1. Plenary Session

Introduction

The plenary session at the Annual Merit Review included a series of presentations from DOE VT management that outlined the Program's goals, objectives, budgets, and activities. The purpose of the plenary session was twofold: 1) to provide attendees at the Merit Review with an overall context for VT mission and goals, to enhance their understanding of the more specific technical areas to be reviewed, and 2) to solicit feedback from a separate set of reviewers (separate from those on the technical review panels) on the overall direction of the VT program. For the review of the plenary session, the review panel was given a set of four specific questions for which they were to provide responses: these questions solicited written comments, not numeric assessments, so no scoring of the plenary session presentations was performed (unlike for the technical sessions, where a numeric score was included as part of the review).

Summary of Important Findings

A summary of major highlights of the responses is presented below, and a complete exposition of the breadth of comments is presented in the pages that follow.

Aspects of VT program that will impact DOE strategic goals

- Hybridization and vehicle lightweighting will make the greatest impacts on fuel use and thus on DOE strategic goals.
- Alternative fuels and advanced vehicle technologies also contribute to DOE strategic goals.
- The shift away from heavy-duty research was seen as detrimental to meeting DOE goals.
- For hybridization, vehicle electrification and battery research were seen as very important to success in meeting DOE petroleum reduction goals.
- Biofuels were also noted as contributing to petroleum reduction goals, but with cautions that environmental and food production concerns must be considered and addressed.
- Accurate economic assessments relative to vehicle technologies were also valuable to meeting petroleum goals.

Trends in VT funding and research focus

- Funding continuity for the program is critical.
- The shifts in portfolio focus demonstrate the program's flexibility to changing market conditions.
- The shift away from heavy-duty research was appropriate to some reviewers and inappropriate to others.
- Hybridization of vehicles is very important, and a research focus on energy storage and power electronics is critical.
- Hydrogen fuel cell vehicles were not seen as a priority by this review panel.

Overall balance of research, demonstration, and deployment

- The level of focus on research, demonstration, and deployment should be balanced, without focus on any one of them.
- Battery research and alternative fuel infrastructure development were noted by reviewers as specific areas for focus.
- Major external drivers on VT show a clear interest in near-term outcomes.

Relative emphasis on deployment (versus industrial involvement in these activities)

- VT should pursue more generic technology development and less company-specific activities. The industrial partnership experience is valuable, though, and the experiences should be shared across DOE offices.
- DOE and VT should take a proactive role in deployment for areas where it can have a beneficial leveraging role to play in closing the gap between laboratory settings and the commercial market.

Amount of high-risk/high-reward research

- DOE should pursue this high-risk research, as it will yield national rewards and is not likely to be undertaken by industry alone.
- High-risk research should be conducted separate from the FreedomCAR and Fuel Partnership.

Balance of light-duty versus heavy-duty research activities

- For some reviewers, there have been too many cuts in the heavy-duty research budget, perhaps pushing resources below a critical mass necessary for success.
- To others, the balance of light-duty and heavy-duty research is appropriate, but neither is funded to a sufficient level.

Additional areas of research focus

- Additional areas suggested included truck auxiliary power units/truck stop electrification, non-ethanol alternative fuels, advanced engines and combustion systems (including diesel-like combustion, batteries for pure electric vehicles, and carbon management modeling.

Investment in enabling technologies

- Enabling technology investment levels are appropriate. Additional areas for consideration in enabling technology include fuel blend impacts, traffic gridlock solutions, truck auxiliary power units, and biodiesel from non-food crops.
- Enabling technology research is a high priority, but should not be solely the funding responsibility of VT. Other DOE offices should participate in funding this research.

Appropriateness of health impacts research

- The health impacts work is useful, appropriate, and (to some reviewers) absolutely necessary.
- Health impacts assessments should be an integral part of VT thinking and planning.

Other comments

- The VT program is well managed and effective, but funding resources are limited.
- The broad scope of the program brings with it management challenges both in having sufficient resources overall to meet the needs of the scope and in prioritizing work to make best use of resources to meet the needs of the scope.
- Energy legislation in recent months is sending signals for the government to take a more active role in energy R&D.

Detailed Summation of Plenary Session Review Comments

The paragraphs below present the complete responses of the Plenary Session reviewers from the 2008 DOE Vehicle Technologies Annual Merit Review, arranged by question in logical subject-related paragraphs. Although the paragraphs below are not arranged in quotation form, they are the words of the plenary reviewers as received through the PeerNet system, with some grammatical adjustments and some efforts made to remove clues to the identity of the various reviewers. Important conclusions or observations of a reviewer or reviewers are emphasized throughout the text with sidebar text boxes.

Question 1: In your judgment, what aspects of the VT program will have the biggest impact and timely contribution to the DOE strategic goals?

Multiple reviewers indicated that the hybridization of both light and heavy duty vehicles combined with light-weight, less-expensive structures (such as carbon fiber composites) will make the greatest impact on reducing fuel usage in the shortest time. A reviewer indicated that a priority should be to make LDVs not only efficient but also safe. Of the presentations at the Plenary Session 1, he stated that there was not a single mention of safety, and yet that seems to be one of the principal impediments in the minds of many consumers against buying small, efficient vehicles. The public impression is that occupants of a small vehicle will be killed in a collision with an SUV or heavy truck. Technology has brought safety of LDV's a long way since Ralph Nader's "Unsafe at Any Speed," and surely more can be done. He cites a paper by Tom Wenzel and Marc Ross, "Safer Vehicles for People and the Planet" in American Scientist, vol. 96, p122, March-April 2008 edition.

Similarly, one reviewer wrote that VT needs to continue to emphasize making vehicles lighter while maintaining or improving their safety. He states this should not be done in a piecemeal fashion, but in a systematic approach for the entire vehicle. The materials chosen can be any combinations that meet the goal. A lighter vehicle can have smaller displacement engines and the fuel economy of the vehicle goes up correspondingly. A key enabler will be the introduction of fabrication, assembly and joining technology in support of lighter vehicles. The manufacturing technology must be less expensive than the current high legacy cost manufacturing systems being used. The manufacturing systems must be flexible so that they can rapidly accommodate shifting consumer preferences at minimal cost. He goes on to state that sales forecasts are made years before the first vehicles hit the road, and "they are always wrong." If the forecast calls for high sales volumes then tremendous capital outlays are made and must be amortized over the predicted forecast. If actual sales are much lower, the manufacturer loses significant profit. Conversely, if sales forecasts are low for niche markets and demand exceeds supply, the manufacturer must be able to respond very rapidly to the higher customer demand.

Hybridization and vehicle lightweighting will make the greatest impact on fuel use.

Again, another reviewer indicated that lightweight vehicles and hybridization will have the greatest and most immediate impact on oil reduction. He added that the public also needs to become comfortable driving lighter vehicles despite perceived safety concerns (the belief that heavier is safer). Comparison crash tests of light, strong vehicles versus heavy vehicles need to be demonstrated, perhaps in a way similar to the sensational 180 mph crashes at NASCAR and Formula 1 where the driver "walks away."

One person commented that strategic goals (including energy diversity and environmental impacts) have tremendous impacts on the program's worth. He went on to say that the advanced vehicle technology programs should have increased emphasis particularly because of CAFE standards and energy demand.

Electrical vehicle technologies, fuel efficiency, and alternative fuels were all indicated as important aspects of the VT program. One person simply listed the following aspects as the entire response to the question: PHEVs, Batteries, and Advanced Combustion Research. Another wrote that the use of alternative fuels and advanced vehicle technologies are very critical to the achievement of DOE's strategic goals. One reviewer noted that, over the long run, more efficient engines and fuels that are alternatives to petroleum will have a large impact.

Expanding on these topics, one reviewer wrote that alternative fuels and advanced vehicle technologies elements significantly contribute to DOE goals and the great decrease in funding for heavy-duty truck research is a significant concern to him. The shifting of DOE funding to more near-term implementation and deployment is considered unhealthy for the DOE government funded formula. This work is important, but it manipulates the "competitive commercial world" without always allowing support for "government" pre-competitive high-risk, high-payoff work that no one will properly pursue for the good of society in general without government funding.

Alternative fuels and advanced vehicle technologies contribute to DOE goals.

Vehicle electrification and battery research are important: batteries are critical to PHEVs.

One reviewer did not feel that there was quite enough information to comment on this topic appropriately. He wrote that the Fuels Technology, Technology Integration and Advanced Combustion Engine program presentation did not disclose the full range of potential program options nor did it provide a comprehensive list of current projects or project areas/objectives. Consequently, he wrote, it is difficult to view and evaluate the present program in these three areas in a holistic way.

This reviewer added that, regarding "timely contribution," materials technology work and battery research have a longer-term impact horizon in general than does the work on hybrid electric vehicle systems (similar to earlier comments). However, the impact time horizon of the program portfolio depends on the mix of specific projects being funded.

Shift to near-term implementation is "unhealthy". Shift away from heavy-duty work is a concern.

Similarly, another reviewer found it difficult to tell (upon reviewing the presentations) which aspects of VT had the largest impact on DOE strategic goals. The reason was that he did not have a copy of the Phil Patterson presentations, which should be the basis for drawing such conclusions. In retrospect, he thought, the Patterson presentation perhaps should have come earlier in the sequence of presentations. Also, in considering the impact on DOE Strategic Goals, this reviewer tends to look at it from the perspective of impact on energy markets, since the DOE Strategic Goals can change over time and are likely to change in response to changes in energy markets, as well as changes in legislation and government policy. Nonetheless, this reviewer thinks that electrification of the vehicle fleet would seem to have the largest impact on energy markets, so it would seem appropriate that this area have a heavy emphasis in the VT portfolio.

