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How vehicle fuel economy improvements can save $2 trillion and help fund a long-term transition to plug-in vehicles

Working Paper 9

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How vehicle fuel economy improvements can save $2 trillion and help fund a long-term transition to plug-in vehicles

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Summary

This paper estimates the technology costs and fuel savings that can be expected from strong fuel economy improvements of conventional light-duty vehicles (cars, SUVs, etc) in the future, and explores the relationship between these and the costs of initiating a transition to alternative-fuel vehicles, specifically plug-in electric vehicles (PEVs, including battery electrics and plug-in hybrids). Strong fuel economy improvements to conventional vehicles, including but not limited to hybridization, could achieve a 50% reduction in fuel use per kilometer for new cars by 2030, in line with GFEI targets. This would help achieve large CO_2 reductions as well, far more than is possible through introduction of PEVs in this time frame. However after 2030, strong growth in PEVs and other very low-carbon fuel vehicles will be needed to continue to decarbonize LDVs and reduce oil use out to 2050 and beyond.

Through 2025, fuel economy improvements worldwide could save drivers an estimated two trillion dollars, and much more in years after. This is due to the projected value of fuel savings being considerably greater than the technology costs of fuel economy improvement (specifically around $5 trillion in fuel savings for an estimated $3 trillion in vehicle technology investments). In contrast, launching PEVs worldwide may require up to $500 billion in vehicle incremental costs through 2025. This could require substantial subsidies to convince consumers to buy these vehicles in targeted numbers, build the market and reduce vehicle technology costs over time. Hopefully after 2025 no further subsidies will be needed as PEVs become fully market competitive. And this estimate excludes the value of fuel savings from PEVs, which could lower the needed subsidies. Thus $500 billion should be considered a high estimate.

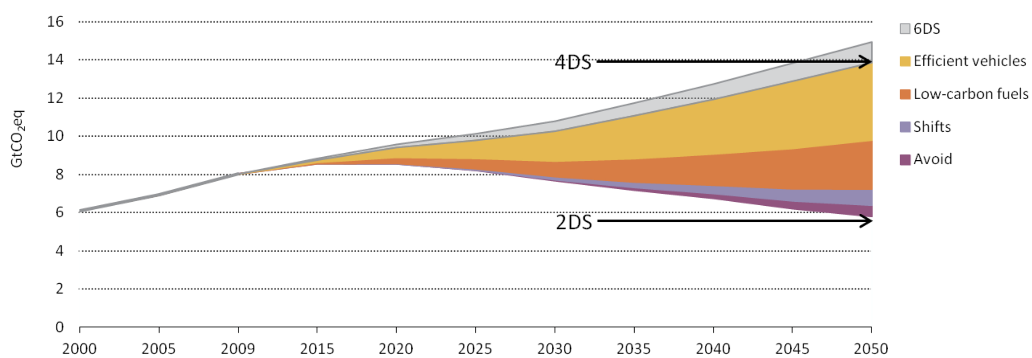
If these projections play out, the value of fuel savings from fuel economy improvements over this time frame would be at least four times greater than required subsidies for PEVs. The paper explores how these could be linked – how the fuel savings from fuel economy improvement might be leveraged to help pay the buy-down costs until a self-sustaining market for PEVs is established. There are at least two ways to use fuel economy savings to fully fund a PEV launch, in both cases letting ICE drivers keep most (about three quarters) of their net savings from fuel economy improvements. Assuming $500 billion is required (and it may be much less), this could be obtained over the time frame from a higher vehicle tax of around $500 for all vehicles sold (or a feebate system with this as an average tax rate), or via higher fuel taxes, around $0.07 per litre. Considerations in establishing such policies are discussed. In any case, the funds would be recycled from car buyers to car buyers, since they would help fund an incentive system for PEVs.

Introduction

As shown in a number of recent studies (1,2), the trend in transport fuel use and greenhouse gas emissions around the world is upward and is projected to continue to increase in the future without strong policy interventions to change course. For example the 4 degree scenario (4DS) in the IEA Energy Technology Perspectives 2012 (Figure 1) shows a near doubling of transport CO2 from 8 gigatonnes in 2010 to about 14 in 2050, whereas a 2 degree scenario is consistent with reducing these emissions to 6, 25% below the 2010 level and less than half the 2050 level in the 4DS.

To achieve this, will probably take a combination of travel demand management and modal shift (“avoid/ shift”) measures and technical solutions to vehicles (“improve” measures). Fuel economy improvement is a powerful approach, and in the IEA 2DS provides nearly half of the overall reduction in CO2 through 2050. Shifts to non-petroleum fuels also play an important role, particularly after 2030. Eventually, a transition to near-zero-carbon fuels will be central to achieving a very low emissions transport system.

Figure 1. IEA Energy Technology Perspectives 2012: CO2 Emissions under 4 degree and 2 degree scenario, with reductions attributable to fuel economy and low-carbon fuels

