ICCT Comments in Response to the Proposed Rulemaking Issued by the National Highway Traffic Safety Administration and the Environmental Protection Agency to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2012-2016

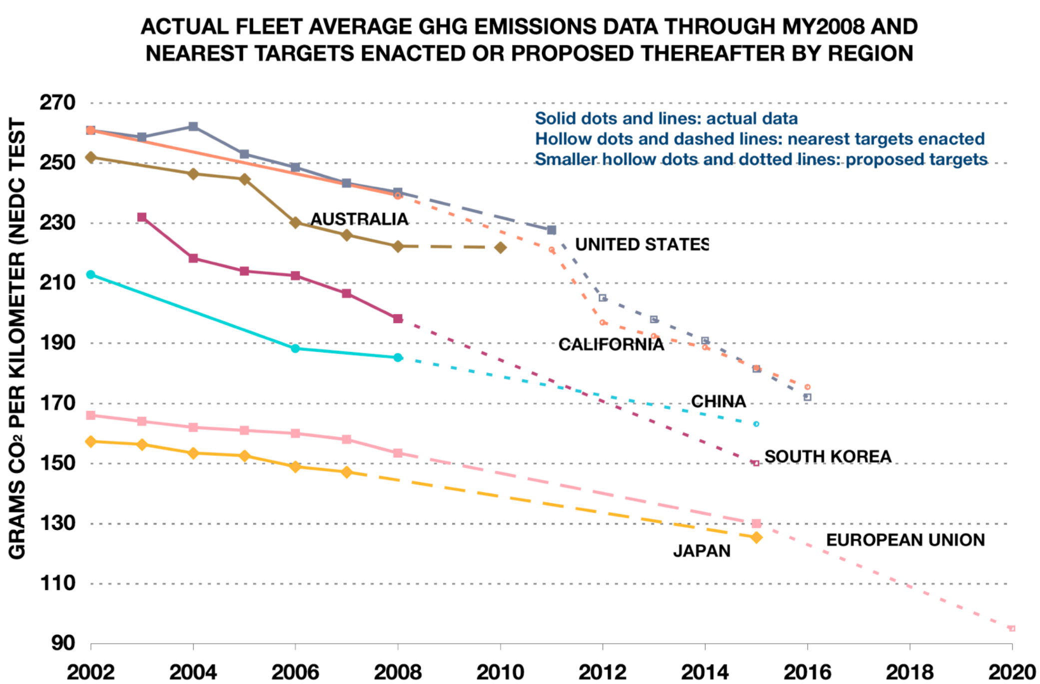
Docket No. NHTSA–2009-0059
Docket ID No. EPA–HQ–OAR–2009–0472

November 25, 2009

These comments are submitted by the **International Council on Clean Transportation (hereafter, "ICCT").** The ICCT is made up of leading government officials and experts from major countries and regions around the world who participate as individuals based on their experience with air quality and transportation issues. The ICCT promotes best practices and comprehensive solutions to improve vehicle emissions and efficiency, increase fuel quality and sustainability of alternative fuels, reduce pollution from the in-use fleet, and curtail emissions of local air pollutants and greenhouse gases (GHG) from international goods movement.

1) Overall

This proposed rule takes a giant step towards catching up with vehicle efficiency in Europe, Japan, and other nations (see graphic below) and will enhance U.S. credibility worldwide. We applaud EPA and NHTSA, along with California, the Administration, and the vehicle manufacturers, for taking the first steps along the road to a sustainable transportation system.



There are tremendous opportunities to dramatically reduce climate change emissions from passenger vehicles in the coming years and it is essential to continue this progress in the future. Long-term goals need to be set, so that manufacturers have consistent, long-term signals to help them develop future technologies and product plans. This is especially important in the context of the recession, with companies reorganizing and investment dollars in short supply. ICCT supports a strong Federal rule and recognizes and applauds the constructive role that California has played in building the technical and public support for this critical rulemaking. We urge all parties to continue the process and set aggressive standards for 2017 and beyond.

ICCT strongly supports the proposed program stringency and is providing detailed comments in support of the following positions on the issues:

- ICCT supports the use of footprint instead of weight as a vehicle attribute. (Comment number 2)
- The rule will enhance consumer welfare. Standard economic theory on consumer behavior is not strictly applicable in this case, due to the effects of uncertainty, consumer loss aversion, and the indirect effects introduced by regulating all consumers. (Comment number 3)
- With respect to safety, the NHTSA model developed by Kahane is not applicable for lightweight materials. Theory and work by DRI strongly support that making vehicles lighter without reducing size will reduce fatalities. (Comment number 4)
- A dynamic estimate should be used to adjust the future rebound effect. (Comment number 7)
- ICCT supports simplifying the cost-benefit models, provided that accuracy is not compromised, making cost assessments more transparent, and replacing the simple RPE estimate with assessments of indirect costs. (Comment number 9)

ICCT also requests that the following improvements be considered for the final rule:

- The footprint-based adjustments program would be more effective if a single footprint line were used for all vehicles, instead of separate lines for cars and light trucks. (Comment number 2)
- Black carbon is an important radiative forcer and should be regulated by EPA. (Comment number 5)
- EPA should revise the assumption of zero-carbon emissions from electricity use by vehicles. (Comment number 6)
- EPA should consider revising the metric used to present efficiency information. (Comment number 8)
- Existing technology investments by individual manufactures should be incorporated into future technology assessments, the leadtime associated with each technology should be better defined, and the indirect cost multiplier category assessments should include the difficulty in integrating a new technology into the existing technology. (Comment number 9)
- ICCT strongly supports the use of volume-based learning curves and offers some suggestions on how to improve learning curve assessments. (Comment number 10)
- ICCT has some specific suggestion on modeling of hybrid costs. (Comment number 11)
- Diesel engines should be considered for small cars. (Comment number 12)

2) Program Stringency and Structure

The technical analyses conducted by EPA and NHTSA are sound and demonstrate that the proposed standards are feasible and the benefits of the rule far outweigh the costs. The analytical framework also provides a good base for further reductions in fuel consumption and greenhouse gas emissions beyond 2016.

We commend EPA and NHTSA for proposing a footprint-based adjustment to the CAFE standards instead of weight-based adjustments. Footprint-based adjustments fully encourage manufacturers to introduce lightweight materials, which can improve vehicle efficiency by 20% or more in the long run. Lightweight materials also extend the electric drive range of electric and plug-in vehicles by a similar amount. This is one area of policymaking where the U.S. is ahead of the rest of the world. Japan, Europe, and China have all adopted standards with weight-based adjustments that effectively discourage the use of lightweight materials. NHTSA pioneered the footprint concept with the 2011 light truck rule and we urge EPA and NHTSA to continue its use in the future.

We also support the proposed change to the shape of the footprint adjustments. The linear slope for all but the largest and smallest vehicles provides a consistent signal to improve efficiency for all vehicles within this range, while the flat line for largest vehicles creates an incentive to make the largest vehicles smaller.

<u>Single footprint curve</u>

The proposed rule maintains separate footprint curves for cars and light trucks. This subjects light trucks with the same footprint to much less stringent standards and gives manufacturers a tremendous incentive to reclassify cars as light trucks. In the past this has brought us such notable trucks as the Subaru Outback, Chrysler PT Cruiser, Dodge Magnum, Mazda 5, Chevrolet HHR, Porsche Cayenne, and BMW X6, which BMW describes as a Sports Activity Coupe. In the future it is likely to cause manufacturers to drop many 2wd versions of their small SUVs and make less efficient 4wd versions standard, so that they can be classified as light trucks instead of cars. This will actually increase overall real world fuel consumption and CO_2 emissions in two ways. First, it will increase 4wd installation and directly increase the fuel consumption of the fleet. Second, it makes it easier for manufacturers to meet the standards, so that they do not have to implement as much technology on other vehicles.

