, e-Source and IHS Markit show (see Figure 3) that 45% of USA+FTA refined lithium supply would be needed to meet US demand for the 41% PEV base case penetration in 2030. Compliance with EPA's proposed requirements in 2030, would consume 71% of USA+FTA refined lithium supply for an average pack size of 70 kWh and 99% of USA+FTA supply for the EPA-referenced average 100 kWh battery.

Figure 3 U.S.+FTA Refined Lithium Supply Required to Meet 60% PEV Share



When we consider the lithium demand of Free Trade Agreement countries in addition to the U.S. (i.e. US+FTA lithium), the aggregate increased demand results in a deficit after 2028 in the base case demand scenario as seen in Figure 4. If US demand is increased to attain a 60% PEV penetration in 2030, the deficit will move early relative to 2028 depending on the PEV ramp-up required to meet EPA requirements. If the FTA countries are allowed to meet their lithium demand first before providing excess to U.S. domestic supply, the U.S. PEV penetration rate is constrained to 36% in 2030 with an average pack size of 70 kWh. Supply from IRA-compliant U.S. and FTA countries would support only a 25% U.S. PEV penetration in 2030 for a 100 kWh size battery if FTA countries meet their lithium demand first before providing excess refined lithium supply to existing U.S. domestic supply.

Figure 4 U.S.+FTA Refined Lithium Supply-Demand Forecast

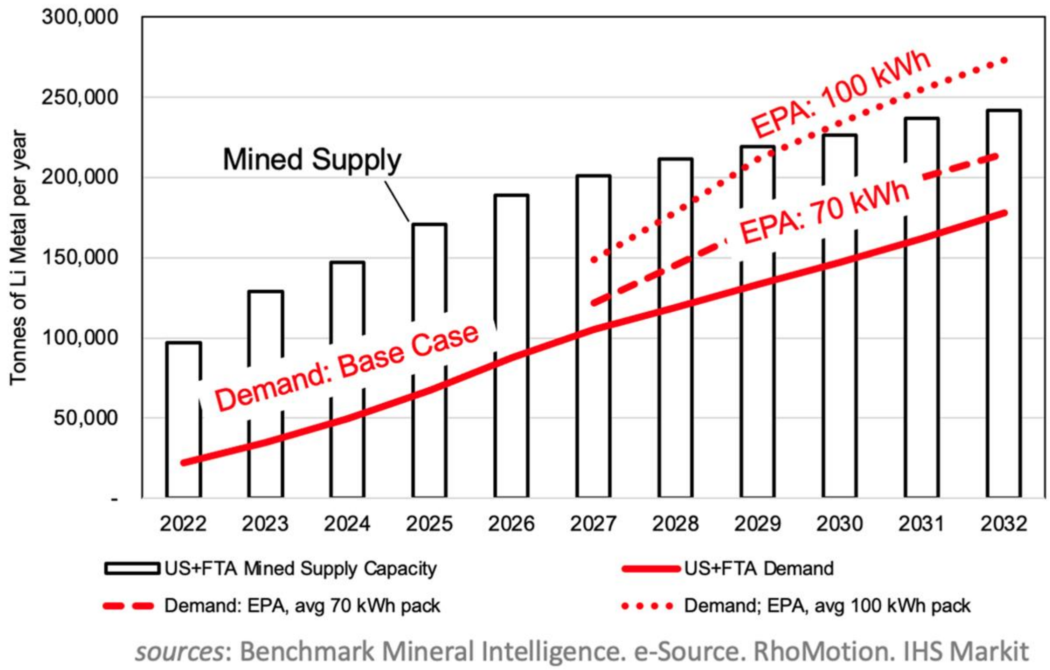


It should be noted that FTA mined supply includes Australia, which is the largest current source of lithium (over 50% of global supply) in the world through its spodumene supply and would qualify under the IRA provisions. However, today 96% of Australian supply is currently sold to and refined in China, a foreign entity of concern.[6] If the refining of Australian supply could relocate to a US+FTA country, the expanded source of lithium supply could potentially satisfy U.S. demand driven by the proposed standards and make the proposal's assumptions about IRA cost savings more realistic as illustrated in Figure 5.

Quickly shifting significant amounts of the Australian mined supply would be extremely challenging. While refineries are faster to build than mines, such an undertaking could be impractical considering existing business partnerships and the effort to establish new partnerships with capital- and operational-intensive infrastructure. It would be most efficient for Australia to establish local refining; however, BMI forecasts Australian refining capacity to be about 15% of China's capacity in 2030. The Australian government has reported that it could provide 20% of the world's needed refining capacity in 2027.[7] However, delays are already occurring for current refining projects and there is uncertainty as to whether Australia will be able to compete with China on prices.

[6] https://www.globaltimes.cn/page/202207/1270447.shtml.
[7] https://www.power-technology.com/news/australia-to-end-dependence-on-china-for-lithium.

Figure 5 U.S.+FTA Lithium Mined Supply-Demand: Australia Supply Included



3 Graphite Constraints

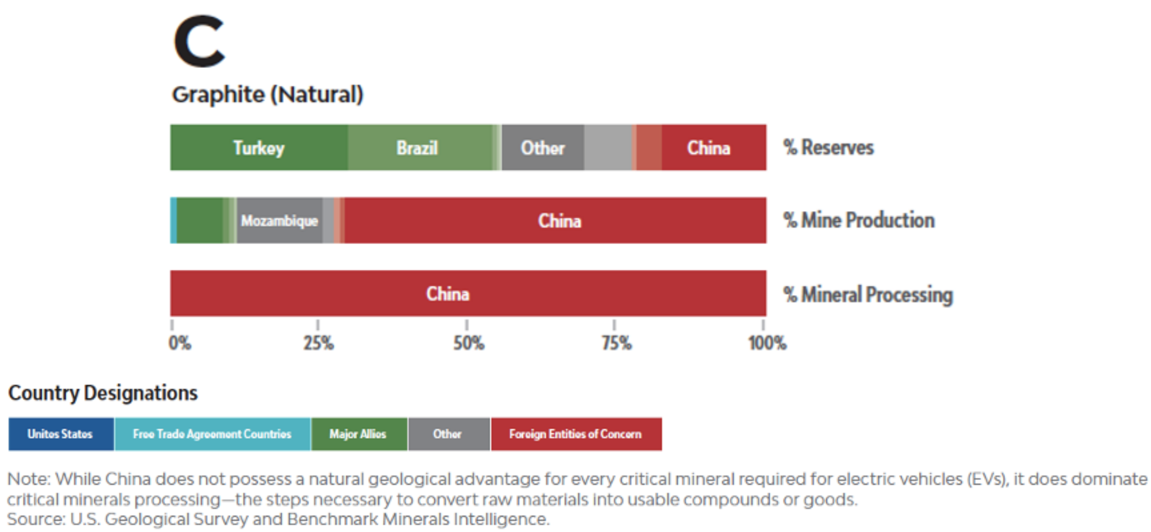
The proposal categorizes graphite as a substitutable material noting "the role of natural graphite in many cases can be served by artificial graphite or highly refined hard or amorphous carbon. However, lithium has no substitute in commercially produced automotive applications at this time."[8]

Toyota understands that IRA-qualifying graphite could restrict US battery production and constrain PEV sales more so than lithium. The U.S. currently does not produce any natural graphite and must rely on imports where most originates from China. Despite growth of natural graphite mining in Africa, which is projected to take over China as the major source of graphite in the mid-

[8] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, Draft Regulatory Impact Analysis (DRIA), April 2023, page 3-23.

2020s[9], the majority of graphite processing called spheroidization which is necessary to improve battery performance takes place in China (see Figure 6).

Figure 6 Countries of Origin for Graphite



source: Center for Critical Minerals Strategy, A Global Race to the Top

China controls every stage of the graphite supply chain and was responsible for almost 60 % of the world's mined production last year and approximately nearly 99% of graphite processing because of its scale of operations, established supply, weak environmental requirements, and low resulting costs. If any portion of a battery's raw material originates from a foreign entity of concern (including refining), the battery would not qualify for part of the consumer tax credit.

For synthetic graphite, there are three US companies planning to produce a combined 12k tonnes per year by 2026, up from 2k in 2022. [10] Only one company is expected to process natural graphite in the US (Vidalia) with operations announced to come online in 2023 at 2.5k tonnes per year and ramp to 10k by 2026. Combined the US is projected to have 22k tonnes of graphite refining capacity per year by 2030. USA+FTA countries are projected to reach 203k tonnes per year .[11]

[9] https://www.greencarcongress.com/2022/08/20220807-benchmark.html.
[10] [FN: PUREgraphite, SGL Carbon, and Amsted Graphite]
[11] Cite BNEF "Metals Data Hub" online database, last updated Oct. 2022

As reference, approximately 1 kg of graphite is needed per kWh of battery capacity. For an average BEV pack size of 70 kWh, the graphite produced from US+FTA countries would support 2.9 million BEVs per year in 2030 which would satisfy only 18% of the 15,814,296[12] annual new vehicle sales projected in 2030. To comply with the 60% BEV share driven by the proposed standard in 2030, 66% of refined graphite would need to be procured from global supplies that are outside of US+FTA control and may not qualify for important IRA benefits to incentivize vehicle purchases.

4 Mining/Processing Limitations

The proposal claims significant deposits of nickel, cobalt, lithium and graphite in the U.S. remain undeveloped primarily because of economic considerations. It also recites Biden Administration and industry efforts toward building a sustainable domestic supply chain and how the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) will accelerate that development.

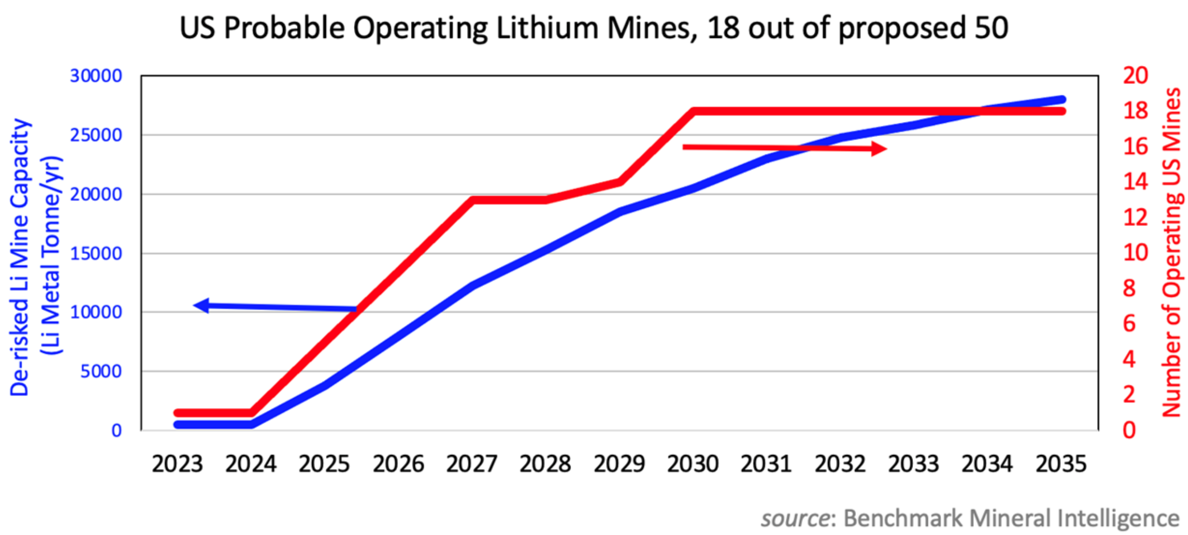
However, the proposal provides no specific roadmap as to how the billions of dollars in available federal and private funds will translate into a schedule of quantified increases in domestic material supplies that will enable compliance with the proposed standards. Instead, EPA relies on anecdotal evidence such as the March 2023 DOE assessment which identified 19 additional lithium production projects in the U.S. in addition to the three BNEF had identified in a December 2022 study. With this information, EPA concluded that there will be sufficient lithium supply to meet end-use demand well beyond 2028.[13]

DOE's assessment of the 19 mines appears to ignore the significant uncertainty associated with starting mining operations. The prospect for a mine to reach the production stage and time that takes hinges on exploration and feasibility studies, approval and permitting processes, potential for project abandonment and delays, learning rates for new companies, and production ramp up.