Two reviewers commented on the importance of advanced batteries, with one stating that they would improve the HEV's performance, and of course are critical to PHEVs. Another person stated that both advanced batteries and super ultracapacitors should be in the program. To make a PHEV work takes a storage device with about 600 W/kg power density and an energy density of 80-100 Wh/kg. He notes that it must also be economical to the application – a worthy challenge, and he hopes DOE gets there first.

A reviewer commented that the success in developing plug-in hybrids and creating liquid fuels from non-food (biomass rather than corn) sources both appear to have the biggest potential impact and timely contribution to the DOE strategic goals. However, he adds, there are additional considerations, outside of the scope of the EERE programs, which need to be recognized to achieve overall success for DOE, specifically related to how cleanly the electricity is generated. He referenced an article from the March/April 2008 Technology Review, entitled, "Tailpipes vs. Smokestacks," which presents estimates for emissions from conventional vehicles, from hybrid-electric vehicles, and from plug-in hybrid electric vehicles with electricity generated from eight different possible technologies. With conventional coal combustion generating the electricity, total emissions are estimated to be less with the hybrid electric vehicle than with the plug-in hybrid. As such, he concludes, technologies related to electric power generation, which are outside the scope and control of VT, must succeed in order for plug-in hybrids to contribute to a net reduction in automotive emissions.

Another reviewer stated that the biggest impact potential of current programs is likely in the bio-fuels area. He indicated that success here would impact cost, availability, green economy, and political/strategic security directly. All other areas of research have major industrial competitive challenges and EPA vs. green conflicts that will likely be settled by complex global industrial competition. He adds that picking the "right" technologies to back will always be problematic.

Biofuel environmental and food production impacts must be considered.

One person noted that, over the last two years, much new information has emerged that indicates that, in general, renewable fuels production is leading to "environmental disaster" in terms of impact on both total world system CO_2 burden and impact on water, specifically on oceanic life systems and interaction with CO_2. This is in addition to the more widely discussed impact on food production and world food prices and availability. (The reviewer has been tracking findings from Europe in some detail.) He believes that new fuel sources will be developed from feeds other than biofuels, and biofuels will become much less attractive as the full impact of their production becomes more widely understood. At the same time, it is becoming clear that technology is emerging from several sources that cleanly and cost effectively produce refinery feeds from tar sands, oil shale, coal, and very likely lignite. North America is far richer in these materials than any other region of the world, and program activities that link with this development will likely have by far the biggest impact on achieving DOE strategic goals.

PHEVs and biofuels (especially from non-food sources) are critical to DOE goals.

Regarding Ed Wall's presentation, one reviewer comments that the VT program on the whole is well balanced, with the R&D in Hybrid & Electric Systems, Materials Technologies, Fuels Technologies, and Engine & Emission Control Technologies all having the potential of making a significant impact. The Analytical Studies part plays an important role in providing scenarios of future impacts. What VT does not appear to provide are opportunities for small projects that explore innovative concepts that not covered by the current program. Mr. Wall mentioned STTR and SBIR, but these programs do not give a direct opportunity to universities and National Labs.

One person stressed the specific importance of applied research aimed at developing measurement and characterization capabilities such as combustion chambers and engines, coupled with advances in

diagnostic tools, predictive modeling and synergistic coupling of these efforts. He believes that the current VT program in these areas is highly laudable and should be expanded relative to specific, single-company-centric projects that are often better classified as product development.

The final reviewer began by stating that this briefing was critical to providing a wonderful mechanism for decision-making regarding factors including individual scenario selection and its "payoff" in various categories: cost, availabilities and long term supply/demand, societal benefit in general, etc. It is unfortunate, he comments, that the reviewers did not receive a handout of Phil Patterson's presentation.

He writes that (while he is not a modeler) he is well aware from others (not associated with VT) that NEMS is hard to use, not easy to modify, and can have buried assumptions. He is also aware that almost all predictions concerning energy "have been wrong." Still, having said the above, he is also of the opinion that developing scenarios remains very important in helping to understand what the consequences might be of not only new technologies but also energy policies. He encourages VT to continue such analyses.

Continuing, he writes that the plenary presentation on analytical studies consisted of an interesting discussion of various analysis methods and functions with EERE related to VT programs. The presentation did not, however, provide any overall understanding (for this reviewer) of how (or whether) systems analysis is used in VT to make management decisions on the portfolio. In addition, the presentation did not provide any numerical results showing the projected impacts of various lines of research or key technologies and how they contribute to the VT goals. Therefore, this question about impact and the following ones on priorities could not be addressed by this reviewer except in a rather "visceral" manner.

VT can provide value through accurate economic assessments.

This reviewer believes that accurate economic assessments will be among the highest value outputs that VT can provide to the nation. The combination of technical information available from the DOE and its partners puts VT in a unique position to develop unbiased assessments of likely consequences of technical deployment and policy encouragement scenarios. He appreciates that policy makers will not always listen to good advice, but the first step must be to develop such device so that the public can hold them accountable when they fail to listen. He applauds the return to VT of Mr. Patterson and encourages the expansion of his rather modest programs.

He also believes that some elements of economic analysis should be applied to DOE/VT funding decisions. He was not satisfied that Mr. Wall's criterion for funding choices (the bottom line is reduction in fuel usage) would be sufficient to make any but the most global choices. Program managers at all levels could benefit from assessments of likely technology adoption based on informed industrial economic judgment. Retrospective studies, even though they are anecdotal, would help to inform the PMs as well as the public of the value of DOE investments and the pitfalls associated with transition to actual deployment.

Question 2: Please comment on the trends over the past several years in DOE VT funding and technical research focus. Provide your specific thoughts on the technology focus shifts (such as from combustion/emission control to plug-in hybrids, from heavy-duty to light-duty, and so on), explaining why you think these shifts in funding priorities enhance or detract from VT support of DOE/EERE strategic goals in a timely manner.

Multiple reviewers commented on the importance of funding continuity. One person wrote that it is always very important to any successful program; however, because of the government realities of funding, an attempt to maintain alternate strategic (with decreased or increased funding realities) paths in place is important. Another reviewer added that funding continuity is key to any program success over time, but in general a decrease (with little time notice) is hugely negative to any "strategic" plan to be executed. One reviewer noted that the increase in Congressional plus-ups for DOE presents a great danger to any funding continuity or serious strategic goal pursuit. One other person noted that Ed Wall's discussion about a "relatively" stable DOE budget except this year (30 million dollar loss in hydrogen programs and increased emphasis in plug-in hybrid and alternate fuels / biofuels) was quite helpful. In fact, the reviewer added, his input provides data to support the strategic funding continuity of the program in most of the program elements over the past few "decades."

Funding continuity is critical.

One reviewer commented that the Budget Summary for Fuels Technology shows that the Budget Request for FY09 is down somewhat from FY08 and FY08. He noted a similar trend for Advanced Combustion Engine R&D. While he realizes that these budgets are not under VT's control, he indicated that these trends are still disturbing as petroleum usage and engine emissions are long term issues.

Three reviewers had general comments regarding overall funding trends. One person indicated that funding trends in this area clearly reflect the shift from more basic R&D to applications, integration and commercialization. However, he added, the large (%) increases in Technology Integration may or may not be warranted. The program should review this strategy based on the track record and future potential effectiveness of Technology Integration activities. Unfortunately, he adds, the Plenary presentation did not provide any insight on these activities. Given the Renewable Fuels Standard, there is a danger that DOE efforts in the Fuels Technology area will be overtaken by events. This could be extremely problematic given the potential that market forces, in the absence of a fuels technology breakthrough, could produce very disruptive changes to food supply and land use. The Fuels Technology Element should look well beyond the short-term ethanol, gasoline-substitution solution and focus on accelerating fuels options with long-term potential.

A second reviewer commented that Mr. Sullivan made clear in his remarks that the "pendulum" had swung very strongly in the direction of near-term goals. While the reviewer indicated he was not sufficiently familiar with the details of the portfolio to judge, based on some brief attendance at sessions later in the week he would agree that the work is strongly near-term. However, the time-line for new materials (such as carbon fiber composites) introduction is generally even longer than most other new technologies, so making this work more near-term is highly desirable.

The portfolio shifts demonstrate responsiveness to changing conditions.

A third reviewer added that it was clear from the presentations that there have been significant shifts in recent years in the VT portfolio. He thinks that this is

generally a good thing, as it indicates that the program is being responsive to changing external dynamics. If electrification indeed has the potential to have a significant impact on energy markets, then the shift from combustion/emission control to plug-in hybrids is the right move. Also, while the program has done a lot of good work in the heavy-duty vehicle area, it also is clear that there is a greater need to focus on light-duty vehicle technology. That is not to say that there do not remain significant R&D opportunities in heavy-duty vehicles; rather, it is just that, given budget limitations, the priority needs to shift to light-duty vehicles. Ultimately, these shifts appear to be in the right direction regarding meeting national energy policy goals and impacting energy markets.

Regarding the value of heavy-duty vehicle research, some reviewers disagreed with the above assessment. One asked, "Why the large reduction on heavy-duty vehicles?" Another commented that too little effort is being given to heavy-duty vehicles, where fuel economy pays for itself very quickly. The electrification of heavy-duty trucks can make them more fuel efficient and reduce the need to run engines at truck stops for hotel and refrigeration loads. Partial hybridization for creeping in congested areas and for regenerative braking will make a difference.

Many reviewers felt more heavy-duty research was needed. A few felt even more of a shift to light-duty was appropriate.

One person added that, in terms of the shift from heavy-duty to light-duty, he thinks the heavy-duty program has made a huge technology impact as relates to diesel, such as fuel consumption and emissions reduction. The findings from this program have led the world to make huge strides in light-duty fuel economy improvement, while in the U.S. this progress has not been effectively implemented in light-duty. A much more effective strategy for DOE would be to continue to push learning in a robust heavy-duty program, but to also drive hard to move the resulting learning to the U.S. light-duty community.