The large majority of light trucks today are based on car platforms with unibody construction. All minivans use unibody construction and cab-and-chassis construction for SUVs is rapidly disappearing. Except for pickup trucks and a few relatively low volume SUVs, such as the Jeep Wrangler and the Suburban, in the 2016 timeframe of the rule all light trucks will be based on car platforms. In addition, due to the empty pickup bed, pickup trucks are considerable lighter than truck-based SUVs with the same footprint and fit much better on a single footprint line. Thus, there is no technical reason to maintain separate footprint lines for cars and light trucks.

EPA recognized the importance of this issue when it established a single Tier 2 emission standard for all cars and light trucks. The issue here is just as important. It is time to also end this artificial distinction between cars and light trucks for fuel efficiency and greenhouse gas emissions. A single footprint function will still give larger trucks a less stringent target to meet, while avoiding vehicle classification games and helping to ensure fuel consumption and GHG emission goals are actually met.

3) Consumer Welfare

The impact of the proposed standards on consumer welfare is the subject of much debate in the proposal, reflecting the lack of clarity and understanding of this issue in general. The debate revolves around the so-called Energy Paradox. Assuming full information and perfect foresight, standard economic theory says that consumers will make optimal tradeoffs between the purchase price and subsequent operating costs. In short, the problem is that consumers appear not to purchase products that are in their economic self-interest.

Both agencies chose to exclude estimates of consumer welfare loss due to changes in vehicle choice. Although this was done primarily because of methodological concerns, ICCT supports this decision and does not believe there is significant consumer welfare loss in this case. Consumers do undervalue fuel savings because of uncertainty and loss-aversion and generally understand that standards do not reduce their welfare, as explained below.

There is substantial circumstantial evidence that most consumers in the U.S. place a low value on fuel economy. For example, Turrentine and Kurani [1] conducted an in depth survey of the car-buying histories of 57 California households. None of these 57 households made any kind of quantitative assessment of the value of fuel savings and only 9 stated they compared the fuel economy of vehicles in making their choice. The selected consumers were largely unaware of their annual fuel cost, in contrast to general knowledge of the daily price fluctuations of a gallon of gasoline. Turrentine and Kurani concluded that: "When consumers buy a vehicle, they have neither the tools nor the motivation nor the basic building blocks of knowledge to make a calculated decision about fuel costs."

Turrentine and Kurani's findings were not based upon a representative sample, but they are generally supported by the results of a 2007 national random survey of 1,030 households (Opinion Research, 2007). When asked about their last vehicle purchase, 39 percent of respondents indicated they did not consider fuel economy at all and, of those who did, only 14 percent mentioned taking fuel costs or gasoline prices into consideration.

The question that has been debated for decades is simply – why? This is an extremely important question, as most of the calculation of consumer welfare is based on the answer. If consumers are already receiving their optimum level of fuel economy, then efficiency standards will decrease their welfare. However, if there are valid reasons why consumers are not making optimal tradeoffs at the time of vehicle purchase, or if the entire question is not being framed properly, then efficiency standards could increase consumer welfare.

NHTSA, EPA, and the U.S. Office of Management and Budget (OMB) all recognize the importance of the Energy Paradox, but state that it is not currently possible to fully account for all effects on consumer welfare. While they all estimate the benefits of the GHG rule would outweigh eventual losses of associated private welfare, they suggest further analyzing the subject of consumer welfare for future rule making:

---

[1] Turrentine, Thomas S., and Kenneth S. Kurani, "Car Buyers and Fuel Economy?" Energy Policy 35 (2007): 1213-1223.

- EPA said they are not able to estimate the consumer welfare loss that may accompany the actual fuel savings from the proposal and asked for comments "on how to assess these difficult questions in the future".
- NHTSA invites comments "on the state of the art of consumer vehicle choice modeling, as well as on the prospects for these models to yield reliable estimates of changes in consumer welfare from requiring higher fuel economy."
- OMB provided a 17 page document containing suggested revisions for sections III.H and IV.G of the preamble.[2] While their suggestions were not incorporated into the text in the proposed rule, their document indicates OMB's concern about consumer welfare and their desire to settle the long-standing issues. Compared to the language in the preamble, the OMB language is more precise and clear and the text is more structured. For example, they would have rewritten EPA's request for comments to say, "EPA is not in a position to produce empirical estimates of the magnitude of these losses. We lay out a framework for how EPA will make progress on this issue for future rulemakings."

Several forms of market failure have been advanced to try to explain the energy paradox, such as:

- Principal agent conflicts.
- Information asymmetry
- Transaction costs, including the time and expense of collecting information
- Bounded rationality
- External costs or benefits

All of these have some validity. However, it is difficult to quantify the effects of these factors, as is evidenced by the fact that there has been little progress in resolving the energy paradox for decades. ICCT believes uncertainties about the cost and value of fuel economy improvements, combined with general loss-averse behavior by consumers, offers a rational and accurate explanation of the failure of the market to optimize fuel cost savings.

NHTSA and EPA accurately discussed the uncertainty-loss aversion theory in the proposal. However, it was presented as one of an array of possible explanations. Not only is uncertainty-loss aversion sufficient to explain consumer behavior by itself, but the other forms of market failure can also be viewed simply as factors increasing the uncertainty of the future fuel cost savings.

With the above discussion as background, what does uncertainty-loss aversion tell us about consumer welfare? Green et al 2009[3] found that using reasonable estimates of the uncertainty of in-use fuel economy, future fuel prices, annual vehicle use, vehicle lifetime, and incremental vehicle price yielded an average customer payback period of about 3 years. Thus, there is not a market failure. Given the large uncertainties in the actual amount of future fuel cost savings and the other ways that consumers can spend their money, the average customer is being quite rational in only wanting to pay for about 3 years of projected fuel savings.

---

[2] "Interagency Review Comment #34 regarding Private and Societal Costs and Benefits", Docket # EPA-HQ-OAR-2009-0472-0317.3

[3] Greene, D.L., J. German and M.A. Delucchi, 2009. "Fuel Economy: the Case for Market Failure", ch. 11, in D. Sperling and J. Cannon, eds., *Reducing Climate Impacts in the Transportation Sector*, Springer Science+Business Media.

Does this mean that customers only value 3 years of fuel savings and that their consumer welfare will decrease if standards force them to save money on fuel from technologies that achieve a fuel-savings based payback in more than 3 years? Not necessarily. There are two important issues that affect the conclusion:

(1) Standards change the status quo by removing the option to buy a vehicle without the additional efficiency technology – it is not presented to the customer at all.
(2) Standards require everyone to purchase higher levels of efficiency technology, not just individual customers, leading to indirect consumer welfare benefits.

Standards change the status quo

David Greene addresses the first issue in detail in a new paper.[4] Loss aversion is context dependent, which leads to the paradox that consumers who would decline a risky bet may reach a higher level of utility if forced to accept the bet. Efficiency standards mandate that only vehicles with additional efficiency technology can be sold. There is no reason why consumers should evaluate the choice limited by standards in the same way they perceive the choice without standards. The lower cost, lower efficiency options are now missing from the choice set, changing the context. Would consumers still perceive the purchase to be a risky bet? Even if consumers still perceive the purchase as a risky bet, do they update their baseline for evaluating their welfare? If consumers value their net gain or loss relative to the new status quo imposed by the efficiency standards, then they will value the future fuel savings and there will be no loss of consumer welfare.

ICCT believes the only valid reference point for loss aversion is the updated status quo that exists when the consumer actually makes the purchase decision. The main cause of lack of consumer interest in increased fuel economy is the bias introduced by uncertainty and loss aversion. After efficiency standards are introduced there is a new, updated status quo. Under the new status quo, consumers will save fuel and will have more money in their pockets. It is irrational to assume that consumers will not acknowledge the fuel cost savings under the new status quo. Thus, consumers will no longer apply the loss aversion discount to the estimated fuel savings and the full value of future fuel savings should apply.

