Declaration of Harry D. Saunders

I, Dr. Harry Duston Saunders, declare under penalty of perjury that the following statements are true to the best of my knowledge:

1. I have conducted ongoing research into the rebound effect since the late 1980s. While I was not the first to discover this phenomenon (the credit for this goes to a 19th century English economist, William Stanley Jevons), I did discover it independently and published a paper in 1992 that was the first to establish a formal theoretical framework for its analysis. Since that time, I have published a series of articles on the subject that have advanced both the theoretical and empirical foundations, and have created tools for economists to assist them in the empirical measurement of rebound (see attached Curriculum Vitae; also http://works.bepress.com/harry_saunders/).

Summary

2. The U.S. Environmental Protection Agency and the U.S. Department of Transportation, in regulations published in the Federal Register on September 15, 2011 (hereinafter: EPA/NHTSA Regulations), specifically addressed some aspects of the rebound effect (http://www.gpo.gov/fdsys/pkg/FR-2011-09-15/pdf/2011-20740.pdf, pp. 57324-57331). Their analysis is both professionally executed and the resulting conclusions reasonable—but only as far as the analysis goes. The authors of the EPA/NHTSA analysis are admirably candid in noting its limitations, and the intellectual integrity this reveals is to be strongly applauded. But because the analysis is overly restrictive in its scope, it does not deliver reliable conclusions as to the likely effectiveness of the EPA/NHTSA Regulations in restraining greenhouse gas (GHG) emissions. The key problems with the EPA/NHTSA analysis are threefold:

3. First, the analysis focuses exclusively on one component of rebound—the so-called "direct" component of rebound (defined in a later section). Accordingly, the analysis fails to account for GHG emissions that will be directly caused or enabled by the EPA/NHTSA regulations due to "indirect" energy rebound effects (defined in a later section).

   Second, even for the direct rebound component, the analysis is too-narrowly focused, ignoring key elements of direct rebound that magnify its effects.

   Third, as part of overlooking "indirect" rebound effects, the analysis specifically fails to account for GHG emissions that will be directly caused or enabled by the Regulations due to "embedded" energy rebound effects (also defined in a later section).

4. In my professional opinion, the consequence of these three limitations is that the EPA/NHTSA analysis fails to reveal that the Regulations are highly likely to result in entirely the opposite of their intent—that is, they are likely to result overall in *increased* GHG emissions within the United States, not decreased emissions.

Overview of Declaration

5. This declaration first defines rebound and then describes its variety of manifestations from a comprehensive economic perspective. The first section sets forth how such multiple manifestations reveal themselves in the Transportation sector of the economy. This section also cites evidence for these rebound effects from the literature. Following sections address the EPA/NHTSA analysis of rebound and its profound shortcomings; present evidence that satisfies EPA/NHTSA's call for a broader consideration of the rebound effect; and explain the significance of EPA/NHTSA's uncertainty in their treatment of the rebound effect. The declaration concludes that the EPA/NHTSA

Regulations fail to deliver their intended goal of reducing GHG emissions and will likely produce the opposite result of an increase in such emissions. Attachment A provides an in depth presentation of the "embedded energy" rebound effect, a proxy name for several indirect rebound effects, which alone rebuts the EPA/NHTSA Regulations' reliance on improved engine efficiency as a means to reduce overall energy consumed and GHG's emitted.

Rebound Defined

6. The simple mental model to which rebound is the counterpoint is one in which an x% increase in energy efficiency leads to an x% reduction in energy use below where it otherwise would be. Such an inference is indicated by simple engineering calculations. On the surface, this seems a rational conclusion. But unfortunately, the actual economy does not behave this way. This is because the economy is flexible, adaptive, and creative in how it accommodates energy efficiency gains. In response to an energy efficiency gain, consumers are flexible—they adjust their consumption patterns to maximize their "utility." Producers do the same—in response to an energy efficiency gain, producers adjust their production patterns: to maximize profits, they can flexibly adjust all their production inputs (including energy), and also the outputs they produce. As explained below, the result on both sides of this supply/demand equation is that actual energy use will be higher than what the simplistic "one-for-one-reduction" mental model would indicate. Energy use "rebounds" to a level *above* the level one would expect if this simple mental model were to obtain in reality. (A quick, high-level introduction to rebound and its implications for climate change mitigation policy is available at: http://www.youtube.com/watch?v=oTV-aBy5A3I&feature=player_profilepage).

The Taxonomy of Rebound

7. Energy rebound arises from several sources. Their interplay is complex and intertwined, but rebound economists have developed useful categorizations of rebound effects that assist in distinguishing these sources.

End-Use vs. "Production-based" and "Embedded" Energy Use

8. For present purposes, the first useful distinction is between the "end-use consumption" sector of the energy economy and the production sector of the energy economy. Rebound mechanisms differ substantially between these two sectors. End use energy consumption comprises energy used directly in households and for personal transportation. The majority of energy consumption, however, occurs in the productive sector of the economy, which provides the goods and services ultimately consumed by consumers (including the provision of government services). The energy used for this purpose is called "production-based energy," the energy required to create and deliver goods and services. In the United States, production-based energy accounted for about 60% of total energy use in 2002 [Bureau of Economic Analysis, 2002 Benchmark Input-Output Use Table, available at: http://www.bea.gov/industry/io_benchmark.htm#2002data]. Globally, production-based energy accounted for about two-thirds of energy use in 2005 and about 60% in North America [ExxonMobil, "The outlook for energy: a view to 2030," (2009), page 5. Available at http://www.exxonmobil.com/Corporate/energy_o_view.aspx.] Thus, this is the portion of the energy economy most significant to mitigating climate. Fuel consumed for road freight falls in this category—the energy used to transport goods is production-based.

9. Any good transported to a consumer has invested in it all the production-based energy required to produce and deliver it. This is referred to as its "embedded" energy. Embedded energy is all the energy used to produce something that is for sale in the economy, including all of the energy that is used to produce all of its constituent parts and elements and deliver it to the consumer.

Direct Rebound

10. A second important distinction is between so-called "direct" rebound effects and "indirect," or "secondary," effects.

11. Direct effects arise because energy efficiency gains reduce the effective price of energy. If energy becomes effectively cheaper, more of it will be used. This effect manifests itself on both sides of the supply/demand equation. Profit-maximizing producers, now seeing effectively cheaper energy, will find that they can produce more of their output for the same cost, thereby "dragging up" energy use (the "output" direct effect). They will also see that energy has become cheaper relative to other inputs they must use (capital, labor, materials and other inputs—called, for reasons known only to economists, "factors of production") and will be incentivized to adjust input proportions to favor greater energy use (the "substitution" direct effect) [H.D. Saunders, The Khazzoom-Brookes Postulate and Neoclassical Growth, The Energy Journal, 13(4), 131-148 (1992). Available at: https://www.iaee.org/en/publications/viewabstract.aspx?id=1091]. As described later in greater detail, this substitution of factors of production can manifest in the Transportation sector of the economy partly, but not solely, in the form of intermodal shifts (shifts among highway, rail, air and water-borne modes) and shifts among classes of vehicle.