[12] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, Draft Regulatory Impact Analysis (DRIA), April 2023, page 4-44.
[13] 88 Fed. Reg at 29321.

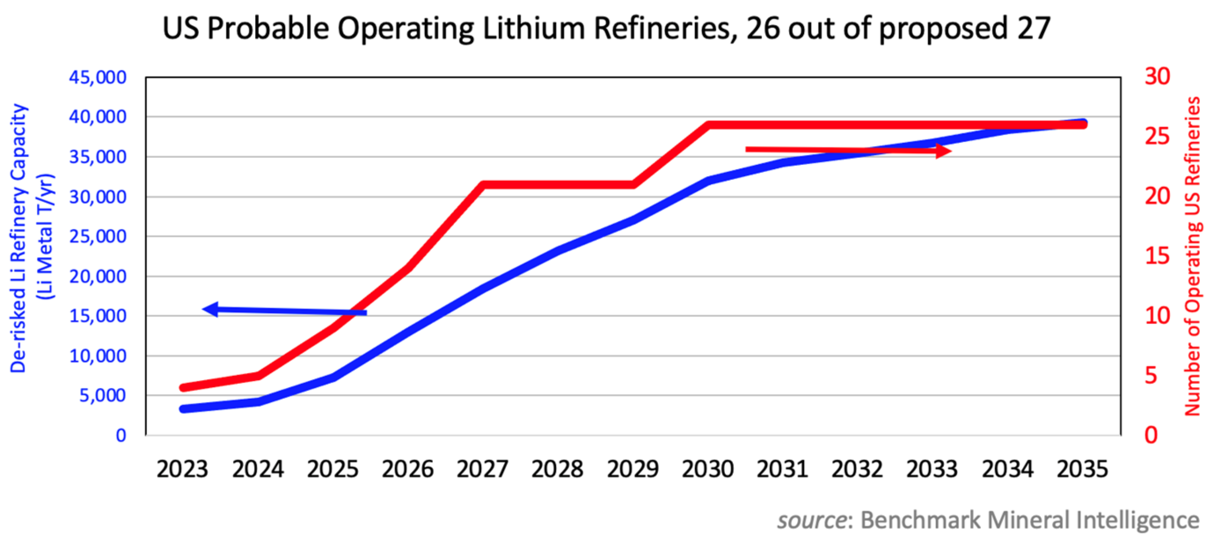
When these risk factors are considered, only 18 out of 50 proposed or announced lithium mining projects in the US are expected to be operational by 2035, according to BMI (see Figure 7).

Figure 7 US Probable Lithium Mines



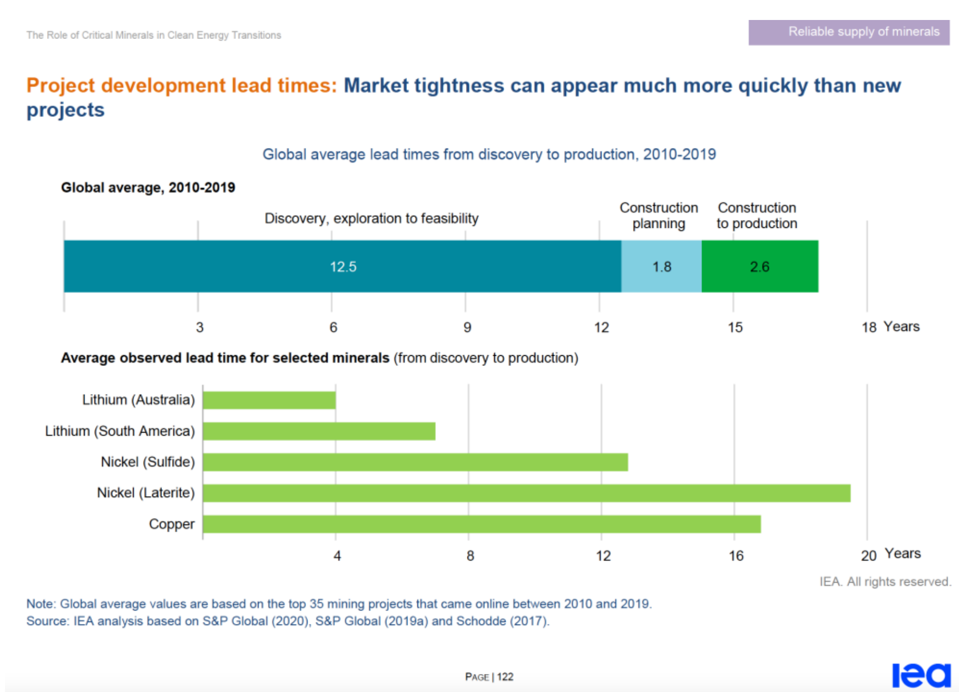
Further, the 18 mines are expected to produce less than 21,000 tonnes lithium per year in 2030 which fills only 21% of the lithium needed to attain a 60% PEV share in that year assuming an average battery size of 70 kWh. These relatively small and young mining operations will not be able to add a meaningful amount of IRA-qualifying minerals, much less relieve expected tight global supply. The U.S. will have more refining capacity than mining capacity, meaning it can absorb and use supply from FTA countries for US production as shown below (Figure 8). However, like the mining capacity, the refining capacity is insufficient for US demand, accounting for only 32% of US demand driven by a 60% PEV share in 2030, assuming an average battery size of 70 kWh. As refineries can come online faster than mining operations, an increase in US or US+FTA refining capacity could reduce this gap. New mining operations are more complicated.

Figure 8 US Probable Lithium Refineries



As seen in Figure 9, reaching the operational stage of a mine entails long lead times. As provided by the IEA below, lead times for lithium mining can take 4-7 years without delays. New nickel mining operations can take 13-19 years.

Figure 9 Mining Project Development Lead Times

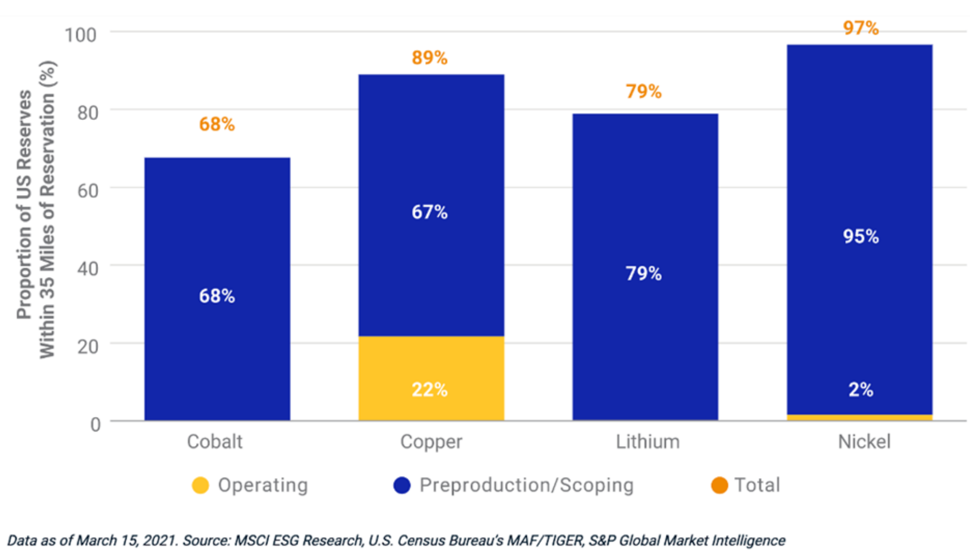


In the U.S, the time to establish an operating mine can take even longer because of regulatory requirements that are stricter than many other countries in the world. Recently, the largest proposed lithium mine at Thacker Pass was approved to start operations but after years of delay.[14] Repeat examples of multi-year delays in mine production and the growing number of small and young companies means there is large uncertainty in the ability of supply to ramp up to meet ambitious demand targets on shorter time scales.

Approvals become more complex and time consuming because the reserves of critical minerals in the U.S. are tied closely with tribal lands, where over 70% of these reserves are within 35 miles of tribal lands as seen in Figure 10. Mining at Thacker Pass mentioned above also carries controversy with its overlap with sacred tribal land.[15]

While an increase in mining operations is necessary to meet supply, a reasonable timeline should be applied to the availability of such supply to meet demand both in terms of time-to-production and time-to-full production capacity. Data from BMI suggests it can take 1-4 years to ramp up to full operating capacity.

Figure 10 Proximity of U.S. Mining Resources



[14] cite: https://www.reuters.com/legal/us-judge-rule-thacker-pass-lithium-mine-case-within-months-2023-01-05/
[15] https://www.npr.org/2023/06/28/1184812267/western-tribes-last-ditch-effort-to-stall-a-large-lithium-mine-in-nevada

Finally, the resolution of environmental concerns can delay the development and opening of new mines. Environmental Sustainability and Governance issues surrounding mining are gaining increased attention. For example, particulate emissions may prove a challenge for natural graphite mines in the U.S.

In summary, establishing mining and processing operations and reaching full, efficient operational entails significant risk and a decade-long process if successful. It is extremely unlikely the U.S. can attain significant mining capacity in the period of the proposed standards. However, increasing refining capacity could be a means to alleviating supply deficits.

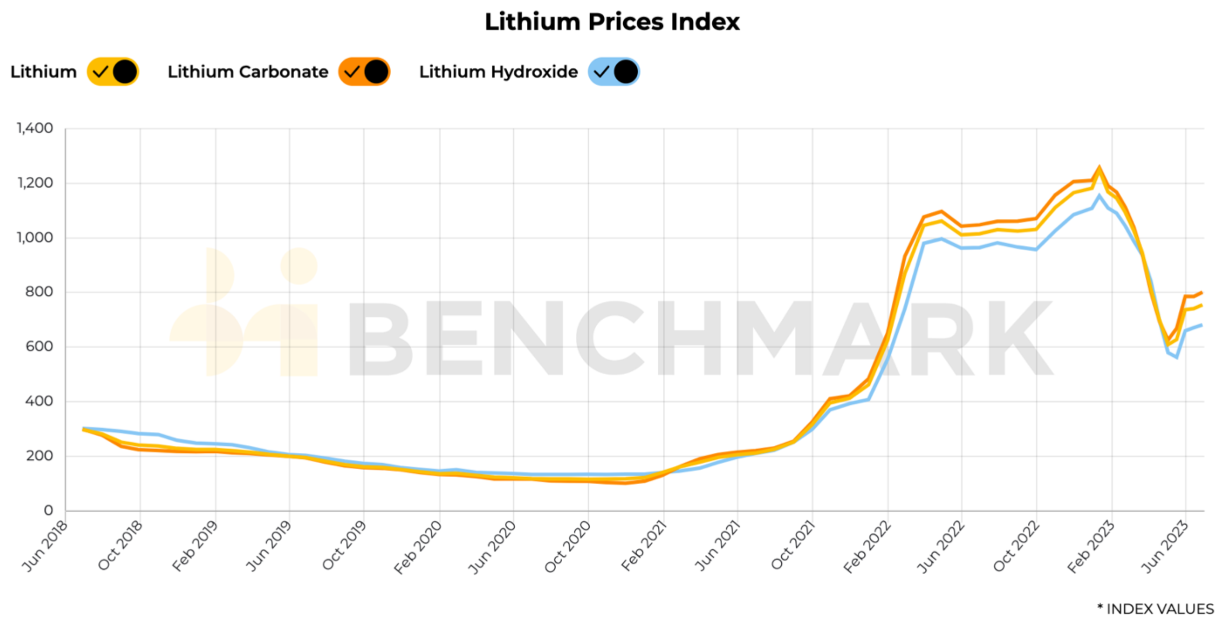
5 Price Volatility

Forecasts for ongoing tight global lithium supply are at odds with EPA's claim that "the price for Lithium is likely to stabilize at or near its historical levels by the mid-2020s."[16] The forecast of strong demand coupled with tight supply over the next decade creates an economic recipe for price volatility. In this fragile condition, every step of complex and intertwined global operations must fall perfectly into place as planned to avoid price spikes.