Indirect benefits from standards that affect everyone

The concept of consumer welfare under standard economic theory is based upon individual choices. However, efficiency standards affect everyone, not just individual customers. This changes the calculation of consumer welfare. The individual's welfare is now the sum of the direct impact on the individual and the indirect benefit to the individual of forcing other customers to buy more efficient vehicles.

This is far from trivial. There are substantial benefits to an individual if everyone else buys more efficient vehicles. It reduces demand for oil, which leads to lower fuel prices and reduced energy security risks. It also reduces carbon emissions and slows down global warming. Most people are aware of these benefits if standards are imposed on everyone and place significant value on them.

[4] Presented at Stanford Energy Modeling Forum's Workshop on the Economics of Technologies to Combat Global Warming, Snowmass, Co., August 3-4, 2009. It has also been peer reviewed and submitted for publication in Energy Economics.

Vehicle emission standards are a clear example of this indirect value. Very few people voluntarily pay extra themselves for a clean vehicle, as they understand there is virtually no benefit to themselves. Despite this, there is broad support for the government setting standards forcing everyone to pay extra for cleaner vehicles. As long as everyone has to contribute equally, few customers complain about having to pay their share for cleaner air. They understand the indirect benefits they receive from being forced to pay extra for their vehicle.

The situation here is similar, except that consumers receive direct benefits individually in addition to the indirect benefits from forcing everyone to contribute. The classic economic model of consumer welfare does not consider the indirect benefits that standards provide to individuals. As long as everyone is forced to pay more for efficiency, most consumers will happily reset their baselines. Either a different model is needed to assess both the direct and indirect consumer welfare benefits or a second model is needed to assess the indirect benefits.

<u>Second and subsequent owners</u>

There is also a potential issue with the consumer welfare of second and subsequent owners. In reality, the original purchaser likely does not assess the full useful life fuel savings, including uncertainty, when making purchase decisions. Rather, the original purchaser likely assesses the fuel savings for his/her ownership period plus the additional amount the second owner will pay for the higher fuel economy, both including uncertainty. Because of uncertainty, the original owner severely discounts what the second owner would be willing to pay for the higher fuel economy. If this discounted value is smaller than the value the subsequent owner would place on the fuel savings, including uncertainty, this creates a loss of welfare for the second owner.

ICCT is not aware of any research on either the value the original purchaser places on the increased resale price or the value subsequent owners place on fuel savings. Thus, there is no way to know if subsequent owners are losing consumer welfare. But it is possible, if not likely, that efficiency standards would increase the consumer welfare of second and subsequent owners.

<u>Usefulness of consumer choice models</u>

EPA asked for comments "on the usefulness of consumer choice modeling results and the consistency and reliability of results from these models." The usefulness of consumer choice models depends on establishing an appropriate consumer discount rate for the fuel savings. As discussed, above, there are numerous unresolved questions related to consumer welfare that reflect the lack of clarity and understanding of this issue in general. There is no point in trying to use a consumer choice model until the issue of consumer welfare is resolved and an appropriate discount rate established.

In addition to the threshold questions raised above, there are other problems with using consumer choice models:

(1) For technologies that are not in the market, such as PHEVs, the models must rely on stated preferences.
(2) Even for existing technologies, the revealed preferences vary by both customer type and market segment. For example:
    - Early adopters have different preferences (and buying power) than much of the rest of the market.
    - Diesel vehicles deliver higher torque at low speeds, which is preferred by a certain class of customers who have to tow heavy loads.

- Vehicles with electric propulsions systems, such as electric or fuel cell vehicles, might be able to accelerate faster than conventional ICE vehicles, but their ability to sustain performance at high loads might be lower than ICE vehicles.

(3) Consumer preferences change over time and choice models do not take that into account.

4) Safety

ICCT is concerned that the safety impacts of lightweight materials are not being properly analyzed in the rulemaking. The 2003 Kahane study relied upon by NHTSA for its safety analysis was an excellent study of vehicle weight. However, it explicitly assumed that size and weight are inseparable. Thus, it did not analyze weight effects, but rather the effect of weight and all correlated size effects. The results of the Kahane study would be great for analyzing the safety impacts of a weight-based attribute system. However, the footprint-based attribute system was established specifically to break the link between size and weight and encourage the use of lightweight materials. Kahane's methodology was simply not designed to assess the safety impact of lightweight materials.

As explained in more detail, below, lightweight materials introduced in response to footprint-based vehicle standards will improve overall safety:

- High-strength steel is stronger and aluminum has better crash properties.
- Footprint-based standards encourage vehicle designs that are less likely to roll over.
- The lower vehicle mass reduces the crash forces that must be managed, while maintaining crush distance and interior space.
- Lighter vehicles handle and brake slightly better, improving the potential for accident avoidance.

Dynamics Research Inc., or DRI, has done three major state-of-the-art reports on the independent effects of size and weight on fatalities. The reports cover multiple scenarios using different vehicle types, model years, and statistical formulations:

- DRI's 2003 report was based on Kahane's 1997 aggregate linear regression method, while DRI's 2004 report was based on Kahane's 2003 logistic regression method.
- Cars were analyzed with 1985 to 1998 model years and 1991 to 1998 model years
- Light trucks were analyzed with 1985 to 1997 model years and 1991 to 1997 model years
- Cars were analyzed using all cars, excluding sporty 2-door cars, excluding both sporty 2-door cars and police cars, and excluding all 2-door cars and police cars.

While the magnitude of the size and weight effects varied, in every single case DRI found that reducing vehicle weight while holding footprint constant *reduced fatalitie*s for both cars and light trucks. The robustness of the results to different scenarios strongly supports the conclusion that the relationship between fatalities and size and weight is real and is not a statistical artifact.

DRI's results are also supported by theory. Reducing vehicle weight reduces the crash forces that must be managed in a crash. If interior space and the space for managing the crash forces are maintained, as is the case with lightweight materials, the reduced weight makes it easier to manage the crash forces and protect the occupants of both vehicles. Also, high-strength steel and aluminum have better crash characteristics than conventional steel. In fact, the ability of high-strength steel to help prevent intrusion and adsorb crash forces is the primary reason for its rapidly increased market penetration in recent years. The weight reduction is a secondary benefit. Aluminum also has safety benefits, as it provides more uniform management of crash forces.

In addition, as Marc Ross testified at the October 21, 2009 hearing in Detroit, fatalities are linked more strongly to intrusion into the passenger compartment than to vehicle mass. Safety experts in Japan and Europe raised this issue previously. Their research suggests the main cause of serious injuries and deaths is intrusion due to the failure of load-bearing elements to properly protect occupants in a severe crash:

- "The results from this project have overturned the original views about compatibility, which thought that mass and the mass ratio were the dominant factors."[5]
- "moreover, if mass appears to be the main parameter linked to aggressivity of cars, it is because this is the easiest and universal parameter that is collected in all accident databases."[6]
- "The scientific community now agrees that mass does not play a direct role in compatibility."[7]

Reducing vehicle weight while maintaining size helps to reduce intrusion, as the lower weight reduces crash forces while maintaining size preserves crush space. Thus, size-based standards that encourage the use of lightweight materials should reduce intrusion and, hence, fatalities. This factor was not considered by NHTSA in its discussion of safety.

Assessing the independent effects of size and weight is not easy, as both size and weight actually have minor effects on fatalities compared to driver behavior, road conditions, vehicle safety design, and vehicle compatibility.[8] As Tom Wenzel pointed out in his testimony at the October 27, 2009 hearing in Los Angeles, "regression models frequently do not, and perhaps cannot, fully account for all the design differences between vehicle models, or their drivers, that contribute to their on-road safety record. Thus, you can always find errors and inconsistencies in any regression model."

