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King Abdullah Petroleum Studies and Research Center

Drivers of Transportation Fuel Demand: Aligning Future Scenarios and Policy Expectations

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology, and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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Key Points

The U.S. light-duty vehicle market represents a key test bed for some of the world's leading vehicle regulatory policy programs. At the federal level, standards for model years 2022-2025 were established in 2012 under the Greenhouse Gas (GHG) Emissions/Corporate Average Fuel Economy (CAFE) program. At the state level, the Zero Emission Vehicle (ZEV) mandate portion of California's Advanced Clean Cars program, adopted by nine other states, was most recently revised at about the same time. Although both are emissions-related policies, they are concerned with different time frames and aspects of the vehicle market. The forthcoming mid-term review for both programs presents an ideal opportunity to reassess likely outcomes in light of new information and changing market conditions, and to align them with policy expectations.

Perhaps the single biggest change since 2012 is the unexpected drop in fuel prices. Low fuel prices imply low fuel cost savings, which reduces the incentive for consumers to pay up front for fuel efficient technologies. This could shorten the time horizon under which meeting GHG/CAFE standards via technology improvements is economically feasible.

The ZEV mandate currently straddles the line between an innovation policy and a technology forcing policy. The near-term goal is to foster innovation and introduction of ZEV technologies in a way that accelerates both cost reduction and consumer familiarity, while the long-term goal is to achieve extensive GHG reductions.

GHG/CAFE and ZEV place different types of requirements on manufacturers simultaneously. It is worth exploring whether their goals could be achieved through a single, unified policy, given the ultimate goal of cost-effective GHG reduction over the longer term. This could require a combination of more stringent performance standards with an appropriately designed system of credits for new technologies.

Summary for Policymakers

In preparation for the upcoming mid-term review of the U.S. GHG/CAFE and ZEV programs, policymakers will be interested in insights as to the likely outcomes, how these compare with policy expectations and how they could be better aligned.

The current U.S. vehicle regulatory structure represents a layer cake of regulations. The layer cake, with carve-outs such as the ZEV mandate, is a valid approach to achieving the ZEV transition. However, a more stringent, single, unified long-term performance based standard, with appropriate ZEV incentives, could also achieve an eventual transition to technologies with zero emission capacity, possibly at lower cost than the ZEV mandate. This would be at a slightly slower, but sustainable, pace, however, with equivalent cumulative GHG impact.

It is important to examine the details of each program and to align the expectations and assumptions made during policy formulation with current realities and likely future scenarios. The GHG/CAFE rulemaking assumed that vehicle manufacturers would not change their sales strategies as a result of changed fuel prices. Low gasoline prices imply low fuel cost savings, which reduces the incentive for consumers to pay up front for fuel efficient technologies. Such conditions could lead to more pricing induced sales shift strategies being adopted by automakers. Under such a scenario, higher emission vehicles could end up subsidizing and supporting sales of lower emission vehicles, an outcome similar to that achieved in Europe by discriminatory taxation of higher emission vehicles. It remains debatable what is the most efficient and cost-effective way of achieving the same outcome.

Data from 2012-2014 suggest that some of the assumptions of the regulatory agencies related to technology deployment, efficiency improvements, market drivers – i.e., fuel price – and consumer acceptance may require adjustment. The model year (MY) 2025 standards require overall fleet energy efficiency to be higher than best existing diesel powertrains, which have greater efficiency than today's top one percent advanced spark ignition powertrains. This calls into question the degree of hybridization and the penetration of advanced turbocharged spark ignition engines that would be needed to meet the standards.

Although originally conceived as an innovation policy, the high market share mandated by the ZEV regulation from 2018 onwards suggests that it would transition to a GHG reduction policy. The ZEV program seems to be evolving in this manner because it is not easy to encourage industry to pursue radical innovation for public good when the externality costs are not internalized. From a GHG reduction perspective, the carbon dioxide (CO_2) abatement costs for ZEVs, relative to conventional gasoline internal combustion engine vehicles are in the range of hundreds to thousands of U.S. dollars per metric ton of CO_2 avoided, which is much higher than the social cost of carbon. Even if the ZEV mandate is still considered as an innovation policy, cost is an important part of the discussion because of the difficulty of scheduling innovation. To round off the cost discussion, it is also important to consider the cost of waiting, with regard to the 'irreversible' effects of GHG emission on climate change.

