2.0 Program Critical Functions

This section provides a description of the FCVT Program structure, as well as the critical functions of the Program. These functions include portfolio decision making, performance measurement, analytical processes and Program evaluation. The expected Program benefits are also described. These critical planning functions are supplemented and supported by the administrative and supporting matters discussed in Section 4.

2.1 PROGRAM STRUCTURE

The FCVT Program develops technology for near- and mid-term automotive and truck fuel economy improvements and emissions reduction while aiding the transition to a hydrogen-based transportation system with advanced vehicle and propulsion technology. EERE Strategic Goals are controlling elements for FCVT goals and analyses, both inside and outside DOE control, and for work with Partners within the FreedomCAR and 21st Century Truck efforts. The structure of the FCVT Program directly correlates with the key Program goals and the key Program outputs, as shown in Figure 2.1.

Vehicle Systems
The Vehicle Systems subprogram funds R&D on advanced vehicle technologies and ancillary equipment that could achieve significant improvements in fuel economy for light-duty passenger and heavy-duty commercial vehicles without sacrificing safety, environment, performance, and affordability. This subprogram includes responsibility for technology validation, for oversight on all technology requirements in the Program, and for supporting modeling and assessment. It includes propulsion subsystem integration and development in a total vehicle system for heavy vehicle hybrids. The Vehicle Systems subprogram contributes to the FCVT Program goals on many levels which encompass those system aspects that, when resolved and adequately integrated into a vehicle's design, will result in improved system efficiency. As an example, parasitic losses in heavy trucks contribute to overall system inefficiencies. When appropriately addressed, improvements in parasitic losses will add to the improvements that are achieved in the other activities.

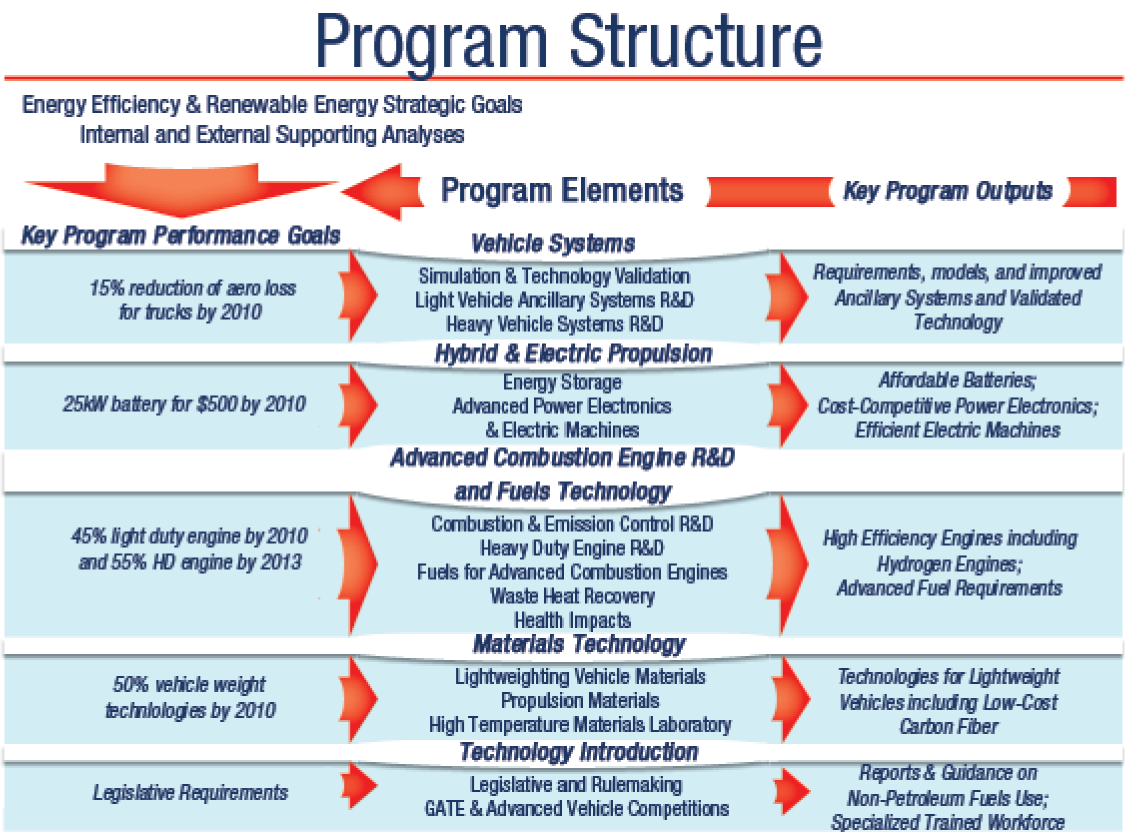

Figure 2-1. FCVT Program Structure

Hybrid and Electric Propulsion

The Hybrid and Electric Propulsion subprogram funds R&D for both passenger light-duty and commercial heavy-duty vehicles. These efforts include research in energy storage systems, advanced power electronics and electric machines. The Hybrid and Electric Propulsion subprogram supports the FCVT Program goals by addressing those technology elements necessary for electric energy storage, electric drives, and energy recovery in new, more efficient and less costly vehicle designs.

Advanced Combustion Engine R&D and Fuels Technology

The Advanced Combustion Engine R&D and Fuels Technology subprograms focus on removing critical technical barriers to commercialization of higher efficiency, advanced internal combustion engines in light-duty passenger and medium- and heavy-duty commercial vehicles. Research is conducted in collaboration with industry, national laboratories, and universities, and in conjunction with industry partnerships. Activities include Combustion and Emission Control, Heavy Truck Engine, Waste Heat Recovery, and Health Impacts research activities. Advanced combustion engines have the potential to contribute over 40 percent of the total efficiency improvements possible for both passenger and commercial vehicles. These improvements are a major contribution to the GPRA estimated oil savings from the FCVT Program. Other than the contributions of hydrogen fuel cell hybrid vehicles, whose potential oil savings grow to become comparable, the most promising method to reduce petroleum consumption in the mid-term (10 to 20 years) is to enable the introduction of high efficiency combustion engines in hybrid vehicles.

These subprograms also support R&D that will provide vehicle users with fuel options that are cost competitive, enable high fuel economy, deliver low emissions, and contribute to petroleum displacement. This supports the FCVT mission to develop more energy-efficient and environmentally friendly highway vehicles that enable America to use less petroleum.

Materials Technology
The Materials Technology subprogram supports the development of cost-effective materials and materials manufacturing processes that contribute to fuel-efficient passenger and commercial vehicles. This subprogram is a critical enabler for concepts developed elsewhere in the FreedomCAR and 21st Century Truck efforts. Key activities include Automotive Lightweighting Materials, High Strength Propulsion Materials, and the High Temperature Materials Laboratory (HTML). Materials Technology will contribute to the FCVT Program goals by developing more cost-effective materials that will make lighter vehicle structures and more efficient power systems possible. Lighter vehicles (that provide comparable safety) require less energy to operate and thus reduce the consumption of fuel. Likewise, better propulsion materials, also included in this element, can make more efficient power systems possible that contribute to reducing vehicle energy consumption.

Technology Introduction
The Technology Introduction element accelerates the adoption and use of alternative fuel and advanced technology vehicles to help meet national energy and environmental goals. These fuels and vehicles will reduce the consumption of petroleum-based fuels, thus contributing to the achievement of the overall FCVT Program vision. The element also contributes to consumer education and to the training of a specialized workforce suitable for the advanced vehicle technologies of the future. As identified in the National Energy Policy, consumer education and demonstration activities are critical to accelerating the use of advanced energy technologies. Key activities of this element are Legislative and Rulemaking, Advanced Vehicle Competitions, and the Graduate Automotive Technology Education (GATE). Primary functions include support to the Energy Policy Act of 1992 alternative fuel and fleet activities, providing educational opportunities for university students to learn and use real-world engineering skills while demonstrating the performance of critical vehicle technologies, and supporting the development of students with technical skills important to the FCVT chosen technology pathways while undertaking research to solve real problems.

Interrelationships
The Program elements are interrelated in many ways. Prominently, Vehicle Systems performs simulations and technology validation supporting all the other elements. Also, technologies developed within each element, such as Materials Technology, can affect the vehicle as a whole and thus, can affect the requirements that technologies

within other elements must satisfy. Also, work in other elements such as Technology Introduction can contribute to Vehicle Systems through activities such as modeling, simulation validation, and verification of total vehicle concepts. The simulation studies within Vehicle Systems are closely intertwined with supporting analyses from other parts of EERE that assess markets and benefits of FCVT technology.

Activities within the FCVT Program elements are closely related to other programs such as HFCIT where the development of hydrogen engine technology is shared. For example, FCVT develops technology such as hybrid technology necessary for the commercialization of fuel cells in vehicles. In addition, materials, power electronics, combustion, and fuels developments on a fundamental level are coordinated in cross-cutting efforts with other EERE programs. Additional technology areas are being defined for cross-cutting efforts.