12. Consumers will behave in a similar manner. The products in which this cheaper energy has been embedded (via efficiency gains) will appear cheaper to consumers so they will consume more of these. In technical economics terms, this consumption is augmented in two ways: one, cheaper products are more attractive to consumers, increasing their propensity to consume them (the "price" direct rebound effect); and two, products purchased that are now cheaper represent a smaller claim on consumers' budgets, so they can afford more of them (the "income" direct rebound effect). In standard microeconomics terms, the combination of these two effects is referred to as "compensated demand," or sometimes, "Hicksian demand."

13. Direct rebound effects can be large, as described at greater length in a later section. For example, in the personal transportation sector direct rebound effects may take the form of increased vehicle miles traveled and increased vehicle power and weight, which together are examples of the consumer-driven "price" and "income" direct rebound effects. An important recent study in Germany has shown that direct rebound effects eroded about 42% of the energy reduction gains one would expect when considering passenger vehicle fuel efficiency gains for single-vehicle households in isolation, meaning that rebound effects for these households in Germany have been about 58%, due solely to increased vehicle miles traveled. [M. Frondel and C. Vance, "Re-Identifying the Rebound: What about Asymmetry?" *International Association for Energy Economics Working Paper*, USAEE-IAEE WP 11-093, November 2011, available at: http://www.rwi-essen.de/publikationen/ruhr-economic-papers/395/].

14. A direct rebound mechanism, in the form of consumer preference for increased vehicle power and weight, has recently been measured in personal transportation in the United

States [C.R. Knittel, Automobiles on Steriods: Product attribute trade-offs and technological progress in the automobile sector, American Economic Review. Dec 2011, Vol. 101, No. 7: Pages 3368-3399. Available at: http://pubs.aeaweb.org/doi/pdfplus/10.1257/aer.101.7.3368]. This study shows that in the personal transportation sector of the United States, a rebound effect of 75% between 1980 and 2006 existed because most of the technical engine efficiency gains were offset by consumers choosing to take improvements in engine efficiency in the form of increased vehicle weight and substantial increases in average horsepower.

Indirect or Secondary Rebound

15. Indirect or secondary rebound effects operate by a different mechanism. Fundamentally, efficiency gains on the productive side of the economy, combined with efficiency-gain-associated consumption shifts, re-configure the entire web of energy flows throughout the economy. These generate broad, systemic energy increases that are substantial.

16. On the consumption side, energy efficiency gains in households increase consumers' disposable incomes, which they may spend on other energy-consuming activities that are highly energy intensive, such as vacation air travel. In the current context, consumers responding to changes in product prices arising from transportation fuel efficiency will tend to shift demand toward products that are more transportation-intensive, thus generating transportation-sourced energy rebound. The EPA/NHTSA Regulations indirectly acknowledge this possibility [§VIII E (5)(b)(ii), p. 57328], and suggest that input-output analysis could be used to measure this effect. In fact, an analysis of this nature has been undertaken in the United Kingdom. While it is not specific to transportation, the UK study shows that when the GHG emissions associated with

energy-efficiency-induced consumption shifts are considered, such indirect rebound effects may lead to *increased* emissions, a rebound condition known as "backfire" [A. Druckman, M. Chitnis, S. Sorrell, T. Jackson, "Missing carbon reductions? Exploring rebound and backfire effects in UK households." Energy Policy 39 (2011), 3572-3581]. This study illustrates the inadequacy of attempting to manage GHG emissions by reliance on policies aimed solely at improving energy efficiency. It demonstrates that money saved as a result of energy efficiency gains, whether those associated with production-based energy or with consumers' end use, will be spent on other energy-consuming products and activities; and depending on the relative energy intensity of these, energy consumption rebound will be more or less (and accordingly, so will be the "rebound" of GHG emissions—greater or less energy use results in, respectively, increased or reduced emissions, all else remaining equal)**.**

17. In fact, the indirect effects are even more powerful than as described in the preceding paragraph. The analysis referenced in the preceding paragraph, based as it is on input-output analysis of the production side of the economy, relies on the related assumption that producers' productive capacity is rigid, locked to fixed factor and output proportions. In reality, producers have significant flexibility to alter these proportions. Since producers supply primary and intermediate inputs to other producers via a complex web of supply mechanisms, changes in the prices of such inputs (as may arise, for instance, from lower transportation costs) will cause them to alter their production decisions, including decisions related to the quantities of energy they use in their own production processes.

18. It is not just the relative proportions of these inputs that will be altered. The scale of production also will be increased as inputs become cheaper (owing to, say, lower transportation costs for delivering these inputs). When output is increased, the overall energy used to produce this output will increase as well. If the producer is one who supplies intermediate products to other producers, the lowered cost of these intermediates will advantage the producers they supply, who will in turn have incentive to increase their production, in a chain of interactions that suffuse and multiply through the economy.

19. In addition, particular industries facing newly-lowered transportation costs for their inputs may find they can now secure these inputs advantageously from more remote locations, thus increasing overall energy used for transportation. A hypothetical (albeit prosaic) example would be a Florida pie-maker who can now afford to secure apples from Washington State that are higher quality and/or lower cost than those available locally, causing overall use of transportation energy to increase.

20. Some of these indirect effects, while complex and subtle, can sometimes be conveniently approximated by considering how energy efficiency gains affect the quantity of energy that will be embedded in the goods and services produced, if the mechanism is clearly-enough defined. In the case of transportation, this is readily accomplished. This "embedded energy rebound effect" is described further in Attachment A.

21. Economy-wide direct and indirect rebound effects are described further in a 2007 report commissioned by the UK government [S. Sorrell, "The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency," UK

Energy Research Center, 2007. Available at: http://www.ukerc.ac.uk/support/tiki-index.php?page=ReboundEffect].

22. All the foregoing discussion focuses exclusively on the efficiency improvements directly related to the use of energy itself. There are also "multi-factor productivity" rebound effects, i.e., efficiency improvements in other factors of production (capital, labor, materials,…) will increase energy use. The economic mechanism by which this occurs is the following: technical efficiency gains in the use of other factors increase the marginal productivity of energy if energy input is fixed, thus spurring expansion of this energy input to bring its marginal productivity back in line with energy price [H.D. Saunders, The Khazzoom-Brookes Postulate and Neoclassical Growth, The Energy Journal, 13(4), 131-148 (1992). Available at: https://www.iaee.org/en/publications/viewabstract.aspx?id=1091; also, "H. Saunders, "Historical evidence for energy consumption rebound in 30 US sectors, and a toolkit for rebound analysts," (under review), 2010, Available at: http://works.bepress.com/harry_saunders/9/].

23. Confirmation of the existence of indirect multi-factor productivity rebound effects in the Transportation sector comes from the Bureau of Transportation Statistics (BTS), which concluded that, "Productivity growth in freight transportation has long been a driving force for the growth of U.S. overall productivity and contributed directly to the growth of the U.S. GDP." By way of illustration focusing initially on labor efficiency, rather than energy efficiency, from 1991 to 2000 "labor productivity rose…23 percent for trucking…"

[http://www.bts.gov/programs/freight_transportation/html/transportation.html]. By contributing "directly to the growth of the U.S. GDP," more efficient trucking labor productivity contributed to increased overall energy use, just as improved fuel economy—or improved marginal productivity of energy—contributes to increased overall energy use. Without the improvement in labor efficiency, energy use would have been lower. The EPA/NHTSA Regulations amplify this effect. For instance, if lower fuel costs enable trucking firms to invest more in computer technology for optimal routing and load matching, which in turn increase labor productivity, they will likewise spur added expansion of transportation and associated fuel use. [see BTS, Productivity Growth in Transportation (Labor Productivity). Available at: http://www.bts.gov/publications/special_reports_and_issue_briefs/issue_briefs/number_10/html/entire.html].