BMI suggests that lithium prices will stabilize (see Figure 11), but there is risk of underestimating potential volatility resulting from future shocks to the system. Historic price volatility has been primarily caused by localized shocks which are impossible to forecast but can have large consequences. For example, the lithium price shock below, driven by the covid-19 pandemic created supply restrictions, which increased prices and spurred supply growth, which has in turn depressed prices again. We will not know if such a spike will occur again until it happens.

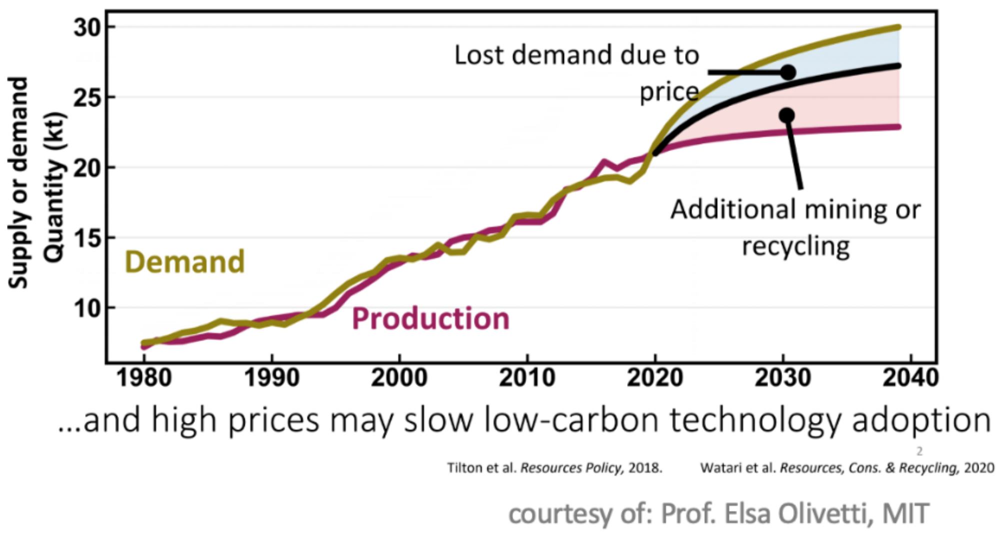
[16] Multi-Pollutant Emission Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles, EPA-420-D-23-003, Draft Regulatory Impact Analysis (DRIA), April 2023, page 3-21.

Figure 11 Historic Lithium Price Trends



Price fluctuations are expected to be a by-product of transitioning the vehicle fleet to PEVs while simultaneously establishing the supply base. Demand for PEVs will be determined by prices remaining in a range consumers can afford which requires sufficient supply so only modest supply-demand gaps occur. Otherwise, demand will contract due to price spikes/volatility. Figure 12 is an image of how a too much demand relative to available supply results in price spikes that suppress demand as part of a feedback loop making it more difficult to meet any government's PEV targets. Mines and refineries seek to avoid excess supply because it results in lower prices and profits which is occurring now and expected to persist for the next few years. Thus, mines and refineries seek conditions that favor high demand and prices, erring on the side of tight or under supply.

Figure 12 Supply-Demand Impacts on Pricing



According to numerous analysts, a temporary "excess" of global supply spurred by more lithium mining projects in conjunction with slower PEV sales in China because of expiring subsidies has resulted in the current lower lithium prices which are expected to remain through the 2026 timeframe but are not expected to hold, as mining and refining companies will adjust supply to avoid that less profitable scenario .[17]

Mining economics are at odds with EPA's conclusion that "rapid growth in lithium demand has driven new development of resources and robust growth in supply, which is likely a factor in recently observed reductions in lithium price, with strong profit margins remaining - even afterward."[18]

6 Conclusion

A deeper analysis of global and IRA-compliant critical material supply and demand is needed to support the final rule. The proposal's high-level assessment results in overly optimistic observations that "critical battery mineral supply is likely to be adequate to meet anticipated

[17] https://internationalbanker.com/brokerage/why-are-lithium-prices-collapsing
[18] 88 Fed. Reg at 29313.

demand, in some cases by a significant margin”.[19] The proposal lacks the evidence to support this finding. Demand for critical minerals today is now higher than the years referenced in the proposal due to new policy and OEM targets. Future demand growth for PEVs is unclear given the uncertain geo-political considerations and supply chain operations beyond the control manufacturers and EPA. It is highly plausible the tight supply-demand for lithium and graphite will lead to volatile prices and the proposal fails to consider how this could suppress demand and annual EV market share. The Final Rule must encompass a significantly deeper analysis based on a boarder array of sources for assessing global supply-demand by country of origin to support the use of IRA tax credits.

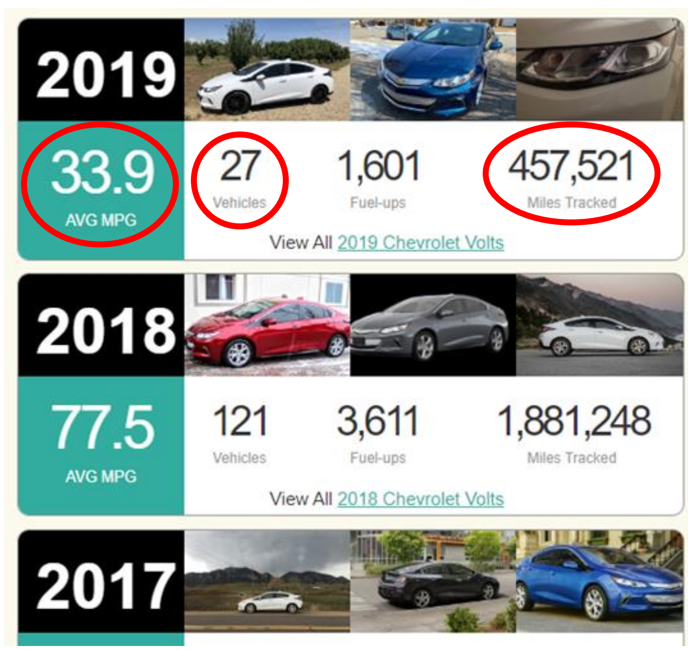
[19] Id

Appendix B – Procedure for (Partial) Cleaning of Fuelly Data for PHEVs

1 Overview of Errors in Using Fuelly Data

When examining Fuelly web site for some make-model (example in Figure 1 shows Chevrolet Volt), it shows multiple data cards, one for each model-year. Each data card shows some notable pieces of information including number of vehicles, total miles tracked and average MPG.

Figure 1 Screenshot From: https://www.fuelly.com/car/chevrolet/volt



One might be tempted to compare the *average MPG* to the *EPA label* for combined cycle MPG in charge sustaining (CS) mode to infer fleet utility factor (FUF). This is how it was done in the 2022 ICCT Whitepaper (which the EPA NPRM relied heavily on), and this is an incorrect approach that includes several errors stemming from limitations of Fuelly data, summarized as follows:

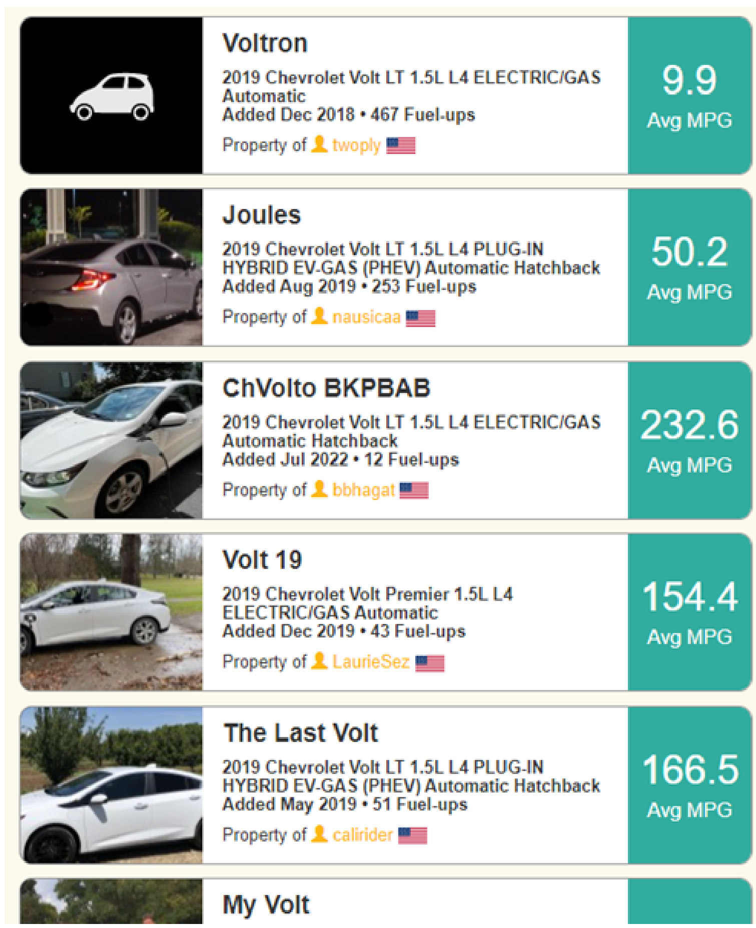
1. The average MPG for make/model/model-year reported on data cards (such as in Figure 1) excludes what Fuelly web site's back-end code considers to be "Outlier refueling" events. Spot-checking Fuelly data suggests that the criteria for being considered an outlier is the "standard" statistical criterion of being outside of 3-sigma (three standard deviations) bounds from the average value. Unfortunately, in case of PHEVs, the variation in "MPG numbers" can be very large, with some PHEVs that are charged regularly capable of attaining more than 200 MPG (as a single vehicle average). Thus, with a fleet that has an average of 100 MPG and standard deviation of 50 MPG is often, a refueling event at *near-zero-MPG* is still *"within 3-sigma",* while a refueling event at *300 MPG* is *"outside of 3-sigma"* thus, large amounts of electric-miles can be missing from the make/model/model-year data card shown in Figure 1.
2. Since Fuelly data is self-report by users and the website (or phone App) has only one data field for the amount of "Fuel", one observed recurring error is when a *user mistakenly enters an amount of electricity* as *"fuel",* which, for a typical electric driving at ~0.33 kWh per mile = 3 miles per kWh, can completely distort the average MPG if/when seen by the back end code of Fuelly as a *"3 MPG" refueling event*
3. Assumption that a PHEV is "exactly attaining" its EPA label for combined cycle CS mode fuel economy, when in fact, most vehicles (PHEVs being no exception) can be somewhat less efficient (within certain limits, 10% to 15% worse MPG than EPA label often considered "normal") *leads to under-estimation of the faction of miles driven on grid electricity.*

In section 2 of this appendix, we show a procedure to correct error #1 and error #2, but Fuelly data, which does not show the split between charge sustaining and charge depletion, is insufficient for making corrections to error #3. As such, *after conducting the data cleaning, the estimated utility factors are still only lower bounds for the true real-world utility factors*.

2 Correction of Error #1 and Error #2

Clicking on an individual data card for make/model/model-year (such as the ones shown in Figure 1) opens a set of data card summaries for each individual vehicle sample, as shown in Figure 2.