From a societal cost-benefit point of view, it is worth considering emission reductions from transport sectors other than transforming the passenger fleet to ZEV. It may be worth analyzing whether the ZEV mandate and the public-private sector support for subsidizing ZEV production and deployment may be a case of sub-optimal allocation of resources. However, when assessing government support for ZEVs, it is important to consider this in the context of government support for other legacy systems such as fossil fuels.

It is worth examining whether the ZEV mandate is the best possible solution to bring innovative research to the market. It is difficult to understand how encouraging one technology over another, i.e., battery electric vehicles (BEVs) over plug-in hybrid electric vehicles (PHEVs), would lead to more innovation. It might be a reaction to the experience in Europe and China, where although PHEVs helped in complying with the GHG/CAFE standard, they continued to run on gasoline.

Europe provides an interesting contrast to the U.S. ZEV program. However, in European countries, a lot more public sector resources are being devoted to ZEV deployment and, thus, from the societal cost-benefit point of view, they may be less justifiable than the U.S. ZEV program.

For sustainable ZEV growth, it might be helpful to understand how the relationships between the three components of the ZEV ecosystem are evolving over time, namely, refueling infrastructure, the new ZEV market and the used ZEV market. Although currently the majority of charging takes place at home, the role of public and workplace charging may increase as the ZEV market expands, especially among owners without garages. Also, public charging, especially workplace charging, provides the opportunity for vehicle-grid integration, especially for coupling with renewables (solar/wind). This could lead to network externality benefits, which could encourage public-private investment in charging infrastructure, where currently low revenues from charging pose a major barrier.

Background to the Workshop

On April 1, 2016, KAPSARC hosted a one-day workshop in San Francisco, California, exploring the possibilities for aligning the policy expectations and likely outcomes associated with the federal GHG/CAFE program and multi-state ZEV program.

Specific attention was given to the policy goals for the GHG/CAFE and ZEV programs, the interactions between them and the current status of the ZEV ecosystem. The workshop discussion centered on four main themes, which are covered in the following sections of this paper:

- Strategies required to achieve the policy goals for GHG/CAFE.
- Intended benefits and expected costs of the ZEV program.
- Evolution of the various elements of the ZEV ecosystem.
- Aligning GHG/CAFE and ZEV programs.

GHG/CAFE – What Would it Take to Achieve Policy Goals?

Role of technology adoption and pricing strategies in meeting GHG/CAFE standards

The GHG/CAFE regulation formulation process assumed that adding technology to improve vehicle fuel efficiency would have no effect on consumers' choice of vehicle. Changes to sales strategies driven by the altered incentives resulting from changes to fuel prices were also not considered. Over time, as the standards become more stringent, the cost of adding technology to meet these standards would continue to increase. Investing and adding fuel efficient technologies is an easy decision for automakers to make if higher gasoline prices are expected, as shown in Figure 1. However, when gasoline prices are low, as is currently the case, this reduces fuel cost savings for consumers. The cumulative effect of this would push vehicle manufacturers to use price induced sales shift strategies to meet the standards. This would imply that higher emission vehicles would end up subsidizing and supporting sales of lower emission vehicles, without the need for discriminatory taxation of higher emission vehicles as is done in Europe. However, it is not clear whether this is the most cost-effective way of reaching the same outcome.