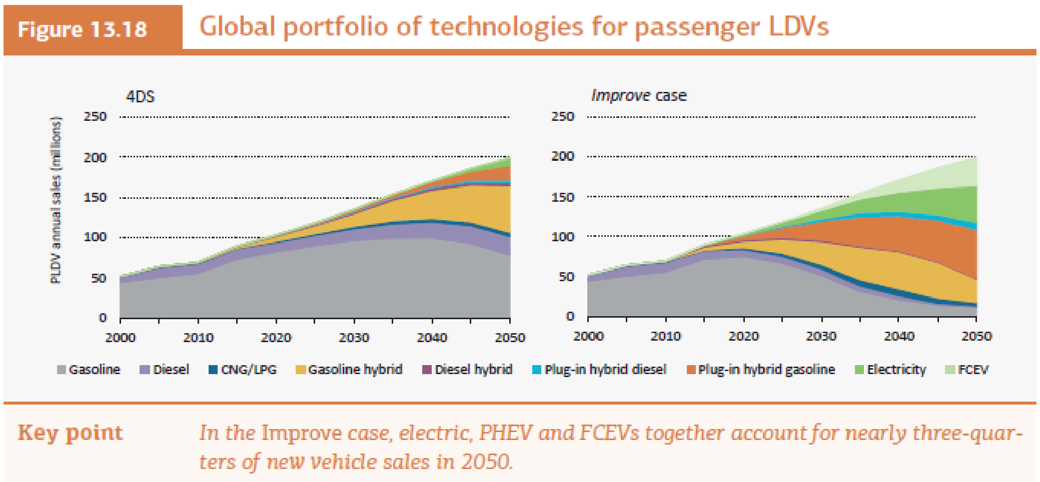


This paper explores the relationship of these two approaches: fuel economy improvement and a transition to new vehicle propulsion systems (such as electric drive and fuel cell power) and potentially low-carbon alternative fuels (electricity, hydrogen). Both are being pursued, though it is not clear how much petroleum fuel savings and CO2 reduction, at what cost, each can deliver in the near and longer term.

To conduct this comparison, the IEA ETP 2 degree scenario is used as a base scenario in terms of the projected sales and characteristics of different types of vehicles, in order to then break down the role they play at different points in the future, their relative costs, and other considerations. Other scenarios could certainly be used but the IEA 2DS is well known and quite suitable for this purpose.

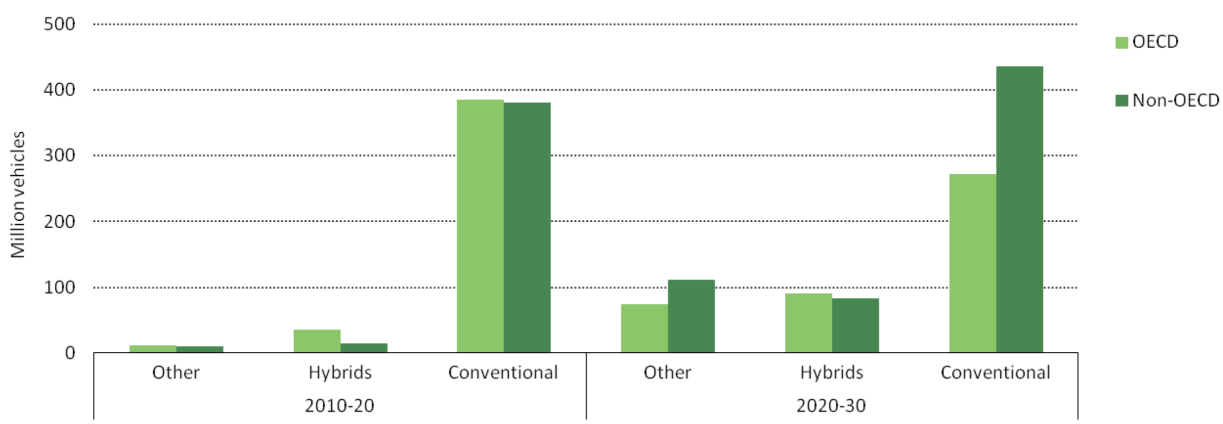
In the 2DS “Improve Case”, gasoline and diesel conventional vehicle sales remain dominant until about 2020 then begin to give way to hybrids, and then gradually to “PEVs” (plug-in hybrids, electric vehicles and fuel cell vehicles) over the following decades (Figure 2). By 2030 PEVs have about a 30% sales share; by 2050 they have close to an 80% sales share. This reflects as a central concept the need to get started producing electric vehicles now, achieve scale-up and learning-by-doing over the next decade or so in order to bring battery and electric vehicle costs down, hopefully incentivizing much larger sales volumes in the decades beyond.

Figure 2. IEA ETP 2012 light-duty vehicle technology sales shares under 4DS and the "Improve" case, consistent with 2DS.



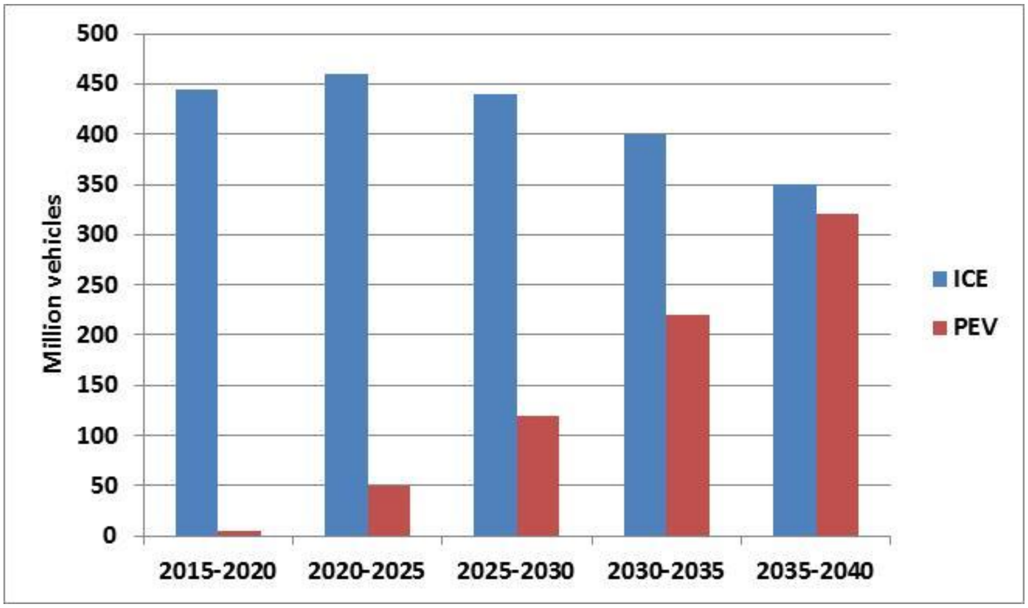
Though the scenario presents a very ambitious transition to PEVs, in fact it leaves conventional internal combustion engine (ICE) non-plug-in vehicles dominant for many years to come. This is shown in Figure 3, which adds up the sales by vehicle category over the 10 year periods 2010-2020 and 2020-2030. Conventional non-hybridized vehicles represent about 95% of vehicle sales over the current decade, and about 2/3 of vehicle sales in the next decade (including hybrids, its about 98% and 80%). The figure also shows that a growing share of vehicle sales will occur in non-OECD countries.