Another reviewer believes that combustion engine system improvement, including the required fuels and emissions controls, is still the most effective way to deliver DOE goals. Hybrids are a viable and important part of that logic thread. The potential impact of pure hybrids is small by comparison, for a variety of very good reasons, but this potential impact is real and should be pursued in proportion to the relative potential impact. One other person comments that the funding shifts are understandable, given pressures from high levels within EERE and from Congress. However, R&D on combustion and emissions can have a nearer-term significant impact than PHEVs. Of course, PHEVs will have internal combustion engines that could also benefit from the combustion and emissions R&D. In this respect, it is disappointing for this reviewer to see the DOE Request for Engine & Emission Control Technologies to be lower than the actual funding for FY07 and FY08.

In contrast, another person notes that the decrease (FY 2007 Appropriation to FY 2009 Request) in the Engine and Emissions Control Technologies budget should have the least overall impact on the program, because the industrial participants in the program should be able to make up for any shortfall in this area. He adds that the other three program areas (Fuels Technologies, Materials, and Hybrid and Electric Systems) show slight increases, and that this is appropriate given the expectations for success.

Multiple reviewers commented on the important of hybrid and plug-in hybrid vehicles. One person states that the hybridization of vehicles is critical, and that both Honda and Toyota have already

demonstrated the direct impact on the marketplace and the halo effect on their brands. The domestic automakers started their hybrid vehicle propulsion programs in partnership with the DOE in 1993. But now, the reviewer asks, where is the deployment? The lead time for maximum market penetration of new technologies is about 15 years, and yet we are just now seeing initial deployment of these vehicles. What have the OEMs been doing? Hybridization of lighter weight vehicles as mentioned in question #1 will provide additional fuel economy gains. Lighter vehicles will also make all-electric or plug-in hybrids more attractive to the consumer as range increases in all electric mode. To this reviewer, hydrogen powered fuel cell vehicles will just be a curiosity until reformers of other liquid fuels are cost competitive and durable. Another reviewer adds to this by stating that the increasing focus on plug-in hybrids is generally appropriate because this technology can have (depending on how it is deployed) a more immediate impact on petroleum consumption (efficiency) and a less disruptive external impact (fuel feedstock) than some other technologies and projects. Another reviewer states that there needs to be more focus on all-electric vehicles with a range of greater than 60 miles. This requires better batteries and power electronics that are capable of supporting a vehicle's hotel load requirements.

Hybridization of vehicles is extremely important. Energy storage and power electronics are key technologies.

One reviewer agreed that the keys to hybrid vehicle propulsion systems are power storage and power electronics. The research seems well-balanced with work on new materials for battery development and power electronics. One concern this person has is the traditional operating mode of the domestic auto industry of trying to leapfrog the competition by introducing an all-new model that incorporates many new technologies at one time. By the time the leapfrog program is ready, the competitors will have already surpassed the point where the new technology is intended to go by incremental improvements and multiple iterations. Then when the leapfrog technology does hit the market, there will be the inevitable glitches multiplied by the number of new technologies multiplied by the changes in the manufacturing processes. The reviewer is concerned that as more PHEVs are in the market, what will be the effect on the electrical grid? There are parts of the country that are already near capacity to transmit electricity. As many commuters come home from work at 4 – 7 PM, an already tight system (especially with summer air conditioning loads) may be overwhelmed.

There were differing opinions on the role of hydrogen fuel sources. One reviewer stated that hydrogen is too expensive, has no delivery infrastructure and is usually made from other fossil fuels with the corresponding emissions being worse when CO_2 capture is not being used. He adds that storage of hydrogen onboard a vehicle and at refueling facilities still need to be addressed. Following up on this, another reviewer noted that there is a large emphasis on hydrogen-powered fuels cells and the refueling infrastructure. The single laboratory with the most experience in hydrogen and its effects on materials is Savannah River National Laboratory. The high pressure laboratory at SRNL is designed to test high pressure vessels to burst. Their sensor technology can be inserted into these high pressure vessels to make them smart hydrogen storage tanks.

Another reviewer stated that the trends away from hydrogen are very positive. The challenges of infrastructure development and hydrogen storage are most formidable and the probability of success seems very low to him. He adds that the trend away from 21st-Century Truck is a mistake in his view. The truck program should be aimed at safety first, efficiency second and multimodal capacity third. He asks, are cooperative programs with DOT adequate? He didn't hear much about interagency partnerships.

Some reviewers felt there was insufficient data presented to highlight the magnitude of the funding shifts and to identify R&D areas being reduced or terminated in the VT program. Therefore, they said, it was virtually impossible to assess the appropriateness of these trends. One person commented that, as was indicated, funding has not really changed much over the last several years when viewed globally, with earmarks more significant than changes in regular appropriations. The reviewers were led to believe that shifts had taken place on a more detailed level, but no history or justifications of these changes was shared, so he cannot really address this question.

Hydrogen fuel cell vehicles were not seen as a priority to these reviewers.

Another reviewer summarized the changes to this part of the VT program as: (1) a shift in emphasis to commercialization and away from R&D and (2) a reduction of effort on heavy-duty vehicles. In general, DOE's commercialization efforts should flow naturally from progress in the technology development projects and focus first on those technologies in which DOE has invested. Such efforts could include technology demonstrations, market demonstrations, promotion, financial incentives, etc. Beyond that, general commercialization efforts (e.g. PHEV value proposition and integration studies) should be undertaken if additional funding is available. (However, knowledge of the PHEV value proposition and grid integration should be known at the outset to some degree – as a prerequisite to funding any R&D work in the area. Hopefully, the planned new emphasis in this area will build on existing knowledge to a large degree). Both elements of this part of the VT program have received significant funding increases from 2007 to both 2008 and the 2009 request. On a percentage basis, these increases are considerably greater for the Materials Technology element. It is not clear to what extent these increases support the stated goals.

Question 3: Please comment on the current mix of activities in the VT portfolio.

Question 3a: What overall balance of research, demonstration, and deployment in the VT portfolio should be pursued, and why?

Many of the reviewer comments centered upon the balance between funding basic research versus funding demonstration and deployment projects. Generally, reviewers agreed the balance between research, development, demonstration and deployment (RD^3) was critical, with one reviewer commenting that it also depends upon forging the right partnerships with industry. One person commented that the demonstration of a few technologies followed be full-scale deployment is of exceptional importance. A few reviewers felt that they had insufficient information to make a judgment.

One person wrote that, while DOE is being directed to more short-term deployments, he believes that their balance should emphasize research more in concert with industrial work and goals. Another added that he recognizes that there are pressures external to VT to move in the direction of deployment. But the nation, the world, and DOE are in for the long haul in reducing petroleum use by and emissions from vehicles. That perspective, the reviewer states, calls for a robust and well-funded research program. One reviewer added that he believes that the high-risk component of research should be most

A balance between basic research and demonstration work should be pursued, without undue emphasis on one or the other.

emphasized by DOE (government) funding. Another person commented that the critical added-value function for DOE is research that is focused on industry needs and is well suited for application. Demonstration and deployment are critical, he adds, but cannot total more than about a third of the total activity without seriously impacting the value of the Office.

Other reviewers were of a differing opinion, with one stating that research should be 10- 15% to quickly cull the choices for additional funding, and demonstration should be no more than 25% - these are usually a handful of products to demonstrate that they perform and get the "gee whiz" factor up. This reviewer adds that deployment is the most critical phase, as this is where the largest investments on the part of manufacturers must be made and where the most help is needed for rapid deployment of developed technologies. DOE can build some incentives for manufacturers that are first to market with technologies that have specific performance goals and rewards. Another person commented that this is not a basic research program in the NSF sense of that phrase. It should continue to address well-defined goals with milestones. On the other hand, he doesn't believe that it should be a product development program either. Some of the programs he viewed later in the week seemed to be of that type.

Another person commented that the VT program is heavily weighted towards demonstration and deployment. From an overall DOE perspective this is balanced by a strong basic research program sponsored by the Office of Science. He could not tell from the discussions at the peer review meeting whether the principal investigators or the DOE program managers had a good awareness of the Science sponsored basic research program. Certainly, with the VT program more commercialization focused, a good awareness of the SC sponsored basic research programs would be beneficial. One reviewer added that he believed that the DOE funding fraction should be more heavily based in pre-competitive high risk/high payoff programs but with strategic goal relevance that is closely tied with the "relevant" industrial partners.

One person commented that he was very uncomfortable with the description by Mr. Goguen of certain programs characterized as "promotion" of E85 and a "marketing campaign" for light-duty diesel technology. This language, the reviewer notes, if not the programs it refers to, has all of the evidence of the government picking market solutions – just the opposite of what he would expect from an VT that is listening to and assisting industry in technology development.

From a broader approach, one reviewer stated that this is a nearly impossible question to answer. The answer depends on a number of factors, including: the status of critical technologies, both within and outside the DOE R&D portfolio, the business climate, market trends, and the external regulatory environment. And all these factors are continuously evolving. For example, recent major legislative initiatives (EISA and its RFS) could have a significant impact on the nature of the DOE RD&D portfolio. One could argue that regulatory mandates REDUCE the need for DOE investments in certain R&D and commercialization efforts because industry is required to do it anyway.

To some, battery research is critical. To others, development of alternative fuel infrastructure is an important focus.

Regarding specific focuses, one person indicated that the continued development of improved batteries is important to hybridization and all electric vehicles for commuter use. Validation testing at

third party facilities is critical to determine performance vs. claims. He goes on to say that more emphasis must be given to making the entire vehicle safe and lightweight at attractive manufacturing costs. Some of this can also be done with parts consolidation. The balance sheets and market values of domestic auto manufacturers require major cost reductions that can be introduced one vehicle platform at a time. As experience is gained new insights and cost reductions can be applied. This can be a self-funding righteous circle. Possibly government guarantees of loans to convert to lightweight hybrid vehicles will jump start the process. Conventional technologies used today estimate the cost of introducing a new vehicle to the market as over $5 billion and because of capital constraints can take 5 – 7 years to deploy, while Toyota may be in its second or third iteration of a similar vehicle. This budget, the reviewer adds, is off by two orders of magnitude. These three items indicate that most activities be directed to demonstration and much more to deployment.