Thus, it is appropriate to critique DRI's work and to suggest ways to improve their analyses. However, NHTSA's critique of DRI's work in the proposal may be biased, as NHTSA only discussed results for the scenario that includes 2-door cars. What about DRI's analyses of light trucks and of cars excluding 2-door cars? Did NHTSA confirm these results, but only choose to disclose problems trying to confirm the results including 2-door cars? Since this information is critical to this rulemaking process, NHTSA is required to disclose its underlying analysis of DRI's reports in order to allow the public sufficient notice

---

5 Edwards, M., Happian-Smith, J., Davies, H., Byard, N., and Hobbs, A., "The Essential Requirements for Compatible Cars in Frontal Collisions (158)", Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles, Amsterdam, the Netherlands, 2001.

6 Faerber, E., "EEVC Research in the Filed of Improvement of Crash Compatibility between Passenger Cars (444)", Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles, Amsterdam, the Netherlands, 2001.

7 Delannoy, P. and Faure, J., "Compatibility Assessment Proposal Close from Real Life Accident (94)", Proceedings of the 18th International Technical Conference on the Enhanced Safety of Vehicles, Nagoya, Japan, 2003.

8 Compatibility refers to how well the safety structures of different vehicles match up. Every vehicle is designed with load paths to handle and dissipate crash forces. If the load paths for each vehicle line up, the vehicles are said to be compatible. However, if the primary load path of one vehicle does not match another, for example if one vehicle overrides the other, then the crash forces are not dissipated properly and there is significantly more intrusion. This is especially important for side crashes. Another compatibility factor is the relative weight of each vehicle. The larger the difference in weight between two vehicles in a crash, the more difficult it is for the smaller vehicle to manage the crash forces.

and the ability to comment on its findings. In any case, the proper remedy is to arrange a meeting with DRI to discuss the discrepancy and determine the cause, not to dismiss all of DRI's other work.

Indeed, it is easy to also find inconsistencies in NHTSA's analyses. For example, the following chart is based on Kahane's work on compatibility in his 2003 Report, which was based only on 1996-99 vehicles. It clearly shows that small SUVs are much safer, both to occupants of other vehicles and to occupants of the small SUVs, than mid-size SUVs, despite being 846 pounds lighter. Certainly the better safety of the small SUVs was likely due in part to more recent designs, such as the Toyota RAV4 and the Honda CRV, although older designs such as the Jeep Wrangler and the Geo Tracker were also included. Regardless of whether or not weight is correlated with fatalities, the results support that improved design is a much more important factor than size or weight.

		Fatality rates per billion case vehicle miles by collision type					
		In My Vehicle				Others	
	Avg curb weight (p 197)	Total (p 198)	Rollover (p 202)	Fixed-Object (p 202)	heavy truck (p 202)	Other Veh + Pedestrians (p 198)	Pedestrians, -bikers-MC (p 202)
Small SUVs	3,174	6.09	1.53	1.98	1.14	4.38	2.11
mid-size SUVs	4,022	9.16	4.42	2.64	0.84	4.52	1.72

The results also demonstrate the importance of encouraging designs similar to those of 1996-9 small SUVs and discouraging designs similar to those of 1996-9 mid-size SUVs. Size-based attribute standards encourage lighter weight car-based SUVs with significantly better handling and crash protection, clearly reducing both fatalities and fuel consumption. This factor also was not considered by NHTSA in its discussion of safety in the proposal.

NHTSA and EPA need to focus on doing the best analysis possible of the safety impacts of lightweight materials in a footprint-based system. Size-based standards encourage better safety design and help to reduce intrusion. Models that do not separate size and weight effects are not capable of evaluating these important factors and should not be used to evaluate the safety effects of a size-based attribute systems.

The DRI model has proven to provide very robust results over a wide range of different scenarios. Thus, in the short term the best approach is to address any possible shortcomings in the DRI work and use their model to assess safety impacts for the final rule.

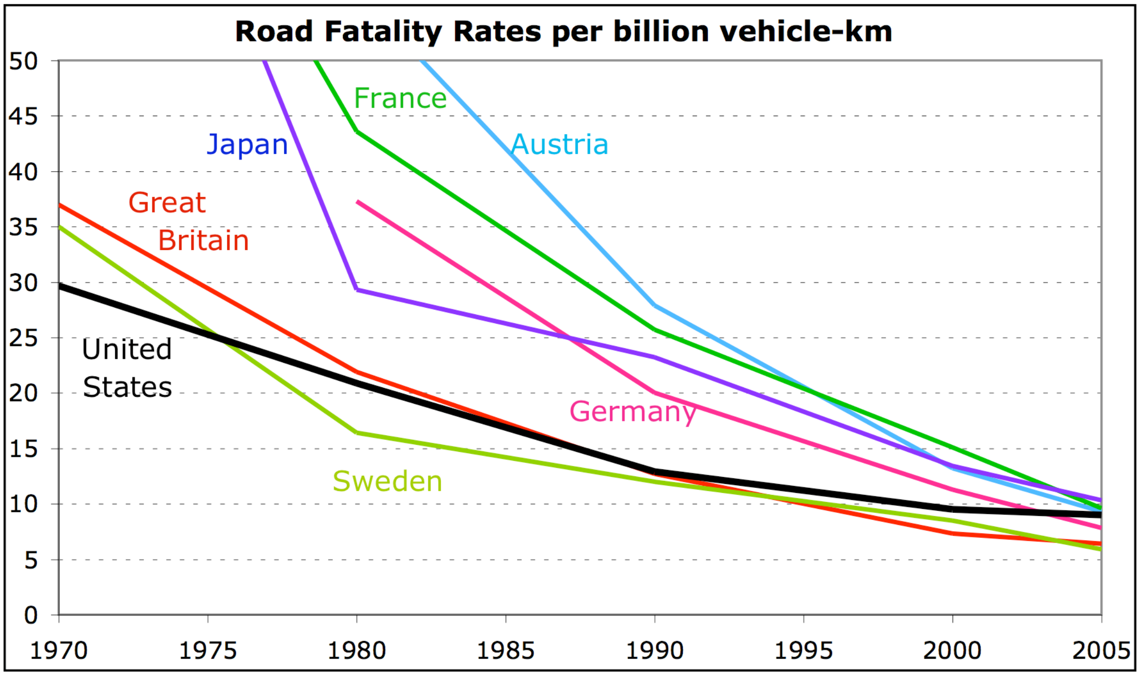
In the long run, ICCT urges NHTSA to conduct new analyses of the independent effects of size and weight. This would be the optimal solution for future rulemakings.

European versus U.S. Fatality Trends

A 2008 International Transport Forum report assessed trends in fatalities from 1970 to 2005.[9] Exerts from Table A.3. are illustrated in the following chart. Although it is difficult to draw conclusions from comparisons of different countries due to the different road networks and vehicles, it is striking that the

[9] Towards Zero: Ambitious Road Safety Targets and the Safe System Approach, OECD International Transport Forum, 2008. Exerts from Table A.3. Road fatality rates per 100,000 inhabitants and per billion vehicle-kilometres, 1970-2005

U.S. went from the fewest fatalities per mile in 1970 to amongst the highest in 2005. The vehicles in all the European countries are far smaller and lighter than in the U.S., yet the fatality rates in 2005 are significantly lower in many European countries and all European countries have achieved far greater fatality reductions. This strongly supports the idea that vehicle and highway design are far more important factors than size or weight in vehicle safety. It also suggests that the rise in sport-utility sales in the U.S. has not helped reduce fatalities.



Fatality Calculations based on the 2005 DRI Report

Table IV.G.7–1 in the proposal presented a "Comparison of the Calculated Worst Case Weight Safety-Related Fatality Impacts of the Pending Proposed Standards Over the Lifetime of the Vehicles Produced in Each Model Year." Although the agencies emphasized, "that the safety-related fatality impacts presented below represent a worst case scenario", a more realistic scenario was not presented. To fill this gap, the following is a simple assessment based on DRI's work.

The results of DRI's full reports were summarized in a peer-reviewed paper published by SAE.[10] Table 9 from the paper summarized the overall fatality impacts, including the impacts of a 100-pound weight reduction. As can be see from the chart, DRI found that reducing the weight of cars by 100 pounds while holding size constant reduced fatalities by 580[11]. Similarly, reducing the weight of light trucks by 100 pounds while holding size constant reduced fatalities by 219, with a total fatality reduction of 799.