24. Another illustration of multi-factor productivity rebound effects is as follows. If the EPA/NHTSA Regulations spur faster development of low-cost materials that permit reductions in vehicle weight ("lightweighting") for medium and heavy-duty trucks with corresponding decreases in capital cost (along with fuel costs), they will in turn spur added expansion of transportation, since lower capital costs will induce trucking firms to expand operations. Analogous to the labor productivity-induced rebound effect described in the preceding paragraph, this a capital productivity-induced rebound effect.

Frontier Rebound Effects

25. Finally, for completeness, there is a category of rebound referred to as "frontier effects." Such effects arise because energy efficiency gains can (at minimum help to) enable the creation of entirely new products and applications and even whole new industries that

consume added energy. A good example is lighting. A recent study by Sandia National Laboratories showed that major energy efficiency gains in the provision of lighting have been almost precisely offset by increases in energy use owing to the rise of new applications for lighting—over 300 years, six technologies, and six continents [J. Tsao, H. Saunders, J. Creighton, M. Coltrin and J. Simmons, "Solid-state lighting: an energy-economics perspective," Journal of Physics D, 43, 2010].

26. Other striking examples of frontier rebound effects are found in the computing and telecommunications areas. The spectacular rise of the mobile communications market has generated enormous demand for energy, and this demand has depended on energy efficiency gains. These technologies have advanced rapidly owing to miniaturization; miniaturization in turn required development of electronic components that use less energy, since heat dispersion must be radically reduced for miniaturization to be possible. Without this type of energy efficiency gain, there would be no modern-day laptop computer, no cell phone, no LED television, no iPad, no GPS navigator …

27. The EPA/NHTSA Regulations are enablers of frontier effects. For instance, the rise of Internet shopping now allows people in San Francisco to purchase products in New York, products they otherwise would have purchased locally. In reducing shipping costs, the EPA/NHTSA Regulations will contribute to expansion of demand for transportation for this purpose, and the energy this transportation demand consumes.

28. As set forth in the next section, the foregoing can, taken together, only lead to systemic energy consumption increases far exceeding the limited rebound effect considered in the EPA/NHTSA Regulations.

The EPA/NHTSA Analysis of Rebound

Direct Rebound Effects

29. The analysis of rebound found in the EPA/NHTSA Regulations is too-narrowly construed because it is limited to the "output" direct effect (the increase in profitable output quantity owing to increased consumer demand)—in this case the change in truck vehicle miles traveled (VMT) resulting from a percentage change in freight rates. The EPA/NHTSA analysis fails altogether to consider the "substitution" direct rebound effect—changes trucking firms make to the proportions of inputs used (and to input/output proportions) as a result of efficiency gains so as to maximize profit. The EPA/NHTSA analysis also fails to factor in any indirect or secondary rebound effects, such as the "embedded energy" rebound effect set forth in Attachment A to this declaration.

30. Multiple prospective examples of the substitution direct rebound effect in the Transportation sector follow. Since the EPA/NHTSA Regulations now make fuel costs less a matter of concern, some trucking firms choose to forgo state-of the art computer technology designed for optimal routing load matching that would have minimized fuel expenditures (substitution of energy for capital if they would have purchased the technology directly; substitution of energy for services if they would have outsourced the technology). Or, trucking firms (or their customers) choose to forgo added warehousing that could optimize load sizes for the same reason (substitution of energy for capital). A more general example involves some portion of trucking firms choosing to centralize more of their operations owing to lower fuel costs, reducing real estate costs and maintenance and repair expenses via consolidation, but resulting in longer average hauls

and greater fuel consumption (substitution of energy for capital and maintenance/repair inputs). As a corollary, some trucking firms choose to use more sleeper cab vehicles, which are less fuel efficient. And, they may choose to employ more double-trailer class 8 trucks than trucks of other classes, which are less fuel efficient than trucks of other classes but require less labor per ton-mile (substitution of energy for labor). Note that while double-trailer class 8 trucks are more fuel efficient per ton-mile than single-trailer class 8 trucks, they are less fuel efficient than trucks of other classes.

31. EPA/NHTSA correctly calls for econometric estimates that consider "economic activity" and "different input prices," [EPA/NHTSA Regulations, §VIII E (5)(b)(iii), p. 57328], which considerations would enable an estimate of the substitution component of the direct rebound effect, in addition to the output component they estimate. The EPA/NHTSA analysis, however, does not consider these variables or conduct any calculation employing them. In fact, a study that looks at "economic activity" and "different input prices," and other crucial variables has been done for the US transportation sector as a whole [H. Saunders, "Historical evidence for energy consumption rebound in 30 US sectors, and a toolkit for rebound analysts" ("Saunders study") (under review), 2010, Available at: http://works.bepress.com/harry_saunders/9/]. Significantly, the Saunders study determines that direct rebound in US transportation over the period 1980-2000 was approximately 60%, much of it due to substitution effects.

32. The Saunders study meets EPA/NHTSA's call for econometric estimates of "economic activity" and "different input prices," Specifically, the Saunders study:

    - Relates transportation energy use to energy efficiency gains via an econometric analysis employing a mathematical functional form for production that is both highly general and enables the specification of energy efficiency gains in concrete engineering terms;

- Accounts for price movements among all inputs to production (capital, labor, energy, and materials);
- Accounts for and controls for efficiency gains among all inputs to production;
- Accounts for a number of other considerations that affect rebound magnitudes;
- Relies on a highly-respected data set meticulously developed by Harvard Professor Dale Jorgenson and his colleagues [Dale W. Jorgenson, 2007-09-22, "35 Sector KLEM," available at: http://dvn.iq.harvard.edu/dvn/dv/jorgenson;jsessionid=5f474ccc4bb102aec4ff946761c8];
- Uses a mathematical functional form for econometric analysis (the "Translog" form) that is not arbitrarily chosen, but rests on a solid theoretical and empirical foundation [H.D. Saunders, Fuel conserving (and using) production functions," Energy Economics 30, 5 (2008), available at: http://www.sciencedirect.com/science/article/pii/S0140988307001454].

33. The Saunders study identifies from the observed (from the Jorgenson et al. data) evolution of inter-factor proportion shifts (capital/energy, labor/materials, energy/materials, …etc.) and the observed shifts in factor-output proportions (capital/output, labor/output, energy/output, and materials/output) over time. Some of these movements will be due to inter-modal shifts (e.g., switching from barge freight to trucking) and shifts among classes of vehicles induced by the energy efficiency gain. Others will be due to producers altering factor inputs directly, as described at Paragraph

30. Importantly, there are many inter-factor substitution possibilities and the system-wide dynamics are complex. Note that substitution among non-energy factors can affect energy use [See H.D. Saunders, "Fuel conserving (and using) production functions," Energy Economics 30, 5 (2008), available at: http://www.sciencedirect.com/science/article/pii/S0140988307001454].