Another reviewer began by stating that millions of FFVs will be manufactured in the next few years. The deployment of fueling stations to enable these drivers access to the fuel will be critical. There is no value to new car manufacturers of the effects of fuel blends on vehicles five or more years older. This is an area in which VT should lead.

One person stated that the scenario modeling for fuel usage of this briefer was excellent. He also believes that the modeling should include: semi-autonomous and intelligent highway scenarios that "eliminate or at least minimize" the gridlock (and fuel usage impacts) of increasingly dense vehicle environments (urban as well as highway).

Lastly, one reviewer offered a multiple-part response regarding the VT portfolio. He states that, looking at the major external drivers on DOE and VT – namely energy market conditions and recent changes in energy legislation – there is clear interest in more nearer-term outcomes. DOE's historical track record has not been good in this area – this goes without saying, according to this reviewer. However, it does not mean that DOE/VT should not attempt nearer term demonstration and deployment programs. It just needs to be done more smartly. He recommends that VT consider three ideas in this regard.

(1) The first is some form of rapid prototyping initiative, i.e. taking research results and moving them more quickly into engineering development. He would recommend that DOE take a careful look at the DARPA experience in this area, and see if there are lessons learned that can be adapted to DOE/VT.

(2) The second idea is to conduct some planning studies in anticipation of a greater thrust in demonstration/commercialization activities. Three possibilities: (1) analyzing the types of partnerships and demonstration programs conducted by the Japanese and Europeans; (2) doing (or updating) studies of deployment incentives (beyond tax credits); and (3) analyzing (or updating) analyses of opportunities to accelerate fleet turnover (i.e. take greater advantage of technology that already is commercial or near-commercial). These analyses could be very helpful in informing future decisions on the program, and also plans and actions by a new Administration.

(3) The third idea is to develop possible benchmarks for determining if and when demonstration and commercialization efforts are successes or failures. Specific ideas for setting benchmarks may emerge from the VT bus program, or from the studies and analyses described above. It also may be appropriate for VT to conduct some case studies of experiences in other federal or state agencies and programs.

Question 3b: Should VT place more emphasis on deployment and technology integration activities or lessen their emphasis and allow industrial partners to pursue this work? Why?

Reviewers indicated a wide range of opinions regarding VT's role in deployment and technology integration activities. Some people indicated that VT needs to allow manufacturers to do the deployment and integration; industrial partners must ultimately do the work because they know the market, the processes and how to reduce the manufacturing costs and increase the overall quality of the product. One reviewer added that the systems modeling work developed at the national laboratories can enable industry to speed up deployment and system integration. Another person stated that the emphasis is now too short-term and too focused on deployment, and that this will dramatically decrease the impact of the VT if this emphasis is pursued for as much as even two years. Others indicated that industrial partner work was critical and that more emphasis should be made in this area, but expressed concerns about using up DOE's precious funding for short-term industrial demonstrations.

VT should pursue more generic technology development and less company-specific activities.

A major concern of reviewers regarding VT involvement in deployment projects was in those situations where only one corporate entity was involved. One reviewer indicated that, in general, he favors government funding on generic technology enablement, not deployment. Shared demonstrations with many industrial partners involved are again preferable to single company product development. Another person added that there was too much emphasis on deployment in some of the research programs he viewed later in the week. In general, programs primarily conducted within a single company are highly suspect in his view as a part of this portfolio. One other reviewer commented that there should be less emphasis on deployment of specific configurations of engines. These are the things industry can and should do using technologies developed by or with the DOE. He was particularly uncomfortable in discussions during the week in which single companies were working on projects that could not be disclosed with likely competitors. Given the limited VT budget, he would encourage continued emphasis on generic technology development, development and sharing of diagnostic and modeling tools, and multi-company shared demonstrations efforts.

In general comments, one person noted that the Budget Summary for Technology Integration shows this area growing relative to the R&D areas. He added that things do not seem out of balance at the present time. Another review stated that this area is an important element but should probably not be increased. However, the industrial partner element is indeed critical to the overall commercial spin-off potential.

Industrial partnerships are valuable. Experience with these should be shared across DOE. These partnerships should have a deployment element to get technologies to market.

Some reviewers suggested the DOE / VT should take a proactive role in the scenarios where it can be of most benefit. One reviewer wrote that, in general, industrial partners should be expected to take the lead in commercialization. However, this does not mean that DOE should not undertake deployment activities on a selective basis. DOE should undertake deployment activities when and where it has a unique role to play or when industrial partners have not moved forward. Another person stated that industrial partners are critical, and VT is never going to be able to compete with the

DOE and VT should take a proactive role in areas where it has a beneficial or unique leveraging role to play, closing the gap between laboratory and commercial markets.

resources available to the vehicle manufacturers. VT should seek opportunities where its funding will leverage support from industry. One other reviewer commented that DOE efforts on deployment and technology integration should first address critical needs arising from the DOE R&D program – to close the gap between the laboratory and the commercial market for technologies in which DOE already has a considerable investment of taxpayer money. Secondarily, DOE should then undertake only those generalized deployment activities for which a DOE role is critical or unique and which history has shown are effective in transforming the market. DOE should be highly selective and concentrated in its deployment efforts. Successful market transformation requires large investments and it is very easy to spread resources too thin.

The role of manufacturers / industrial partners was also a source of significant interest for the reviewers. One person stated that it seemed over the past three or four decades DOE has experimented with many approaches to deployment and technology integration. The key is flexible partnerships with industry, particularly small companies because they are the most innovative and hungry. The relative share of the funding burden can be adjusted on the basis of individual project or program requirements, but industry should always be required to pay its share. VT has a wealth of relevant experience deriving from PNGV. Are experiences and techniques shared across the Department? What can VT learn from FE, for example? Another reviewer, more bluntly, stated that VT should have a "big stick" nearby to remind manufacturers of the investment in this partnership. Similarly, one person commented that deployment is where the rubber hits the road. Future R & D collaborations with auto manufacturers should have a deployment clause in them so that when the goals of the collaboration are met then these should be in vehicles within an agreed period of time. The penalty may be to revoke some or the entire governmental share of the collaborative funding. High-risk projects can have different terms than lower-risk projects. Why? Too often the developments sit on the shelf waiting for the next major platform change for insertion. By then those that are familiar with the technology may have already moved on to new assignments. One other reviewer wrote that industrial partners should be willing to do more of the deployment work when they identify a technology they believe to be profitable, but noted that technology integration may still require strong DOE input.

Lastly, some reviewers suggested a more proactive role for VT in this area. A reviewer commented that industrial partners are very important, but advanced technology efforts at DOE should not be deemphasized because industries are not necessarily inclined to properly assess these technologies without DOE core funding support. In a similar vein, one reviewer wrote that deployment should be emphasized with the manufacturers. They prefer to remain their comfort zone, even while the company is being downsized. They will keep doing that which they know and feel threatened by revolutionary change. Another reviewer commented that it's all about deployment, stating that we already have a "crippled industry." Others suggested specific roles that the government can play in the deployment activities, with one reviewer writing that the industrial partners need access to loans to rebuild their factories to be ready to incorporate the new systems that are being made available. Most industrial partners have poor balance sheets and may not have access to borrowing funds. Many parts manufacturers have already moved off shore and may need incentives to bring the jobs back to the

USA. A form of loan guarantee made by the Federal Government may be what will have the most impact. Similarly, one person suggested changes in IRS rules to enable corporations to more rapidly write off capital equipment.

Question 3c: How much high risk/high reward research (of the sort that industry would likely not perform on its own) should VT be pursuing?

Multiple reviewers commented on the importance of DOE's role in high-risk/high-reward research, with the general sentiment being that, if DOE does not pursue this type of fundamental work, the high-risk technologies developed will not be properly pursued and/or assessed by the industries themselves. One reviewer commented that DOE should be heavily involved in high-risk/high-payoff efforts with industrial partnership. Another individual wrote that this is the area he believes should receive the major attention. In general, industry consortia working with the Labs is a pretty good model for establishing targets, and the VT is to be commended for this strategy. Another person indicated that difficulty in commenting on this item without information as to relative funding levels within VT. He adds, on the whole, however, it's very important for EERE generally, not just VT, to pursue high-risk/high-reward research as the nation and world are in this for the long haul. One other reviewer stated that high-risk, high-payoff research is indeed important and he believes that the amount of funds in this category should be increased to better reflect the governmental "pre-competitive" nature of DOE's mission.

High-risk research is important since industry is not likely to undertake this work, and it can yield rewards for the nation as a whole.

One reviewer stated that, at one time, EERE did have a high-risk/high-reward research program. Called ECUT, this program was more applied than anything sponsored by the Office of Science, but more fundamental than the core EERE research programs. The Office of Fossil Energy (FE) also used to sponsor such a program. He added that, in the case of FE, they found that a high percentage of the high-risk research programs moved into the core research program and eventually resulted in products that moved into the market place. So, the high-risk research programs were indeed high-reward. Thus, based on experience, there is merit to dedicating a portion of the budget to high-risk/high-reward research. Finally, similar to above, he states that industry in general is unlikely to sponsor such high-risk research even with the prospect of a high reward.