This particular FCVT Program structure comes from a rich history and evolution of government support for research and development of advanced vehicle technologies. The structure has been defined to tightly integrate activities for the key beneficial outputs of the Program, and to make the groupings necessary for planning, management decisions, and resource allocations.

2.2 Portfolio Decision-Making Process

A broad and comprehensive set of processes and activities is used to manage the FCVT portfolio–consisting of all projects aimed at achieving FCVT's goals. Both continuous and cyclical processes are used to keep the portfolio on an optimized track. A dynamic and cyclical decision process is a key aspect of these processes. The project list is constantly updated and revised; resources are allocated and reallocated to selected and active projects; new projects are planned, evaluated, selected and prioritized; and existing projects may be accelerated, terminated or de-prioritized.

Portfolio management includes definition of the measures used to analyze and describe portfolio performance. It also includes the tracking, reporting, and evaluating of projects to provide the bases for modifications and improvements to the portfolio.

For the purposes of explaining FCVT portfolio management, it has been divided into five interrelated elements: Planning, Budgeting, Execution, Tracking & Reporting, and Analysis & Evaluation. Each element involves a large number of participants and encompasses a vast number of integrated activities at different levels within the FCVT Program. These activities are undertaken in both continuous and cyclical processes.

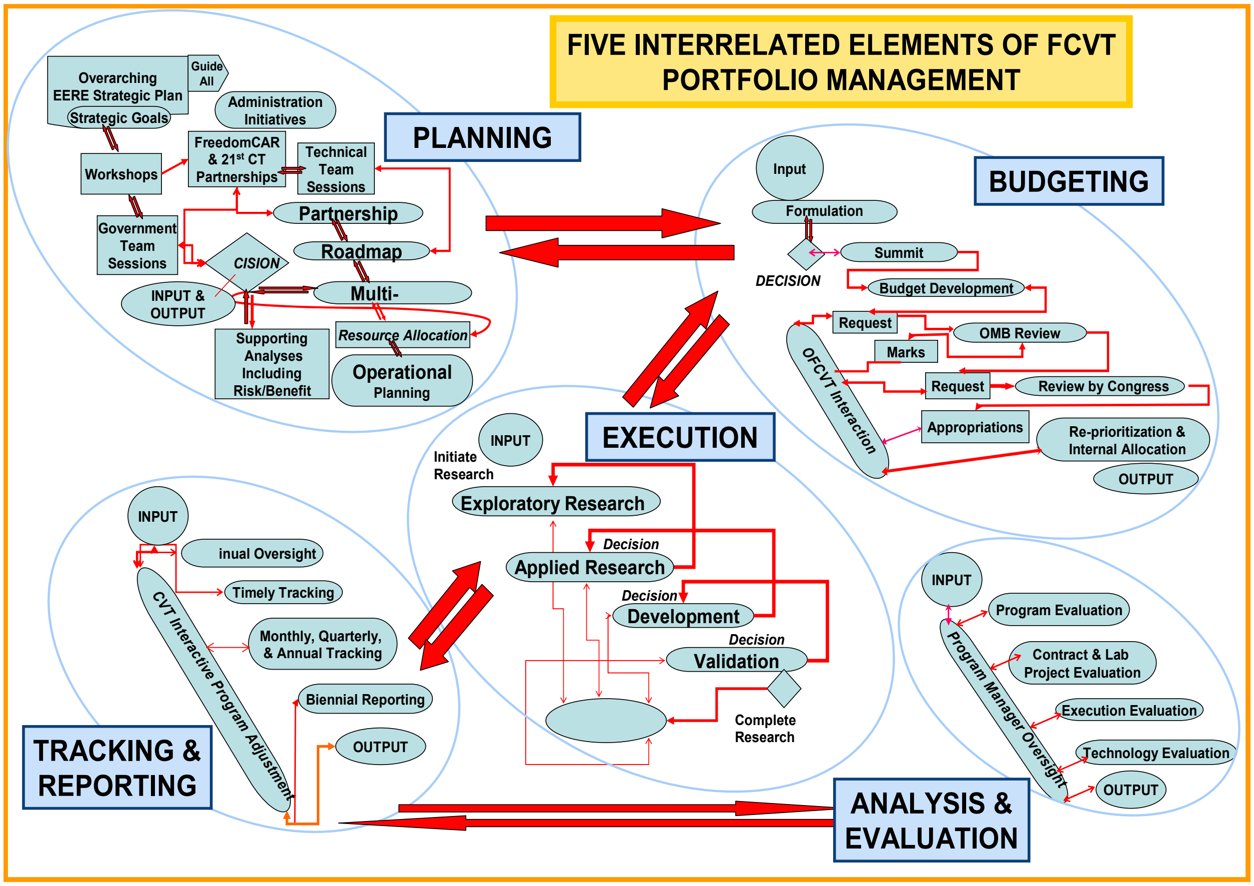

Figure 2-2. FCVT Portfolio Management

That is, each element is always ongoing and each element has cyclical processes designed to produce various products that range from documents, decisions, and information to technology. These products are necessary to manage and keep an optimized portfolio. The processes of portfolio management are continuously refined with the application of improved analytical tools, office automation systems, and feedback from stakeholders and independent peers.

The process is not only cyclical but also non-linear in nature. It has numerous feedback loops and steps within each element and among the elements. Thus, portfolio management and decision making within FCVT is an integrated cyclic process with well defined steps.

Planning

An exceptionally strong planning effort provides the foundation for the FCVT Program and for the management of its portfolio. Planning is based on the flow down of a number of overarching Program and policy influences. Foremost among these are the vision, mission, and goals EERE has set forth in its strategic plan. These act as the process starting point and the point to which FCVT returns periodically to gauge its selected courses of action. EERE is just one of many stakeholders playing a role in this process and all stakeholders play more than one role.

Planning is interrelated with each portfolio management element, and feedback from Budgeting, Execution, Reporting, and Evaluation are all important to the continual and cyclical planning process.

Initial planning is conducted collaboratively with stakeholders in workshops focused on the identification of opportunities and technology issues. Preliminary identification of potential technical barriers and research directions to achieve Program mission are identified. These results are then used as the basis for more detailed planning.

With stakeholder input as a framework for discussion, partnerships are formed (e.g., FreedomCAR and Fuel Partnership and 21st Century Truck Partnership) and more detailed plans are jointly developed. As a part of this planning process, long range goals are set, along with initial plans for key intermediate milestones and/or decision points. While goals and major milestones are changed infrequently, they are subject to revision as information in the other elements is generated from benefit/impact analyses, independent peer reviews of the partnership program, and other evaluations of R&D progress dictating any necessity for change. This represents the cyclical feedback in the R&D decision and portfolio management processes. Because the partnership peer reviews only occur on a biennial basis, changes to the partnership plan do not normally occur more than every two years. Other factors can come into play as well. Changes in external conditions that affect the urgency or efficacy of the plans are one example. Major changes in the petroleum market or in the vehicle manufacturers' product market are two external conditions that could mandate change.

Technology roadmaps are developed with the stakeholders using overarching goals as end points. Roadmaps define potential pathways and barriers that must be overcome to accomplish the defined endpoints. These pathways and barriers provide a framework for defining Program activities which are defined in more detail through the FCVT long-term plans and annual budget development planning. Roadmaps also serve to help define risk and opportunity and thus are useful references when making future decisions regarding priorities and in the selection of R&D activities. Feedback from the other elements such as evaluations of R&D progress, proposals in response to R&D solicitations, and technical input from external sources can add information that modify the conclusions defined by a roadmap and thus warrant a revision of the roadmap.

FCVT's its *Multi-Year Program Plan* is updated annually. The Plan is developed using partnership plans, R&D roadmaps, and current technical plans as a basis for defining Program goals, objectives, and activities in the plan. These may differ somewhat from those defined in the partnership plans because the government's desired outcomes may be slightly different from those of industry. As with the previously defined plans, change can be dictated by new information that forces new thinking. Information from activity evaluations, peer reviews, innovative proposals, DOE priorities, analyses, or changes in external drivers can each force changes in goals, objectives, pathways, barriers, opportunities, etc. Thus, priorities and directions can shift as circumstances dictate. And because some areas of the MYPP require updating more often than others, and the MYPP serves as a control document for other FCVT planning, the MYPP is considered a living document. Content control is established by FCVT management and is an important part of Portfolio Management.

Strong planning provides the basis for the budget formulation and feeds interplay with the Budget Element described below. Once the cyclic budget process is complete and appropriations are provided, the MYPP becomes the control document for rolling activity into one-year operating plans. It is in these latter plans that the projects to be funded are defined and the assignment of responsibilities is made; for projects, measures, and milestones for example.