34. The "materials" component in the Saunders study is an aggregate of several inputs—to illustrate, the Bureau of Economic Analysis shows some 130 commodities input to the "Truck transportation" industry [Bureau of Economic Analysis Benchmark Input-Output tables for 2002, http://www.bea.gov/industry/io_benchmark.htm#2002data]. The scope for substitution among inputs is extensive and complex.

35. EPA/NHTSA determine differing rebound effects for the three broad categories of engines and vehicles that fall within the medium- and heavy-duty motor vehicle sector: 15% rebound for vocational vehicles (single unit trucks), 10% for medium-duty pick-up trucks and vans, and 5 percent for combination tractors in classes 7 and 8, which classes EPA/NHTSA state alone produce the majority of greenhouse gasses. EPA/NHTSA select different rebound effects for these three categories of vehicles by arbitrarily selecting values that fall within the ranges of the studies of VMT rebound that they consider. However, there is no acceptable reason in the discipline of economic science, nor do EPA/NHTSA advance one, for choosing differing rebound effects for these categories of vehicles. Furthermore, since EPA/NHTSA acknowledge that combination tractors are responsible for emitting the majority of greenhouse gasses within the sector of motor vehicles covered by the Regulations, another way that EPA/NHTSA

underestimate the direct rebound effect they try to measure is by assigning to combination tractors the bottom end, 5%, of the 5 to 15 % range of rebound effects that they factor in.

36. While the Saunders study's treatment of the Transportation sector is not specific to medium- and heavy-duty engines and vehicles, it very strongly suggests that the EPA/NHTSA choice of rebound figures ranging from 5 to 15% associated with the direct rebound effect alone is exceedingly conservative. Given my professional opinion, recited above in paragraph 31, that the direct rebound effect in the US transportation sector as a whole is on the order of 60%, the EPA/NHTSA figures for direct rebound alone are in all likelihood too low by, for combination tractors (classes 7 and 8) a full order of magnitude (factor of ten); for medium-duty pick-up trucks and vans, a factor of six; and for vocational vehicles, a factor of four.

Indirect Rebound Effects and Embedded Energy Rebound

37. Taken together, the highly-restrictive limitations of the EPA/NHTSA analysis of rebound—neglect of a major component of the direct rebound effect, the substitution rebound effect; neglect of indirect multi-factor productivity rebound effects; and neglect of frontier rebound effects—provide a strong basis for concluding that the EPA/NHTSA Regulations may lead to a backfire condition (that is, will cause an increase, not a decrease, in GHG emissions) arising from increased energy use within the trucking segment of the Transportation sector itself.

38. EPA/NHTSA's neglect altogether of indirect effects renders the conclusion of a backfire condition compelling. Transportation is a unique sector of the economy. Virtually every product purchased by final consumers has made its way to their households by means of

transportation. These goods have taken energy to produce, and accordingly have generated associated GHG emissions. Unlike, say, any particular manufacturing segment, the Transportation sector "touches" nearly every product, sometimes through a very long chain of transport services, starting with the transportation of primary inputs to the manufacturer of an intermediate product and the transportation of these intermediate products to the final producer and then the consumer. Reductions in transportation costs have a direct effect on energy used at every phase of production of all purchased products. More energy will be "embedded" in these products, since more will be demanded.

39. This "embedded energy" indirect rebound effect creates a very large rebound indeed. As shown in Attachment A, a very conservative set of assumptions about the EPA/NHTSA Regulations delivers an embedded energy rebound effect of well over 100%, a backfire condition due to embedded energy rebound effects alone. Moreover, scenarios set forth in Attachment A yield rebounds exceeding 500% under assumptions that are reasonable.

40. A separate indirect rebound effect arising from the EPA/NHTSA Regulations, not addressed in Attachment A's analysis of the embedded energy rebound effect they cause, is a "spillover" rebound effect. A direct rebound effect for class 7-8 vehicles will be accompanied by an increase in transportation demand for other vehicle classes. Class 7-8 vehicles are part of a network of delivery services for transporting goods among producers and to final consumers. Goods reaching final consumers often will have gone through one or more distribution centers, with goods transferred to smaller (non class 7-8) vehicles at various points, such as vocational vehicles, pick-up trucks, and vans. As with the embedded rebound effect, increases in volumes of goods carried by class 7-8

vehicles will “spill over” into increased demand for transportation in other classes leading, of course, to increased fuel consumption by these vehicles. This effect is likely to be large. This “spill over” is further reason to doubt EPA/NHTSA’s approach of cabining the rebound effect to only its direct effect on increased vehicle miles traveled, without taking into consideration, in this instance, that improved fuel economy in one category of truck will increase demand not only for that category of truck, but also for the other categories of trucks.

41. The upshot of these considerations is that there is compelling evidence that the EPA/NHTSA Regulations will have the exact reverse of their intended effect: they will lead to outright increases in overall fuel consumption and consequently, GHG emissions.

Uncertainty

42. The EPA/NHTSA analysis of rebound forthrightly and admirably acknowledges the high degree of uncertainty surrounding the authors’ estimate of a 5 to 15% rebound effect, which, as shown above, considers only the direct rebound effect, and only the “output” component thereof. Accounting for the multiplicity of other rebound effects outlined in this declaration only magnifies the uncertainty of EPA/NHTSA’s methodology and estimate.

Conclusion

43. In my professional opinion, based on all of the foregoing and my knowledge as an expert in this field, to a reasonable degree of professional certainty, it is mistaken for the U.S. Environmental Protection Agency and the U.S. Department of Transportation to conclude that mandated, improved fuel economy in the medium- and heavy-duty trucking sector will automatically lead to a decrease in total overall energy consumed. Regulations of

Geenhouse Gas emissions are misdirected if they focus exclusively on regulating vehicle fuel efficiencies. Such an approach, as embodied in the EPA/NHTSA Regulations, will inadvertently lead to GHG emissions well above intended targets and are reasonably likely to lead to absolute increases in total overall energy consumption and GHG emissions.

44. In my professional opinion, EPA and DOT would be well advised to refocus their efforts on measures carefully designed specifically to limit GHG emissions themselves, given full consideration of direct, secondary/indirect, and specific to the latter, embedded energy rebound effects.

Attachment A: Analysis of the Embedded Energy (Indirect) Rebound Effect

45. In sum, the embedded energy rebound effect, a powerful proxy for several of the indirect rebound effects arising from the EPA/NHTSA Regulations, will lead to an absolute increase in economy-wide energy use (and associated GHG emissions), a condition known as “backfire.”

46. The underlying idea is that a 5% direct rebound effect (the lowest figure cited in the EPA/NHTSA Regulations), since it reflects a 5% increase in demand for freight shipment by class 7-8 vehicles owing to lower fuel costs, must equate to an increase in consumption of the goods shipped. The increase in freight shipment that the EPA/NHTSA Regulations cause arises from the customers of shipping services, who drive the demand for it. But since additional goods so shipped have required energy to produce, this increased energy invested in their manufacture becomes “embedded” in them and must be accounted for when calculating rebound effects. As shown in the following analysis, this embedded energy increase exceeds the energy saved by the Regulations. This is because, as demonstrated below, the embedded energy rebound effect is broad and systemic.