Reviewers generally agreed that DOE should pursue a significant amount of "pre-competitive" high-risk/high-payoff research, with one reviewer adding that it is safe to state that DOE should fund more unique research in general – starting with the highest priority areas of the DOE strategic plan in VT. Another person indicated that he believes that on the order of 10% to 20% of the portfolio of VT should be of this nature (high-risk/high-payoff). The bulk of the portfolio should be focused and implementable R&D, perhaps another 60% to 70%. The remainder, perhaps 20% to 30%, should be deployment and integration. One reviewer suggests a budget of 5% of the total be for pursuing new ideas and conducting Pasteur Quadrant-like research cooperatively with the Office of Science. He suggests a LDRD seed money type program be developed to stimulate new ideas, adding that SBIR is not the same thing. The money could fund projects in industry, academia or in the Labs. LDRD has been enormously productive over several decades. He asks, why not use the idea and expand on it? One other reviewer states that high-risk, high-reward research should always form a credible part of the VT portfolio. In terms of funding, he indicates that 15 - 20% would seem to be a reasonable target

number, depending on exactly how the program defines "high risk, high reward." Does this term include all basic and applied materials, fuels and combustion research, or just the more far-out conceptual projects? The specific magnitude of funding also depends partly on funding levels by the Office of Science in VT-related areas. VT should work closely with OSC to gain as much "basic" research funding as possible in areas related to transportation technologies, pushing the envelope between basic and applied in VT's favor as much as possible.

Multiple reviewers indicated that none of this high-risk/high-reward research should be with the FreedomCAR partnership. One reviewer stated that the FreedomCAR and Fuels Partnership is designed more to be a demonstration and deployment program. The high risk/high reward research should be done outside the partnership. Another stated that, without industry participation, the rate of adoption of new technology will be even lower than it is now. But he adds that the high risk/high reward portion should not be a part of the FreedomCAR Partnership.

High-risk research should be outside the FreedomCAR and Fuel Partnership.

Speaking generally, one reviewer commented that there always will be new ideas for R&D, and he doesn't think anyone can specify all of them at any given time. Instead, what is needed in the VT portfolio is a research program area, or a process, or both, that can anticipate the need for, and support new ideas (most likely investigator-initiated), and assess further R&D opportunities on an on-going basis.

One reviewer asks if anyone is working on wireless energy transmission for quick remote charging of batteries, or if there is a way to use the huge amounts of CO_2 that will be captured from power plant exhausts for making carbon composites for automobiles?

Lastly, another reviewer emphatically states that, regarding high-risk/high-reward, it is critical to couple these two phrases. Generally, he has serious concerns over some of the polymer composites research in this regard. It is certainly high reward if actually adopted. But he does not share the belief held by some advocates that graphite-reinforced composites will make significant impacts on the body-in-white in the next decades. Prior to that, if there is a sufficient reduction in price and improvement in various technologies, there are some highly specialized parts on ground vehicles that could be entry points leading to modest weight savings with modest cost offsets. He goes on to state that, if DOE had a realistic view of the entry path to market (as can be readily followed from the history of composites development in the DOD and eventual tortured transition to significant commercial use by Boeing in the 777 forty or more years later), a different VT program would evolve. He believes, for example, that near-term focus on applications outside of vehicles (e.g. wind power) would focus the R&D, lead to more likely near-term adoption and "incentivize" the development of a carbon fiber industry that is unlikely to evolve if it must wait twenty years or more before significant masses of fiber are actually introduced into vehicles. One thing is almost certain, he adds, the current target of $5-7 production costs do not even begin to include the capitalization costs that industry would need to invest and the infrastructure transformation required to deal with the waste product. He closes by stating that nothing he said here should detract from the quality of much of the research, but he believes that some, perhaps much, of it would not be justified under a more realistic scenario of likely application.

Question 3d: How well does the VT research portfolio reflect the balance of research needs for and the relative importance of the light-duty and the heavy-duty vehicle sectors?

There was some disagreement surrounding the amount of support given to the heavy-duty vehicle program. Multiple reviewers indicated that, while research needs were well represented in the light-duty section, there had been too many cuts in the heavy-duty sections, to the degree that it was now noticeably under-funded. One reviewer stated that more emphasis on heavy-duty trucks is needed and on coupling trucks with rail, but not at the expense of reducing effort on LDV. Similarly, another reviewer commented that light-duty research seems to be covered relatively well, but heavy-duty research is dramatically and significantly decreased below a critical mass needed to provide successful results – at least from within the DOE program.

There have been too many cuts in the heavy-duty budget, perhaps below a critical mass necessary for success.

Multiple reviewers stated that they felt they were not given information regarding the balance of current research needs. One person added that it seems VT is planning to put more emphasis on light-duty vehicles, and that this seems appropriate as petroleum consumption of light-duty vehicles easily exceeds that of heavy-duty vehicles and there are seemingly more opportunities for improvement in light-duty vehicles such as PHEV's, diesel engines for light-duty vehicles (including cars at some point), and alternative fuels. One review followed up by stating that part of the answer depends on the market readiness of each sector to adopt technologies, particularly technologies that may apply to both sectors. This factor, as well as others, could alter the balance that might seem appropriate based simply on aggregate sector fuel consumption. Another person, similarly, commented that it looks the VT program has given up on the heavy-duty vehicle programs. He states that APUs and electrification are very much needed, but does not state by how they should be pursued. Making trucks more aerodynamic is now just a function of collaboration between manufacturers and labs with wind tunnels. Since the trucks and trailers are made in much smaller volumes and fuel efficiency is so important to their operating margin, acceptance of the design changes may be rapid.

Other reviewers felt that the VT research portfolio seemed like it had a good balance between the two sectors, but the absolute funding amount should increase to properly assess the most promising technologies. One person noted that vehicle manufacturers have been reducing their R & D staffs, and that this program is critical to their survival.

The light vs. heavy balance is good, but absolute funding levels for both needed to increase.

One person suggests that the research needs for and relative importance of heavy and light duty need to be considered, but more importantly the heavy-duty sector makes a much more effective area for technology development, so a much stronger emphasis should be placed on developing technology in this sector and then applying it in the light-duty sector, with research portfolio design specifically articulating this strategy. Adding to this, another reviewer states that there appear to be large R&D opportunities in the area of heavy-duty vehicle technologies, but these need to be placed in context with the needs in the light-duty market. Given the consolidation and globalization that has taken place with respect to heavy-duty vehicle manufacturers, perhaps there are further opportunities for leveraging of R&D investments in this area.

Question 3e: Are there areas of research outside the current VT portfolio (such as pure electric vehicles, new fuels, and so forth) that DOE should consider for investments in research funds?

One reviewer briefly mentions that the current VT portfolio should expand to include heavy-duty truck APUs, streamlining, and electrification, while a number of other reviewers that that alternative fuels (especially non-ethanol) needs to be better funded. One reviewer comments that, in terms of fuels, ethanol is receiving all the attention these days at the national level. But ethanol has many problems, and alternatives should be pursued. Another reviewer stated that new funds should go to alternative fuels and advanced internal combustion engines, with unique hybrid engine considerations also a high priority. Similarly, one person commented that alternate fuels (innovative blends) and advanced (unique) vehicle technologies are prime areas for strategically and surgically made DOE research investment opportunities. One other person noted that it appears that a lot of hydrogen R&D has been done or is underway, and it would be appropriate to phase this down. Without a large new source of hydrogen supply, it would appear that hydrogen likely will have a niche role in the near-term and mid-term, e.g. in special applications, such as fleets, or in limited dual-fuel applications.

Additional research areas suggested: truck APUs, alternative fuels, advanced engines, diesel-like combustion techniques, and carbon management modeling scenarios.

One reviewer stated that he felt all relevant research areas seem to be covered, but often not in a sufficient critical mass to make a significant difference in a timely way. He, like the reviewers above, suggests placing a premium on alternatives other than ethanol. Ethanol from corn is getting a lot of bad publicity these days because of rising food prices. While ethanol from cellulose is what everyone is expecting to get us beyond corn, there are many potential environment impacts. The effects of alternative fuel blends on new and existing vehicles needs to be studied. The vehicle fleet takes about 15 years to turn over. The reviewer asks, how will these blended fuels affect these older cars and other internal combustion engines? Similarly, one review asks, will new lubricants be needed with these new fuel blends? How will they affect air quality?

Advanced diesel technologies are also of high importance to some reviewers. One person comments that diesel-like combustion cycles still have by far the most promise for major fuel consumption reduction, in both heavy and light duty, through efficiency improvements with attendant low criteria pollutant and CO_2 emissions. He continues that this is why, worldwide, diesel fuels are in high demand and short supply, and since fuels are traded freely worldwide, this is the reason that diesel fuel is now $0.50/gal more expensive than regular gasoline in the US, even though production cost is around $0.30/gal less for diesel than gasoline. He believes that fuel savings in the U.S. therefore will depend for technical viability on development of clean diesel-like combustion engines and will depend on widespread market acceptance on the simultaneous development of inexpensive fuels to match these cycles. This will require highly saturated hydrocarbon refinery feeds from domestic sources and will require very high volume feed production to press costs down. This technology is the likely the only way to improve both combustion engine vehicle fuel efficiency and hybrid engine vehicle efficiency in very large fleet sizes.

In a similar vein, one reviewer asks, are there cleaner and cheaper replacements for the Fischer-Tropsch process for making diesel fuel? Another person commented that light-duty diesel engines were mentioned (such as the new Cummins/Dodge project) but it was not clear how large the overall

effort was. He adds: diesels are an important pathway for automobiles (not just light trucks) and should be appropriately addressed in the program, including near-term deployment efforts, given the rapidly evolving status of this technology and the huge market uptake in Europe.

One commenter indicated that DOE should enhance the development (already providing good results) of modeling scenarios for carbon management (the reviewer here references the EPA CO_2 Senate Bill) which will have dramatic effects on the fuel efficient/CO_2 tradeoffs throughout the U.S. for many years to come.

Another person stated that the main limitations to pure electric vehicles are the limitations of currently available batteries. To the extent that the R&D on high-energy batteries for PHEVs results in improved batteries for that application, then those same batteries (or modifications there to) are likely to be adapted for pure electric vehicles.