Valuation of GHG/CAFE program elements

During 2012-2015, automakers outperformed the standards. The passenger car fleet performed 4 grams of CO_2 per mile (g/mile) better than the standard without credits. It also generated 14 g/mile of credits that could provide compliance flexibility for future model years. On the other hand, the light duty truck fleet performed 17 g/mile below the standard

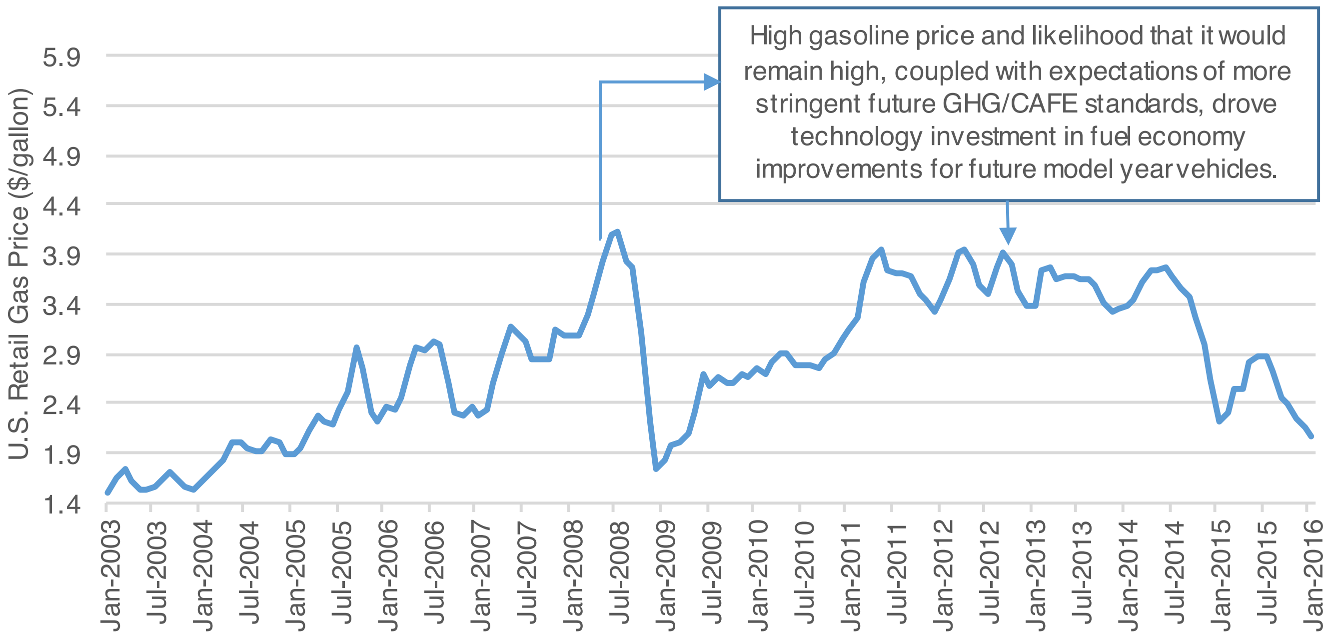

Figure 1. U.S. retail gasoline prices ($/gallon).

Source: U.S. Energy Information Administration.

without credits. Use of credits was necessary to achieve compliance. The largest contribution to credits came from flex-fuel vehicles (FFVs). However, credits for FFVs will be reduced in MY 2015, so it will then require more effort on the part of automakers to meet the standard for the truck fleet.

Interaction between market drivers and consumer acceptance

When setting the standards, the U.S. Environmental Protection Agency (EPA) and Department of Transportation's National Highway Traffic Safety Administration (NHTSA) made assumptions as to the types of technologies that manufacturers would use to meet set targets. These were made and sensitivity analysis was performed on the cost and effectiveness of such technologies, their deployment rate, market drivers (gasoline prices) and consumer acceptance. These may, however, require further assessment going forward, especially the interactions between market drivers and consumer acceptance.

In terms of consumer acceptance, since there are separate standards for cars and light duty trucks and, since the standards are footprint based – i.e., fuel economy targets decrease with the footprint – these are quite flexible and account for consumer preference to some extent. This flexibility in the standards is quite apparent while gasoline prices are low, which has already led to a boom in the sales of light duty trucks. As more consumers buy light duty trucks, the standard adapts and becomes less stringent, because of the lower fuel economy standards for light duty trucks.