Important to the FCVT R&D decision process and portfolio management is the development of information from analyses of the impacts or consequences of the outcomes from selected (or potential) R&D pathways, the assumed degree of success, and the timing of success. Analyses include those at the corporate level, Program level, e.g. portfolio and risk/benefit analyses, and at the technical level. Risk/benefit analyses are significant in establishing a plan with a balance of activity. Important to planning are the analyses from the Analysis & Evaluation Element. Analyses are mostly performed by office staff (FCVT; Planning, Budget, Formulation and Analysis; and Energy Information Administration) and as part of funded projects, but also come from independent sources, e.g. Massachusetts Institute of Technology. These analyses are generally assumption dependent but serve the purpose of indicating the sensitivity to timing, technology success, and other factors. They can also indicate trends, e.g. EIA petroleum use projections. Results of analyses can feed the decision making at the budget formulation/project selection stage as well as providing feedback to the various planning stages such as in multi-year planning.

Additional feedback into the Planning Element is described in the following paragraphs as the other Elements of Portfolio Management are presented.

Budgeting

Budgeting encompasses the acquisition and use of resources to implement the optimized portfolio and, of course, is necessary for the conduct of activities in each of the other elements of portfolio management. As mentioned in the discussion of the Planning Element, budget formulation is based on a strong planning activity. Activities of all the other elements provide important inputs to the Budget Element, but Planning, Tracking & Reporting, and Analysis & Evaluation are particularly contributive of necessary information. Status and progress of the Program comes from Reporting, and supporting analyses for budget decisions come from Evaluations. Once the budget is set and allocated, the output from the Budget Element provides the basis for assignment of resources, the development of operating plans, and the execution of the Program. Additional outputs from Budgeting are agreed-upon measures to be reported and clear Program-budget linkage.

Decision-making and the portfolio can be strongly influenced by feedback provided by stakeholders during budget formulation (e.g. EERE guidance at the budget summit, DOE Corporate Review Budget (CRB) action and determinations of the Budget Request, and Office of Management and Budget (OMB) pass-back guidance) and later through Congressional input from the budget appropriation. These sources of input do not always originate from a rational decision process but can trump what has otherwise evolved as Program priorities from the previously discussed planning process. These expected, but not predictable, influences often require rebalancing priorities that underscore the need for contingency planning. Such planning and decision making is stakeholder-driven by the preparation that has gone on throughout the planning process and by follow-up discussions prior to project definition and establishment of the Portfolio.

Execution

Projects or project areas are defined through the planning process, most notably the development of technology roadmaps. Prioritization is established through a consensus-building process with the stakeholders (e.g., the FreedomCAR and Fuel Partnership utilizes industry/government technology teams for much of this). It is fine tuned by the budgeting process. Specific projects are defined by developing competitive solicitations and the subsequent review of proposals. Proposed projects are selected using a team of impartial technical evaluators who develop a consensus of proposal rankings and relative merit. Projects are also initiated at the laboratories using the same technical consensus developed with stakeholders in the technical teams. As explained in the Planning Element discussion, at the start of the year each project identifies key milestones, decision points, deliverables and outputs in Annual Operating Plans.

Two 'improvements' to the execution process have been emphasized by EERE in FY 2005 – relating to risk management and to decision-gate processing. Risk-management is being more formally treated in projects where pertinent (as well as on a Program level in planning). Decision-gate, a phased decision process, described below is being applied in the FCVT Program where appropriate.

Successful technologies will go through a four phase R&D Process as depicted in Figure 2-3; although, not all of the phases of the process will necessarily be funded by FCVT. Projects may be initiated at any point in the process; however, it is not likely that many, if any, projects will begin in the technology validation phase. The exploratory research phase leads to many of the FCVT projects is funded by the Office of Science; hence, most projects begin in FCVT at the applied research phase. As technologies move through these phases from exploratory research to

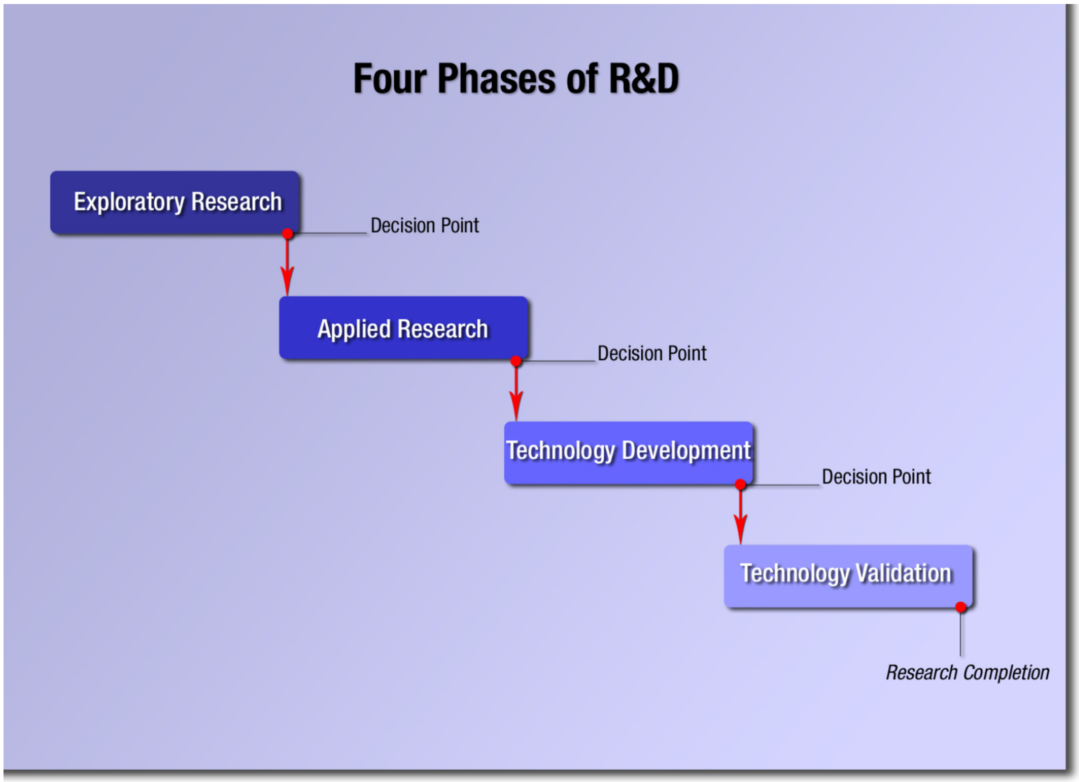

Figure 2-3. FCVT's Four Phases of R&D

validation, the cost of the project and involvement of industry increases. Also, the risks and benefits become better defined. The definition of the four phases and the criteria to move from one phase to the next receives emphasis at the outset of a project where pertinent; and, milestone/decision 'gates' with the passing criteria are utilized. Projects in which actual results exceed expectations will likely move to the next phase. Projects which fail to meet expectations could be recycled, put on hold, or simply stopped

Exploratory research, characterized by stretching the limits of science, is used to help define future research direction. It is often high or unknown risk but with high potential benefit. By investing small amounts of R&D funds in areas where our knowledge base is limited, discoveries will point to opportunities to significantly extend the technologies currently being researched. FCVT often capitalizes on the research results of the Office of Science, Basic Energy Sciences (BES) discoveries and performs applied research based on these discoveries. As an example, capacitor technologies discovered in the BES Program are now undergoing applied research to determine their suitability for power electronic inverters. Similarly, BES-funded combustion research is carried through the applied research phase by FCVT and contributes to achieving the engine efficiency goals. Exploratory research is also conducted at the national laboratories in Laboratory Director's Research and Development (LDRD), at universities with National Science Foundation (NSF) funding, and in industry with internal funding. Industry cost share is not expected in this phase of R&D and in fact, industry involvement is not likely to occur.

A large portion of FCVT's funding is committed to the Applied Research Phase. The primary performers in this phase are the national laboratories. When industry is involved, some cost share may be appropriate – likely in the 20% range due to the high risk, long-term nature of the research.

Technology development is also a phase accounting for significant FCVT expenditures. Because this phase is addressing the technology cost and performance requirements, industry involvement is appropriate, if not required. Likewise, at this phase of R&D the risk has been reduced and the benefit is sufficiently defined that industry cost share of at least 50 percent is appropriate. At the completion of this phase, many/most technologies should be picked up by industry and carried to commercialization.

FCVT's involvement in the validation phase is generally limited to measuring and documenting the technology benefits. In most situations, FCVT's financial commitment will be limited to laboratory tests to validate performance, while industry will move toward product development and commercialization. A successful technology, validated to have met the FCVT performance goals, may be years away from reaching the consumer. After this phase, industry must take the technology through the even more expensive product and process development phase prior to commercialization.

Throughout the R&D process, decision points/milestones are used to evaluate the progress and determine the appropriate next step for the technologies being studied. Prior to the initiation of any phase of a project, the projected outcome (what will be accomplished) in that phase is documented. At the conclusion of the phase, the projected outcome will be compared with the actual project results. Projects and technologies which meet or exceed expectations will likely move to the next phase. Projects which fail to meet expectations could be recycled, put on hold, or simply stopped. To be recycled, there should be new information or new ideas providing optimism that if the phase is repeated, it will be successful. When another approach to developing the technology appears to have a higher probability of succeeding, the manager may choose to put a project on hold. Projects that are put on hold will be sufficiently documented/archived so that if necessary or desirable, they may be restarted with minimal perturbation. When a project is stopped, it is presumed that this approach to the technology is no longer needed or has been superseded by another approach. A stop indicates there is no intention of restarting the research, but there is still the obligation to document the research results. Performance criteria and decision dates are established for decision milestones.