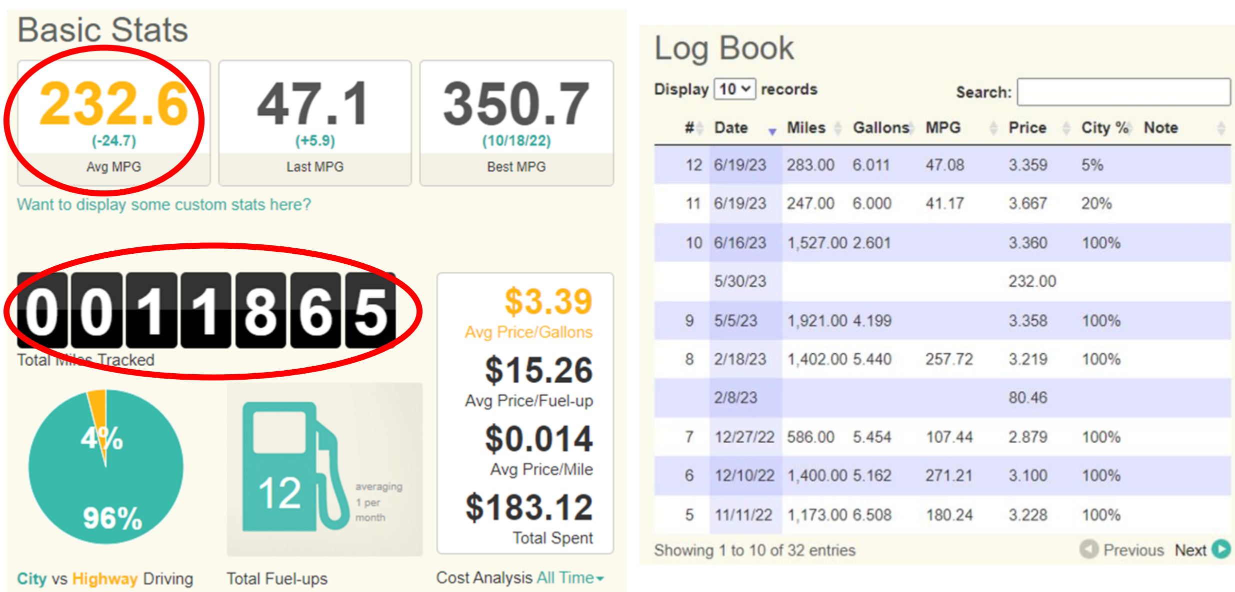
Figure 2 Screenshot From: https://www.fuelly.com/car/chevrolet/volt/2019



Next, one needs to click on the data card of each individual vehicle sample in order to open a detailed page for the individual vehicle sample, as shown in Figure 3 and Figure 4. Details included in these pages show the total miles tracked, as well as the average MPG of the vehicle (throughout its total miles tracked). These numbers should be noted separately for each vehicle (thereby bypassing Error #1). The detailed page also includes the log book of miles travelled and refueling events, which one needs to carefully inspect for entries that may have incorrectly reported electricity usage as gasoline (example in Figure 4), and if discovered, the affected vehicle sample is excluded.

Ones then needs to repeat the procedure for every individual vehicle sample. Next, would be to infer (lower bound of) each vehicle's fraction of electric miles, and then lastly, one can estimate (lower bound of) overall fleet utility factor.

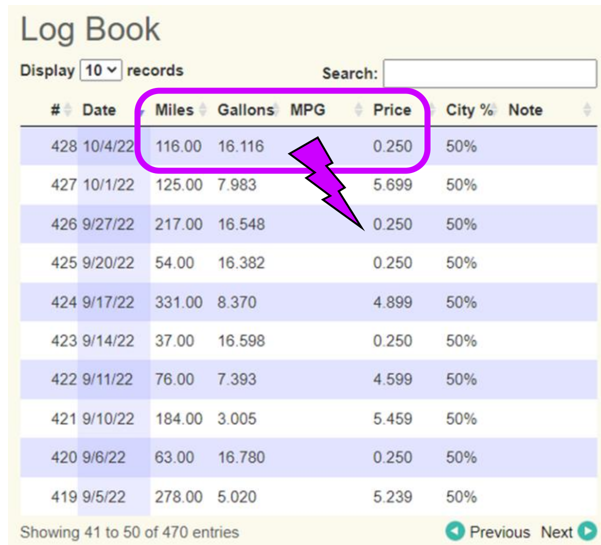
Figure 3 Screenshots From:
https://www.fuelly.com/car/chevrolet/volt/2019/bbhagat/1155376



#	Date	Miles	Gallons	MPG	Price	City %	Note
12	6/19/23	283.00	6.011	47.08	3.359	5%	
11	6/19/23	247.00	6.000	41.17	3.667	20%	
10	6/16/23	1,527.00	2.601		3.360	100%	
	5/30/23				232.00		
9	5/5/23	1,921.00	4.199		3.358	100%	
8	2/18/23	1,402.00	5.440	257.72	3.219	100%	
	2/8/23				80.46		
7	12/27/22	586.00	5.454	107.44	2.879	100%	
6	12/10/22	1,400.00	5.162	271.21	3.100	100%	
5	11/11/22	1,173.00	6.508	180.24	3.228	100%	

Figure 4 Screenshots From:

https://www.fuelly.com/car/chevrolet/volt/2019/twoply/880546



Log Book

Display 10 records Search:

#	Date	Miles	Gallons	MPG	Price	City %	Note
428	10/4/22	116.00	16.116		0.250	50%	
427	10/1/22	125.00	7.983		5.699	50%	
426	9/27/22	217.00	16.548		0.250	50%	
425	9/20/22	54.00	16.382		0.250	50%	
424	9/17/22	331.00	8.370		4.899	50%	
423	9/14/22	37.00	16.598		0.250	50%	
422	9/11/22	76.00	7.393		4.599	50%	
421	9/10/22	184.00	3.005		5.459	50%	
420	9/6/22	63.00	16.780		0.250	50%	
419	9/5/22	278.00	5.020		5.239	50%	

Showing 41 to 50 of 470 entries Previous Next

Appendix C – Materials from EPA-Toyota Meeting on SAE Utility Factor for PHEVs

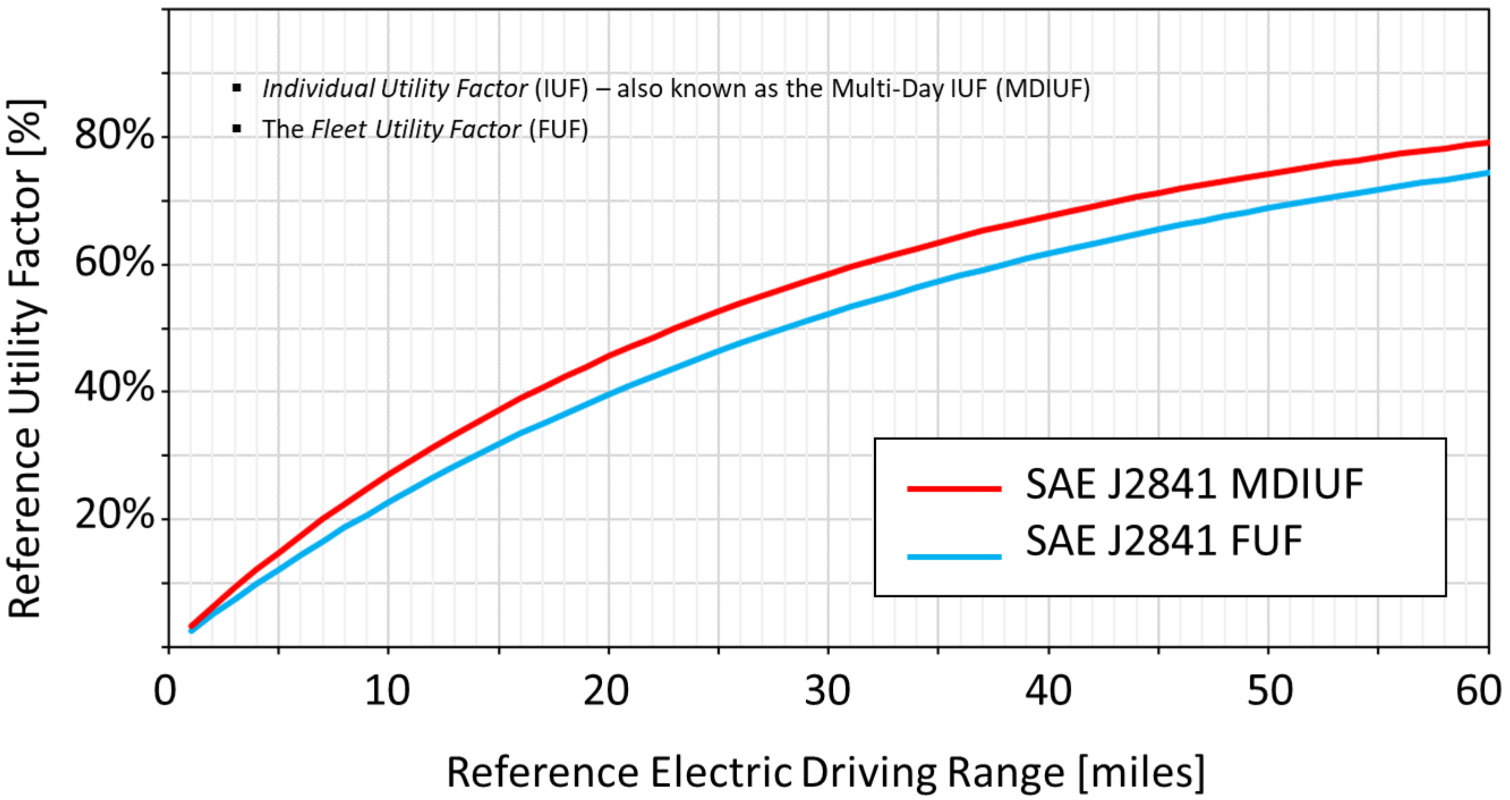
ICCT WHITEPAPER ON SAE UTILITY FACTOR FOR PHEVS

Toyota Evaluation of Methodology and Findings

March 16, 2023

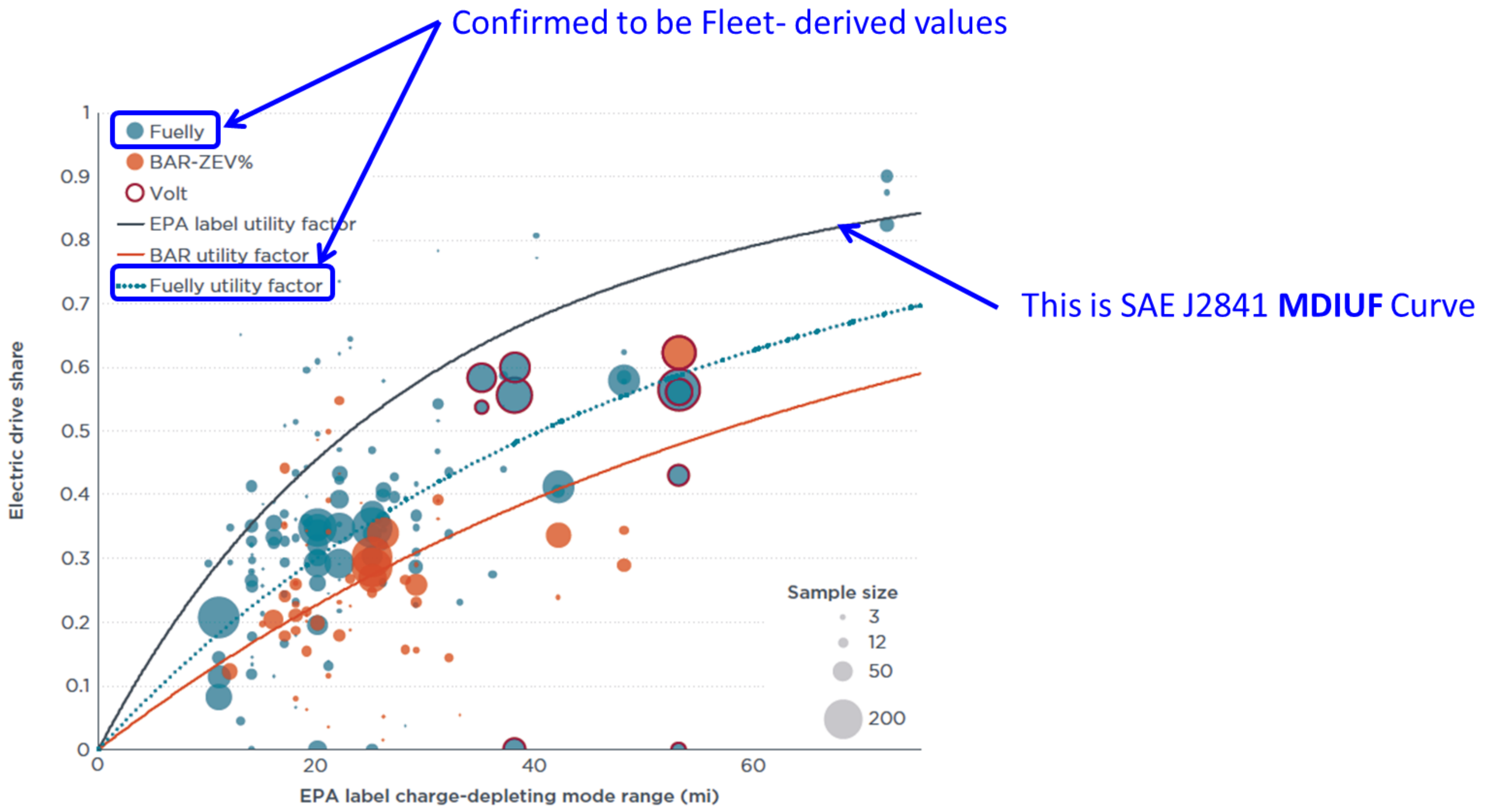
TOYOTA MOTOR NORTH AMERICA
Sustainability and Regulatory Affairs
Environmental Regulation

BACKGROUND – DIFFERENT UTILITY FACTORS IN SAE J2841



FUF (or any "Fleet"-derived) numbers typically have lower values because the vehicles driving longer distances are typically driving more miles in HEV mode.