Figure 3. Sales of conventional, hybrid, and "other" vehicles (PEVs) in the 2DS



Thus while PEVs are projected in the 2DS to achieve 2/3 of sales by 2050, they account for a relatively small share up to 2030. This is one reason it is very important to start selling these vehicles now; it may take several decades of steady increase in their collective sales share to reach a significant share of the stock of cars on the planet (currently around one billion). Simplifying this picture a bit but taking it out further, towards 2040 (Figure 4), it can be seen that PEVs do not reach the same sales levels as non-PEV ICE vehicles until about 2040. In other words, to save oil and cut CO2 emissions from cars before 2030, the story is almost completely about improving the fuel economy of non-plug-in conventional ICE vehicles, and these conventional vehicles remain an important part of sales until well after 2040.

Figure 4. Global sales of ICEs v. PEVs by 5 year period, 2DS



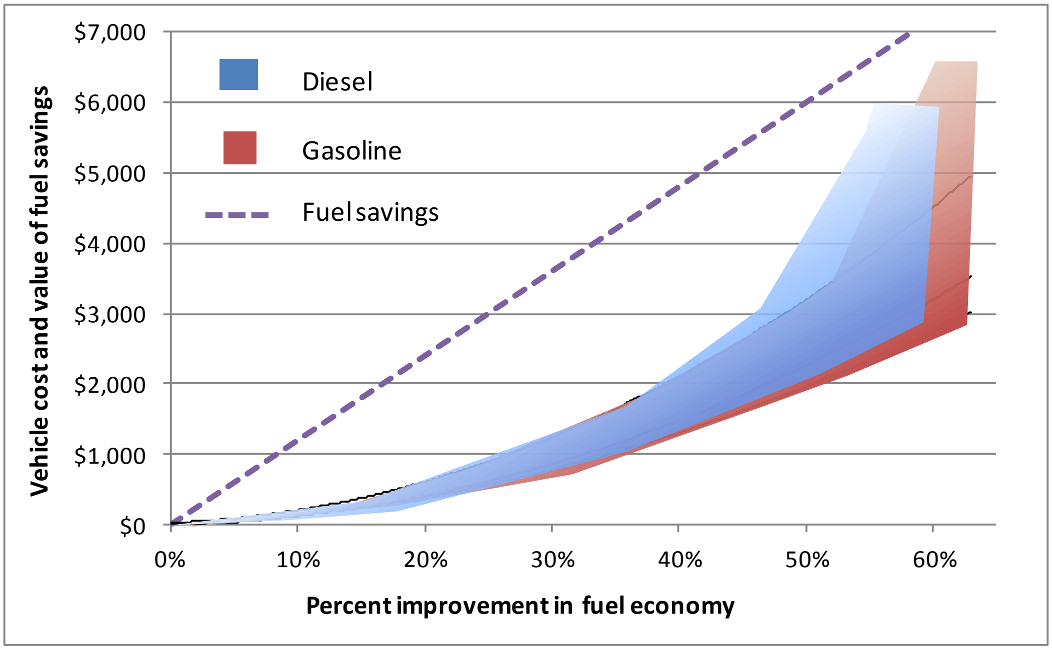
In this context, improving the fuel economy of ICE vehicles includes selling more hybrids, but it also includes incorporating a range of other fuel economy technologies that can make conventional vehicles much more efficient – up to twice the miles per gallon or kilometres per liter, or (equivalently) half the litres per 100km of new cars by 2030 compared to 2005 levels. This 50% reduction in energy use per kilometer by 2030 is in fact the Global Fuel Economy Initiative target. It is possible that hybridization and even plug-in vehicles will be needed to achieve this target, but increasingly it appears that car makers will be able to get very close just through incremental technology improvements to engines, drive-trains and vehicles themselves (weight reduction, aerodynamics, accessory energy loads)(3).

An important fact, and the basis for considering fuel economy improvement to be a promising fuel saving and CO2 reduction option, is that the cost of improving vehicle fuel economy is typically less than the value of fuel savings over time, especially using a "societal cost" set of assumptions[1]. Figure 5 shows the range of costs associated with increasing levels of fuel economy improvement for gasoline and diesel light-duty vehicles. For example, to achieve a 30% reduction the cost for gasoline vehicles is estimated to be between $700 and $1300 per car. For a 50% reduction it is $2000-4000. Clearly the

[1] "Societal cost" refers to private (internal) plus public (external) costs, and include resource costs but not transfers related to taxes. Therefore calculations here use a relatively low (e.g. 5%) future discount rate and exclude vehicle and fuel taxes. All costs in the paper are in constant (roughly 2012) dollars. See additional notes under Figure 6.

marginal cost rises with more fuel economy improvement. Yet the value of this fuel economy improvement (dotted line in the figure) in terms of the fuel it saves is higher than the cost even at 50% or higher levels of improvement. For example a 10% improvement in fuel economy, if it reduces fuel use from 9 to about 8 L/100km on road, saves 150 litres of fuel for a vehicle that travels 15,000km per year. Over 8 years, this amounts to 1200 litres, which at a fuel price of $1.00 per litre saves $1200 roughly as shown in the figure. These are reasonable assumptions; obviously savings would be higher if one considers more years of car ownership, more driving per year, or a higher fuel price, and lower if lower estimates are used). If the cost of that fuel economy improvement, in terms of a higher vehicle price, is $200 (roughly as shown in the figure), the net savings is $1000 over the 10 years. At 30% improvement there is around $3000 of net savings per car. At 50% improvement (probably including hybridization), the cost rises sharply but still has a net savings of anywhere from about $2000-4000 per car.