The FCVT Risk Management process has two primary elements, the risk benefit analysis and risk mitigation. FCVT is formalizing and documenting its risk/benefit analysis and performing this activity during all phases of research, including prior to project initiation. In the early phases of research, this quantification may be very uncertain, but effort must start somewhere. Current plans include using the merit review process to update these risk benefit analyses annually.

Risk mitigation becomes necessary when the benefits of a technology are so great that everything must be done to improve the probability of success or when the impact of failure goes beyond that of the technology itself. Where it can be afforded, risk mitigation can take the form of parallel approaches to technology development. Another approach is by partnering with industry or other DOE programs to share the risk. The partnering will bring more resources to bear and create more stakeholders with a vested interest in the research success. These two approaches are currently being used in the engine/combustion research of homogenous-charge compression-ignition (HCCI) and Low Temperature combustion (LTC) regimes. The third avenue of risk mitigation is portfolio diversity. Not all funds should be invested in the one long-term, high-risk, high-benefit project. FCVT has developed a mix of risk and benefit in the projects funded. Finally, within a project there may be research specifically focused on reducing the risk, failure modes, etc.

Tracking and Reporting

Active monitoring of the Program is carried out on a continual and a periodical basis. The period varies from almost daily to annually and even biennially in the case of reviews for the partnerships. Progress is reported on an annual basis in the form of Annual Progress Reports for each technology area. The regular reporting and evaluation of project milestones, major deliverables and project status (including costs) is vital to the Program. These milestones are reported to the Corporate Planning System (CPS) and actively monitored throughout the year. When milestones are due, decisions are made to continue or redirect projects based on technical progress, stakeholder input, and other factors. Monthly cost reporting is provided to track the status of expenditure of funds compared to the plans. This system of regular internal reviews ensures that project performance is monitored and that appropriate corrective action is taken if necessary. As other types of new information are received such as stakeholder input, new technology, and major decision milestone completion it is fed back into the planning/selection process.

Milestones, deliverables, decision points, and project phases are identified and tracked throughout the project lifecycle. High priority measures and milestones are tracked and reported to higher DOE managers on a quarterly basis in the "Joule" milestone tracking system. Automated tools are used to facilitate these processes. In addition, FCVT teams and FreedomCAR technical teams regularly review the research portfolio and make decisions regarding the appropriateness of technical direction and emerging opportunities. A regular evaluation of ongoing projects takes place through these government-industry team meetings and at regular Program reviews. In addition, Technology Development Managers maintain a prioritized list of potential new projects. Therefore, as projects come to an end or are terminated, prioritized new projects are available to be initiated.

Analysis and Evaluation
The last step in the cycle is the evaluation of project performance and of Program/partnership planning effectiveness. Peer reviews performed at both the project and program level provide independent feedback to the FCVT Technology Team Leaders and Technology Development Managers. For projects, the reviews serve to gauge both individual progress and technology advancement, as well as to provide a comparison between projects in a common area. Project reviews are performed annually. Peer reviews at the program or partnership level provide a broader perspective giving the Program feedback on the quality and effectiveness of planning as well as the progress of the research. These reviews deal with the broader issues of the relevance of selected goals and objectives, adequacy of funding relative to selected pathways, and the effectiveness of plans to guide and direct the Program in addition to the progress and status of the R&D. Because Program reviews cover a much broader spectrum of issues and because these issues are less subject to change, Program peer reviews are held biennially.

Additional evaluation is generated through the review of project progress reports and contract reviews by cognizant FCVT staff. Contract reviews are held at annual or semi-annual intervals. The development process of Annual Progress Reports for major FCVT technology areas under the leadership of DOE staff adds to the overall evaluation strategy. This process includes collection and review of all project/contract/milestone reports and assessment of status of the technology area.

In addition to peer reviews, contract reviews, and progress reports, a technology element may have major milestone/decision points as part of the element plan. These decision points result in technical reviews with a narrower scope and usually with pre-established criteria, but with a limited set of actions defined as possible outcomes, e.g. stop work on selected technologies or increase focus on the most promising technology or move the project through the 'gate' to a more advanced development phase. These decision points occur at predetermined positions in the element plan as dictated by the expected time needed to generate the necessary information, not on a fixed interval such as with peer reviews. As covered above in Tracking and Reporting, the regular reporting and evaluation of project milestones, major deliverables and project status (including costs) is vital to the Program. These milestones are reported to the Corporate Planning System (CPS) and actively evaluated throughout the year.

The purpose of these reviews for portfolio management is to create feedback loops to the various stages of the cycle and feedback from these evaluations can enter the cycle at various points. Program peer review results tend to mostly affect Program planning, but can also provide input to the budget development phase. As a comparison, project reviews primarily affect the annual budget development and the funding decision process.

FCVT decisions and portfolio management are made by balancing the available information (reviews, reports, and analyses) and driving factors (e.g. EERE Vision) along with the framework of the established Program plan to make decisions regarding priorities and project selection. Consensus determination with the Program stakeholders helps insure that unrecognized bias does not unduly affect the decision process. A comprehensive and quality process is in place for portfolio management. Steps are always under way to improve the portfolio management process. Some of the areas that are being strengthened include greater formalization of risk/benefit analysis, portfolio analysis, Program Assessment Rating Tool (PART) analysis, risk management on the technology level, and a greater formalization of a milestone/decision, phased execution element.

2.3 Program Analysis

The FCVT Program employs a strong foundation of analyses to guide its efforts and determine the most favorable risk-cost approaches. These analyses have been significant throughout the history of the Program, with some elements beginning before the PNGV but strengthening in the 1990s under that Partnership and continuing under the FreedomCAR and Fuel and 21st Century Truck Partnerships.

Early analyses in this rich history dealt with all of the potential technology options to reduce vehicle petroleum consumption, preserve energy security for transportation, and improve the environment. First analyses identified potential fuel economy improvements from technology pathways including components of the vehicle and the technology options for the component. These analyses addressed potential fuel economy improvement from engine improvements and compared those to weight reduction, or hybrid propulsion; a variety of engines from improved ICE to advanced Turbine to Fuel Cells were examined. Aerodynamic drag, rolling resistance, propulsion and hybridization, power source, weight, usage patterns (like idling), waste heat, Heating, Ventilating and Air Conditioning (HVAC) and other ancillary equipment, etc. were all candidates for fuel economy improvement and potential Federal support.

After these early studies identified promising candidates, ‘well-to-wheels’ analyses were conducted and used to refine the identification of the most viable technologies. DOE conducted its own studies but also profited from studies by other notable industry and university sources. Well-to-wheels studies conducted by General Motors Corporation and independently by Massachusetts Institute of Technology (MIT) have verified the FCVT analysis of the potential significant benefit of the most promising automotive technologies (e.g., hybrids and fuel cells). Currently and for its near-term plan, FCVT uses an integrated systems approach to develop, maintain, and employ analytical tools, techniques, and test facilities to benchmark emerging technologies and support the development and validation of DOE-sponsored technologies in a vehicle systems context. As depicted in Figure 2-4, the Program uses analytical and empirical tools to model and simulate potential vehicle systems, validate component performance in a systems context, benchmark emerging technology, and validate computer models. Extensive collaboration with the technology development across FCVT, as well as HFCIT, is required. The analytical results of this subprogram are used to estimate the national benefits and/or impacts of DOE-sponsored technology development as discussed in Subsection 2.7.