WRONG SAE UTILITY FACTOR CURVE USED



FUF Numbers erroneously plotted on MDIUF Curve.

FUELLY DATA NOT APPROPRIATE TO CALCULATE PHEV UTILITY FACTOR

- Intended for liquid fuel users to input miles driven, refuel amount, and fuel price to calculate fuel economy and costs incurred
  - No interface for electricity consumption
  - Some EV users attempt to track electric driving efficiency by inappropriately entering miles driven, kWh used, and electricity rate ($/kwh)
  - Some EVs recorded consuming gasoline
- Results in ultra-low, incorrect fuel economy data points
- Correcting data starts to approximate real-world fuel consumption but not PHEV UF

Corrected Fuelly data provides Real-World FE, not CD / CS driving miles.

MAJOR ERRORS IN TREATMENT OF FUELLY DATA

"Data Point" Corresponds to **27 Vehicles** of **2019** Chevrolet **Volt**

- ICCT plots the "data point" as if all 27 Vehicles had Zero Electric Miles

But the reality is that is because **2** (out of 27) **vehicles** included **Errors** in **avg. MPG (9.5 MPG & 8.6 MPG**, impossible values), **dragged the average** of the group to **less** than the **charge sustain rating** of 42 MPG

Electric Charging got (Incorrectly) **Reported as Gasoline**

Log Book

Display 10 records Search:

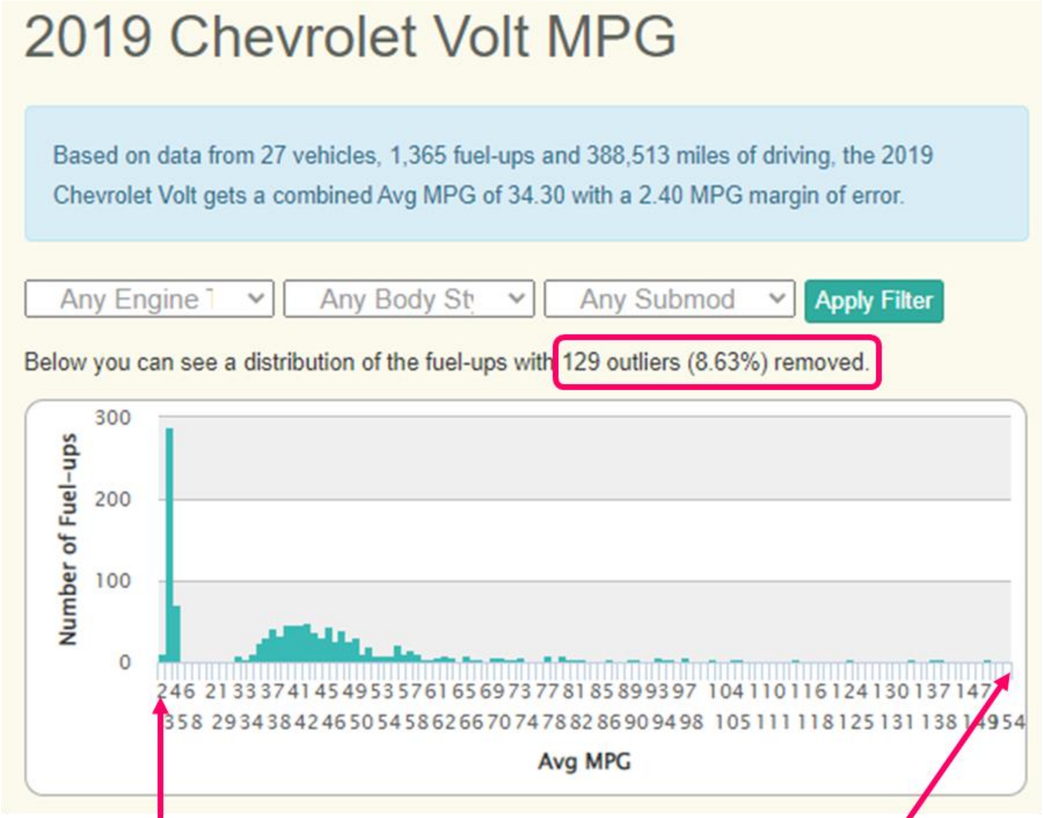
#	Date	Miles	Gallons	MPG	Price	Note
538	1/4/23	37.00	13.200	2.80	0.130	
537	1/4/23	34.00	12.000	2.83	0.130	
536	1/3/23	49.00	17.300	2.83	0.130	
535	12/21/22	45.00	13.900	3.24	0.130	
534	12/21/22	191.00	5.232	36.51	2.549	
533	12/20/22	34.00	13.200	2.58	0.130	
532	12/20/22	34.00	13.200	2.58	0.130	
531	12/19/22	37.00	13.000	2.85	0.130	
530	12/19/22	221.00	6.195	35.67	2.749	
529	12/19/22	30.00	11.000	2.73	0.130	

2019 Chevy Volt LT
2019 Chevrolet Volt LT 1.5L L4 ELECTRIC/GAS Automatic
Added Mar 2021 • 539 Fuel-ups
9.5 Avg MPG

Voltron
2019 Chevrolet Volt LT 1.5L L4 ELECTRIC/GAS Automatic
Added Dec 2018 • 448 Fuel-ups
Property of twoply
8.6 Avg MPG

Errors result in impossibly low MPG values being inappropriately included.

MAJOR ERRORS IN TREATMENT OF FUELLY DATA



Keeping "2 MPG" Fuel-ups…

But excluding higher than 154 MPG Fuel-ups

Electric miles in Fuelly Model-Year Average MPG) excluded because **filtering metric is std. dev. of MPG**…

- **"2 MPG" can be "less outlier"** (in terms of 3-sigma) from the average **than 200 MPG**
- But **200+ MPG** Fuel-up **is quite common for Volt owners who charge regularly**

Errors result in large portion of electric miles being excluded.

MAJOR ERRORS IN TREATMENT OF FUELLY DATA

Limitations of the Mathematical Model*

$$FC_{RW} \cong (1 - UF_{RW})FC_{CS,Rated}$$

- Equation can be applied in “Forward direction” (to ***Estimate*** Real-World **Fuel Consumption** from ***measured/reported*** Real-World **UF**)
- Or… could be applied in “Inverse direction” (to ***Estimate*** Real-World **UF** from ***measured /reported*** Real-World **Fuel Consumption**)
  - **May lead to** less than zero **(negative value) UF** Estimates if Real-World Fuel Consumption is slightly more than rated Charge Sustaining MPG

ICCT says they did a “correction” so the value is no less than zero

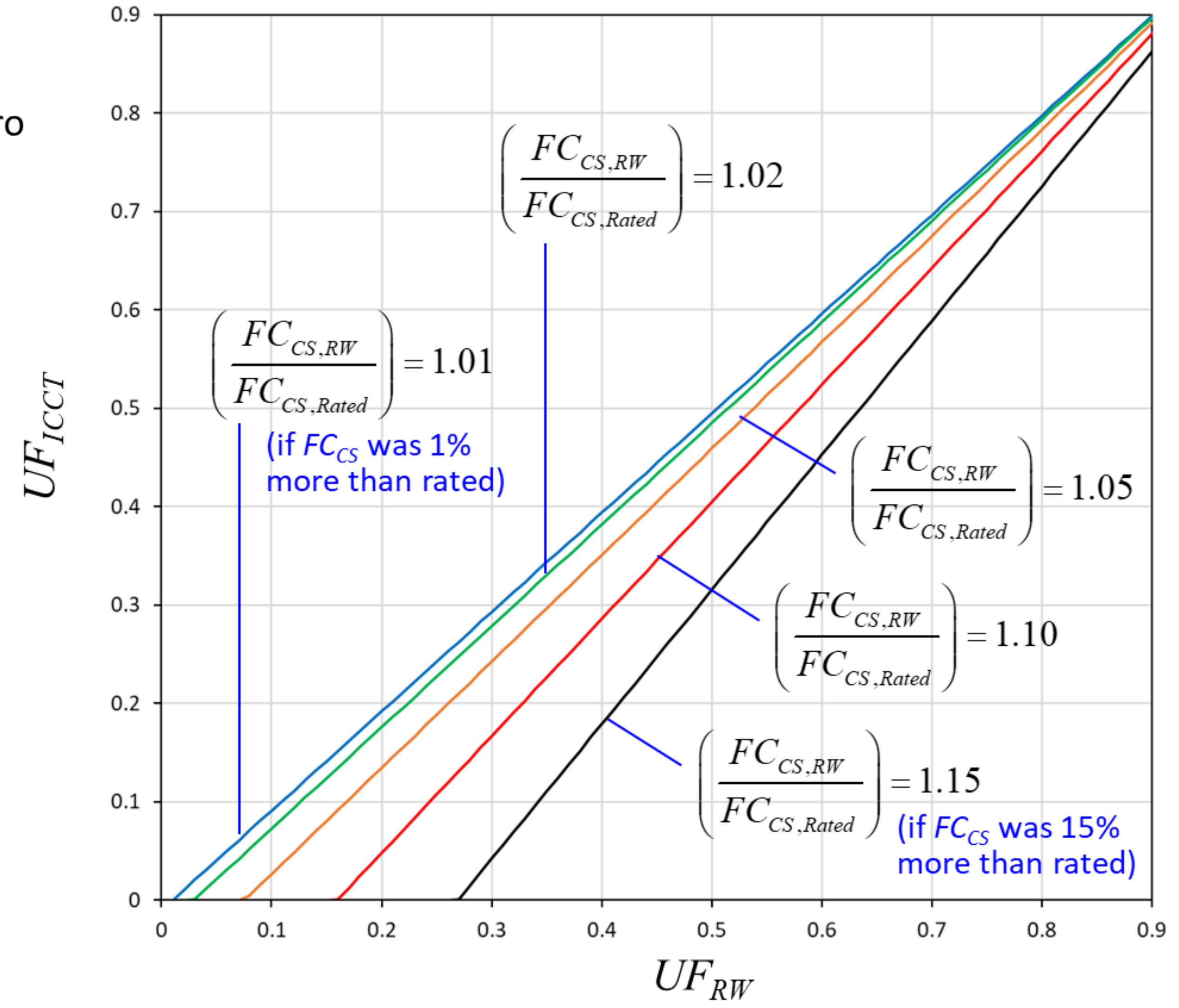
- But that type of **correction should have been done Vehicle by Vehicle** (not on group average as how the ICCT did it)

* In addition to limitations detailed on this slide, the equation assumes the PHEV exactly attains it rated charge sustaining fuel economy. If for any reason (cold weather, towing, aggressive driving …etc.) the real-world charge sustaining fuel economy was more than rated value, then this equation will under-estimate the vehicle utility factor

UF ESTIMATION VIA ICCT CALCULATION VS CORRECTED MATH MODEL

$$UF_{ICCT} = \left[1 - \left(\frac{FC_{CS,RW}}{FC_{CS,Rated}}\right)\right] + \left(\frac{FC_{CS,RW}}{FC_{CS,Rated}}\right) UF_{RW}$$, or Zero

Note:
It is not uncommon (and is generally acceptable) for a vehicle w/ any type of powertrain, to be within ±10% of its EPA label or even ±15% of its EPA label for "smaller sample size" (such as the few hundred vehicles on Fuelly)



MAJOR ISSUES/CONCERNS ABOUT BAR DATASET

Evaluation limited to the whitepaper because data is not publicly accessible.