47. This analysis accounts for the share of goods moving via the trucking mode, and for the share of the goods specifically shipped by class 7-8 vehicles. The analysis could also be performed for the other categories falling under the Regulations, vocational vehicles and medium-duty pick-up trucks and vans. However, to ensure that this analysis errs on the conservative side, I am using the most conservative value for rebound that EPA/NHTSA have selected, 5%.for combination tractors. Thus, the analysis and results are based on data for class 7 and 8 trucks, but the conclusions would be assured of holding also for the

other two categories of vehicles, vocational and pick-up trucks and vans, for which the Regulations arbitrarily assign a higher rebound effect value.

48. This analysis also accounts for the likelihood that some portion of the increased demand for shipping services will be in the form of increased haul lengths, not simply increased volumes of goods delivered.

49. The analysis proceeds in two steps. Employing estimates provided in the EPA/NHTSA Regulations, the first step is to quantify the total overall energy use associated with a 0% rebound condition and a 100% rebound condition. In the second step, the quantitative difference between these two overall amounts of energy is compared separately to the added energy consumed arising from the increase in embedded energy delivered to consumers. If the overall increase in embedded energy exceeds the quantitative difference between the 0% and 100% rebound conditions, this will be a "backfire" condition—more energy will be consumed economy-wide than the EPA/NHTSA Regulations could even potentially save in the absence of any direct rebound.

50. Since the Regulations do not contain within them all the data required for this analysis, further data-based assumptions are needed, as outlined below. Also, assumptions must be made that are potentially subject to contention. This analysis evaluates these assumptions by means of scenario analysis, which demonstrates the sensitivity of embedded energy rebound to different choices for these assumptions, even though under any reasonable assumption, the conclusion is clear that the Regulations produce rebound effects that extend beyond the point of backfire.

51. In the following sections, the two steps of the analysis are shown separately, each beginning with the assumptions used. Note that where the data are incomplete or

ambiguous, estimates are used that are *conservative* in terms of rebound magnitudes they generate.

Step #1: Establish the Magnitude of the Difference between 0% Rebound and 100% Rebound

Data-based Assumptions for Step #1

1. Economy-wide energy use: **99.4 quadrillion BTU's** ("Quads")

   Source: BTS data, Table 4-4, 2008 available at: http://www.bts.gov/publications/national_transportation_statistics/index.html#chapter_3

2. Transportation share of economy-wide energy use: **28.2 %**

   Source: BTS data, Table 4-4, as above.

3. Class 7-8 Share of Transportation energy use: **17.8%**

   Source: BTS data, Table 4-5, available at link designated above for Table 4-4. Data are for 1999, the latest data available. This figure is the sum of the shares for "Combination truck" and "Single-unit 2-axle 6-tire or more truck."

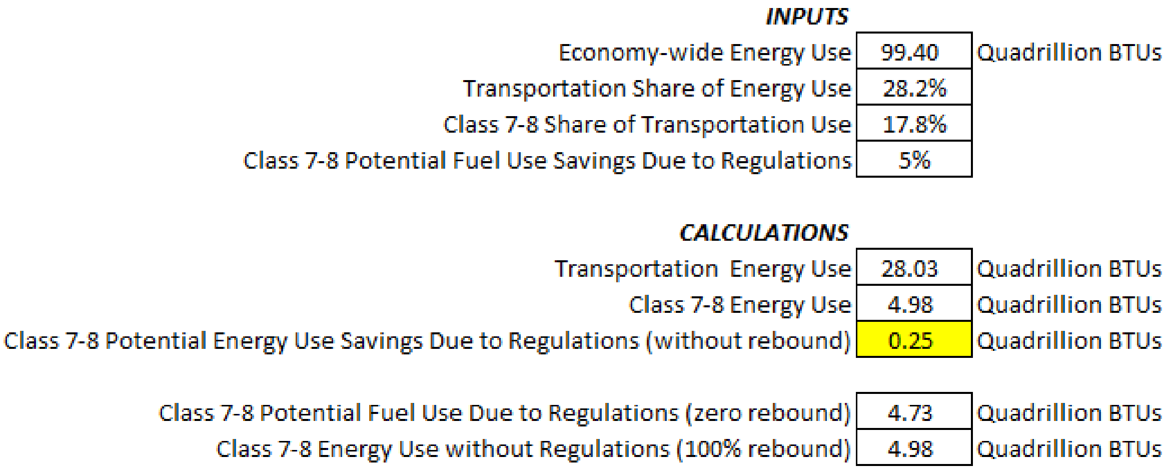
4. Potential class 7-8 fuel use savings due to regulations: **5%**. Coincidentally, this is the same percentage as the percentage of direct rebound that EPA/NHTSA estimate the Regulations will cause.

   Source: The EPA/NHTSA Regulations report projected fuel use savings in absolute terms, not percentage terms, and do not report total fuel consumption by affected vehicles in classes 7 and 8, the "control case scenario. To estimate the savings on a percentage basis, I will take total fuel consumption from 1999 (the latest data available) from BTS data, Table 4-4, and estimate that it grew annually according to the average annual growth rate from 1990-1999 (4.7% for combination trucks, 1.3% for Single-unit 2-axle 6-tire or more trucks—a combined rate of 3.7%/year is used; this is the average of the two average annual growth rates weighted by 1999 fuel consumption for each class) to emulate "control case" fuel consumption. This is then compared to the fuel consumption reductions projected in Table VIII-7 of the EPA/NHTSA Regulations (page 57324), which represent 95% of the potential fuel use savings given the 5% rebound value assumed there. The resulting potential fuel use savings for class 7-8 trucks for 2020 are then 4.4% for 2020 and 5.9% for 2030, declining thereafter. The value of 5% assumed here is conservative, leading to a conservative estimate of the embedded rebound effect. This assumption is tested using scenario analysis, as explained further below.

Methodology and Calculations for Step #1

5. From the above inputs can be calculated the total energy use potentially saved by class 7-8 vehicles due to the EPA/NHTSA Regulations. The calculations are shown below. As can be seen, transportation energy use is economy-wide energy use mulitplied by transportation's share (99.4 x 28.2% = 28.03 quadrillion BTU's). Class 7-8 energy use is 17.8% of this (28.03 x 17.8% = 4.98 quadrillion BTU's). The magnitude of this potential energy savings is then the total energy used by class 7-8 vehicles multiplied by the potential fuel use savings, or 0.25 quadrillion BTU's (4.98 Quads x 5%). Also showing (for clarity) is that this value is the difference between quantities of energy use that would be realized in the 100% and 0% rebound conditions—class 7-8 energy use would be 4.98 quadrillion BTU's in the absence of the EPA/NHTSA Regulations and 4.73 quadrillion

BTU's, or five percent lower, if the Regulations fully "took" and there were no rebound effect (recall that "Quads" are units of energy use, quadrillion BTU's):



INPUTS		
Economy-wide Energy Use	99.40	Quadrillion BTUs
Transportation Share of Energy Use	28.2%	
Class 7-8 Share of Transportation Use	17.8%	
Class 7-8 Potential Fuel Use Savings Due to Regulations	5%	
CALCULATIONS		
Transportation Energy Use	28.03	Quadrillion BTUs
Class 7-8 Energy Use	4.98	Quadrillion BTUs
Class 7-8 Potential Energy Use Savings Due to Regulations (without rebound)	0.25	Quadrillion BTUs
Class 7-8 Potential Fuel Use Due to Regulations (zero rebound)	4.73	Quadrillion BTUs
Class 7-8 Energy Use without Regulations (100% rebound)	4.98	Quadrillion BTUs