Figure 5. Cost of Fuel Economy Improvement and Value of Associated Fuel Savings (4)



Taken in a macro context, a 30% improvement across all new vehicles adds up to a lot of fuel – and money – savings over time. For example, in a country with sales of 1 million vehicles, these vehicles will eventually save society $3 billion using the assumptions above. In a world with around 80 million sales per year, this is $240 billion of potential savings if all vehicles were 30% more efficient. At 50% fuel economy improvement, more fuel is saved but since the technology cost is higher, the net cost savings may be not be much more than the 30% case (and with a wider degree of cost uncertainty).

If one considers new technology, plug-in (PEV) vehicles in a similar way, the economics don't look nearly as good, at least in the near term. The costs of plug-in vehicles are currently quite high relative to the value of their fuel savings, and this poses a problem in terms of trying to achieve large-scale market penetration with these vehicles. In fact, if there was no expectation that these costs will drop in the future, they probably would not be worth pursuing, since (apart from low private benefits), the societal cost of fuel savings and CO2 reduction would be too high to be interesting. However, there is good reason to believe that technology costs for batteries and other components will drop significantly over time, and as a function of vehicle production (scale and learning effects). The National Research Council study (3) provides new projections of cost reduction and indicates continued (and even increasing) optimism that technology costs will drop over time – effectively, "if we build them, they will eventually become cost-effective".

Figure 6 shows the potential near term (e.g. 2013-2015) cost estimates for PEV, along with longer term estimates (roughly 2025-2030 but possibly as soon as 2020 based on NRC) and fuel savings associated with different types of conventional and plug-in vehicles. The vehicle costs represent incremental purchase costs over a base 2010 conventional mid-size car. Other specific assumptions for this figure are indicated below it; clearly if one changes the fuel cost assumptions, amount of driving per year, etc. this would change the results. But the figure gives a clear indication that a) fuel economy improvement is more cost effective today than selling plug-in vehicles and b) in the longer term plug-in vehicles also become cost-effective and begin to compete in terms of cost effectiveness (except perhaps for longer-range plug-in hybrids). In the long run PEVs start to look economically attractive, at least in terms of fuel savings exceeding incremental purchase costs compared to a base vehicle today. And since they are likely to play an important long-term role in reaching a very low oil, low CO2 transport system, this is very good news.

Figure 6. Vehicle incremental cost and fuel savings, technology comparison in near and longer term

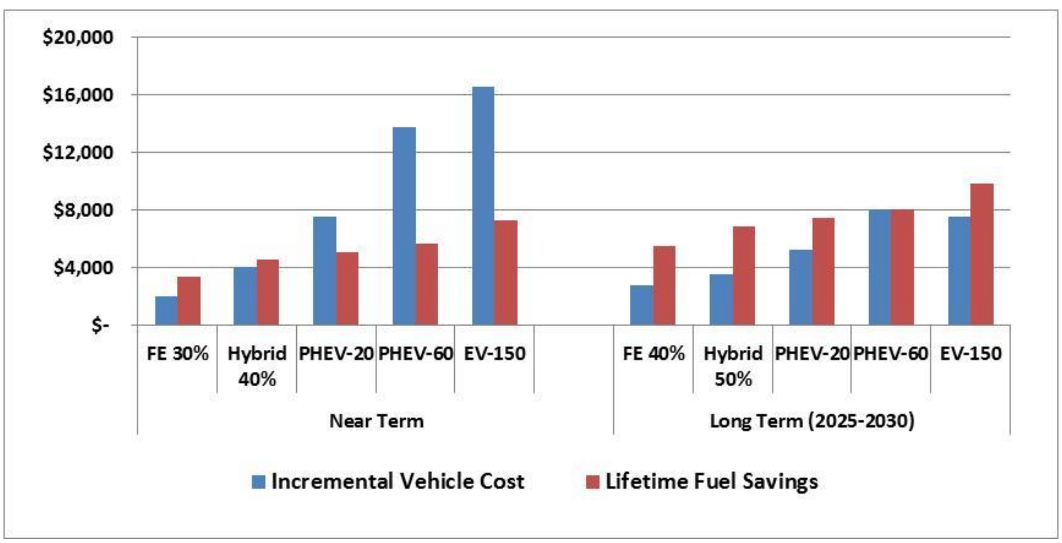


Figure notes: "FE 30%"=fuel economy improved by 30% in L/100km; "PHEV-20"= plug-in hybrid with 20 km electric range; fuel savings estimated over 160k kms of driving; all related to a base gasoline vehicle of 9 L/100km; oil prices $100/bbl near term, $130/bbl long term; battery costs decline over time from $600 to about $300/kWh. Additional notes in footnote 1 above.

But the problem for PEVs is that in the near term they are expensive and we must get through this near term phase in order to reach the longer term, more attractive economic situation. This will require someone to pay for the near term incremental costs, the "buy-down" costs of these vehicles. If we sell millions of PEVs at the relatively high up-front cost, this will be expensive. Just how expensive will it be?

Governments are very concerned about this, since they are the ones most likely to pay much of this incremental cost through subsidies and various incentive programs.