---

[10] R. M. Van Auken and J. W. Zellner, Dynamic Research, Inc., SAE 2005-1-1354 (2005)

[11] Total fatalities in 1999 for crashes involving passenger cars, including pedestrians, bicyclists, and motorcycle riders was 25,335. Total fatalities for crashes involving light trucks were 19,179. There were 6,881 fatalities in

These results need to be adjusted for two factors; the actual weight reduction estimated for the proposed rule and the change in the overall baseline fatalities from the 1999 calendar year used by DRI and 2020 as used by NHTSA.

The proposed weight reduction was addressed in the preliminary RIA, which states, "As can be seen, the overall reduction in vehicle weight is projected to be 4%." All of the weight reduction is from the use of lightweight materials. The proposal assumes that vehicle size does not change. The average amount of weight reduction was 127 pounds for cars and 199 pounds for light trucks.[12]

Table 9. Estimated Effects of a 100 lb Vehicle Weight Reduction and Corresponding Changes in Wheelbase and Track on 1999 Fatalities Based on Data for 7 States

Vehicle Parameter Change	Estimated Net Change in 1999 US Fatalities Involving					
	Passenger Cars		LTVs		Total	
	Est.	(2σ)	Est.	(2σ)	Est.	(2σ)
100 lb curb weight reduction	**-580**	**(260)**	**-219**	**(179)**	**-799**	**(316)**
corresponding wheelbase reduction	**368**	**(174)**	**174**	**(81)**	**542**	**(192)**
corresponding track reduction	**191**	**(134)**	**106**	**(104)**	**297**	**(170)**
Combined weight and size reductions	-21	(340)	61	(222)	40	(406)

Fatality trends by year were addressed in section IV.G.7 of the preamble, which states, "The agency (NHTSA) assumed that the safety trends will result in a reduction in the target population of fatalities from which the weight impacts are derived. Using this method, we found a 12.6 percent reduction in fatality levels between 2007 and 2020. The estimates derived from applying Kahane's percentages to a baseline of 2007 fatalities were thus multiplied by 0.874 to account for changes that the agency believes will take place in passenger car and light truck safety between the 2007 baseline on-road fleet used for this particular analysis and year 2020." As DRI based their fatality estimates upon fatalities in 1999, the 12.6 reduction between 2007 and 2020 was linearly extended to 1999, yielding a fatality reduction estimate of 18.7%.

Thus, DRI's estimated reduction in car fatalities of 580 for a 100 pound weight reduction is increased to 127 pounds and reduced by the 18.7% reduction in baseline fatalities, yielding a reduction in fatalities involving cars of 599. Similarly, adjusting the light truck fatality reduction of 219 for a 100 pound weight reduction to 199 pounds and for 2020 overall fatalities yields 354 fewer fatalities. Thus, the proposed rule is expected to ***reduce*** overall fatalities by 953, not increase fatalities as projected by NHTSA.

---

crashes between cars and light trucks, which were considered in both the car and light truck analyses. Thus, total fatalities in 1999 were 37,663 (25,335 + 19,179 – 6,881).

[12] The actual weight reductions in the proposal varied by vehicle size, with larger vehicles assumed to have larger weight reductions. As this would decrease the difference in weight between smaller and larger vehicles, it would have a beneficial impact on vehicle compatibility and would produce fewer fatalities. Thus, using an average weight reduction of 4% for all vehicles is conservative estimate of the fatality reductions from the use of lightweight materials and the actual reductions in fatalities would likely be larger.

5) Black Carbon

New research published since the Fourth Assessment Report has revised upward the IPCC estimates of black carbon radiative forcing. Both the work of the IPCC and scientific research published since then leave little doubt that black carbon is a major contributor to global climate change and must be addressed. This rulemaking offers a clear opportunity to finally acknowledge black carbon as a potent climate-forcing agent and to take specific actions to address our concern that light-duty vehicles may become a significant source of this pollutant in the future.

There are reasons to be concerned about black carbon emissions from the light-duty fleet. Although emissions of black carbon are practically undetectable from current vehicles, measurements of black carbon from light-duty vehicles powered by gasoline direct injection engines suggest they can produce significant black carbon emissions of up to 0.03 g/mile. According to our calculations, a light-duty vehicle emitting on average 0.01 g PM/mile would represent 0.5-6.8 g CO2-eq/mile emissions[13]. This would not only partially offset the CO2 climate reduction benefits of such vehicles, but it would also have adverse health impacts.

Both the US EPA and CARB have regulatory provisions for non-CO2 climate forcing agents, such as methane, nitrous oxide, and hydroflourocarbons. The IPCC in its Fourth Assessment Report quantified the radiative forcing of black carbon and produced an estimate that ranks it third among the largest contributors to historical radiative forcing. Estimates for methane, nitrous oxide and hydroflourocarbons rank second, fifth, and seventh, respectively. Thus, regulation of black carbon would be substantially more important than regulation of nitrous oxide and hydroflourocarbon.

The IPCC in its Fourth Assessment Report did not publish a Global Warming Potential (GWP) for black carbon. Despite the absence of a published value, IPCC authors did not exclude the possibility of calculating a GWP from data published in the report. With expert guidance from several IPCC co-authors, ICCT estimated the 20-year GWP of black carbon at 1600, the 100-year GWP at 460 and the 500-year GWP at 140. These values are derived directly from radiative forcing values published in Table 2.5 of Chapter 2 of the IPCC Working Group 1 report and from emission inventory estimates used in the suite of AEROCOM studies from which these radiative forcing estimates were derived. They have since been published independently by IPCC co-authors in the peer-reviewed literature.

Two precedent-setting steps are necessary to design a black carbon component for this regulation:

(1) Selection of a measurement method for black carbon. Scientific debate within the climate science community has centered on which of two methods to use to measure black carbon – optical or thermal – and this has led to different definitions of black carbon.

(2) Although the IPCC did not publish a GWP value for black carbon, we believe a pragmatic approach based on the IPCC's own data is justifiable. Action by the US EPA to authoritatively address this issue and establish a GWP value for black carbon would be a precedent-setting advance that would almost certainly be leveraged by other regulatory authorities around the world.

---

[13] Assumes 20-50% BC fraction of PM with the remainder as OC; assumes between 460 and 1600 GWP for BC and -69 to -240 GWP for OC. GWP values are derived from the ICCT report *A policy relevant summary of black carbon climate science and appropriate mitigation strategies* available at http://www.theicct.org.

Not only is it important to ensure light-duty vehicles remain a negligible source of black carbon, there are also strategic values for other vehicle source categories (i.e., heavy-duty vehicles, marine, etc.). Establishing procedures to control black carbon from light-duty vehicles would provide a precedent that could be leveraged to control more significant sources of this pollutant from other vehicle source categories.

It is also important to acknowledge and give credit to regulations established by the US EPA that already control some fraction of transportation-related black carbon emissions. This includes vehicle emission standards for on-road and off-road heavy-duty vehicles, as well as for light-duty vehicles. In its recent endangerment finding, the US EPA claimed that such regulations already capture black carbon. We urge the agency to make an effort to quantify the climate benefit of these regulations.

6) Zero-carbon assumption for electric vehicles – Section III.C.3 of the Preamble

EPA proposed to assign zero carbon emissions for electricity used by vehicles. The agency acknowledges that in reality CO_2 emissions would be higher due to emissions from electric utility generation and that this is not an appropriate long-term approach. However, EPA sees a value in using zero carbon emissions as an interim solution in order to promote electric vehicles and asks for comments on this proposal.