However, when choosing between models with a similar footprint, at a time of low gasoline prices, a consumer is less likely to pay more for a vehicle that has higher fuel economy, as the return on investment does not justify this. Going forward, it would be important for both the automakers, as they make their long-term portfolio plans, and regulators in deciding the fuel economy standards for 2022-2025, to bear in mind that low gasoline prices may persist, since previously much higher prices were assumed.

Current low gasoline prices have resulted in higher cash flows and profits for the industry due to greater demand for higher margin light duty trucks. At the same time, the credits generated through selling flex-fuel light duty trucks have allowed them to meet the standards. Current profits could provide the boost needed to fund GHG reduction improvements in future vehicles.

Future technology deployment scenarios

The EPA/NHTSA had estimated that 2-3 percent of hybridization would be required to meet MY 2025 standards. However, the MY 2025 standards require the overall fleet energy efficiency to be higher than best existing diesel powertrains, which have higher efficiency than today's top one percent of advanced spark ignition powertrains. Thus, meeting the MY 2025 standards might require either a higher degree of hybridization or a bigger penetration of advanced turbocharged spark ignition engines as against the technology projection assumed by the agencies.

ZEV – Intended Benefits and Expected Costs

Barriers to ZEV transition

At the regional level, the ZEV mandate in California and nine other U.S. states promotes the adoption of ZEVs. However, multiple infrastructure and consumer related barriers still exist. In terms of infrastructure, one of the major barriers is the lack of profitable business models to support charging facilities. Two main segments with a standalone model for such infrastructure are automakers and utility companies. However, since the revenue from charging is low, it is difficult for infrastructure providers to justify such investments. For governments to support public infrastructure spending, the network externality benefits must outweigh costs. The network externality benefits could be related to a higher capacity utilization rate, especially with off-peak charging, or by batching with renewables (solar/wind).

Consumers' unfamiliarity with the technology represents another barrier. The effects are clearly seen in the market, where the majority of consumers prefer to lease ZEVs rather than buy them. Leasing instead of buying reduces the risk, especially of uncertain battery decay, battery replacement cost, resale value and technology improvements. High battery costs and driving range uncertainty represent other major disincentives. The driving range of ZEVs is reduced on hot and cold days. Risk averse consumers want a greater range, though they are also price conscious. Considering the cost of batteries, it is inevitable that the available range remains low. Although the range offered – around 80 miles – could easily satisfy the majority of U.S. consumers' daily commuting needs, there are differences between why people buy a vehicle and how they use it. It is important to consider that daily commuting, and, to some extent, even mobility, only account for one of the co-products of vehicle ownership.

The ZEV mandate – is it an innovation policy, technology forcing policy or GHG reduction policy?

The ZEV mandate was set up to accelerate the transition to electro mobility, so as to enable ZEV states to achieve their GHG reduction targets by 2050. It is worth considering whether this is the most cost-effective way of deploying the ZEV technology. However, an argument could be made that near-term cost discussion is not relevant for the ZEV mandate, as it is an innovation policy. The near-term goal is to stimulate investment, encourage innovation and increase consumers' familiarity with technologies that have zero emission capability. The long-term goal is greenhouse gas reduction. It is important to keep the end goal – 80 percent reduction in CO_2 levels by 2050 – in mind when discussing the cost of ZEV mandate.

To achieve such levels of CO_2 reduction means the light duty vehicle fleet needs to be net zero emissions by 2050. To achieve this, decisions need to be made now, as there is a cost of waiting, especially considering the irreversible effects of GHG emissions. The decisions made today may not be optimal, but the environment related transaction costs involved in negotiating and finding the optimal solutions add up as well. This is the balancing act for regulators: between environment related transaction costs and the cost of treading the non-optimal path in deciding what technologies to promote and the corresponding infrastructure investment needed.

Even if the ZEV mandate is viewed as just an innovation policy, it can be argued that cost is important to the discussion because of the difficulty in scheduling innovation. There is a big difference between encouraging innovative research that addresses societal issues and pushing innovation in the market, including setting a schedule for achieving particular levels of adoption. From a research perspective, it is generally difficult to set a timeline for accomplishing radical innovation. The ZEV mandate sets a timeline not only for achieving radical innovation but also for achieving specific levels of adoption for the innovative product in the market.