Step #2: Establish the Magnitude of the Embedded Energy Increase due to the Regulations

Data-based Assumptions for Step #2

6. Embedded energy share of transportation-enabled economy-wide energy use: **35%**

Source: Account must be taken of the fact that not all energy used in the economy will be embedded in goods shipped via transportation. Establishing the fraction of energy actually embedded in physical goods is confounded by the fact that there are no publicly-available data available indicating the share of energy that is invested in these goods. However, there are data that allow strong inferences to be made in this regard. United States Energy Information Administration (EIA) data show that in 2010, energy used by the industrial manufacturing sector was 31% of total, economy-wide energy used [EIA, Annual Energy Review, 2011, Figure 2.1a. Available at: http://www.eia.gov/totalenergy/data/annual/pdf/sec2.pdf]. All this energy will be energy embedded in products that must be transported to consumers. In addition, the commercial sector will invest additional energy in these goods. According to EIA, the commercial sector accounts for 19% of total economy-wide energy use. The EIA defines the commercial sector as consisting of wholesale and retail service-providing facilities and equipment belonging to business, government, and other private and public organizations [EIA Monthly Energy Review, January 2012, Glossary]. An example of embedded energy in this commercial sector arises from the typical retail goods merchant. Every merchant must expend energy for lighting, climate control, etc. for goods to reach the final consumer. Services provided by the commercial sector, as well as goods, contribute to transportation-related embedded energy. An example is a food service provider such as a restaurant. The food served to the customer not only contains the energy embedded in the cultivation, harvesting, processing, and delivery of the food to the restaurant, but also contains the energy invested by the restaurateur—for refrigeration, cooking, lighting and climate control needed to provide the service and the good (food) to the restaurant-goer. While data are not available on the portion of commercially used energy that becomes embedded in transported goods, whether goods transported to the retailer or wholesaler or goods transported from these establishments to other establishments, a conservative estimate is that 20% of energy used in the commercial sector becomes embedded in this way as the good moves through the various nodes of the transportation chain. This figure is very conservative, since it is difficult to imagine a retail establishment that does not provide some goods, or goods used to enable the provision of services, to the final consumer (or a wholesale establishment that does not participate in the chain of this provision of goods). Hair salons use products delivered via transportation: your broker/financial advisor/tax consultant uses office products and, ultimately, computer servers that require delivery. The figure above of 35% results by adding this portion of commercial energy use to industrial energy [31% + (19% x 20%) = 35%].

7. Trucking share of the value of all goods shipped by freight: **75%**

   Source: Bureau of Transportation Statistics and U.S. Census Bureau, *2002 Commodity Flow Survey*, Preliminary United States Data, December 2003. Available at:

   http://www.fhwa.dot.gov/environment/air_quality/publications/effects_of_freight_movement/chapter02.cfm

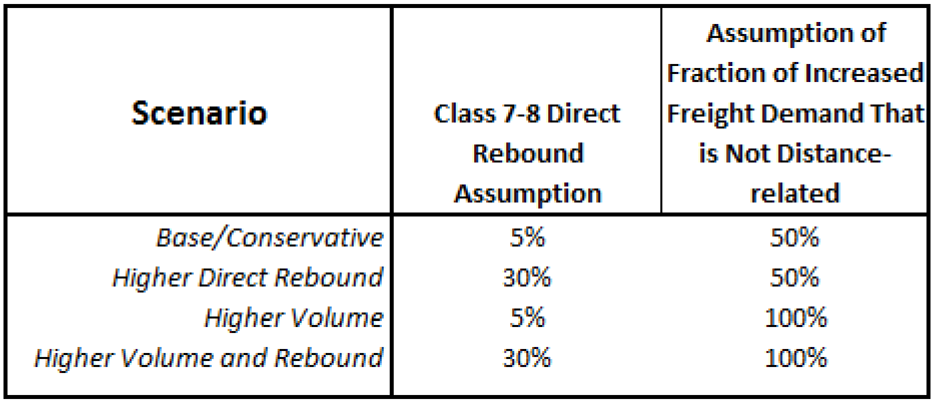
8. Class 7-8 share of the value of all goods shipped by truck: **45%**

   Source: There are apparently no data indicating shipment value by class of truck. However, proxy data are available [BTS, Freight in America, http://www.bts.gov/publications/freight_in_america/pdf/entire.pdf]. BTS data (largely from the BTS Commodity Flow Survey (CFS)) show that 45.3% of freight shipment value traveled over 250 miles in 2002 [Figure 3, page 18]. While a portion of this 45.3% would presumably be by non-class 7-8 vehicles, a portion of the hauls shorter than 250 miles would be by class 7-8 vehicles. As another indication, interstate freight shipments by all modes accounted for "…nearly 60 percent of the value of CFS freight shipments by all modes." [page 40]. Finally, combination tractors traveled approximately 64% of truck vehicle miles traveled [Figure 8, page 278]. Clearly, the 45% value assumed here is conservative and leads to a conservative estimate of rebound magnitude.

Scenario Assumptions for Step #2

52. For Step #2, there are two required assumptions for which no data exist, and which may be subject to contention, to enable exploration of different rebound and embedded energy scenarios. The first assumption involves the magnitude of the direct rebound effect in the class 7-8 segment of the transportation sector itself. The second assumption is the fraction of the increase in the demand for transported goods (due to Regulations-generated cost reductions) that will manifest as the increased quantity of goods demanded across the same distances compared to increased distances traveled for the same quantity of goods. (The EPA/NHTSA analysis treats the direct rebound effect as an increase in vehicle miles traveled, but it fails to distinguish between increased vehicle miles for existing vehicles and increased vehicle miles from new vehicles required owing to increased freight volumes. The EPA/NHTSA analysis correctly treats direct rebound as an "own-price elasticity" of demand for trucking services. But this elasticity is agnostic as to whether the demand manifests as increased quantity of goods demanded for the same miles traveled or increased distances traveled for the same quantity of goods. In reality, it will likely be a combination of both, but any particular elasticity/transport cost combination will reflect a fixed quantity of ton-miles added corresponding to the decrease in shipping costs. In the scenarios set forth below, this fixed quantity of ton-miles added is divided into two parts, a "volume-related" fraction and a "length-of-haul-" or "distance-related" fraction, which must, in total, equal 100% of the fixed quantity of ton-miles added due to lower transportation costs.