ICCT recognizes that there is sound justification for providing a temporary incentive for electric vehicles in order to help them overcome market and infrastructure barriers. However, we are concerned that applying a zero carbon value for electric vehicles creates a loophole enabling OEMs to comply with the standards primarily by producing and offering a relatively small number of electric vehicles. This would allow manufacturers to either scale back the use of efficiency technology on the majority of their vehicles or to use the technology to enhance vehicle performance, putting manufacturers that did not offer electric vehicles at a competitive disadvantage and continuing the horsepower wars.

ICCT was founded around the Bellagio Principles, which were set forth by principal regulators around the world in 2001. This was a consensus document on preferred government policies for shaping the future of motor vehicle technology and transportation fuels worldwide. The second Bellagio principle states: "Base policies solely on performance compared to societal objectives, and not give special consideration to specific fuels, technologies, or vehicle types." In keeping with this principle, we recommend that the agencies include a realistic assessment of incremental upstream emissions from passenger vehicles.

The multiplier used for electric vehicles and plug-in hybrids for 2012 through 2015 already provides an incentive for electricity use. Funding and financial incentives offered by federal, state, and other governments provide additional incentives for electric vehicles. Thus, there is no need for an additional incentive, especially one that could distort the efficiency of the standards.

In the long run, it is important to address the issue of enormous regional differences in carbon from electricity generating powerplants. For example, based on current electricity generation, electric cars would be a great idea for reducing CO2 emissions in France because of its heavy reliance on nuclear energy, but would not be so good in Germany because of the high percentage of coal use. Similar regional differences in carbon intensity exist from state to state in the US. It is important for EPA to address these differences when developing a sustainable policy on electricity use in vehicles.

7) Rebound effect

The agencies used a fixed estimate of 10 % for the *rebound effect*. A wide range of historical studies was considered by the agencies in arriving at this estimate and NHTSA conducted some modeling of their own. Recent studies by Small and VanDender (2007)[14] and Greene (2009)[15] demonstrate that the rebound effect is linked to personal income and vehicle efficiency, as well as fuel prices, and has been declining over time.

EPA stated that if they used a dynamic estimate of the future rebound effect based upon the Small and VanDender work, they would use a value of 5 % or lower. EPA invited comments:

- "on other alternatives for estimating the rebound effect".
- "on the extent to which the short run elasticity of demand for gasoline with respect to its price can provide useful information about the size of the rebound effect".
- "on whether it would be appropriate to use the price elasticity of demand for gasoline, or other alternative approaches, to guide the choice of a value for the rebound effect".

The Small and VanDender work is the proper basis for calculating the rebound effect. Small and VanDender made a major contribution to the field by incorporating economic impacts and the cost of driving into calculations of price elasticity of demand. This is much more appropriate than assuming a fixed 10% rebound effect that does not take into account future changes in vehicle efficiency, fuel prices, and future income. Dynamic estimates should be used to calculate the future rebound effect.

ICCT believes that estimates of the short run elasticity of demand for gasoline with respect to price can provide a useful point of comparison for rebound estimates derived by other methodologies, but should not be used to guide the choice of a value for the rebound effect.

8) New efficiency metric

The agencies asked for comments on how to present efficiency information for electric vehicles. The current metric, miles per gallon (mpg), does not apply to electricity use for battery-electric vehicles and plug-in vehicles. Thus, the electricity use must be converted into an equivalent number of gallons or a different metric must be used.

ICCT believes this is an opportunity to start supplementing the use of mpg with a better metric. Not only does mpg not work for electricity consumption, but it is also not appropriate for conventional vehicles as it is a non-linear metric. The linear metric is gallons per mile. MPG is the inverse and distorts the

---

[14] Small, K. and K. Van Dender, 2007b. "Long Run Trends in Transport Demand, Fuel Price Elasticities and Implications of the Oil Outlook for Transport Policy," OECD/ITF Joint Transport Research Centre Discussion Papers 2007/16, OECD, International Transport Forum.

[15] Greene Report to EPA, March 24, 2009. This report has been submitted for peer review, which is expected to be completed prior to the final rule.

relationship between the rating and the amount of fuel used. The higher the mpg rating, the greater the distortion.

Any linear metric would work better, such as gallons per 100 miles, liters per 100 km, BTU (or kWh) per mile, grams CO_2 per mile, or $ per mile. The latter three suggestions would also solve the problem with comparing electricity use to gasoline use. Grams CO_2 per mile has the additional benefit of treating vehicles and fuels together on a consistent basis.

Canada's experience could provide a valuable guide in how to change the labeling system. Canada added liters per 100 km to their fuel consumption guide, in addition to mpg, many years ago. Such a dual labeling system would be an excellent way to supplement the use of mpg with a better metric and would allow electric vehicles to be compared using the alternative metric.

9) Modeling of costs and benefits

EPA and NHTSA used different models to assess costs and benefits. NHTSA used the Volpe model, which they have evolved over their last several CAFE rulemakings. EPA has developed an independent model with some significant simplifications and that does not depend on confidential manufacturer product plans. While both models are capable of properly assessing costs and benefits, ICCT prefers the overall EPA approach because of its relative simplicity and better transparency.

ICCT is generally in favor of simplifying models, as long as accuracy is maintained. For example, the EPA model assesses technology over 5 year redesign periods, instead of for each model year. This is a good simplification, as manufacturers' redesign plans change frequently and annual assessments are likely to be no more accurate than assessing technology over redesign periods.

A simplification that does not work as well is that EPA appears to assign the same technology package improvements to each manufacturer. EPA's model begins by determining the specific CO_2 emission standard applicable for each manufacturer, based on the footprint and projected sales of each model, and accounts for differences in technology for the baseline model year. However, the model implicitly assumes that every manufacturer will implement the same technologies in the same order in the future based on industry $/kg estimates, without looking at the specific knowledge and experience base for each manufacturer. This simplification may be missing important differences between manufacturers. For example, Volkswagen is unique in having heavily invested in diesel engines in the U.S. for decades and having a substantial share of diesel engine in their fleet, but is far behind some manufacturers in developing and introducing hybrid vehicles. Given their existing investments, Volkswagen's future technology mix is likely to be very different from most manufacturers. Similarly, Honda has been an industry leader in variable valve timing and cylinder deactivation, Toyota a leader in hybrids, Nissan a leader in continuously variable transmissions (CVTs), and Ford and a few other manufacturers have been especially aggressive in developing direct injection, turbocharged gasoline engines. NHTSA's model is capable of assessing leadtime, benefits, and costs independently for each manufacturer. While this is not critical for assessing overall costs and benefits, it does help to evaluate competitive impacts.

In the long run, the agencies should cooperate in developing a single model for setting vehicle standards, incorporating the best features of each model while maintaining as much simplicity and transparency as possible.

Leadtime

For most aspects of the technology assessment, EPA and NHTSA have done a commendable job of making the assumptions and analyses transparent and understandable. However, the proposal, including the related support documents, did not address when each manufacturer can implement different technologies and how long it will take to spread the technologies across the fleet. These factors are critically important in determining how quickly standards can be increased and they affect cost estimates as well. Thus, we urge EPA and NHTSA to document their analyses and assumptions with respect to timelines and leadtime in the final rule.

Cost Assessment

Properly estimating costs is perhaps the most difficult task in assessing economic impacts from rulemaking. In the past, this has often been done by obtaining piece cost estimates from suppliers, adjusting these estimates based on input from vehicle manufacturers, and adding a Retail Price Equivalent (RPE) markup. There are two significant concerns with this approach. First, there is little public information on costs. While most cost estimates have likely been reasonably accurate, there is no way to validate the cost estimates. Second, a generic RPE markup is used to cover a wide range of factors that are not consistent over different technologies.

The proposal makes three substantial improvements:

(1) ICCT agrees that the best way to derive direct technology cost estimates is to conduct real-world tear down studies. Not only is this likely to be more accurate than supplier and manufacturer estimates, but the results are public, greatly increasing the transparency of the cost information. Potential downsides are the cost of conducting the tear downs and accounting for differences in components used from manufacturer to manufacturer; but this is still the best method of assessing direct technology costs.
(2) EPA's assessment of indirect costs specifically addresses the factors that increase the retail price compared to the direct costs.
(3) The indirect costs are adjusted based upon the complexity of the technology.