The cost problem can be further compounded by penalties for automakers that are not achieving the required levels of adoption for their innovative product. However, it could be argued that the credit trading provision under the ZEV mandate, where non-compliant automakers may purchase credits from automakers with excess credits, could be seen as a means of encouraging those who are doing more than their fair share of innovation.

Another important question is whether allocating more credits for selling BEVs rather than PHEVs would lead to more innovation in battery research. If it is not clear whether one path would lead to more innovation than another, then near-term cost effectiveness becomes an important part of the discussion. However, this can be seen as a case of providing a clear market signal to encourage a particular type of innovation, i.e., development of longer-range batteries for BEVs than shorter-range batteries for PHEVs.

When the ZEV mandate was conceived, the main intention was to encourage innovation. However, due to the evolution of the credit and incentive structure and more impetus being given to technologies with full zero tailpipe emissions, the mandate now sits somewhere between being an innovation policy and a technology forcing policy. The ZEV program has evolved along this line because it is not easy to encourage industry to pursue radical innovation for public good when the externality costs are not internalized. Thus, in the absence of a carbon tax, a policy such as the ZEV mandate is needed in order to encourage innovation in ZEV technologies.

With the targets for ZEVs poised to increase to a 15 percent market share by 2025, it is fair to say that the ZEV mandate will be transitioning to a GHG reduction policy, which is its long-term objective. When the target market share rises to such levels, it is important to consider the cost of the GHG reduction achieved and whether this is the most economical option.

Alternative to ZEV mandate

Industry has argued that a flexible performance-based approach that has the same end goal of higher reduction in CO_2 levels would make more sense. Such an approach would align with federal fuel economy standards. Moreover, since carbon emissions are a global rather than a local problem, having a more stringent federal fuel economy standard throughout the U.S. would be more beneficial than a ZEV mandate type program confined to a few states.

In such a case, it is not hard to imagine that the industry would opt for a cost-effective incremental approach. Carrying out incremental research and promoting adoption of incrementally improved products among a majority of consumers is relatively easier to achieve than their respective radical counterparts. The public sector support for infrastructure related investment could also be scaled in proportion to consumers' adoption patterns. This would limit the risk of underutilization of the refueling infrastructure.

Taking this approach with alternative fuel vehicles (AFVs) – including PHEVs, BEVs and fuel cell vehicles (FCVs) – PHEVs may gain the most consumer interest in the beginning. However, if consumers buy PHEVs without recharging them with electricity, this could defeat the policy objective, as happened in the case of E85 flex-fuel vehicles, where consumers were not refueling them with ethanol. To avoid this, it might be helpful to link PHEV's fuel economy with consumers' actual behavior in terms of electric vehicle miles traveled (eVMT).

ZEV Ecosystem

Three components of the ZEV ecosystem – new car buyers, used car buyers and public refueling infrastructure – are strongly interlinked. New and used car buyers feel encouraged to buy ZEVs once the refueling infrastructure is in place, which also alleviates range anxiety. Investment in infrastructure is also justified when there is adequate demand from new and used car buyers.

Market for new and used ZEVs

To sell more new ZEVs, factors other than just high fuel economy need to be considered. A major reason for Tesla's perceived success could be that it provides not only high fuel economy, but also an element of fun, excitement and innovation, albeit for rich buyers. It would be helpful for ZEV manufacturers to balance the vehicle's high fuel economy, quiet ride and innovative powertrain with superior handling, styling and the statement it makes about the owner.

An important aspect of the current ZEV market is the high leasing rate and associated turnover rate. In California, almost 75 percent of Nissan Leafs are leased, and the majority of them end up in the used car market at the end of the lease period, which is typically three years. This is flooding the used car market with ZEVs, negatively impacting their resale value. To ensure sustainable ZEV growth, it is important to take into account the effect on the used market of strategies used to encourage ZEV sales in the new car market.