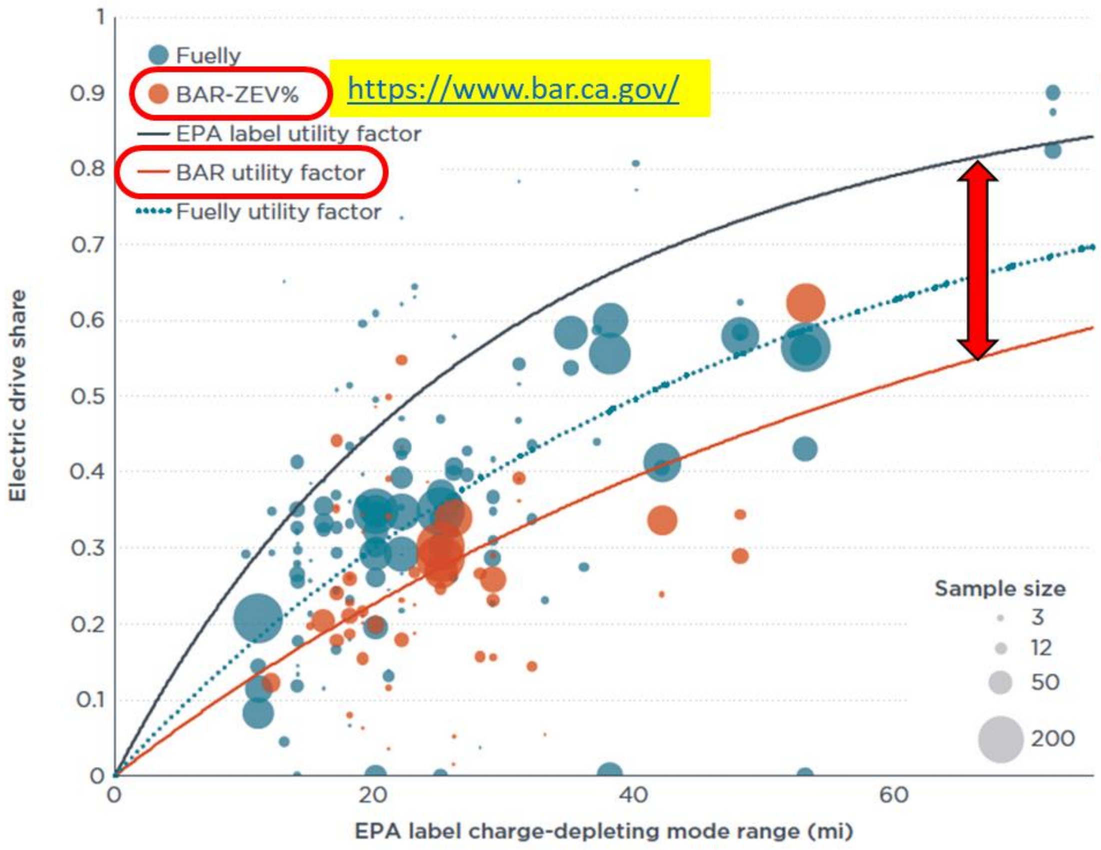
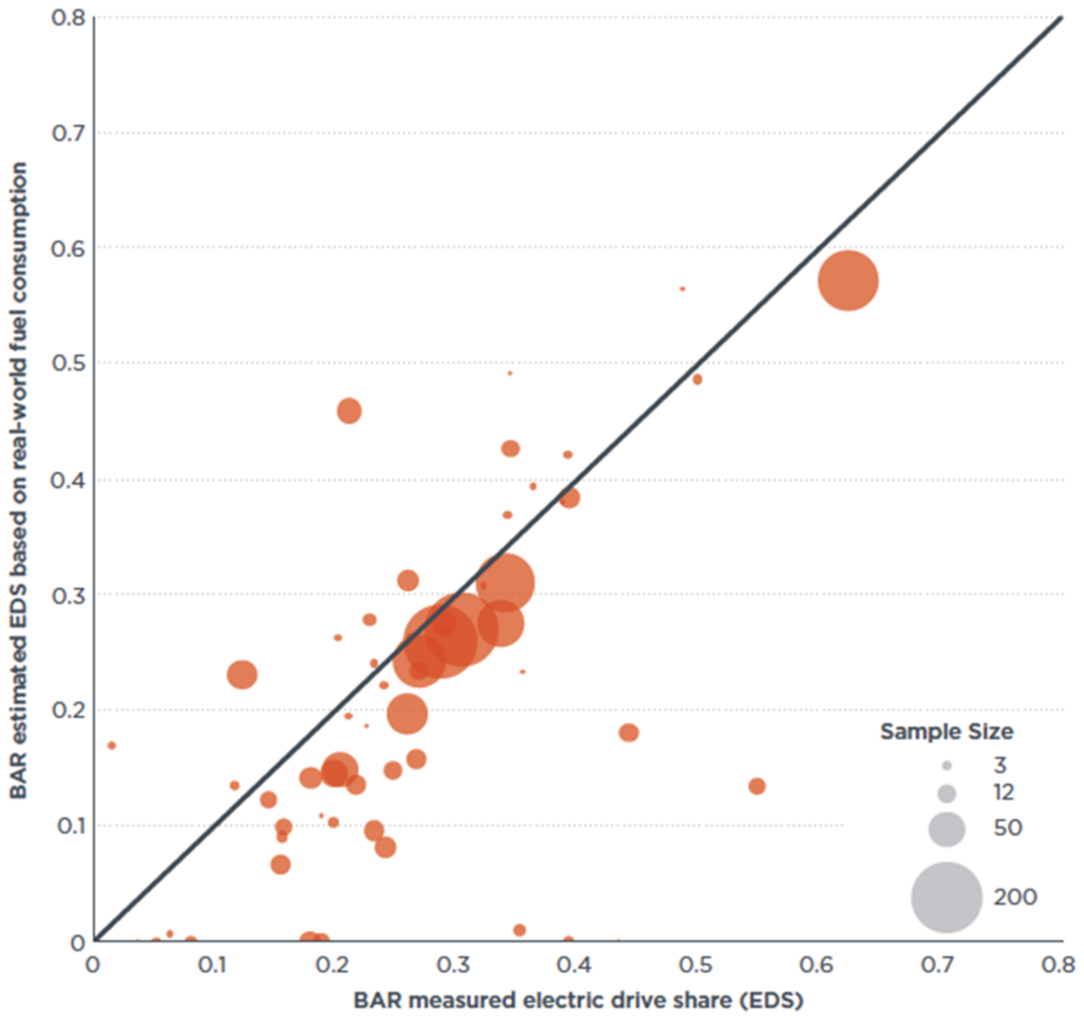


Figure ES1. Calculated utility factors and adjusted utility factor curve based on California BAR (using direct measurement of all-electric travel fraction) and Fuelly (calculated from fuel consumption) datasets.

California's Bureau of Automotive Repair collects on-board diagnostic (OBD) data on all vehicles subject to testing (BAR, 2022). Through its 2015 OBD II provisions, new California-registered PHEVs must track relevant real-world energy consumption parameters, including total distance traveled and total fuel consumed, distance traveled and fuel consumed in CD mode (with engine on and off), and grid electricity into and out of the battery. Because the data reported to BAR is mandatory, this dataset avoids the self-selection bias inherent in the other datasets. However, since new cars are exempt from OBD testing and data collection for 8 years except for vehicles changing ownership or newly entering the state, the BAR dataset only contains those PHEVs subject to the exceptions. As such, many of the PHEVs in the

- Includes only **MY2019+ PHEVs that have Recently Changed Hands** or came from out of state which severely limits the data set.

MAJOR ISSUES/CONCERNS ABOUT BAR DATASET



As shown in Figure 4, EDS calculated from average fuel consumption (Equation 2) tends to be lower than actual EDS calculated from the direct measurement of the fraction of all-electric travel. This discrepancy may be due to real-world fuel consumption in CS mode being higher than label CS mode fuel consumption. Calculated EDS is, on average, 12% lower than measured EDS. All vehicles which have a calculated EDS of 0 (average fuel consumption greater than FC_{CS}^{EPA}) have measured EDS of higher than 0 (recorded engine-off distance >0). Nevertheless, estimating EDS from fuel consumption represents actual EDS, as recorded by OBD systems in the BAR data, fairly well.

- ICCT possesses BAR information about "true" Miles Travelled in EV Mode, yet still used the indirect method to infer UF from Fuel Consumption
- ICCT acknowledges **Electric Drive Share** derived from **Indirect Method** is 12% Lower than calculating it from actual **Miles Traveled in EV mode** in BAR dataset

CONCLUSIONS/NEXT STEPS

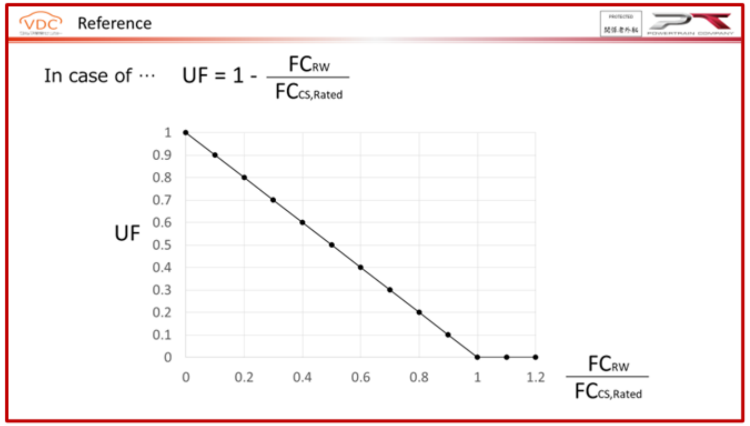
- ICCT whitepaper should not serve as basis for evaluating real-world PHEV operation
  - Fuelly website is not designed for PHEVs
    - ICCT methodology fails to correct resulting data errors
    - At best, corrected data provides indication of fuel consumption
    - Charge Depleting and Charge Sustaining modes cannot be derived from fuel consumption
  - BAR dataset is inaccessible; whitepaper description casts doubt on its validity
    - ICCT methodology attempts to infer UF from fuel consumption ignoring available data on miles traveled in electric-mode
    - Would deeper evaluation of BAR dataset be valuable?
    - If so, could EPA help us gain access?
- Toyota is in process of collecting and analyzing data from our PHEV products during real-world use
- Propose future meeting to share our findings, conclusions, and recommendations

APPENDIX

ICCT MATH MODEL ITSELF HAS ISSUE (EVEN WITH CORRECTED FUELLY DATA)

$$FC_{RW} \cong (1-UF_{RW})\ FC_{CS,Rated} \quad \Rightarrow \quad UF_{RW} \cong 1-\left(\frac{FC_{RW}}{FC_{CS,Rated}}\right)$$

As pointed out by TMC, this can **under-estimate UF**



Corrected Math Model

$$FC_{RW} \cong (1-UF_{RW})\ FC_{CS,RW}$$

For the equation to be correct, this needs to be the **Real-World Fuel Consumption** in **charge sustaining** mode (Not available in Fuelly dataset)

We then re-write ICCT equation as

$$FC_{RW} \cong (1-UF_{ICCT})\ FC_{CS,Rated}$$

Combine both equations & re-arrange

UF that ICCT calculated

UF from Corrected Mathematical Model

$$UF_{ICCT} = \left[1-\left(\frac{FC_{CS,RW}}{FC_{CS,Rated}}\right)\right]+\left(\frac{FC_{CS,RW}}{FC_{CS,Rated}}\right) UF_{RW}$$, or Zero

Appendix D – U.S. Air Quality Studies by Toyota

US Air Quality Studies by Toyota

TOYOTA MOTOR CORPORATION
Regulation and Certification div.
Certification Dept.2
Toru Kidokoro, Taiga Yamada

Toyota's Basic Stance on the Activities

Guiding Principles at Toyota (1992)

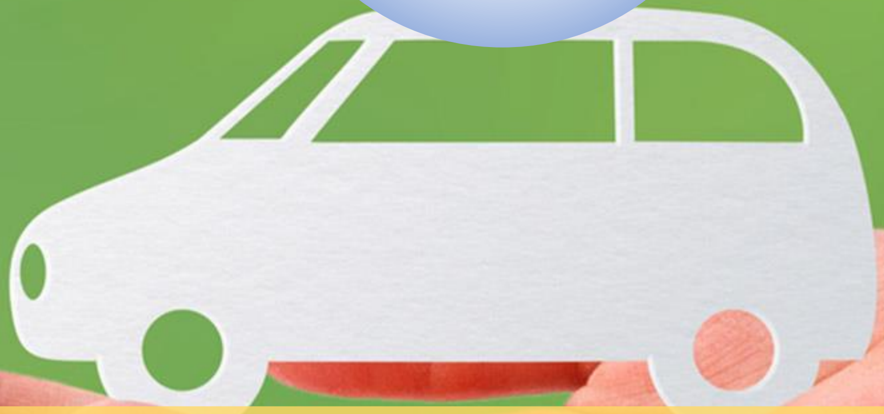
"Dedicate our business to providing clean and safe products and to enhancing the quality of life everywhere through all of our activities."