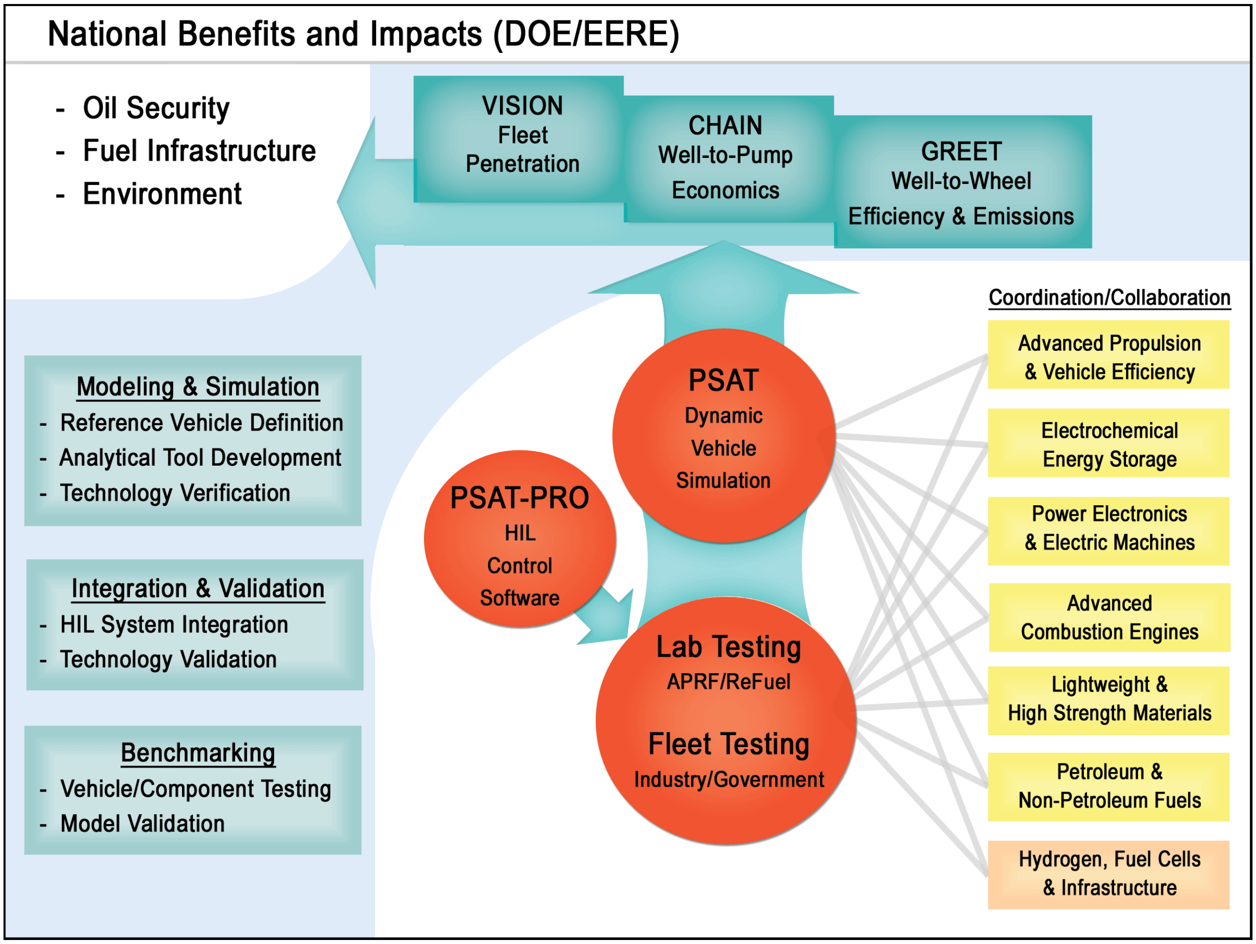

Figure 2-4. FCVT Integration of the Analytical and Experimental Activities

To maximize the probability of successful technologies being adopted and commercialized, the FCVT Program works with the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership. These partnerships contain government and industry participants, an arrangement that seeks consensus on all key performance goals, activities and decisions. All the partners independently undertake their own research activities on advanced vehicle and/or fuel technologies relevant to achievement of the vision or through separate legal arrangements. The USCAR partners jointly conduct related collaborative pre-competitive R&D. Companies will make independent decisions on commercialization depending upon establishment of viable business cases.

A unique set of tools has been developed and maintained by FCVT to support the Program. The primary tools are depicted in Figure 2-4. Outside FCVT, the Program works with the Office of Business Administration (BA) to utilize such models as

VISION, CHAIN, and GREET to forecast national-level energy and environmental parameters including oil use, infrastructure economics, and greenhouse gas contributions of new technologies, based on FCVT vehicle-level analyses that predict fuel economy and emissions using ADVISOR, Powertrain Systems Analysis Toolkit (PSAT) or PSAT PRO (PSAT Prototyping software). Dynamic simulation models (e.g., PSAT) are combined with DOE's specialized equipment and facilities to validate DOE-sponsored technologies in a vehicle context (e.g., PSAT-PRO control code and real components in a virtual vehicle test environment). The Advanced Powertrain Research Facility (APRF) and the Renewable Fuels and Lubricants Facility (ReFUEL) are used to test light-, medium- and heavy-duty vehicles (operating on a variety of liquid and gaseous fuels), propulsion systems, and components in controlled environments to acquire scientific data. Fleet tests are used to assess the functionality of technology in the less-predictable real-world environment. Modeling and testing tasks are closely coordinated to enhance and validate models as well as ensure that test procedures and protocols comprehend the needs of coming technologies. This integrated approach ensures the availability of the very highest quality analyses to support the Program in setting baselines, measuring progress, comparing technologies, comparing FCVT with other EERE pathways, and determining GPRA measures and benefits from the Program.

Overall portfolio analysis encompassing each project in the FCVT Program also is employed to guide decision making with appropriate risks, benefits and Program balance. In addition, portfolio review has been conducted on a broad scale in the past and is planned to be conducted in detail during the course of this MYPP by the Program Manager.

Although analysis processes are still under development within EERE and analysis tools are under investigation for the coming years, a system by Taratec has been employed to analyze selected portions of the Program. The purpose of the analysis was to provide DOE with a tool to assess the quality of its research portfolio and to determine the relative position of potential new projects in the portfolio in order to aid the DOE decision process. The overall model is indicated in Figure 2-5. The overall process involves assessment of risk, technical and commercial, and the mission impact of each project. Projects are compared on a comprehensive chart of risk versus impact/benefit.

Analyses are used to identify the potential of technology but decision to pursue and the establishment of goals is always tempered by government role, expert review, and the results of R&D effort as they are fed back into the decision process. The FCVT Program benefits from auto and truck industry participation, as well as from many stakeholders throughout the nation and independent reviewers such as the National Academy of Science.

Project & Portfolio Assessment Model

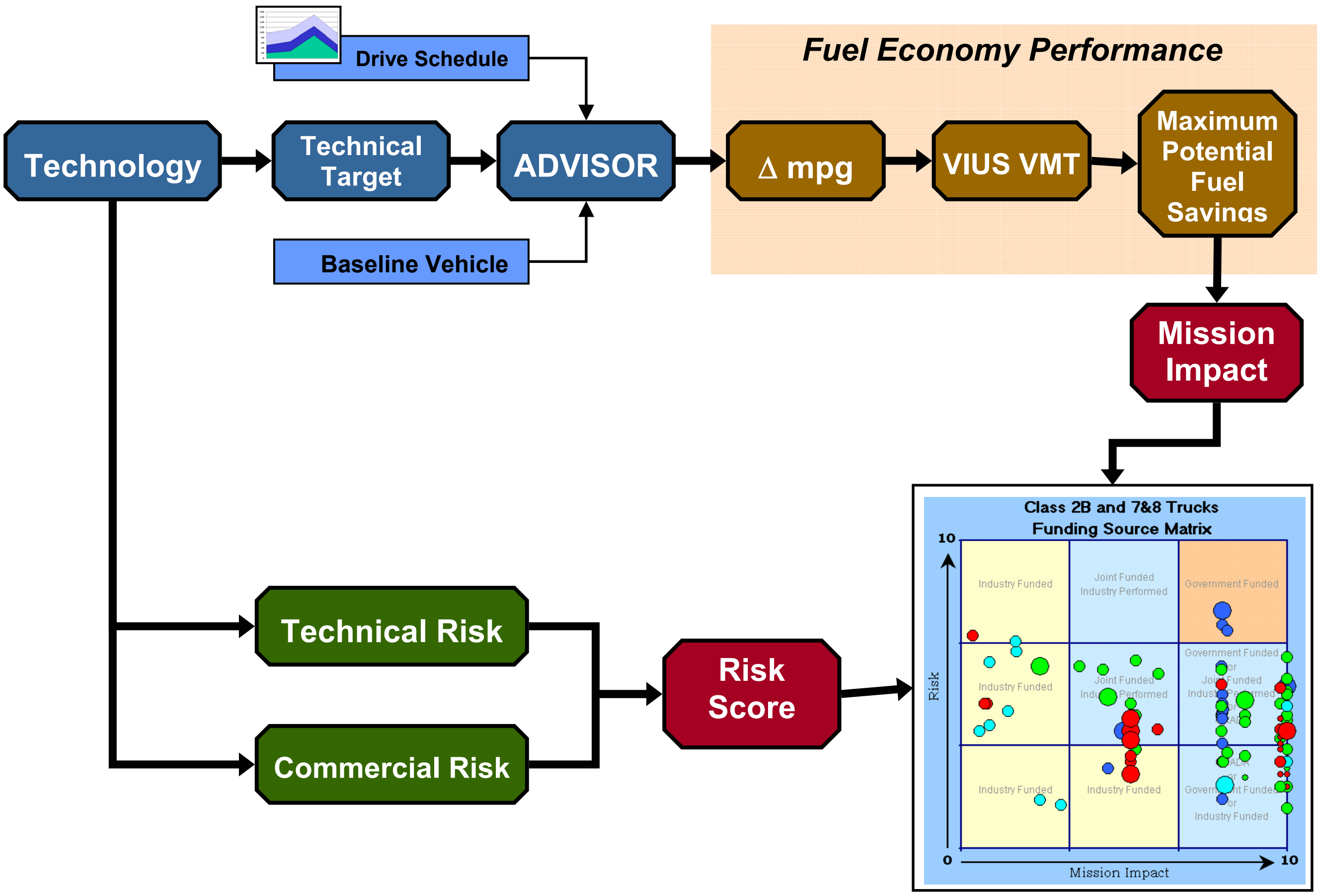

Figure 2-5. Portfolio Assessment Model, developed by Taratec

In addition to these analyses, FCVT sponsors with BA a variety of efforts such as consumer, usage and market analysis to improve knowledge and provide guidance for the Program.