The reviewers disagreed on funding for pure electric vehicles, with one stating an emphatic NO to this category of vehicles, while another person stated that the pieces for pure electric vehicle are in place now, and that VT should continue funding battery and power electronics technology to increase vehicle range. One reviewer, in a multi-part response, states that considerations for new research areas, or areas for additional funding, need to be evaluated on a corporate DOE basis. For example, as noted in the reviewer's answer to an earlier question (see Technology Review, "Plug-In Hybrids: Tailpipes vs. Smokestacks""), unless DOE's investment in demonstrating CO_2 sequestration is successful and results in the wide deployment of CO_2 sequestration, plug-in hybrid electric vehicles, or for that matter all electric vehicles – where the electricity would come from conventional coal-fired power plants with no carbon sequestration – do not reduce emissions over currently available gasoline hybrid vehicles. The reviewer adds that investments in new fuels have the same caveats (he references an attached article from the Economist, "Ethanol and Water Don't Mix," March 1, 2008). This article notes the high demand for water required in current ethanol processes, and states that "A backlash against the federally financed biofuels boom is growing around the country, and 'water could be the Achilles heel' of ethanol…." So, the reviewer concludes, consideration of new or supplemental investments in research requires a strategic and integrated portfolio evaluation.

Question 3f: Comment on the level of DOE's investment in enabling technologies (i.e., those that do not directly achieve petroleum reductions but rather enable the use of other technologies that do achieve petroleum reductions, such as materials, heat and mass transfer technologies, etc.) and the types of projects that should/should not be funded.

Multiple reviewers stressed that the investment in enabling technologies is appropriate and that the overall portfolio mix is about right, with one reviewer adding that the work on materials is paying off "big-time." Multiple reviewers specifically stated that this category of work at DOE is very productive but requires a significant increase in funding to adequately meet the DOE goals. Another reviewer noted that there was a good current overall portfolio in enabling technologies, but warned that decreasing research emphasis for the Government (DOE) is dangerous.

Enabling technology investment levels are appropriate. VT should consider fuel blend impacts, traffic gridlock, truck APUs, and biodiesel from non-food crops.

More specifically, some reviewers pointed to

individual enabling technologies that they felt should be explored more fully. One person commented that VT needs to look at the impact of different blends of fuel and the impact these have on new and old ICE engines, while another reviewer stated that anything VT programs can do to eliminate gridlock will help. One reviewer stated, similarly to their previous comments, that work on APUs for heavy-duty trucks and their electrification should continue. Another person suggested that DOE needs to invest in technologies that make biodiesel from non-food products, such as renewable crops, algal systems, and gasification.

A number of reviewers felt that they were not provided information on the current level of DOE's investment in enabling technologies, but that, from their point of view, such research is very important to continue and there can always be unanticipated benefits. One reviewer stated that, in general, the investment level in enabling technologies must be based on their degree of leverage in achieving the goals. This has to be informed by systems analysis. The conceptual linkage between advances in materials and heat transfer technologies has to be clearly described and quantified in an analytical framework that is consistent among all technologies in the VT portfolio. The existence of such a framework and its routine use to inform decisions, the reviewer adds, was not evident in the Plenary presentations. Another reviewer added that materials always play an important role in any new technology development. He adds that it's difficult to comment on the precise level or percentage of a program that should be devoted to materials, but it is an important part of the VT program.

One commenter stated that R&D on enabling technologies, such as high-temperature materials or carbon fiber manufacturing, is a high priority, in part because of the many areas of applications. However, in view of the many competing demands on VT, this reviewer comments that it is not appropriate that support for these technologies fall solely on VT, or to the VT budget line item. He would recommend that VT initiate a study, with participation of other DOE offices (FE, NE, OS, CFO) to look at options for how the enabling technologies should be managed and funded, including options for putting this work under a separate management structure, or keeping it within VT, but perhaps as a separate budget line item that would have less conflict with VT-specific program objectives. This is especially needed if VT is going to continue the current trend to place a greater focus on nearer-term RD[3].

Enabling technology R&D is a high priority, but not solely the responsibility of VT: other DOE offices should participate.

Lastly, one person suggests VTP should work very closely with BES and OER to crosscut the stovepipes more effectively. BES has made a very good start with its technology problem oriented workshops, but a strong follow-on is required. One area needing strengthening is electro-chemical, electro-physical and electro-biologic research.

Question 3g: Is the VT investment in environmental and health impacts assessments of its future technologies appropriate and useful? Why?

Numerous reviewers commented on the overall importance of VT investment in environmental and health impacts assessments, with comments ranging from it being appropriate and useful to being absolutely necessary. One reviewer added that the assessment of the consequences of the DOE programs was necessary to assure that research guidance provided from the DOE programs does not lead the industry and the country to deliver fuel consumption and emissions reductions with unintended consequences to human health and the environment. These assessments must be done

from the very earliest stages of research and should be an integral part of the VT thinking. Similarly, another person stated that analyses should be done before investments are made, and as technologies are maturing. These kinds of assessments and evaluations could help prevent the kinds of situations described in The Economist article, where water usage for ethanol production may make many sites for potential production facilities unfeasible. This needs to be part of the VT scope of responsibility, but perhaps could be greater leveraged, either with DOE (BER), EPA, NIH and industry. In other words, VT needs to be cognizant of the health and environmental issues of its fuels and vehicle technologies, but perhaps can leverage other research resources to a greater extent. Other reviewers commented that this activity had insufficient funding.

Health impacts work is appropriate, useful, and (to some) absolutely necessary.

Another reviewer stated that the environment is crucial, adding that the transportation sector emits more GHG than power plants, but cleaning up the NOx and particulates is still key to diesel and other compression ignition systems, contributing as much to oil-use reduction (and GHG reductions) as their potential promises.

Multiple comments were made regarding the insufficient amount of information given in this area. One reviewer stated he could not tell from the four plenary presentations, nor from the FY 2009 VT budget request, whether there is an investment being made in environmental and health assessment impacts of future VT technologies. He went on to add that the Plenary presentations provided no information on the amount of investment in environmental and health impacts of future technologies, yet it is critically important that these issues be explored comprehensively, including the impacts of alternative fuels on global food supply and land use. Regarding PHEVs, these studies should include a very realistic and unbiased assessment of impacts on the electric system, in terms of its capital investment and operations as well as emissions.

One reviewer referenced that the February 25, 2008 edition of *USA Today* had an article citing several studies that suggest that PHEVs will increase emissions in regions heavily dependent on coal-fired powered plants. The reviewer adds that it would certainly be best to avoid any future MTBE-like situations where a promising transportation-related technology had problems that could have been avoided if there had been some in-depth studies ahead of time. In the process of going to a hydrogen economy, many pollutants will be released into the air especially when coal is used as a source of the hydrogen. CO_2 capture must also be considered.

Question 4: Please provide any other comments you may have on the overall VT program.

Multiple reviewers commented that, overall, the VT program is well thought out, well managed, interesting, and effective. One reviewer commented that there had been continuous improvement every year. Multiple reviewers, with regards to overall funding for the VT program, commented on the limited financial resources / under-funding of the program. One of these reviewers noted the urgency in reducing petroleum use and CO_2 emissions, noting that he appreciated that, as part of a Federal Agency, VT can't advocate for a different budget than the DOE Request. Another reviewer noted that the review itself was well-conducted and handled.

The VT program is well-managed and effective, but funding is limited.

One reviewer stated that he was generally impressed by the overall quality of the R&D portfolio. He added that this was based upon the quality of the presentation materials, and well as quality of the detailed congressional budget justification write-ups.

With regards to deciding the RD³ strategy for the program, one reviewer commented that VT has turned to models and that these are becoming better tools thanks to the VT investments. He goes on to add that both policy and technology changes need to be modeled. The next administration will be much more interested in managing GHG and will support policies that will tax carbon emissions by some means, and it will subsidize low-emission fuel and transportation technologies. He notes that VT should factor this likely trend into its decisions about the portfolio. VT may have to pay EIA to help VT change and run NEMS to answer the right questions. It looks like the right portfolio of models is being or has been assembled.

Another reviewer added that he was most impressed with the presentation on economic analysis presented by Mr. Patterson. He encourages expansion of this effort in two directions: first, the path of improving and updating models used to reflect new understanding and realities is critical. Second, he recommends adding some modest amount of retrospective analysis to "prove" the cost/benefit value of some VT efforts in past years. Not only is there obvious political value here, but, if properly analyzed, such retrospectives can aid in future program planning and execution.

One reviewer commented that little was said about the other transportation and transport modes. He asks: should aircraft, rail and ships be included? If not VT, who?

Another reviewer acknowledged that VT has a very broad programmatic scope, having to address R&D requirements for different classes of vehicles, and address both fuels and vehicle technologies. He noted that this creates two major management challenges: achieving an overall level of resources commensurate with the program scope, and prioritizing R&D projects within this broad scope. He adds that he is not suggesting that the program be reorganized (except for enabling technologies, which he discusses later), but that he is simply stating that these challenges may be larger for VT than for other program offices in EERE. VT is organized by areas of technology and most of the information is presented in that structure. However, he thinks that there is a need for a better integration matrix that better connects technology organization to end-use markets – light vehicle, heavy duty, etc. Also, he indicates a need for a third dimension of the matrix that identifies the major programmatic thrusts. Although it was not specifically stated this way by the presenters, his take-away from the plenary presentations was that there are three program thrusts: more efficient engine/vehicle combinations, fuel diversification (e.g. ethanol, hydrogen), and electrification. External observers need to understand all three perspectives in order to fully appreciate the program portfolio.

The broad VT program scope creates management challenges in having sufficient resources to accomplish the scope, and prioritizing work appropriately within the scope.