These are all welcome refinements for assessing technology costs.

Indirect cost multipliers – Section 3.3.2.2.2–3.3.2.2.4 of the Draft TSD

ICCT agrees with the general approach of assigning technologies to several complexity classes for determining the indirect cost multipliers (ICM), as presented in Table 3-2. Trying to determine the indirect multiplier for each technology would be extremely difficult and time consuming. The indirect costs should be a function of the complexity of the technology; so assigning them by complexity class will improve the accurate of the overall cost estimate without the excessive work of defining separate multipliers for each technology.

However, when defining the classes that make use of the same ICM, it is important to realize that relevant aspects are not just the complexity of the technology itself. It is important to also consider the difficulty in integrating a new technology into the existing technology already on the vehicle. This includes powertrain calibration as well as durability, drivability, noise, vibration, and harshness (NVH). For example, cylinder deactivation, turbocharging, and aggressive shift logic are all listed as 'low' complexity technologies in table 3-2 on page 3-15 of the TSD. This is accurate from a hardware point of view.

However, cylinder deactivation causes problems with regard to NVH that require offsetting measures. Turbocharging creates turbo lag, detonation, and hot spots that must be managed with engine calibration and better materials. Finally, aggressive shift logic is difficult to accomplish without compromising drivability. Taking these aspects into account, those technologies should be listed in the 'medium' or 'high' complexity group. By comparison, VVLT-discrete (OHV) is much easier to integrate, yet is listed as 'medium' complexity.

EPA is implicitly applying a separate learning curve to indirect costs, though the reduction in the long-term multiplier. However, as indirect costs are a multiple of direct costs, learning curves applied to direct costs also reduce indirect costs. How does the reduction in indirect costs due to learning for direct costs interact with the reduction in the long-term multiplier?

10) Learning Curves – Cost reduction through manufacturer learning – Section 3.3.2.2.4 of the DTSD

ICCT agrees with the concept of manufacturer learning and supports the use of learning curves to adjust costs. This empirical observation was described for the first time by aircraft pioneer Wright in 1927 and has been found to be true for many technologies and industry sectors in general. Therefore, it is reasonable to expect direct costs for fuel economy measures to decrease as market introduction of the technologies applied proceeds, as suggested by both agencies.

Determination of appropriate learning curves and how they should be adjusted over time and production volumes is not easy. However, the adjustments have a major impact on costs assessments. ICCT believes this area should be developed further for future rulemakings. Following are some specific suggestions for areas of improvement.

Volume-based vs. time-based learning curve effects

According to learning curve theory, the observed decrease of production costs is ascribed to three effects[16]:

(1) "Learning by searching": Optimization of product properties caused by scientific research (e.g. reducing the amount of a catalyst needed for an exhaust after-treatment device).
(2) "Learning by doing": Optimization of production processes caused by experience gained during ongoing production (e.g. reduction of mounting times for an existing assembly line manufacturing process).
(3) "Economies of scale": Reduction of production costs caused by advantages from transition from prototype manufacturing of small quantities to mass production (e.g. lower purchase prices for pre-products and raw materials due to increased market power).

Except for "learning by searching" the cost reducing effects are caused by increased production volumes rather than time passing. For most of the technologies assessed in the proposal it is reasonable to assume that most of the time-dependent research would have been completed by 2012, which is the first year of learning curves are applied in the proposal. Given generally accepted elements of the concept of learning

[16] See e.g. (Twiss, 1993) for more details on the concept of learning curves: Brian C. Twiss (1993): *Managing Technological Innovation*, Pitman Publishing (London).

curves, a production volume-based assessment of future costs is more appropriate than a time-based approach.

Learning curve rates

The learning curve rate describes the rate of cost reductions for each doubling of production volume. For example, a volume-based learning curve rate of 10% would mean that initial costs would be reduced by 10% as cumulative production volume doubles. An important feature of the concept is that doubling of cumulative production volume happens at a relatively fast rate during early implementation of a new technology but more slowly later on. Consequently, cost reduction slows down as application of the technology becomes more widespread.

The estimated learning curve rates for various products presented in table 3-3 on page 3-17 of the draft Technical Support Document (TSD) are in line with data from literature sources available to the ICCT. For example, a meta-analysis[17] based on 97 academic studies for various products came to the conclusion that learning curve rates observed are generally in between 0 to 40%. The distribution was found to be similar to a Gaussian form with an average learning curve rate of 15%.

The learning curve rates tend to differ for different industry sectors and types of product. For example, rates for electrical engineering are generally found to be higher than rates for mechanical engineering. Evidence also exists that learning curve rates tend to be higher for small modularly manufactured products than for more complex technologies[18].

Given this context, it is appropriate to apply different learning curve rates to different technologies. In addition, as discussed by the agencies, it is reasonable to assume only minor or no learning curve effects for technologies that have been on the market for a long period of time or are relatively simple with respect to their technical properties.

The agencies handle these differences by classifying technologies into groups for which none, volume or time based learning curve effects are assumed (Table 3-4 on page 3-10 of the TSD). ICCT agrees it is appropriate to apply a lower rate of learning to some of the technologies assessed. However, the agencies applied a flat rate of 20% for all technologies to which learning was applied, and did not apply any volume based learning to other technologies. A better approach would be to vary the learning curve rate while retaining a volume-based approach for all technologies. A differentiation of learning curve factors by type of technology would likely improve the accuracy of the proposal.

It would also be helpful to conduct a more detailed analysis of learning curve rates anticipated specifically within the automotive sector.

---

[17] Pankaj Ghemawat (1985): *Building strategy on the experience curve*, Harvard Business Review, March-April.

[18] Pierre Foussier (2006): *From Product Description to Cost – A Practical Approach (Volume 1)*, Springer (London).

Slowing down of the learning rate for mature technologies

As a technology becomes more mature and production volumes grow, the cost reduction process tends to slow down. The learning curve concept includes this effect, as the doubling of cumulative production volumes occurs at a faster rate during implementation process and at a slower rate later on.

The agencies end the learning curve process and assume a 3% time-based decrease of production costs after completion of two 20% volume-based (NHTSA) or time based (EPA) learning curve steps. While this recognizes that the learning process slows down, the change is abrupt and somewhat arbitrary. ICCT believes it would be advantageous to use a model that is able to dynamically take into account cumulative production volume over time. This would apply a continuous learning curve rate over the entire lifetime for each technology, without having to assess threshold values for changing learning curve rates and floor cost values.

Additional issues on cost reduction through manufacturer learning

NHTSA assumes production costs to decrease by 20% as soon as a cumulative production volume of 300,000 units has been reached. This implies that the technology incremental cost estimates given in tables 3-20 to 3-22 of the draft TSD should be interpreted as costs for a cumulative production volume of 150,000 units. It would be helpful to clarify the correctness of this interpretation, in order to be able to compare the costs with other technology cost data.

For learning curve effects, the overall worldwide cumulative production volume of a technology is relevant, not just volume in the U.S. It is not clear if the agencies accounted for production volumes in other regions of the world. For example, diesel technology has been produced and applied in large quantities in Europe for years. This would likely affect production costs in North America and, therefore, should be taken into account. ICCT would appreciate it if the agencies could clarify how these effects are accounted for in the learning curves.

ICCT does not agree that volume-based learning is over for the 'power-split hybrid electric vehicle' and only time-based learning curve is to be applied. While power-split hybrids have been on the market long enough to achieve high production volumes, the production ramp up has been very slow and the initial costs were very high. In addition, virtually all power-split hybrid vehicles have been equipped with NiMH batteries. Future vehicles will make use of Li-Ion battery technology, bringing about changes to the entire vehicle technology design.