2.4 Performance Measurement

This subsection presents the main performance measures used by the Program to determine Program progress. Measures are presented that are consistent with the budget as well as important to Departmental and Administration performance rating tools. In the Performance Accountability Framework (Figure 2-6), performance measurement is contained to the left column of internal Program functions for which the Program is ultimately responsible.

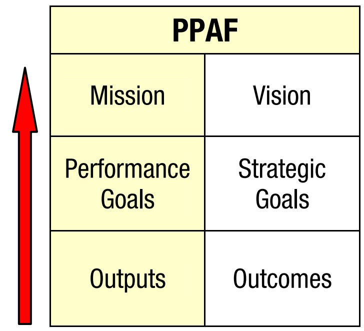

Figure 2-6. Section 2.4, Performance Measurement

The FCVT Program supports the "Energy Strategic Goal" of DOE's Strategic Plan to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy. The FCVT has established Program priority goals that contribute to the "Energy Strategic Goal." These goals are aimed at R&D of technologies that can enable cars and trucks to become highly efficient, and improved domestic fuel specifications that work in concert with advanced power systems. In addition, the Program R&D focuses on reducing the cost and improving other attributes of advanced vehicle technologies so that they will be both performance-competitive and cost-competitive. The priority performance goals defined in Section 1 are shown below with their measures and intended progress over time.

Vehicle Systems: Parasitic loss (aerodynamics, cooling, and compressed air) for heavy vehicle systems is to be reduced by 38% by the end of 2006. Figure 2-7 shows graphically the loss as a percent of engine output from the 39% baseline in 1998 to a 24% target in 2006.

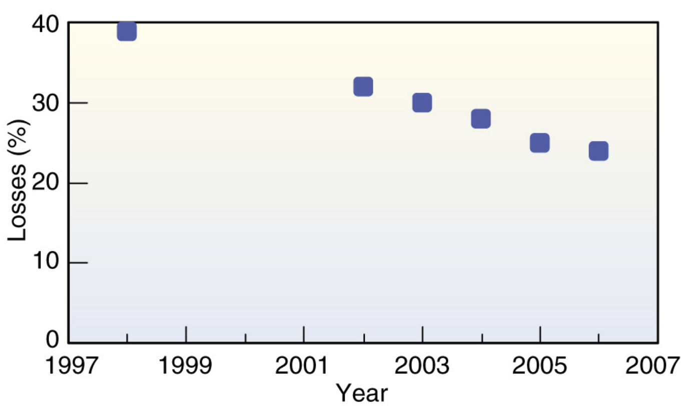

Figure 2-7. FCVT Performance Measure 1: Heavy Vehicle Parasitic Losses

Hybrid Electric Propulsion: This element has a goal to reduce the cost of high power batteries by 83% by 2010. Progress is indicated by cost per 25 kW battery system estimated for a production level of 100,000 battery systems per year. The measure is shown from the $3000 baseline in 1998 to the $500 goal in 2010 in Figure 2-8.

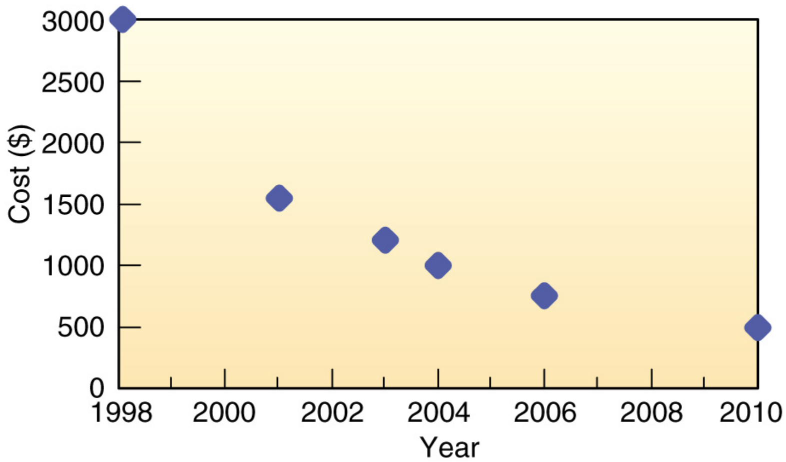

Figure 2-8. FCVT Performance Measure 2: Cost per 25-kW Battery System

Advanced Combustion Engines: Improve the efficiency of internal combustion engines from 30 percent (2002 baseline) to 45 percent by 2010 for passenger vehicles and from 40 percent (2002 baseline) to 55 percent by 2013 for commercial vehicle applications while utilizing an advanced fuel formulation that incorporates a non-petroleum based blending agent to reduce petroleum dependence and enhance combustion efficiency. The goals are measured in terms of engine efficiency (percent) and are depicted in Figure 2-9.

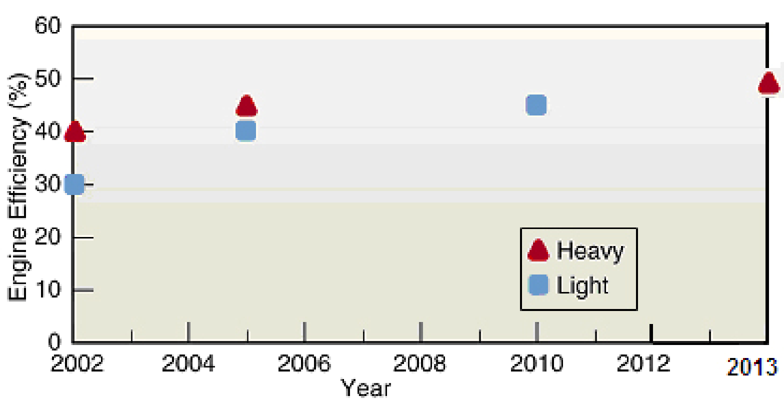

Figure 2-9. FCVT Performance Measure 3: Efficiency of Light- and Heavy-Duty Internal Combustion Engines

Materials Technologies: A goal to enable the reduction of overall passenger vehicle weight by 50% by 2012 has been set. Although there are a number of materials and measures involved, one priority measure has been identified and tied into the Departmental Joule system which is the cost of carbon fiber in dollars per pound. Figure 2-10 shows the cost of carbon fiber from the baseline of $12/lb in 1998 to a goal of $3/lb in 2006.

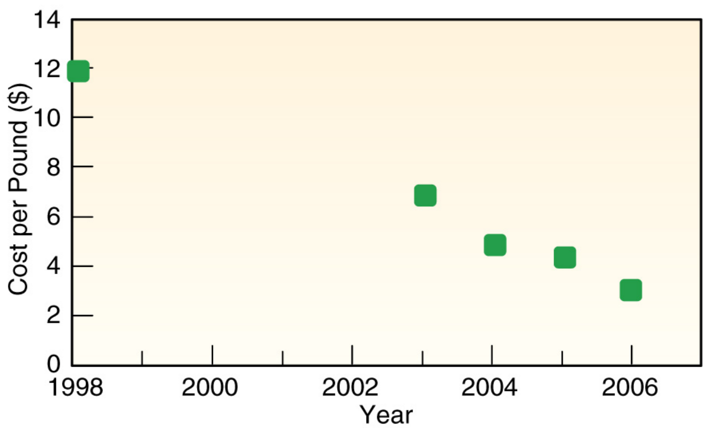

Figure 2-10. FCVT Performance Measure 4: Cost of Carbon Fiber

To assess progress toward achievement of these priority goals, targets have been established at intermediate dates. At the technology level, technical targets have been established for these goals and others as presented throughout Section 3 of this Plan that give measures for Program performance. FCVT-developed technologies are evaluated to validate that the FCVT-developed component/subsystem technologies meet the technical targets. This validation process involves the following methods:

- Computer simulations using the vehicle models updated with embedded component/subsystem models that virtually replicate the technology-representative point designs developed in the FCVT component/system technology development activities.
- "Hardware-in-the-loop" (HIL) testing that replicates a complete vehicle by employing a blended combination of (1) actual test hardware provided by the FCVT component/subsystem technology development activities and (2) computer models.

These measures with targets and status for the priority performance goals are summarized in the following table with some key measures for outcomes from the Program.