As far as the various government monetary and non-monetary incentives are concerned, these strategies affect the new and used ZEV market in similar ways. The buyers of both new and used ZEVs get access to public refueling infrastructure and to the car-pooling or high occupancy vehicle (HOV) lanes on congested highways, even when driving alone. The monetary incentives also indirectly trickle down to buyers of used ZEVs as a result of their lower resale value. However, this comes at the cost of artificially reducing the retention value of new ZEVs. Defined strictly on a manufacturer's suggested retail price (MSRP) basis, the retention values of ZEVs are much lower than those of their respective internal combustion engine vehicle (ICEV) counterparts. It is only when considering the MSRP minus incentives that the retention values of ZEVs are comparable to those of ICEVs.

Charging infrastructure and consumer charging behavior

When considering the charging infrastructure component of the ZEV ecosystem, it is important to understand the role of home, workplace and public charging. Currently, the majority of the charging takes place at home. However, as the market for plug-in vehicles expands, home charging might decrease if future buyers choose not to buy or are unable to install a Level 2 home charger.

An increase in the electric range for plug-in vehicles could encourage those potential buyers who may not have the ability to charge at home to adopt them. This would increase the use of public charging. At the same time, for long-range plug-in vehicle owners with Level 2 chargers at home, the need for away from home charging would decrease. Thus, it is not clear whether increasing battery range would lead to better use, or underutilization, of public charging infrastructure. In addition, whether investment in raising the electric driving range or increasing charging infrastructure would lead to higher ZEV adoption requires further investigation.

The presence of public charging, especially direct current (DC) fast charging, also provides psychological comfort, encouraging consumers to purchase plug-in vehicles. Most of the existing DC fast chargers are located at interstate exits, enabling plug-in vehicle owners to undertake long-distance travel. Interestingly, these DC fast chargers are also used as much or more by local vehicles than by vehicles traveling on the interstate. Public charging and workplace charging also provide the opportunity for vehicle-grid integration, especially for batching with renewables (solar/wind). This could lead to the realization of network externality benefits, which in turn could further encourage public-private investment in refueling infrastructure.

Recent studies on consumer charging behavior have reported similar eVMTs for PHEVs (Chevy Volt) and BEVs (Nissan Leaf). This then raises the question of whether PHEVs should be assigned credits similar to BEVs, as they displace an equal amount of fossil fuel based VMTs. This again depends on the intended purpose of the ZEV program, i.e., whether the aim is to encourage innovation or produce extensive carbon reduction. In any case, incorporating an eVMT based credit structure into the ZEV program has the potential to transform it into a cost-effective performance based program.

Aligning Vehicle Regulatory Programs

Layer-cake versus coordinated regulation

The current U.S. vehicle regulatory structure represents an incremental layering of regulations. There are multiple regulatory programs, both at the federal and regional level. These various programs are driven by different motivations, such as emissions reduction, energy security, climate change, resource management and traffic congestion. Usually these support each other, but sometimes they can be incompatible and end up pulling the industry in different directions and, it is argued, diffusing long-term policy signals. For example, the renewable fuel standards encourage automakers to develop vehicles that can accommodate increasing amounts of biofuels. This is somewhat at odds with the ZEV mandate, which requires more ZEVs on the road. Given that all the players involved have finite resources, a more coordinated program might achieve the desired outcome at a lower overall societal cost.

Timeline for regulation

These various vehicle regulatory programs also have different timelines. In order to meet short-term regulatory goals and to take advantage of short-term incentives, the industry generally tends to optimize its portfolio in the near term. Although this leads to achieving the desired outcome at lower societal cost in the near term, it can also lead to dead end paths. For example, natural gas vehicles have lower GHG emission than gasoline-based vehicles and also currently generate a lot of CAFE credits, but it is not clear whether they can be part of the 2050 solution if zero-tailpipe GHG emission is the main goal. In such a case, much private and public sector investment in infrastructure and R&D could end up being abandoned as society moves on to a different technology suite. Thus, there is a need to balance the long-term vision with short-term regulatory goals and incentives as these can influence the long-term outcome and overall societal cost.