Two reviewers commented on the need for a wider view in approaching some of these different challenges. The first stated that the imbalances and disconnects with the most current research findings worldwide are driven by political guidance that almost always is received with no opportunity

for dialogue and thus does not have the benefit of the technical currency of the VT staff. He adds that a small program budget activity that documents and reports emerging technology findings worldwide for strategy consideration might offer a means to engage a bit more in strategy dialogue with those who provide guidance to VT. This activity should probably also articulate potential unintended consequences of specific strategy directions.

The second reviewer suggested that DOE needs an oil security "czar" who would look comprehensively at the energy problem from all its many aspects, technology, policy, resources, costs, environment etc. He notes that DOE has many of the pieces, and that he hopes DOE will put it all together. One good way to start a comprehensive analysis is to follow the lead of the National Commission on Energy Policy.

Project partnerships and the complicated relations between government and industry entities were also commented on by a number of reviewers. Multiple reviewers noted that funding needs to be increased and manufacturers / U.S. partners need to speed up deployment of advanced technologies on a large scale. One of these reviewers added that this is one of the most critical programs to keep high-paying jobs in the USA, and it needs more funding to broaden the scope. Both government and automotive industry forces were of concern, with one reviewer commenting that it was not clear how much mission-relevant RD^3 the automotive industry is supporting. He adds that they are almost certainly not investing as much as they need to. Another reviewer added that the issue of the government role in energy R&D is becoming increasingly more complex, with perhaps an especially difficult challenge for VT.

Traditional paradigms for government research are being challenged. Energy legislation is sending signals for the government to take a more active role in energy R&D.

In a similar vein, another reviewer wrote that, in general, the traditional paradigm – i.e. government support for technology creation (i.e. basic and applied R&D) and industry leadership in technology application (development, demonstration and deployment) – has become increasingly blurred. For example, in some technology areas (electronics and biotechnology industries), venture capital has become a major source of R&D investment for technology creation, with the expectation that new discoveries will be brought quickly to market. Some industries have reduced their role as R&D performers, and have entered into more partnerships with universities to perform R&D. Finally, the 2005 and 2007 energy legislation, and pending climate legislation, signals Congressional intent for the government to take a more active role in accelerating the R&D process, and towards taking a more active role in commercial demonstration and deployment.

The reviewer adds that, for VT specifically, determining the appropriate government role in vehicle technology R&D is further complicated by the relationships between the government and the vehicle manufacturing industry. The government's primary role is safety and environmental regulation, and so the government-industry relationship is mainly an adversarial one. Also, industry product plans tend to be more secretive than in other business sectors that partner with DOE. This creates challenges in determining if the VT R&D portfolio complements private sector R&D, and especially in assessing whether VT programs can accelerate the pace of technological innovation.

Another reviewer pointed out that one major point that was not addressed in the presentations is that VT R&D must be very cognizant of the optimization challenges in vehicles. A commercially successful new engine or vehicle technology has to be optimized to achieve multiple-objectives: performance, energy efficiency, cost, safety, infrastructure (including fuels), and disposal. This adds to the technical challenges of selecting R&D projects and is especially difficult in commercialization. How these multiple objectives are assessed in R&D project planning was not discussed.

Lastly, and also regarding governmental influence, one reviewer commented that a general impression that emerged from the plenary presentations was a need for better integration of the VT R&D portfolio with new and emerging federal regulatory requirements, including the new CAFÉ standards, the new RFS. and the new EPA rulemaking on tailpipe CO_2 emission standards. In addition, he comments that it is increasingly likely that the next Congress will enact a mandatory greenhouse gas emissions reduction program, most likely through cap-and-trade, which will further complicate the relationship of VT R&D to the commercial market. He suggests that VT needs to more effectively plan and/or articulate the relationship of its program to the changing dynamics of the regulatory environment affecting vehicles and fuels. While the Bush Administration remains opposed to mandatory requirements for greenhouse gas emission reductions, it would appear to be appropriate for VT to conduct studies and analyses of the possible interaction between potential new regulatory requirements and the scope and schedule for VT R&D.

Questions and Answers with the Reviewer Panel During the Plenary Session

Questions from the Reviewer Panel

Q: What process do Project Managers use to measure success to make sure the programs are making progress?

- A: (Ed Wall) The ultimate measure of success is whether the technologies make it to the marketplace and save petroleum. This process of moving technologies to the marketplace, however, can take many years. For example, the Cummins light-duty diesel pickup truck motor was developed using DOE money starting in 1996 and will reach production in 2010.

Q: How are these technologies prioritized?

- A: Sometimes through direction from senior management: there has been some effort recently to reorient the portfolio to nearer-term work to fit the Assistant Secretary's vision. DOE also looks to analytics and its expert judgment to determine where to place its funds. The decisions are often difficult, but must be made on the basis of maintaining emphasis on the biggest petroleum savings areas.

Q: The safety implications of each of the technologies and programs were not mentioned. The technologies will need to be evaluated to ensure that the public safety is not compromised (e.g. lightweighting materials affecting the crash performance of a small car and a large SUV). These new efficient vehicles must be "ultra-safe" for consumers. Also, since we are looking at technologies for 20 years out, what assumptions are being made within the program on carbon management (carbon taxes and the like) to decide on the research focus.

- A: (Ed Wall) Safety is incorporated in each technical area, even if it was not explicitly mentioned earlier. For example using lightweight materials to decrease vehicle weight by 50 percent will be done while also maintaining or increasing the utility to the customer and the safety of the vehicle.
- A: (Ro Sullivan) Similar goal wording appears in the battery technical area. Each of the PHEV contracts addresses safety. VT will now be examining safety more closely now that a portion of the hydrogen program dealing with safety and codes/standards has been moved into the VT budget. It may be a good idea to centralize the safety for both programs in one activity.
- A: Relative to carbon management, VT is not including any carbon taxes or other carbon management concepts in its modeling.

Q: Since it takes quite a bit of time for new technologies to make inroads to the market, and since few vehicles are currently made in very large quantities (market fragmentation), can DOE use its loan guarantee authority to assist manufacturers in making the critical move toward lightweight materials in niche vehicles as a way to help manufacturers through the critical learning period before moving to mass production? Can VT work with OEMs to significantly incorporate lightweight materials on a few niche vehicles (30,000 – 50,000 annual sales) to use as a learning process to give them the experience to reduce the cost to enable use of these materials on other higher-production models?

- A: (Ro Sullivan) Yes, and DOE has worked with OEMs to have lightweight materials incorporated into production models in the past. For example, the engine cradle for the Chevy Corvette Z06 was designed in magnesium to reduce weight, and these vehicles are on the road now. However, the costs need to come down before they can be widely incorporated on typically passenger cars.
- A: (Ro Sullivan) The loan guarantee program will potentially help manufacturers incorporate lightweight materials in their vehicles. VT has submitted such ideas to the proposal process for

loan guarantee projects within DOE, and if these ideas make it to the final proposal process, this will help.

Q: The health and environmental impact of these technologies was not discussed. VT needs to make sure that new technologies do not have unintended consequences and cause harm to either people or the environment.

- A: This will be addressed in detail during a specific Health Impacts session at the merit review meeting: the program addresses fuel and combustion consequences of new technologies.

Q: Ro Sullivan mentioned the downward trend and low funding level for heavy-duty vehicles. What VT heavy-duty programs remain? Will this "pendulum" swing back to heavy-duty research?

- A: (Ed Wall) There have indeed been shifts in recent years in the heavy truck area. VT has attempted to maintain the funding for core projects with the largest petroleum reduction impacts (combustion and aerodynamics) even though the overall funding has decreased. VT has cut back on other areas, such as medium-duty hybrids, that do not use much fuel and thus will have less potential impact. This specific application is already being addressed in the market through hybrid vehicle options from Eaton and Oshkosh. Heavy vehicle lightweighting is not being addressed directly as the petroleum savings are limited to second order effects (i.e., more cargo will be carried if the vehicles are lighter) and these materials have cost considerations in these applications. Advances in these materials, low-cost carbon fiber for example, for light-duty vehicles can reduce the costs of these materials and benefit the medium- and heavy-duty vehicles once the materials are available.

Q: The portfolio seems to be very well balanced, but can be refocused because of political input (PHEVs and biofuels, for example), that may not have been included previously, or were not a primary thrust. Many of these new directions don't involve dialogue among interested stakeholders. Could DOE develop a program that captures new directions and their impact on strategic directions and document this? There isn't currently any way to open a dialogue on this at present.

- A: Staff do track advancements and developments worldwide and maintain their knowledge base. VT has recently initiated work to identify and evaluate potentially disruptive technologies with three entities that have worked with DOD and the CIA. Also, VT had a $1 million PHEV assessment several years ago, and were thus ready to quickly make the leap to a major PHEV program when it became a White House focus.

Q: The plenary reviewers are asked to assess the balance of DOE programs, but do not have enough information, especially budgetary, to adequately review the programs and projects to determine whether the research and funding shifts from year to year is appropriate. Subtle shifts have been made, and it is difficult to determine the magnitude of these.

- A: (Ed Wall) VT staff will get the reviewers a detailed full budget breakdown. Directions for the program are shown in the areas of emphasis discussed in the budget requests and in the response to that request by Congress. (For example, Congress emphasized hybrids in its last appropriation language.) In general for 2009, funding levels have been flat except for a $7M increase for battery development and a $3M increase for non-petroleum based fuels. The shifts in projects within the programs are not captured at this level. As noted earlier, $31M of additional funding in the 2009

request came from moving several hydrogen programs to VT. Funding trends between 2007 and 2008 were similar.

Q: The suite of models used in the program (and their capability) is amazing. Gasoline PHEVs were part of the discussion, but was a diesel PHEV evaluated? It was not shown in the presentation. Also, how close are we to the goals of PNGV (80 mpg)?