In addition to these metrics, certain milestones are selected and monitored to measure status and progress. One set of milestones, specified and reported quarterly each year, are "Joule" milestones identified in Section 2.2. These milestones corresponding one for one with the priority goals are highest priority and monitored on the Departmental level by high level managers using the "Joule" reporting system. Other measures, some of which are shown in the chart below, are monitored and assessed to gage the overall performance of the Program. These include the number of R&D 100 Awards, outcomes such as technology that makes it into the market place, and administratively–obligations, costs and uncosted obligations. Ultimate measures of the Program success (outcomes) must relate to the GPRA benefits estimates–carbon emission reductions, nonrenewable energy savings, and energy savings in billions of dollars.

2.5 Performance Assessment

Performance assessment includes the reporting, monitoring, and program evaluation to allow routine evaluation of progress against goals along with in-depth evaluation of program rationale, process, impact, and cost-benefit. The FCVT Program employs a variety of different activities and processes in conducting performance assessment. Many of the processes are discussed above as a part of portfolio management. These processes encompass all of the basic types of performance assessments used by EERE programs: results-based performance reporting; peer reviews; general program evaluation studies; and technical program reviews.

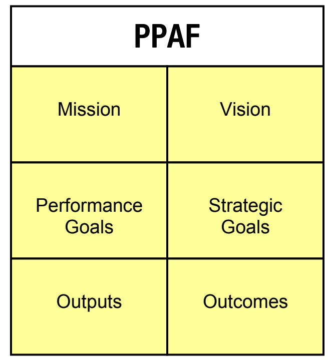

Figure 2-11. Section 2.5, Performance Assessment

Results-based Performance Reporting
The White House Office of Management and Budget's Program Assessment Rating Tool is utilized to assess the overall Program performance once a year in conjunction with the annual budget request. Also, with BA, FCVT uses accepted R&D investment criteria to support its budget proposals. In addition, DOE has established the Joule automated Performance Measurement Tracking System. FCVT specifies milestones that correspond to its priority goals at the beginning of each Fiscal Year and reports quarterly on these milestones.

Peer Reviews
Two basic types of reviews by outside independent experts are conducted for FCVT. On a biennial basis, two peer reviews are held covering each partnership for light and heavy vehicles. These reviews examine all aspects of the partnerships with emphasis on accomplishments, productivity, quality, and relevance to goals, management, and recommended changes. The National Research Council of the National Academy of Science is typically employed to these independent partnership reviews. In 2006, the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership will be the subject of an independent peer review. Beginning in 2008, one partnership will be reviewed each year. Thereafter, the partnership reviews will take place on alternate years.

The other type of review is performed at the project level. These reviews are conducted by DOE using various technical experts to evaluate the numerous Program areas. Technology experts, sometimes the recipients of DOE funding and often independent by the nature of their work in other agencies, are selected by DOE program leads on the basis of their expertise. These names and expertise labeling are then passed to a third party contractor for independent assignment to specific projects. Each expert is required to sign a conflict of interest form to avoid potential issues arising from the review of competitors. This type of review allows for more detailed evaluation of each project than is possible in the Program review. Beginning in 2007, FCVT Program technical project reviews will be held every year. In 2006, reviews are planned for Energy Storage, Vehicle Systems, Advanced Combustion, Fuels, and Power Electronics and Electric Machines.

Program Evaluation Studies

Many different program evaluation efforts are conducted in varied areas by FCVT. Prominent among these is the overall cost benefits analysis, which is cycled on a several year basis. This analysis is reviewed annually to support GPRA potential benefit assessments used in future budget formulation and requests. Also, FCVT has initiated risk-benefit analysis in specific areas of the Program and plans expansion across the Program in FY 2006 and 2007 with periodic updates every few years thereafter. This analysis provides information on the balance of risks and benefits in the Program and is one input for program improvement. Other studies, such as focus groups examining market forces and other aspects, are conducted on an as-needed basis with BA. The FCVT industry Partners conduct studies which contribute to overall evaluation of the Program. One such study on technology successes within the Program is conducted by USCAR on an annual basis.

Sometimes studies that are not funded by DOE are conducted by interested parties and provide useful data and information to support or change the Program. Two such studies on impacts of technological pathways to more petroleum-efficient vehicles were conducted in recent years by General Motors and the Massachusetts Institute of Technology respectively. Another part of the overall Program evaluation is the annual progress review and report conducted by each FCVT Technology Manager and Team Leader. FCVT technology managers and team leaders regularly commission studies to assess their R&D activities. In 2004, Kline & Company evaluated the progress that had been made on the reduction of cost in manufacturing carbon fiber for the Materials Technologies subprogram. The Advanced Power Electronics and Electric Machines activity hired Energy and Environmental Analysis, Inc., to perform a cost analysis of the Toyota Prius hybrid drive system and its components. Both of these studies will be updated in 2006. Another example is a recent case study, *High Temperature Materials Laboratory, A National Asset*, conducted in 2005. Expertise at HTML significantly contributes to solving critical problems for the FCVT Program, as well as supporting industrial users in solving difficult problems; creating business opportunities and jobs; and educating researchers including post doctoral, students, and professors. In addition, this study found that research papers resulting from HTML user project are cited 17% more frequently than peer articles.

Technical Program Reviews
The FCVT Program Manager conducts reviews of selected technical areas on a monthly basis. The Program Manager's review includes examination of all milestones, reported on a monthly basis (or quarterly in the case of Joule milestones) into the automated CPS. Also, the Program Manager holds a senior management review on an annual basis with higher level managers including the Deputy Assistant Secretary for Technology Development. Decision or go/no-go milestones are reviewed as due. The continual review of milestone status in the Program provides a check on how well the Program is being implemented and progress is being made. Another evaluation is given by the monitoring and validation of planned deliverables that are validated by tests and simulation and modeling to prove achievement. Another very important activity of technical review is the continual review and evaluation of specific technical areas and its projects by government-laboratory-industry technical teams formulated under the Partnerships. Input is provided to DOE managers on a continual basis. Outside activity such as awards from independent groups provide another input, and measure, into the evaluation of the technical program.

2.6 Logic Models

Many different types of logic models and logic diagrams are used throughout the FCVT Program to help define and guide efforts and to help describe the efforts to stakeholders and interested parties. Only the broadest Program models are presented in this section.

An overall logic flow for the FCVT strategic approach is shown in Figure 2-12. The process begins with analyses to identify promising technologies shown in the blue horizontal bars. Technology is advanced through the R&D phases which require passage through major decision points to reach validation and later commercialization into advanced energy savings outcomes shown in the green ovals. Earlier work is chosen to offer energy savings in the near term but also to apply to the commercialization of even more beneficial technologies in the long term.

While always pursuing the EERE Strategic Goals, the Program has evolved from examining vehicle platforms for energy savings possibilities with industry partners to utilizing analyses and workshops to define the technological cross-cutting pathways and identify the specific beneficial advance to be pursued by government investment. This includes establishing technological goals (priority ones shown in Figure 2-13) that will lead to the beneficial outputs with potential to achieve the energy and petroleum savings outcomes. The logic flow includes strong emphasis on tracking, reporting, and evaluating progress and performance to continually improve the Program.

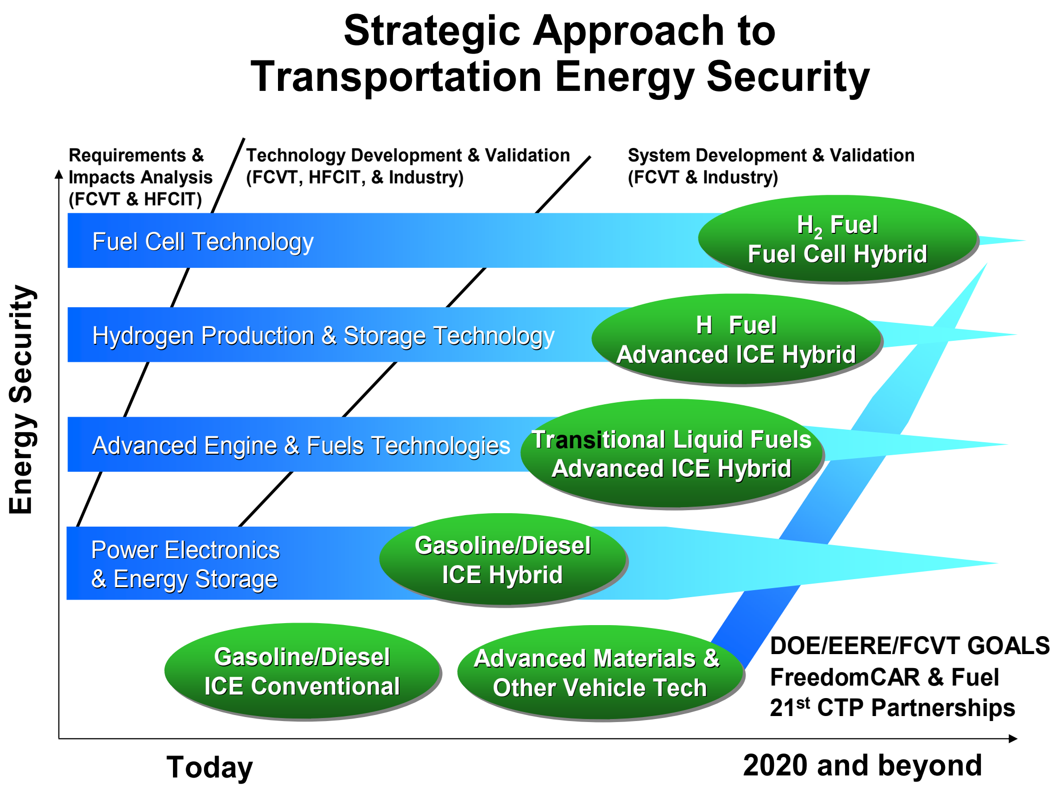

Figure 2-12. One Pathway to the Introduction of EERE-Supported Technologies into Commercial Products after the FCVT Program has validated the components