11) Hybrid System Sizing and Cost Estimation Methodology – Section 3.4.2.3.2 of the Draft TSD

Parameters to be considered when selecting an appropriate battery type

When discussing the application of batteries for hybrid electric vehicles, the agencies assume that cost considerations will drive the selection of NiMH or Li-Ion battery technology. While this assumption is reasonable in general, the higher energy density of Li-ion batteries should not be ignored. Energy density of NiMH cells is about 40 to 80 W-hr/kg, while density for current Li-Ion technology is about 100 to 140 W-hr/kg and could go higher in the future. Thus, for the same amount of energy the Li-ion battery would be significantly lighter, resulting in lower fuel consumption and possibly improved drivability.

CISG (crank integrated starter generator) power

11 kW is too low for the power from CISG systems. Even the Honda CISG systems have higher power than this and the newer CISG systems from Hyundai, Mercedes, and Nissan will be higher power yet. 20 kW would be more appropriate.

CISG battery capacity

1 kW-hr is too high. CISG systems need very little energy storage. Their battery capacity is determined primarily by high power rates for acceleration assist and regenerative braking recovery. Current NiMH batteries on CISG systems are oversized, in order to provide the necessary power without undue battery deterioration. Even so, the new Honda Insight still only uses a 584 Wh NiMH battery pack. The new high-power Li-ion batteries will deliver the same amount of power with far less size and energy storage and will support high power rates (> 20 kW) with energy storage of only around 300 Wh. The battery capacity for CISG should be cut to no more than 800 Wh for NiMH batteries and 500 Wh for Li-ion.

Cost assessment for NiMH batteries

EPA and NHTSA give initial costs ($500/kW-hr) and mass-volume costs ($320/kW-hr) for Li-Ion battery technologies in the draft TSD, but do not state any initial costs for NiMH. It would be appreciated if similar data would be given in the assessment.

In the long run, the agencies assume that both NiMH as well as Li-Ion batteries would cost $320/kW-hr at high production volumes. However, for NiMH batteries the text states that the costs were revised from $350 to $320 "to match the updated costs for Li-Ion batteries". What are the reasons to assume that production costs for both technologies would be identically in the future?

Cost assessment for Li-Ion batteries

According to the agencies, long-term costs are estimated to be $320/kW-hr. EPA and NHTSA refer to a study by Deutsche Bank from 2008, which lists costs for Li-Ion batteries of 300-400 Euro/kW-hr without any specific details on underlying assumptions of base year or production volume. EPA and NHTSA then apply two learning curve steps for arriving at $320/kW-hr.

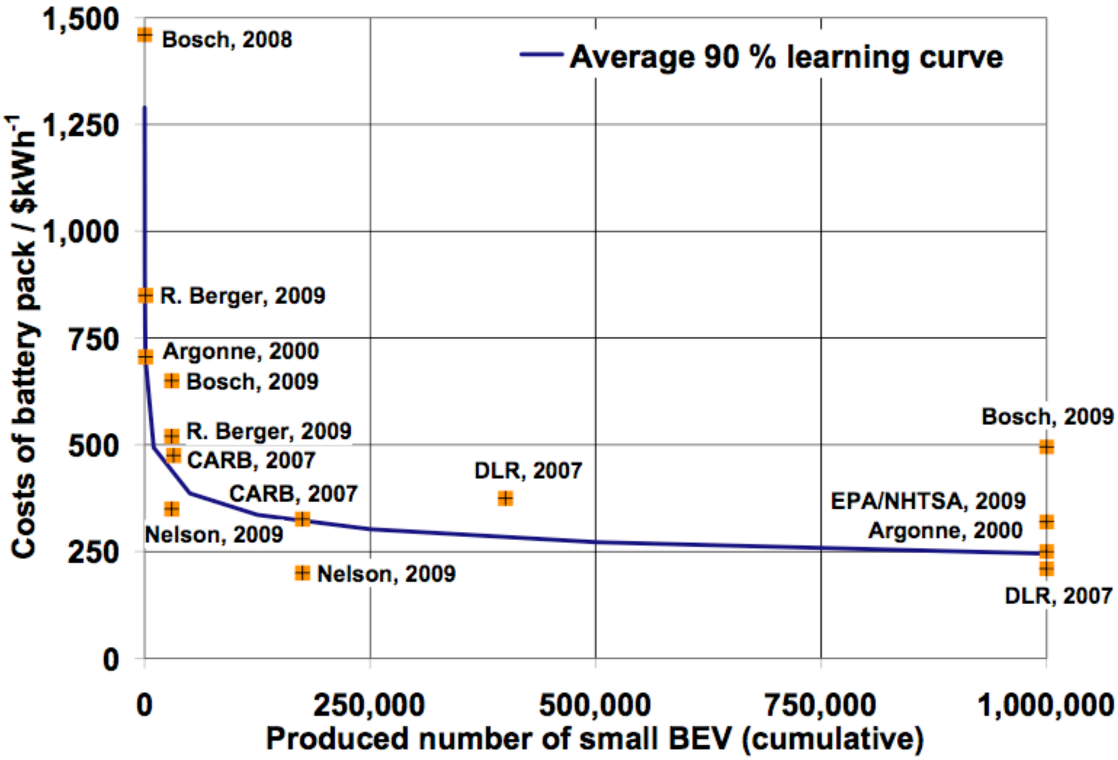
The long-term estimate of $320/kW-hr is reasonable and is in line with estimates from a more recent study by Deutsche Bank[19], a Li-Ion battery cost model of Argonne National Laboratory[20], and several other sources included in the following summary graph compiled by German Aerospace Center (DLR)[21].

---

[19] Deutsche Bank (2009): *Electric cars: Plugged In 2*, November 2009

[20] Paul A. Nelson et al. (2009): *Factors determining the manufacturing costs of Lithium-Ion batteries for PHEVs*, 24th International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium (EVS24), Stavanger

[21] Peter Mock (2009): *Assessment of future Li-Ion battery production costs*, Plug-In 2009 Conference, Long Beach (updated version including more data points than original graph presented at the conference)



Current Li-ion battery costs are much higher due to relatively low production volumes and design improvements still in the development phase. For example, the new estimates from Deutsche Bank are \$650/kW-hr for current batteries, dropping to \$488/kW-hr in 2015 and \$325/kW-hr in 2020. Thus, the issue is not the long-term price of \$320/kW-hr, but how quickly prices will drop to this level. A more thorough assessment of future battery costs, including different types of cell chemistries, is needed in order to avoid incorrect conclusions.

<u>12) Diesel Engine Technologies</u> – Section 3.4.2.1.11 of the Draft TSD

EPA and NHTSA conclude that 'the application of diesel engines on small vehicles is not a viable or cost effective option'. Thus, the cost and effectiveness estimates did not include the technology of a diesel engine with lean NO_x trap (LNT) catalyst after-treatment on a small car.

While the market share of diesel passenger cars in general is currently at a very low level in the US (<1%), the technology should not be completely ignored for the following reasons:

(1) Volkswagen and Mercedes have a history of selling diesel cars in the US, with regular customers eager to buy diesel cars in the future.
(2) Average market share of diesel passenger cars in Europe is about 50%. European manufacturers are interested in exporting some of their diesel models to the US to establish an additional business segment.
(3) Diesel engines are able to meet Tier 2 standards in small cars without needing a deNOx catalyst or urea injection (Selective Catalytic Reduction – SCR), making compliance easier and cheaper than for larger diesel vehicles.

Volkswagen's success in selling smaller diesel cars in the US supports this assumption. Volkswagen of America recently announced that 5,072 diesel vehicles were sold in June 2009, representing 26% of total sales for the month. Diesel engines accounted for 81% of Jetta SportWagen sales, and 40% of Jetta sedan sales. For 2010 VW is introducing a diesel version of the Golf and expects that 30% of all Golf hatchbacks sold in 2010 will be equipped with a turbocharged diesel engine.

Given this background, ICCT suggests considering diesel technology for small passenger cars and assessing their cost and effectiveness.