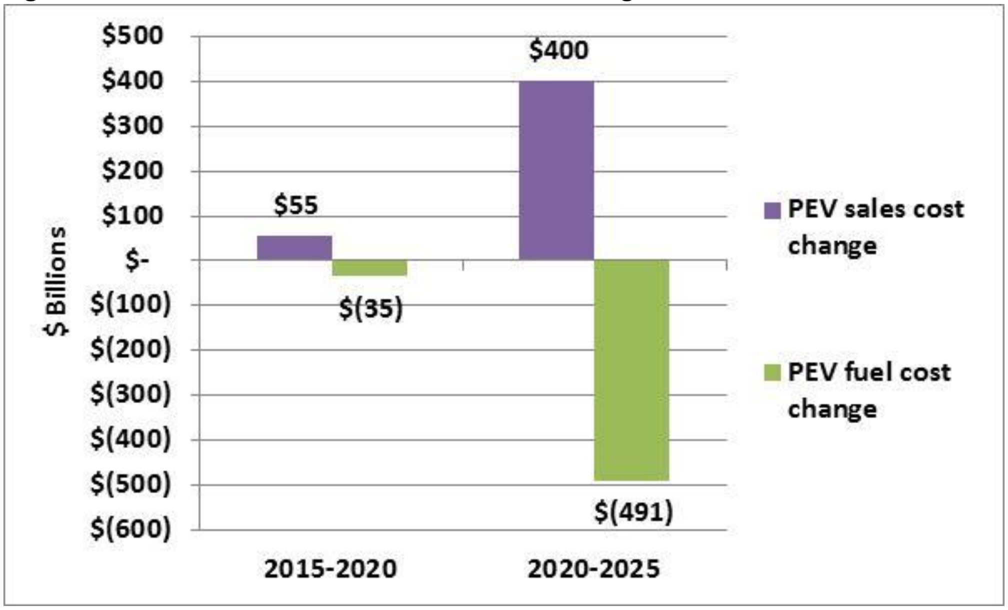
The following section considers these costs, in the context of the next 2 decades where we will be likely to sell many more conventional ICE vehicles that provide a strong net financial benefit.

A rollout scenario for Fuel economy and Alternative Fuel Vehicles

The IEA 2 degree scenario includes cumulative sales of 20 million PEVs between 2010 and 2020, and an additional 50 million between 2020 and 2025. This paper follows the 2DS with one exception: the 2010-2020 total PEV sales number is reduced from 20 to 5 million, since it now appears unlikely that 20 million can be reached, given 2012 sales of about 120,000 PEVs worldwide (IEA 2013). It would require a near doubling of sales each year through 2020; a 5 million total relates to 30% annual sales growth which seems more realistic at this point (though still very challenging to achieve).

Using these sales assumptions and the near term projected costs up to 2020 and the longer term (lower) costs up to 2025 shown above in Figure 6, for a mix of electric and plug-in hybrid vehicles, the total incremental costs of the PEV sales (compared to a base ICE vehicle) in this scenario are shown in Figure 7. The fuel cost savings from these vehicles are also shown. If consumers ignore fuel savings and require a full purchase cost subsidy on each PEV they buy (to bring the purchase price in line with similar conventional ICE vehicles), the required incentives would amount to $55 billion dollars up to 2020, and an additional $400 billion up to 2030. This simplifies a very complex purchase decision, where a range of factors influence buying patterns and a range of incentives may be offered by city and national governments. For example, if EVs receive free access to bus lanes or free parking, these have value, and are not considered here. Indeed if consumers factor in fuel savings (and some certainly do), then there is already a projected net benefit from PEVs by 2025 (since fuel cost savings are greater than vehicle incremental costs). But it appears that first cost is a critical factor in the buying decision, so the assumption that PEV price must be brought equal to competing ICE vehicle price seems a reasonable approximation for the subsidy cost of building these markets or at least an upper bound. Again, these reflect one set of assumptions and there is considerable uncertainty around these figures – the assumed required subsidy (and the point at which fuel cost savings become greater than vehicle incremental costs) are sensitive to many assumptions.

Figure 7. PEV incremental sales and fuel costs through 2025



The main point of the figure is to provide an order of magnitude estimate of the cost of putting 55 million PEVs on the road by 2025, and the rough answer is that it could cost close to $500 billion. This is a large figure, and begs the question – where will such funding come from? It is helpful then to put this cost into the context of the conventional vehicles that will be sold over the same time frame, and their relative costs and fuel savings. This is done in Figure 8. This figure continues to show the costs related to PEV sales and adds the costs and fuel savings associated with conventional ICE sales assuming they become (on average) 30% more efficient by 2020 and 50% more efficient by 2030.

It is clear from the figure is that aggregate numbers associated with both ICE sales cost (incremental cost over 2010 base vehicles) for more efficient vehicles, and the fuel savings they provide, are far greater than the numbers associated with PEV sales. This is mainly related to the far greater number of ICE vehicles that will be sold over this time frame (as shown above in Figures 3 and 4). In the 2015-2020 time frame, the increased cost of more efficient ICE vehicles worldwide would be nearly $1 trillion, but the fuel savings provided by these cars over their useful lives (discounted as described above) approaches $2 trillion. This is more than an order of magnitude greater than the costs and fuel savings of PEVs. In the next time period, 2020-2025, the numbers are even higher since more vehicles, with bigger (and more expensive) fuel economy improvements are sold. Although PEV aggregate costs are also rising (with numbers identical to the previous figure), these costs continue to be fairly small in comparison.