TOYOTA EARTH CHARTER (1992)

"Support government environmental policies"

Toyota Environmental Challenge 2050 (2015)

"Reduce global average CO_2 emissions during operation from new vehicles by 90% from Toyota's 2010 global level"

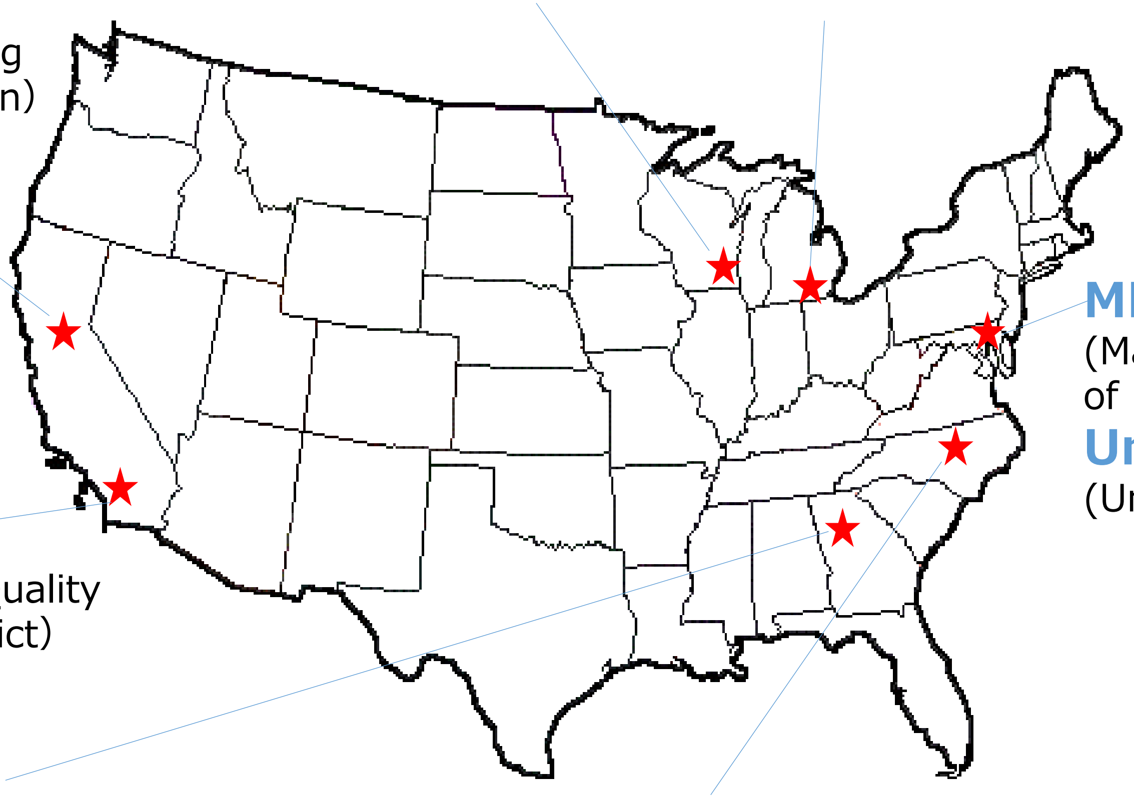


To improve air quality and to reduce health effects, Toyota supports and contributes to scientific analysis of air quality study around the world.

<u>Through Air Quality modeling of future conditions,</u>
<u>Toyota is conducting studies on how automakers could have an impact.</u>

Toyota's Activity in US

Toyota promotes this activity in cooperation with authorities, university and conference all over the US.



Trends in Strengthening $PM_{2.5}$ NAQQS

On January 5, 2023, EPA proposed to strengthen the PM NAQQS. Their proposal is to revise the level of the primary (health-based) annual standard for fine particles ($PM_{2.5}$) from its current level of 12 μg/m³ to within the range of 9 –10 μg/m³. EPA is soliciting comment on revising the level as low as 8.0 μg/m³ and up to 11.0 μg/m³.

EPA United States Environmental Protection Agency

Summary of Current Standards and Proposed Revisions

Current Standards – Last Revised in the 2012 Review*					Decisions in 2012 Review	Decisions in 2020 Review	Proposed Decisions in 2022 Reconsideration
Indicator	Averaging Time	Primary/ Secondary	Level	Form			
$PM_{2.5}$	Annual	Primary	12.0 μg/m³	Annual arithmetic mean, averaged over 3 years	Revised level from 15 to 12 μg/m³**	Retained	**Revise level to 9-10 μg/m³** (Comment on 8-11 μg/m³)
		Secondary	15.0 μg/m³		Retained**	Retained	**Retain**
	24-hour	Primary and Secondary	35 μg/m³	98th percentile, averaged over 3 years	Retained	Retained	**Retain** (Comment on revising as low as 25 μg/m³)
PM_{10}	24-hour	Primary and Secondary	150 μg/m³	Not to be exceeded more than once per year on average over a 3-year period	Retained	Retained	**Retain**

* Prior to 2012, PM NAAQS were reviewed and revised several times – established in 1971 (total suspended particulate – TSP) and revised in 1987 (set PM_{10}), 1997 (set $PM_{2.5}$), 2006 (revised $PM_{2.5}$, PM_{10})

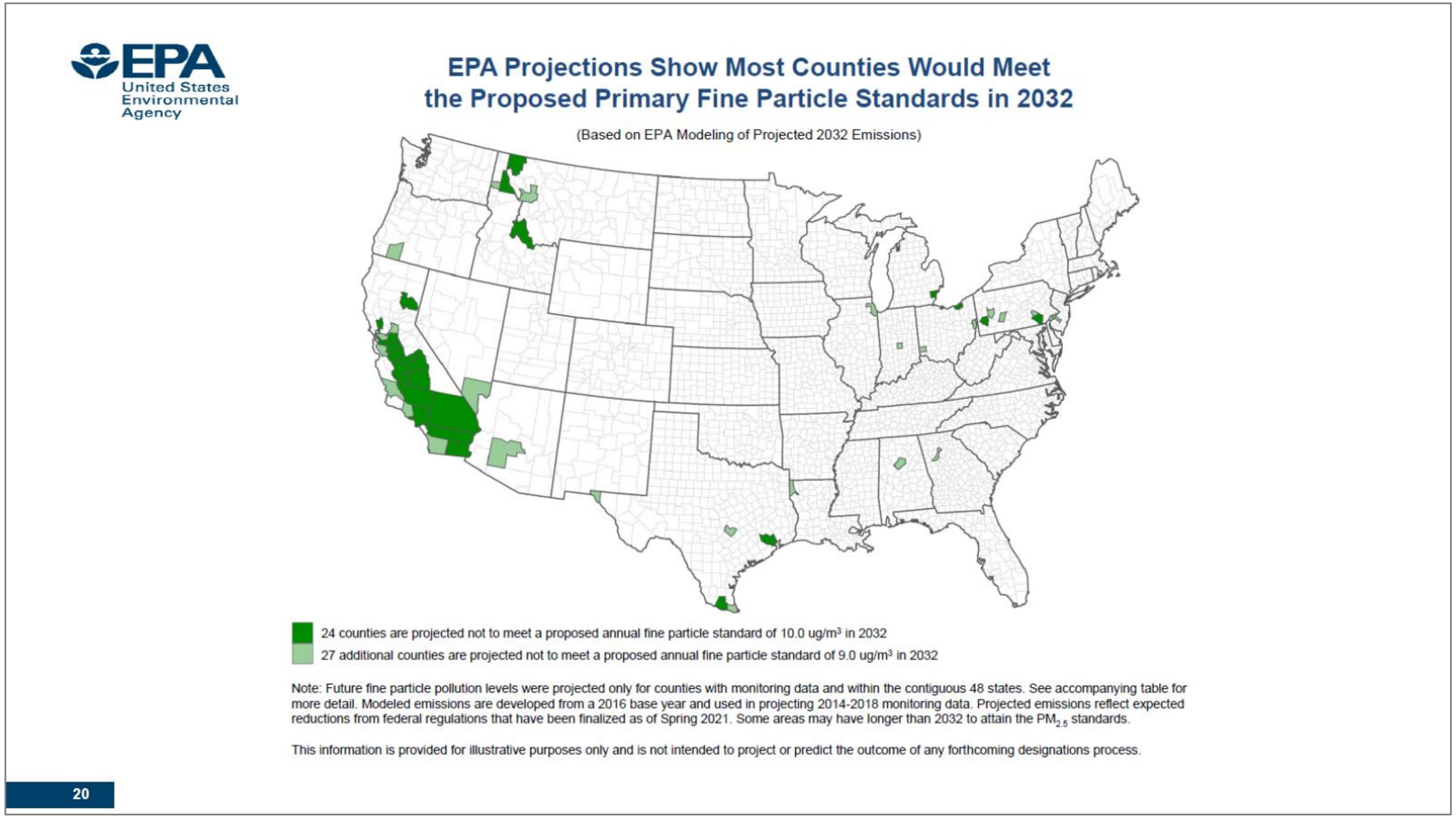
** EPA eliminated spatial averaging for the annual standards

4

*PROPOSED REVISIONS TO NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER, EPA, Jan. 2023

Trends in Strengthening $PM_{2.5}$ NAQQS

At the same time as announcing the proposal to strengthen the NAQQS standard, the EPA also announced its expected achievement as of 2032. Most counties except California are expected to meet proposed new standard level.



*PROPOSED REVISIONS TO NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER, EPA, Jan. 2023

Specification of US Air Quality Modeling

In FY2022, we commissioned the research to Ramboll Environ US Corporation to conduct atmospheric research.

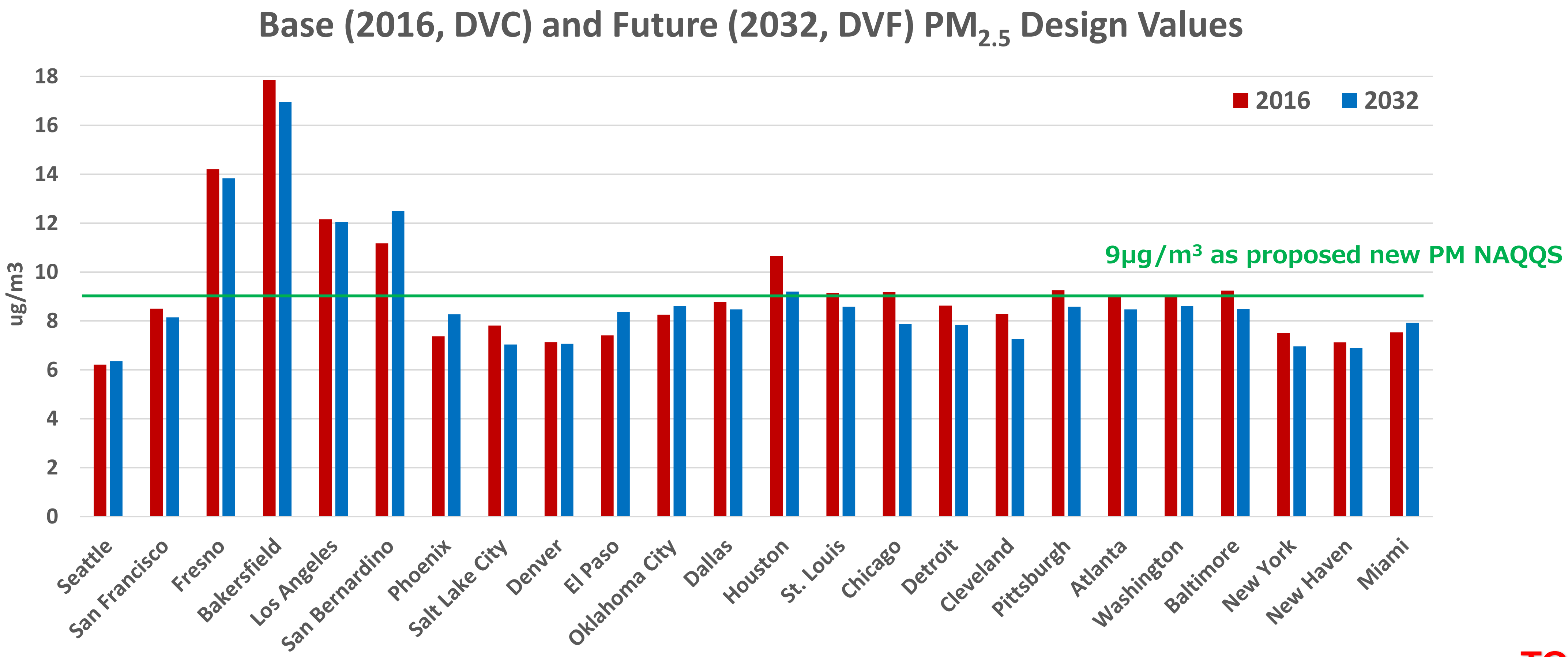
Simulation tool	CAMx ver.7.2 w/ 2016v2 EPA modeling platform
Target	$PM_{2.5}$: Average of full year
Attribution Determining Method	P-SAT : Source Apportionment
Emission source	- Anthropogenic sources 1) Mobile source LDGV emissions 2) Mobile source HDDV emissions 3) Other mobile source emissions 4) Off-road emissions*1 5) Point source emissions*2 6) Other anthropogenic sources*3 - The other emissions include natural 7) Global Boundary Conditions 8) Non-US 9) Natural