53. Four scenarios will flesh out different permutations of the two assumptions discussed above, (i) the magnitude of the direct rebound effect for class 7-8 vehicles and (ii) the fraction of increased freight demand that is volume-related, versus length-of-haul- or distance-related. These scenarios are:



Scenario	Class 7-8 Direct Rebound Assumption	Assumption of Fraction of Increased Freight Demand That is Not Distance-related
Base/Conservative	5%	50%
Higher Direct Rebound	30%	50%
Higher Volume	5%	100%
Higher Volume and Rebound	30%	100%

Scenarios Used for Analysis

54. For the Base/Conservative scenario, the (conservative) data-based assumptions are used along with the conservative 5% direct rebound value used by the EPA/NHTSA analysts. For this scenario, it is also assumed that 50% of the freight demand increase is in the form of an increased volume of goods traveling through the system from source to destination (meaning the remaining 50% is in the form of the same volumes traveling greater distances). This also seems conservative, since it is likely that the fraction of goods demanded by consumers (including consumers of intermediate products) in response to lower transportation costs from newly-distant locations is small relative to new goods demanded from existing locations, for the following reason: For a scenario to obtain in which 100% of the freight demand increase is due to the same volume of goods traveling greater distances (solely an increase in VMT), it would mathematically require that volumes traveling shorter distances be reduced or eliminated, an unlikely scenario.

(To comprehend this, imagine a histogram composed of vertical bars distributed along the x-axis, where the variable along the x-axis corresponds to different haul distances (distances increasing to the right), and where the vertical height of any one bar represents the volume of goods transported that particular distance. The total system-wide volume transported will be the sum of the heights of all the bars. The volume-weighted average haul distance can be represented by a line rising vertically from a point on the x-axis. Now suppose one is told that the weighted average haul distance has increased but that the total volume of goods transported remains fixed. One can picture increasing the weighted average haul distance by increasing the height of one or more bars to the right of where the volume-weighted average haul distance vertical line formerly stood. But one cannot do this, and still preserve the fixed sum of all bar heights, without simultaneously reducing one or more bar heights to the left of this line, meaning some shorter-haul transportation must necessarily be reduced.) It is difficult to imagine that the Regulations would disadvantage local producers in this way.

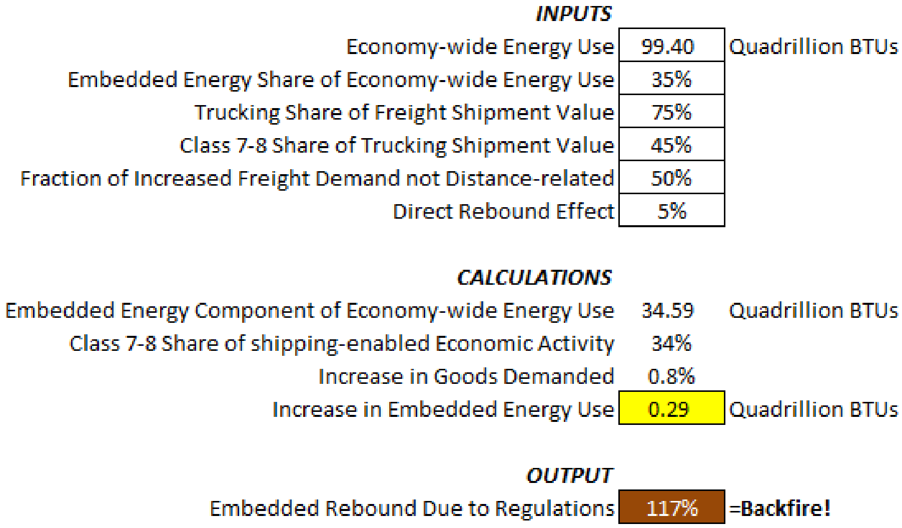
55. The “Higher Rebound” scenario tests the effect of increasing direct rebound from the 5% level assumed in the EPA/NHTSA analysis to a level of 30% (well below the econometrically-measured 60% value cited in the declaration, at Paragraph 31, for the Transportation sector).

56. The “Higher Volume” scenario tests the effect of returning direct rebound to the 5% level and increasing the volume-related fraction of increased shipping demand to 100%.

57. The “Higher Volume and Rebound” scenario tests the effect of combining a 30% direct rebound effect with a volume-related fraction of increased shipping demand at 100%. All scenarios retain the conservative data-based assumptions.

Methodology and Calculations for Step #2

58. The methodology for Step #2, employing the data-based assumptions for Step #2, is depicted below for the Base/Conservative scenario. Explanation of the calculations is in the next paragraph.



INPUTS		
Economy-wide Energy Use	99.40	Quadrillion BTUs
Embedded Energy Share of Economy-wide Energy Use	35%	
Trucking Share of Freight Shipment Value	75%	
Class 7-8 Share of Trucking Shipment Value	45%	
Fraction of Increased Freight Demand not Distance-related	50%	
Direct Rebound Effect	5%	
CALCULATIONS		
Embedded Energy Component of Economy-wide Energy Use	34.59	Quadrillion BTUs
Class 7-8 Share of shipping-enabled Economic Activity	34%	
Increase in Goods Demanded	0.8%	
Increase in Embedded Energy Use	0.29	Quadrillion BTUs
OUTPUT		
Embedded Rebound Due to Regulations	117%	**=Backfire!**

59. First, the embedded energy component of economy-wide energy use is calculated from its share of economy-wide energy use: 99.4 Quads x 35% = 34.59 Quads. Then, the class 7-8 share of shipping-enabled economic activity is calculated as the product of the trucking share of freight shipment value and the class 7-8 share of trucking shipment value (75% x 45%), yielding 34%. This is the percentage of goods flowing through the economy via class 7-8 shipping, and the freight value percentage that is susceptible to an increase in demand arising from reduced shipping costs caused by the Regulations and associated with these vehicles. (Note that this does *not* account for added "spillover" rebound effects arising from additional small vehicle use for distribution, as described at Paragraph 39.) Then, this increase in the demand for goods (due to the Regulations) is calculated by applying the direct rebound effect (here showing as the rebound assumed by EPA/NHTSA), corrected for the possibility that some of this increase will manifest in

the form of longer distance transportation, not volume increases (5% x 34% x 50%), yielding a volume-related increase in the goods flowing through the economy (and thus an increase in the goods produced) of 0.8%.

60. The increase of 0.8% in goods produced will require a commensurate additional energy to produce them. The energy use increase will be the increase in economic activity multiplied by the overall share of energy used for production (34.59 Quads x 0.8%), yielding an economy-wide increase in embedded energy use of 0.29 Quads, which surpasses the ostensible baseline amount of energy saved by the Regulations' mandated improvement in fuel efficiency by 17%.

61. The foregoing approximation would be accurate under an assumption that the increase in truck transportation demand arises uniformly across all productive sectors. An accurate analysis would require information on sector-specific responses to lowered transportation costs and the energy use of each sector. However, such data are not available. Indirect indications are that the Base/Conservative scenario is conservative with respect to rebound magnitudes. BTS data for commodity flow by mode of transportation for 2002 show that the top commodities by ton-miles shipped by truck are high energy-containing commodities. Lower transportation costs will cause more commodities to ship both that are transportation-intensive and that contain large embedded energy, in comparison to commodities with less energy invested in them. In this case, the rate of increase in overall embedded energy will exceed the rate of increase in overall production. The BTS data show that the top four commodities in terms of ton-miles of truck transportation consumption (total miles instead of ton-miles would be a better measure, but this is not provided by BTS) are "other prepared foodstuffs and fats and oils," 8.77% of total ton-

miles for trucks; "nonmetallic mineral products," 8.14% of ton-miles; "base metal in primary or semi-finished forms and in finished basic shapes," 5.93%; and "wood products," 5.13% [Calculated from BTS, 2002 Commodity Flow Survey, United States, Table 7. Available at: http://www.bts.gov/publications/commodity_flow_survey/2002/united_states/]. Similarly, the U.S. Energy Information Administration lists "food and kindred products," "stone, clay and glass products," "primary metal industries" and "paper and allied products" among the top six "high consumers" of energy, from 1985 to 1991 [EIA, Measuring Energy Efficiency in the U.S. Economy, 1995, Chapter 6, Table 6.2. Available at: http://www.eia.gov/emeu/efficiency/ee_ch6.htm]. This is a strong indication that truck transportation cost reductions due to engine efficiency gains are likely to favor increased production of commodities having greater, not lesser, embedded energy.