Figure 8. PEV and ICE incremental sales and fuel costs through 2025

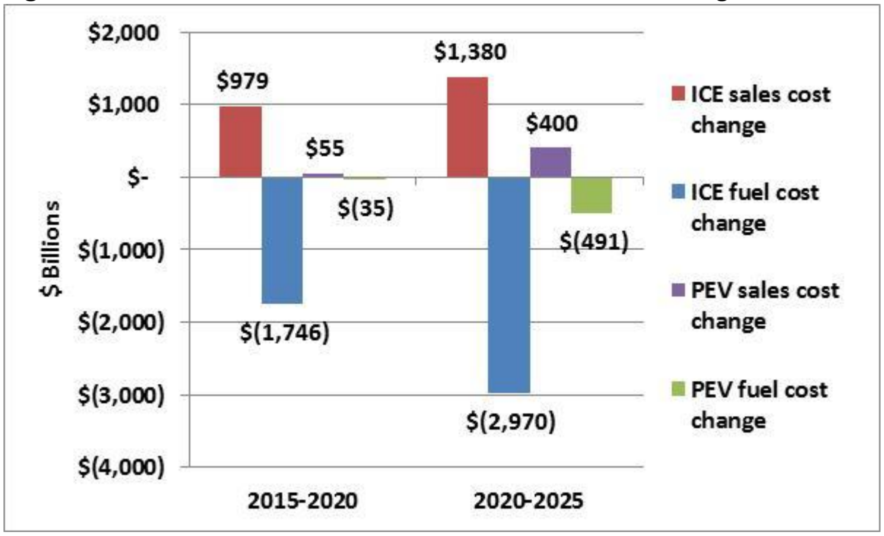
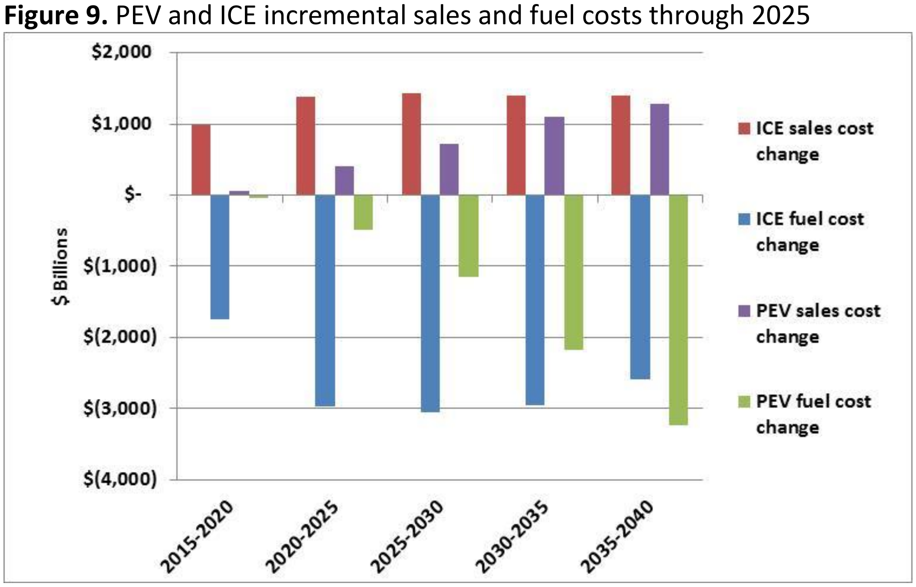


Figure 9 continues this comparison out to 2040. (It also contains all the bars shown in Figure 8, but with the y-axis compressed to accommodate the longer bars from increasing costs and fuel savings over time). Several things are apparent in this figure. ICE incremental costs and fuel savings remain roughly constant, with fuel savings always significantly greater than vehicle costs; incremental costs and fuel savings for PEVs rise over time as their market grows, but the fuel savings increases faster since the incremental vehicle costs drop over time, whereas fuel savings per vehicle actually rise as gasoline prices rise. Up until about 2040, the net savings (fuel savings minus vehicle cost) from ICE fuel economy improvement is greater than that for PEVs, meaning fuel economy is more cost-effective in the aggregate; but around 2040 PEVs catch up. Since there is still some cost reduction associated with PEVs after 2040, and the marginal costs of conventional vehicle fuel economy are likely still to rise after this date, the cost effectiveness of PEVs is likely to be better than ICEs after 2040.

Figure 9. PEV and ICE incremental sales and fuel costs through 2025



These economics can be presented from the point of view of CO_2 as well. Using assumptions regarding CO2 per kilometer from conventional vehicles (declining as they get more efficient) and PEVs (assuming average CO2 emissions from electricity generation that improve over time, consistent with the IEA 2DS), Table 1 shows the well-to-wheel CO_2 savings from fuel economy and PEVs. Fuel economy improvement saves far more CO_2 in the early time periods, but PEVs catch up by the 2035-2040 time frame, reflecting both growth in the numbers of vehicles and the decreasing carbon intensity of electricity generation. These are cumulative CO_2 reductions over each 5 year time period, and can be summed to see the total reduction across LDVs for the entire time frame. By 2040 there is a single-year combined reduction of 4 gigatonnes, resulting in total LDV CO_2 emissions of about 3 Gt instead of a baseline growth to 7 (starting from about 4GT in 2010). By 2050 in the 2DS, LDV CO2 emissions drop to about 2GT thanks in part to PEVs achieving very low per-kilometre CO2 emissions by then.

The cost per tonne for the CO2 emissions reductions is also shown, relative to the base 2010 vehicle. For fuel economy the net cost is always negative, since the value of fuel savings is always greater than incremental vehicle cost (and this is the reason that fuel economy improvement is generally considered a very cost- effective option for CO2 reduction). PEVs in contrast are fairly expensive in the 2015-2020 time frame but the cost drops rapidly, already to below $0 in 2020-2025, using the technology cost assumptions noted above. However it should also be noted that this cost per tonne remains higher than fuel economy improvement until after 2035, which means that compared to an increasingly efficient base ICE vehicle over time, switching to PEVs still yields a positive (greater than $0) cost per tonne. In other words, on-going ICE vehicle fuel economy improvements result in PEVs remaining less cost effective than if the base “reference” vehicle did not change, and so an increasingly efficient base vehicle over time makes shifting to plug-in vehicles somewhat less interesting. But even in this comparison, PEVs become more cost effective than fuel-efficient ICEs by 2040, so finally achieve a less-than-zero cost per tonne in comparison.