- A: (Phil Patterson) We don't get to the 80 mpg goal with any of the technologies we've examined. The fuel economy values used come from the Argonne National Lab PSAT model. Diesel HEV and diesel PHEVs are certainly possible. The model may not show any significant sales because it is accounting for the fact that the diesel fuel pool may be used up by other vehicles, with not enough additional fuel to allow for diesel HEV/PHEVs to have a significant presence.
- A: (Ro Sullivan) VT has tested all of the PHEV conversions and has seen above 100 mpg in some, but this is not accounting for electric energy use to charge the pack.

Q: Is there an Oil Czar within DOE looking at all aspects of oil use?

- A: (Phil Patterson) No, that's an issue, as many sectors using oil are not currently being addressed.

Q: The current best estimate is that diesel fuel costs $0.30/gallon less than gasoline to produce, but costs $0.50/gallon more than gasoline at the pump, because of world diesel demand and the imbalance of refinery capacity in the U.S. The rest of the world is moving faster than us on diesel fuel, and this is straining capacity which will likely result in increased diesel fuel costs. How does the VT work influence this? This issue will be a limitation for light-duty diesels.

- A: (Phil Patterson) The refineries in the U.S. are set up to produce more gasoline than diesel. Because fuel demand is a global system, some of the diesel fuel is exported, while gasoline is imported. As time goes on this problem, and the price difference, will get worse, especially as the heavy-duty sector (almost entirely diesel powered) is growing quickly. This is a complex situation.

Q: The modeling looks impressive, but has VT evaluated the values and estimates used as inputs to determine if they are accurate? Have studies been done looking at alternative research portfolios to show the potential impacts of other technologies getting to the market at all, or sooner, based on higher funding and activity levels? What is the effect of a change in investment on a change in technology?

- A: (Phil Patterson) A risk model is being done now for the first time. In general, as funding for a technology increases, the risk decreases and the probability for success increases due to the additional R&D and marketing. Kevin Stork is the VT staff member who is leading this effort, but similar efforts are being done across EERE.

Q: What about the rebound effect (increased fuel efficiency resulting in increased VMT and reduced fuel savings): are there plans to examine the magnitude of this effect?

- A: (Phil Patterson) The UC Irvine work is sufficient to estimate this effect at present. This effect is relatively low at this time. Changes result from the general increase in affluence of the nation.

Q: Is the impact of intelligent highway/automated vehicles (i.e. Intelligent Transportation Systems [ITS]) on fuel (reductions in gridlock and the like) being modeled?

- A: (Phil Patterson) Not yet, but this could be represented somewhat by reducing VMT for passenger cars. Mode shifting for transport is not modeled. The modeling team would like a list of suggestions from the reviewers on these ideas.

Q: In reference to DOE marketing and promotion of technologies, this is tied intimately to policy/subsidy efforts. To what extent will these get integrated?

- A: (Phil Patterson) Programs like Clean Cities help this by making these new technologies more attractive: this effect is being modeled now.
- A: (Ed Wall) There is interest in understanding the policy activities with the greatest impacts. Harvard recently conducted a study of hybrid purchases by interviewing hybrid owners to determine what mattered most to these purchasers (fuel cost was third, based on the preliminary information). Studies such as this can inform policy makers to get the best "bang for the buck". UC Davis has conducted a STEPS multipath analysis program to get at similar information. Studies on driver psychology have indicated that fuel economy displays (such as on the Prius) have a positive impact on fuel efficiency because drivers seem to drive less aggressively (creating a kind of competition on how high they can get the display to go).

Q: As hybrid transit buses are becoming more popular and widespread, is VT including these advances in the modeling?

- A: (Phil Patterson) Transit bus fuel usage is so small compared to the overall fuel usage, that it does not show up on the chart, so including the impact of hybrids would not be worth the effort. It is useful to keep aware of this sector, however.

Q: What is VT doing on ultracapacitors? How much funding is being put toward this?

- A: (Ro Sullivan and Tien Duong) VT continues ultracapacitor work with a small effort (less than $1M annually) that is focused on evaluating commercially available ultracapacitors. Historical benchmarking of these devices has also been done back in the late 1980's and 1990's. DOE funded research by two companies, but that work has been completed. The main reason DOE has not pursued more research is that ultracapacitors have very poor specific energy (<3 Wh/kg) and energy density (<3 Wh/liter), making packaging difficult. DOE has looked at asymmetrical capacitors, but these are very expensive, especially when compared with lithium-ion batteries. There are, however, opportunities for ultracapacitors in urban medium- and heavy-duty vehicles with frequent stop/start duty cycles that require large amounts of power, but not necessarily energy, to accelerate the vehicle. They can be included in stop-start systems that provide idle shutoff for the vehicle to save fuel.

Q: A recent Supreme Court ruling required EPA to develop CO_2 regulations in the next year. However, it may be difficult to add a CO_2 standard on top of the Renewable Fuel Standard (RFS). What is VT doing to assist and how will this affect future decisions on technologies and funding to meet these requirements?

- A: (Ed Wall) VT supplied data to EPA, but the form of the CO_2 standard seems to be shifting to be included in the new RFS, rather than being separate legislation.

- A: (Phil Patterson) CAFE and CO_2 standards are in competition since both are essentially fuel economy standards.

Q: EPA must legally do something on carbon dioxide emissions from vehicles. What are the technology tradeoffs between CAFE, RFS, and CO_2 legislation, and how does this affect diesels?

- A: (Phil Patterson) CO_2 legislation may hurt diesels, since carbon taxes will drive carbon out of fuels, and PHEVs powered by carbon-free (i.e. renewable) or low-carbon generated electricity will have a lower CO_2 footprint than diesel.

Q: How will long-term emission studies on new and old flex fuel vehicles (FFV) have on future FFV implementation?

- A: The big challenge was set by the 36B gallon biofuel mandate by 2022 in the RFS. This will put a huge amount of biofuel into the transportation sector. FFVs have been in the fleet and have been effectively used on E85 where the fuel is available (typically near the production in the Midwest). The RFS will represent a step change in the amount of fuel and even though the E85 fueling infrastructure is being improved, it is doubtful that E85 and FFVs could use all of the additional biofuel. Currently only E10 and E85 are considered and accepted for use in vehicles. Intermediate blends between E10 and E85 are not approved fuels for non-FFVs. This is why the DOE is evaluating the effects of lower level intermediate blends (e.g. E10-E20) on the legacy fleet of vehicles not designed to use ethanol, to determine the effects on the vehicles and emissions. Emissions increases will be a showstopper, so analysis of this effect is included. In addition to the legacy on-road engines, there are millions of engines in small handheld equipment (e.g. weedwhackers, chainsaws, etc.), lawn equipment, golf carts, and many other applications, so the effects of these higher ethanol blends on these engines are included. DOE has put together a test program to make the right decisions on intermediate blends on emissions and utility.

Q: Half of the advanced materials budget is on carbon-fiber and carbon fiber components, but VT has been working on these materials for a long time with very little progress relating to commercial applications. What justifies the risk (not the opportunities) to the expense?

- A: (Ro Sullivan) A risk study was just completed by a 3rd party for carbon fiber from low-cost carbon precursors and conversion technology. The initial goal for low-cost carbon fiber was $3/lb, but the goals have been adjusted recently to $5-7/lb based on the cost study. The study showed that low-cost precursors and low-cost production could meet that revised target.

Q: What is the current earmark level?

- A: (Ed Wall) The Vehicle Technologies Program was moved from the Interior to the Water Committee for FY 2006. A total of $16M in incremental funding was provided to cover earmarks, but this was offset by $24M in earmarks ($8M had to be made up with existing funds). 2007 was a year of a continuing resolution, so no new earmark projects were added. The 2008 budget that was shown in the presentation earlier did not include earmarks, which were an additional $18M in a separate package over and above the budget.

Q: What are the VT thoughts on the carbon legislation being considered on the Hill? The bill probably won't pass this year, but may do so in 2009 or 2010? What about the cost of electricity under a carbon constrained world (might it increase 50 percent)?

- A: VT has made a significant investment in PHEVs, keeping the sensitivity of both electricity and petroleum pricing in mind, even if electricity prices may rise more rapidly in the future than gasoline.

Q: Need to include the increasing cost of electricity in modeling efforts. Oil prices may slow or stagnate, while electricity prices may increase to the point that it does not provide an advantage. Another consideration is electricity supply, as there hasn't been much investment in generating capacity leading to the question of whether electricity will be available to meet future demand.

- A: (Phil Patterson) Agreed.

Q: Has the VT considered using stack gas, sequestered CO_2, or the atmosphere as a CO_2 feedstock for carbon fiber?

- A: No, but it's certainly possible. However other fields are using stack gasses to "feed" algae being grown for fuel and food.

Q: What fraction of the VT budget is devoted to "way out" proposals?

- A: The SBIR and STTR programs are designed to answer this need, with a standard holdback from all VT line items to fund it. This program has produced some success, most notably with A123 Systems which was started with an SBIR grant.

Questions from the General Audience

Q: Regarding the modeling predictions, since garbage in = garbage out, have the VT modelers revisited models from 5 or 10 years to evaluate how close the predictions were to what actually happened?

- A: Yes, historical predictions have been informally evaluated, and in many cases the predictions did not materialize in the market in the same way.

Q: How will post-election changes that could push the R&D vs. deployment pendulum away from the current deployment focus affect the VT portfolio? Is VT ready for a shift if it happens? Also, what are VT thoughts on corn ethanol versus other renewables to meet RFS goals?

- A: The program is very adaptable. VT is well positioned to move back towards a more R&D focus if needed, since they have not moved away completely from R&D, but rather moving some focus to deployment. Relative to the corn ethanol question, the new EISA legislation specifies only "biofuels" while limiting the use of corn ethanol to 15 billion gallons. To be successful we will need breakthroughs in cellulosic technology.