Comparison in Total Overall Energy Used Between 0% Rebound and Base/Conservative Rebound Scenarios

62. Lastly, the economy-wide increase in embedded energy of 0.29 Quads resulting from the Base/Conservative scenario is then compared to the quantity of energy potentially saved in the class 7-8 freight segment, calculated in the section on *Methodology and Calculations for Step #1* above as 0.25 Quads. The conclusion is that the quantity of energy potentially saved due to the class 7-8 Regulations is more than offset by the increase in energy used economy-wide. This is stated as a rebound of 117%, decisively a backfire condition resulting from the EPA/NHTSA Regulations.

Results

63. The results of the analysis for the four scenarios are shown in the table below (Note that all scenarios use the same conservative data-based assumptions for Step #1 set forth at Paragraph 49 above):

DS
7/9/12

TOTAL EMBEDDED (INDIRECT)
REBOUND
DUE TO
REGULATIONS

DS
7/9/12

DS
7/9/12

Scenario	Class 7-8 Direct Rebound	~~Class 7-8 Direct Rebound Assumption~~	Assumption of Fraction of Increased Freight Demand That is Distance-related
Base/Conservative	5%	50%	117%
Higher Direct Rebound	30%	50%	704%
Higher Volume	5%	0%	235%
Higher Volume and Rebound	30%	0%	1408%

Embedded Energy Rebound Scenario Results

64. It is evident that the embedded energy rebound effect quite readily leads to a backfire condition: an actual and absolute increase in economy-wide energy use and associated GHG emissions due to the Regulations, rather than the intended decrease.

65. {NOTE: The spreadsheet model from which these calculations derive, and which can be used to test alternative assumptions, is posted online and is available to anyone who cares to examine or use it. The site is http://www.dropbox.com, a free service for sharing files provided by Dropbox©. All that is required is for an individual to download the Dropbox™ software and send an email to hsaunders@decisionprocessesinc.com and I will add his or her email address for authorized access.}

Further your declarant affirmeth naught.

Harry D. Saunders
Danville, California

FEBRUARY 12, 2012
Date

Attachment B: Curriculum Vitae of Harry D. Saunders

Dr. Harry Saunders conducts research in energy economics, evolutionary biology and law of evidence theory. He earns his living by consulting to corporate executive teams facing major risky decisions.

EDUCATION

Stanford University	Engineering-Economic Systems	Ph.D, 1981
University of Calgary	Resources, the Environment, and Planning	M.Sc., 1974
University of Alberta	Honours Physics	B.Sc, 1970

CURRENT AFFILIATIONS

Managing Director, Decision Processes Incorporated
Charter Member, International Association for Energy Economics
Senior Fellow, The Breakthrough Institute
Founding Fellow, Society of Decision Professionals
Occasional lecturer, Stanford University
Course Developer (Master's level course), 2010, *The Economics of Oil, Gas and Energy*, University of Liverpool.

PAST EXPERIENCE

Director, Decision and Risk Analysis, Inc.
Senior Associate, Cornerstone Research
Senior Associate, Strategic Decisions Group
Manager of Strategy, Tosco Corporation
Special Assistant to the Deputy Executive Director, International Energy Agency
Special Assistant to the Administrator, National Oceanographic and Atmospheric Administration
Independent Consultant, Gulf Oil Corporation
Independent Consultant, Gulf Oil Canada Ltd.
Electric Power Research Specialist, Alberta Energy Resources Conservation Board

PUBLICATIONS & OTHER ACADEMIC ACTIVITIES

Energy Economics – Rebound

H D Saunders, **Historical evidence for energy consumption rebound in 30 US sectors, and a toolkit for rebound analysts**, *(submitted and under review, December 2011*; includes open-source software.)

J Y Tsao, H D Saunders, J R Creighton, M E Coltrin and J A Simmons, **Solid-state lighting: an energy-economics perspective**, *Journal of Physics D: Applied Physics*, 43 (5), 2010, http://iopscience.iop.org/0022-3727/43/35/354001.

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H D Saunders, **Understanding rebound**, video clip: excerpts of interview, 2011. http://www.youtube.com/watch?v=oTV-aBy5A3I&feature=player_profilepage

Other Rebound works available at: http://works.bepress.com/harry_saunders/

Harry's academic work in rebound economics has been cited in various publications, including *Nature*, *The Economist*, *The New York Times*, *The New Yorker*, and a recent book by David Owen, "*The Conundrum*."

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H D Saunders, **On the inevitable return of higher oil prices**, *Energy Policy* 1984; 12(3); 310-320.

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Energy Economics – Energy Shocks

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H D Saunders, **A Note on Rowen and Weyant, 'Reducing the economic impacts of oil supply interruptions: an international perspective**,' *The Energy Journal* 1984; 5(4); 55-64.

H D Saunders, **The macrodynamics of energy shocks, short- and long-Run**. *Energy Economics* 1984; 6(1); 23-34.

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Energy Economics – Biofuels

H D Saunders, **Virtual Biofuels – A cheaper, better, faster alternative?** *Energy Policy*, Energy Policy 36 (4) 2008, 1247-1250.

Evolutionary Biology

H D Saunders, **A genotype-distinguishing model of senescence** *Evolutionary Ecology Research* 11 (2009): 1141-1168.

Other Evolutionary Biology works available at: http://works.bepress.com/harry_saunders/

Law of Evidence Theory

H D Saunders, **Re-thinking the criminal standard of proof: seeking consensus about the utilities of trial outcomes"** *International Commentary on Evidence* 7(2) 2009 (with Larry Laudan).

H D Saunders, **Quantifying reasonable doubt: A proposed solution to an equal protection problem**, ExpressO, 2005. Available at: http://works.bepress.com/harry_saunders/2

Other Law of Evidence works available at: http://works.bepress.com/harry_saunders/

Other Academic Activities

Invited Presenter, European Commission "Green Week." **Status of USA rebound effect activities**. Brussels 24-27 May, 2011.

Invited Presenter, International Risk Governance Council Workshop "Energy Efficiency Policies and the Rebound Effect," organized by Carnegie Mellon University Climate Energy Decision Making Center and the University of Stuttgart, **Rebound in US productive sectors**. Washington, DC 27-28 June, 2011.

Invited Presenter, Workshop of international genetic and micro-biologists, "From Homo Sapiens to Homo Sapiens Liberatus," Moscow State University, **Programmed vs. Stochastic Aging Mechanisms.** Moscow, May, 2010.

Invited Presenter, Workshop of international law of evidence scholars, "Sobre Epistemologia Juridica," Universidad Nacional Autonoma de Mexico, **Quantifying Reasonable Doubt.** Mexico City, September, 2009.