Table 1. CO2 savings and cost projections in 2DS

	2015-2020	**2020-2025**	**2025-2030**	**2030-2035**	**2035-2040**
CO2 savings from ICEs (Gt)	**5.4**	**7.5**	**7.9**	**7.8**	**7.1**
CO2 savings from PEVs (Gt)	**0.1**	**1.1**	**3.0**	**6.1**	**9.7**
Cost from ICEs ($/t)	**$ (143)**	**$ (212)**	**$ (214)**	**$ (215)**	**$ (198)**
Cost from PEVs ($/t)	**$ 211**	**$ (81)**	**$ (143)**	**$ (175)**	**$ (201)**

Implications for Policy and Funding Strategies

The foregoing analysis has some potential implications for setting policy. The fact that fuel economy improvements could save society (and car owners) large sums of money over the next 20 years is not usually considered in the analysis of the costs of transitioning to PEVs. But one might consider the following points:

1. As shown above, PEVs are estimated to have a total incremental cost close to $500 billion between 2015-2025. This would be paid back by fuel savings, but for purposes here we will assume that to sell the cars, the full $500 billion would need to be offered as incentives to prospective buyers.
2. There will be around 1 billion ICE vehicles sold worldwide in this time frame.

3. For a PEV subsidy of $500B from 2015-2025, this would require an average tax (or fee) of $500 per vehicle for ALL vehicles sold – i.e. on each of the world's 1 billion ICE vehicle sales over this time frame (slightly higher if PEVs are not charged a fee.)
4. Such a tax/fee across all new car sales would provide enough to create a $10,000 per vehicle subsidy for the 50 million PEVs sold over this time frame.
5. Over the same time frame, drivers of conventional cars will save about $2 Trillion net from fuel economy improvements, or roughly $2000 per vehicle. Thus a $500 tax would still allow consumers to keep ¾ of this fuel economy-related savings.

In other words, the cost of subsidizing PEVs through 2025 would be one-quarter of the savings from fuel economy improvement. In essence, a small share of the savings from fuel economy improvement could be used to fund the transition to PEVs. This does assume that no subsidy would be needed for PEVs after 2025 – and in fact it would be important that the subsidy phase down over time in line with reductions in the incremental cost of PEVs. The $500 per car assumed here represents an average over the time period, that might be higher for some years then start to decline.

There are a number of other concerns with such a scenario. One is that consumers won't directly see the fuel economy savings – all such savings are relative to a future that doesn't happen – the "contrapositive" case. Although consumers will spend far less on their combined vehicle and plus fuel purchase costs, they won't ever experience the higher net costs that would have occurred under a no-fuel-economy-improvement case. Thus they may not realize how much they are saving; but they will very likely notice the direct vehicle tax they are paying in the above scenario. This suggests that a mechanism, such as a publicity campaign, may be needed to raise awareness. Alternatively, a feebate type approach, with subsidies given to PEVs and other low-carbon, fuel efficient vehicles and a tax on higher fuel-consuming cars (and a still higher tax on extreme "gas guzzlers") that averages $500 per taxed car to pay for the PEV subsidies would certainly be possible. A feebate design would also make the fuel savings more explicit and essentially provide this benefit up front, in the form of a rebate. Such a system will not only help people understand the combined economics better but provide a very clear price incentive for fuel economy *and* for PEVs, and may be more publically acceptable (even popular, as feebates already have proven to be in some countries).

The estimated $500 billion needed to pay down the cost of PEVs could of course be raised in any number of other ways, but one other way worth considering here is an increase in fuel taxes (which could take the form of a CO2 tax on fuels). For example in the foregoing scenario, the 1 billion conventional ICE cars sold through 2025 will use 8 trillion litres of fuel (down from 13 trillion litres in the reference case, thanks to the fuel economy improvements). Raising $500 billion dollars from 8 trillion litres would require about a 7 cent per litre fuel tax above existing taxes, perhaps 8 considering elasticity effects (such as reductions in driving). Again, this is a relatively small amount relative to the amount drivers save in the scenario ($5 trillion just on fuel costs, $2 trillion net on fuel/vehicle costs). Importantly, such an approach would also be useful to reduce driving rebound effects from the lower fuel costs of driving brought about by fuel economy improvement.

Conclusions

This paper has explored the relationship between fuel economy improvement of conventional vehicles and a transition to alternative fuel vehicles, specifically plug-in electric and hybrid vehicles. Strong fuel economy improvements, from applying a range of technologies such as hybridization, could yield a 50% reduction in fuel use per kilometer for new cars by 2030, and save drivers an estimated $2 Trillion through 2025, with much more in years after. This is due to the fuel savings being considerably larger than the technology costs of fuel economy improvement. In comparison, launching PEVs worldwide may require up to $500B in vehicle price subsidies through 2025, at which time the fuel savings from PEVs becomes strongly positive and it is assumed that subsidies could be ended. Thus the expected savings from fuel economy improvements is around 4 times greater than the expected costs of the buy-down costs of PEVs.

Along with changes in travel behavior, fuel economy improvement gets us about half way to a low carbon LDV system; PEVs eventually will be needed to help get the rest of the way, especially after 2030. With the assumptions used here, fuel economy improvement is more cost effective than PEVs until around 2035-2040, but even PEVs become negative cost-per-tonne compared to changing nothing (i.e. sticking with a 2010 base vehicle into the future) in the 2020-2025 time frame.