*1 : Locomotive, Marine sector, etc.
*2 : Electric generating units, Portland Cement Facilities, Refueling, etc.
*3 : Prescribed and agricultural fires and other area sources and including Residential fuel combustion, solvent utilization (e.g. Paint, Printing), Dry-Cleaning, Fugitive dust emissions, etc.

Fig. 12 km grid over the contiguous United States.

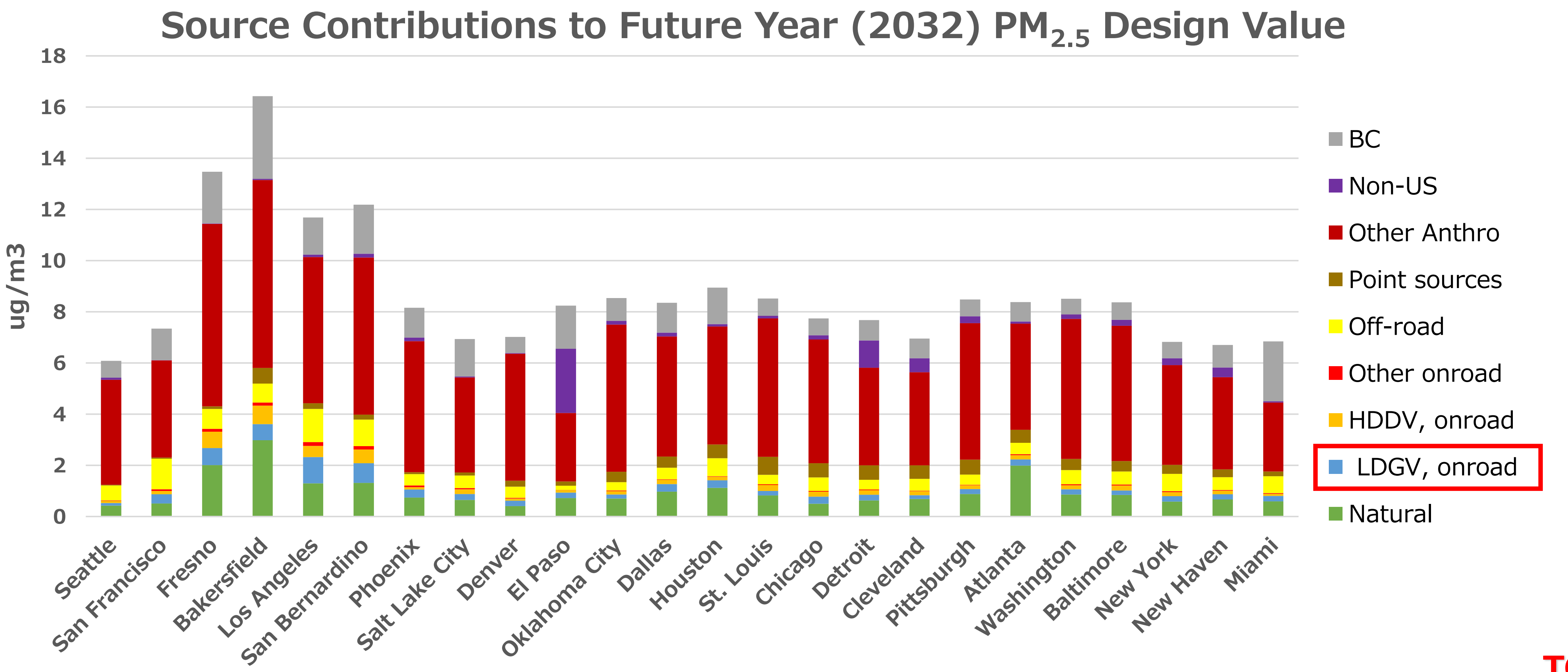
Future Design Values of $PM_{2.5}$

The results of the 2032 Future Design Values across the United States, similar to the data released by the EPA, indicate that the new PM NAQQS is broadly expected to be achieved in major regions except California.



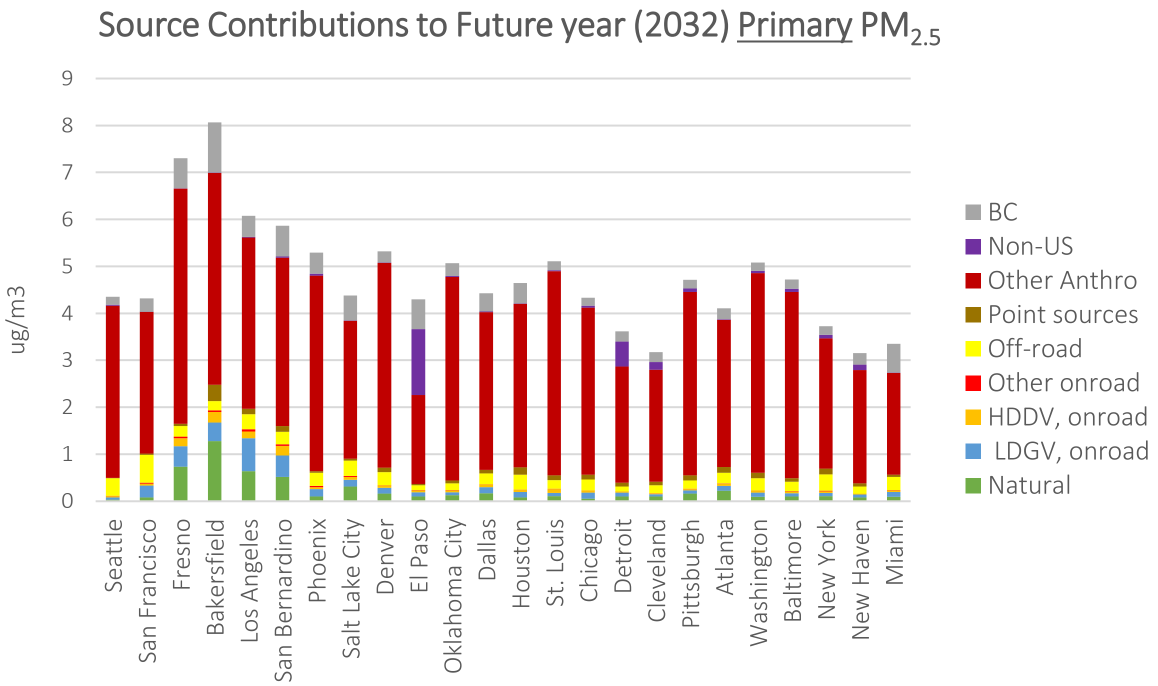
Source Contributions study (PSAT)

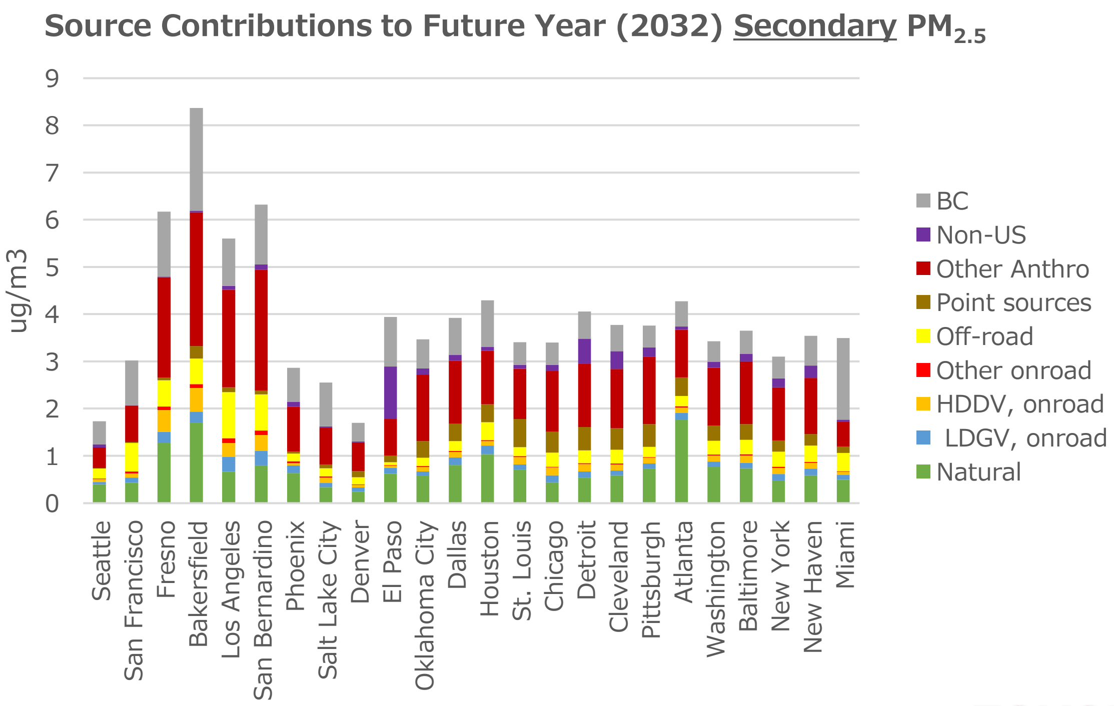
- The result of source apportionment study, the other anthropogenic source category is major contributor and Off-road is the next largest anthropogenic source in most locations.
- Emissions from LDGV have already been reduced by emission regulations so far and the contribution is very limited, with ranging from 1.5% in Seattle to 3.8% in Phoenix except California.



Source Contributions of Primary and Secondary $PM_{2.5}$

- To understand the reasons for the relatively large contributions of other anthropogenic sources at all the cities considered, we calculated the primary (directly emitted $PM_{2.5}$) and secondary ($PM_{2.5}$ formed by atmospheric chemistry) components of $PM_{2.5}$.
- The other anthropogenic source sector is the dominant contributor to primary $PM_{2.5}$, indicating the influence of primary anthropogenic fugitive dust and agricultural/prescribed fires emissions to the total $PM_{2.5}$.





TOYOTA

Summary

- We will cooperate in the consideration of effective measures through scientific analysis to comply with the proposed new NAQQS.
- Simulation of future PM2.5 concentration in 2032 shows the new PM NAQQS is broadly expected to be achieved in major regions except California.
- Our study quantitatively clarifies the source apportionment. As a result;
  1. The other anthropogenic source category is major contributor.
  2. The contribution of LDGV is very limited, with ranging from 1.5% in Seattle to 3.8% in Phenix except California.