Technology pull versus technology push

To achieve the long-term vision, either the technology forcing route, such as the ZEV mandate, or technology pull route, such as a performance based standard, could be chosen. In principle, a technology forcing route, such as the ZEV mandate, promises to achieve large emission cuts, but at a high societal cost. On the other hand, a performance based standard, such as the GHG/CAFE standard, could achieve similar emission reduction, possibly at lower societal cost. From society's point of view, it is important to strike a balance between the pace and the cost of achieving emission reductions from the passenger fleet.

Understanding success and failure

When deciding between different long-term programs, it is important to understand what leads to sustainable success. For example, although regulations such as the ZEV mandate can be shown to pull technology into the market, it remains to be seen how sustainable such programs would be in the absence of government subsidies. Removing these subsidies can have a significant impact on ZEV sales, as was seen recently in the state of Georgia. On the other hand, the current perceived failure of the GHG/CAFE program, with more consumers buying SUVs at times of low gasoline prices could be seen as a success of the flexibility of the programs to take into account consumer preferences.

Understanding the counterfactual

It is also important to understand the counterfactual aspects and assess whether things could have been done even better. For example, with the ZEV mandate, it is important to understand whether more success could have been achieved by devoting the resources to development rather than subsidizing deployment. Similarly, it is important to consider whether the extent of the cost reduction in batteries over the past few years would have been possible without the pressure of the ZEV mandate, i.e., whether the efforts to achieve economies of scale – e.g., the Tesla gigafactory – would have taken place in the absence of the ZEV mandate. However, it could be argued to what extent is the ZEV mandate responsible for the success of battery research and scale up efforts given the demand for improved battery performance from smartphones and laptops. The case of the 18650 cells used in the Tesla battery is one such example. Also, the higher cumulative ZEV sales seen in Europe and Asia make it difficult to attribute the progress made in batteries exclusively to the U.S. ZEV mandate.

Unintended consequence of AFV incentives in the federal GHG/CAFE program

Special weight factors and multipliers have been assigned to AFVs for the GHG/CAFE compliance calculation to incentivize AFV production and sales. The lower calculated AFV emissions allow for the sales of higher emitting vehicles, while still effectively meeting the standard. While the difference between true and calculated AFV emissions is not real, the difference between balancing vehicle emissions with and without AFV incentives is real. Thus, the provision of AFV incentives can result in higher GHG emissions in the near term. Moreover, given the higher CO_2 abatement costs for AFVs (relative to conventional gasoline ICEVs) – which can be of the order of thousands of dollars per metric ton of CO_2 avoided – the AFV incentives in the GHG program could also result in large societal costs.

De-linking or merging federal GHG/CAFE program and the multi-state ZEV mandate

Given that ZEV production and sales are also encouraged by the ZEV mandate, and given the near-term counterproductive effect of including ZEV incentives in the GHG/CAFE program, it may be argued that the ZEV incentives could be eliminated from the GHG/CAFE program. However, doing so could make it difficult for automakers to meet the GHG/CAFE standards. Although, according to the EPA's likely compliance scenarios, a high degree of electrification is not needed to meet the 2025 GHG/CAFE standards.

Another possible alternative is to leave the AFV incentives as part of the GHG/CAFE program, and make the overall GHG/CAFE target more stringent. With that scenario, the ZEV mandate could be eliminated altogether, leaving just a more stringent, single, unified, long-term performance based GHG/CAFE program. Such a performance based standard could enable GHG reductions at lower societal cost. A more stringent GHG/CAFE target would also encourage timely innovation. In addition, such a long-term, unified vision would enable various stakeholders to use their limited resources productively. Since GHG reduction is not a local issue, introducing a more stringent federal program in line with worldwide GHG/CAFE programs could be more beneficial than having multi-state ZEV programs. It would also encourage automakers to sell ZEVs all over the U.S., rather than in just a few ZEV mandated states.