There are at least two ways to use fuel economy savings to fully fund a PEV launch while still letting ICE drivers keep around three-quarters of their net fuel economy savings. These are via a higher vehicle tax of around $500 for all vehicles sold (or feebate systems with this as an average tax rate), or via slightly higher fuel taxes, around $0.07 per litre.

Clearly the specific numbers will vary depending on the assumptions used, but the general finding that the savings from fuel economy improvements are likely to be far higher than the buydown cost of PEVs seems fairly robust. At a level of $10,000 per vehicle, the incentives assumed here are higher than most countries currently offer. The biggest risk may be that PEV costs do not drop as much or as fast as anticipated, but in fact over the past 3 years battery costs (the key cost component) has dropped faster than was anticipated, with prices now around $500/kWh, down from perhaps $800/kWh in 2010 based on various reports over the past 3 years. Reports such as the NRC study provide reasonable confidence that this will continue, perhaps reaching $300/kWh or less by 2025. In contrast, battery costs here are assumed to reach $300 only by 2030.

More work is needed to explore the relationship between fuel economy improvement and the introduction of advanced vehicle technologies, perhaps considering heavy duty vehicles, as well as interactions with the introduction of biofuels. Hydrogen fuel cell vehicles also were not explicitly considered in this paper; their introduction would add additional vehicle and fuel infrastructure costs but if large numbers are sold (e.g. in place of some of the electric vehicles in this scenario), this might not change the overall cost results significantly. Fuel cell vehicle costs are also expected to drop substantially at large volume and over time, according to NRC and other sources.

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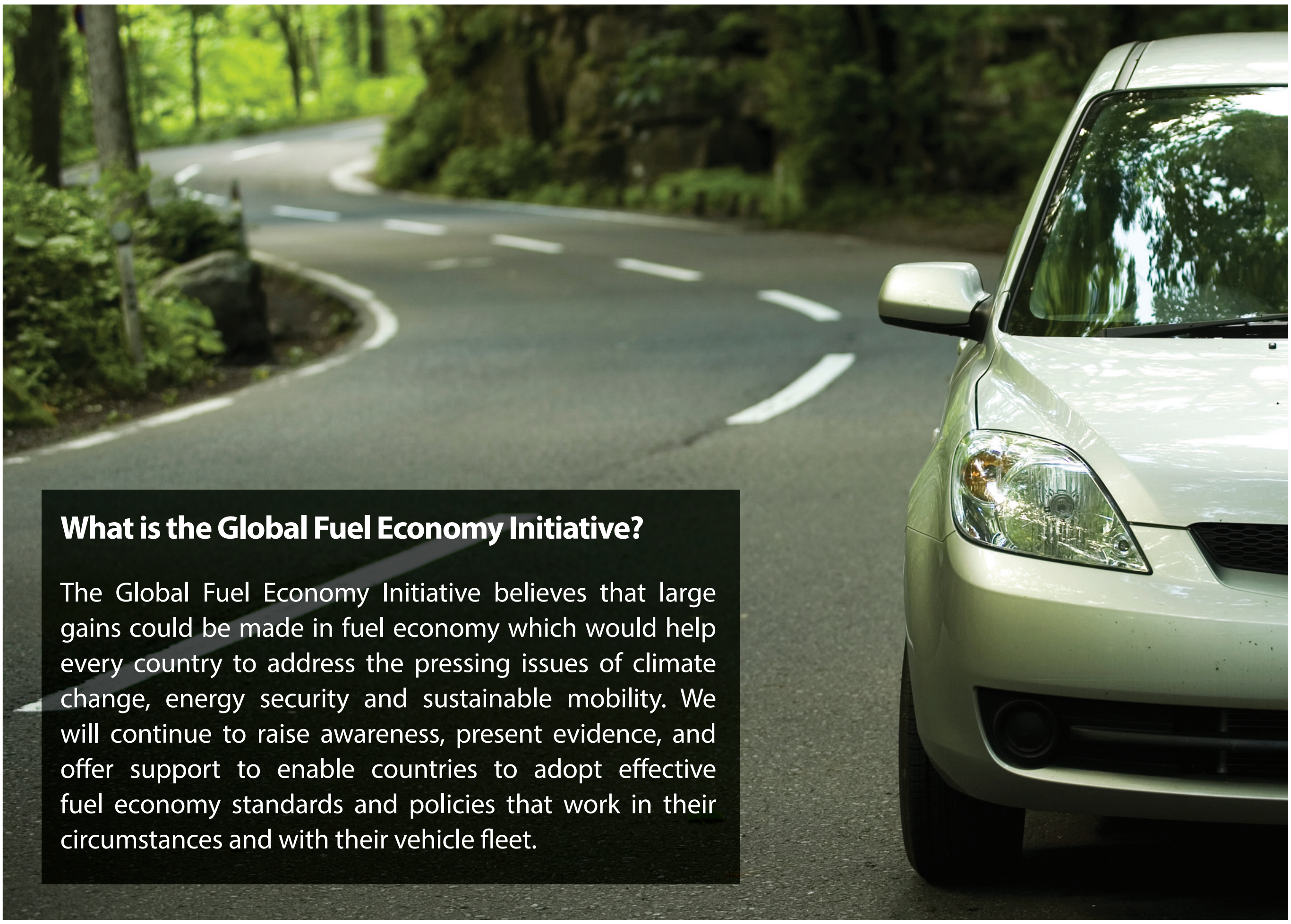

What is the Global Fuel Economy Initiative?

The Global Fuel Economy Initiative believes that large gains could be made in fuel economy which would help every country to address the pressing issues of climate change, energy security and sustainable mobility. We will continue to raise awareness, present evidence, and offer support to enable countries to adopt effective fuel economy standards and policies that work in their circumstances and with their vehicle fleet.

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