However, eliminating the ZEV mandate could potentially result in slowing down the pace of ZEV innovation and battery production scale up efforts. This is because in the near term automakers could meet more stringent standards without any serious need for electrification. Yet understanding the long-term target would maintain pressure on automakers to maintain a commitment to develop and deploy ZEV technology.

Purpose of regulation

The key policy goal for both programs is emissions reduction; the only difference being the cost and pace. If the aim is to achieve emission reduction at minimum societal cost, then a technology forcing regulation may not be the best option. The carbon abatement costs for ZEVs (relative to conventional gasoline ICEVs) are in the range of hundreds to thousands of dollars per metric ton of CO_2. Given that the best estimates of societal cost of carbon emissions lie in the range of tens to hundreds of dollars per metric ton of CO_2, it is difficult to justify support for ZEV forcing regulation from a societal cost-benefit point of view.

Apart from lower emissions, higher consumer surplus is often considered as a major societal benefit associated with ZEV transition. However, it is also meaningful to look at competition from incumbent technologies and fuels when analyzing consumer surplus during transition. The stakeholders associated with incumbent technologies and fuels will compete to maintain their current market share, including cutting prices. Lower fuel prices imply lower cost savings in switching from ICEVs to ZEVs. Lower fuel cost savings, coupled with the higher upfront costs of ZEVs, will reduce consumer surplus and the net benefit to society from transitioning to ZEVs. The decrease in sales of subsidized ZEVs under current low gasoline prices, despite more ZEV models being offered, is a case in point.

From a societal cost-benefit point of view, a key question is whether it is possible to achieve similar or higher emission reductions from other sectors at lower cost before moving the passenger fleet to ZEV technologies. Do the ZEV mandate and public-private sector support for subsidizing ZEV production and deployment result in sub-optimal allocation of resources? However, such questions are rarely just about economics. Policymakers weigh support for ZEVs against other government programs for legacy systems such as fossil fuels.

But, if the main objective is a faster transition to zero emission capable technologies, is the ZEV mandate the only option, or could a more stringent long-term performance based standard also achieve an eventual transition to ZEV technologies? Since technology forcing mandates currently seem less aligned with consumer preference than performance based standards, making a long-term bet on a technology forcing mandate risks incurring additional costs to persuade consumers to comply. Ironically, if consumers see more benefits from ZEVs than just fuel economy and environmental friendliness, then a technology forcing mandate becomes unnecessary. The hope is that, once they have been exposed to ZEVs, consumers will never want to go back.

When considering the alternatives and counterfactual aspects of the U.S. ZEV policy program, the European experience comes to mind. In European countries, proportionately more public sector resources are being devoted to ZEV deployment in the form of huge monetary and non-monetary incentives. On a long-term basis, such programs may be less sustainable and less justifiable from a societal cost-benefit point of view than the ZEV program in the U.S.

As part of the upcoming mid-term review of GHG/CAFE and ZEV regulation, policymakers will no doubt focus on both the overarching vision and on the details. Achieving a consensus on the future of these programs will be more likely if there is a shared understanding of the purpose of each regulatory program, the benefits to society, the costs involved and the timelines that would ensure sustainable progress.

About the Workshop

KAPSARC convened a workshop in April 2016 in San Francisco with more than 40 international experts to explore possible ways to align policy expectations and likely outcomes associated with the U.S. federal GHG/CAFE program and multi-state ZEV program. Specific attention was given to the policy goals for the two programs, the interactions between them and the current status of the ZEV ecosystem. The workshop was held under a modified version of the Chatham House Rule - participants consented to be listed below. However, none of the content in this briefing can be attributed to any individual attendee.

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About the Team

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Nicholas is a research fellow focusing on the future of transportation energy demand in China and India. He holds an MA from the Johns Hopkins University and a BA from the University of Michigan-Ann Arbor.

About the Project

The workshop series 'Drivers of Transportation Fuel Demand' provides a forum for discussing key sustainability issues in transportation and current policy strategies to address them. In particular, much emphasis is placed on the adoption of fuel-efficient and alternative-fuel vehicles for road transportation, innovation in fuel and vehicle technology mixes and the shift from road to other modes of transportation.

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