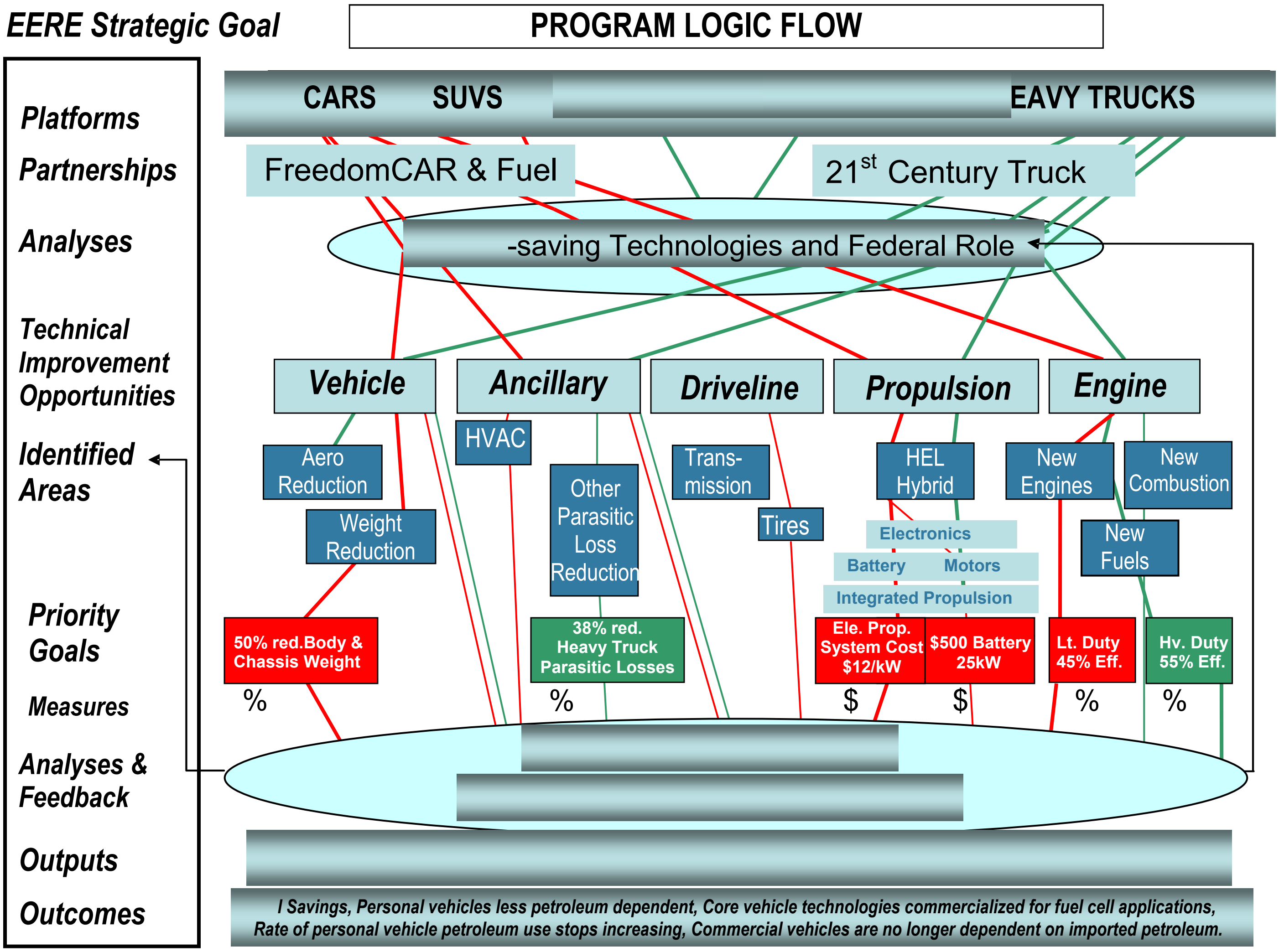

Figure 2-13. Overall Program Logic

2.7 Program Benefits

"Hydrogen can be produced from domestic sources–initially, natural gas; eventually, biomass, ethanol, clean coal, or nuclear energy. One of the greatest results of using hydrogen power, of course, will be energy independence for this nation. … If we develop hydrogen power to its full potential, we can reduce our demand for oil by over 11 million barrels per day by the year 2040. That would be a fantastic legacy to leave for future generations of Americans."

President George W. Bush
The National Building Museum
February 6, 2003

"Now, there's a lot of obstacles that must be overcome in order to make fuel cells economically viable. And, therefore, we're promoting more research and development. In January, Secretary Abraham announced a $150 million FreedomCAR plan."

President George W. Bush
The South Lawn
February 25, 2003

The FreedomCAR and Fuel Partnership is designed to reverse the United States' growing dependence on foreign oil by developing the technologies that lead to hydrogen-powered hybrid fuel cell vehicles. Approximately 70 percent of the request funding is for fuel cell and hydrogen research; the other 30 percent is for nearer-term automotive technologies within the FCVT Program that improve energy efficiency and provide the transition to hybrid fuel cell vehicles using hydrogen. The R&D conducted by FCVT serves the objectives of the Partnership in three ways:

1. Reducing petroleum dependence in the near term by improving hybrid vehicle technology [with gasoline or diesel internal combustion engines] and clean fuels while fuel cell technology is still being developed.
2. Developing additional technologies, such as power electronics, energy storage, and lightweight materials that will eventually be needed for fuel cell vehicles.
3. Stimulating the development of a hydrogen infrastructure through the near-term use of transitional liquid fuels and hydrogen in ICEs.

The HFCIT Program Multi-Year Research, Development and Demonstration Plan presents the rationale and potential national benefits for pursuing technologies that provide an increase in energy security through reduced petroleum dependence and a reduction in both criteria pollutants and greenhouse gas emissions in transportation. The factors that provide the rationale for a government role in R&D in vehicle energy use can be summarized as follows:

- U.S. crude oil production can provide for some of the nation's petroleum needs; however, crude oil production peaked in 1970.
- It has declined steadily since the mid-1980s, even with the addition of oil from Alaska's North Slope.
- Oil imports are a growing national concern.
- The United States imports more than half its oil (compared with a third during the 1973 oil crisis).
- Oil imports are expected to exceed 70% by 2025.
- Three trillion barrels of recoverable oil exist worldwide—a finite resource (U.S. Geological Survey).
- One fourth of the oil has already been produced and consumed.
- One-fourth of the oil has been discovered and "booked as reserves."
- One-half is either reserve growth or probable, but undiscovered, resources.
- Oil is relatively abundant, but it is distant from most major consumers, has an uneven geographic distribution, and is often concentrated in regions that have environmental sensitivities.
- Global transportation trends in petroleum consumption will increase oil demand.
- Transportation oil use continues to grow in industrialized countries.
- Growth in transportation oil consumption in developing countries will accelerate as their economies modernize. For example, in terms of vehicles per person, China is where the United States was in 1913; but it is growing at twice the current U.S. rate.

In addition, carbon emissions, which are directly proportional to the carbon in the fuel, result in greenhouse gases, such as carbon dioxide and methane, which are considered to have a detrimental effect on the global climate. The conclusion, from the energy and environmental trends, is that the world cannot remain dependent on petroleum fuels forever; a transition will be necessary at some point. The earlier the transition is begun, the smoother the process is likely to be (e.g., there will be fewer economic shocks due to fuel price spikes). The FreedomCAR and Fuel Partnership provides for such a transition. The transition strategy involves developing advanced personal and commercial vehicle technologies that will help dramatically reduce oil consumption as soon as possible, while also helping achieve the nation's long-term goal of driving fuel cell vehicles. These new technologies include components for hybrid electric vehicles (batteries, electric drivetrains, and controllers), lightweight materials, improved fuels, advanced combustion engines, and other improvements that make today's hybrids more efficient and that will serve as "core components" in tomorrow's fuel cell vehicles.

Energy Security Benefits
Of the oil we consume, the amount imported from foreign countries is nearly 60 percent – and growing rapidly. Improving the efficiency of personal and commercial vehicles will have a dramatic and positive impact on energy security.

The oil savings benefit of successful market penetration of DOE-supported technologies in the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership has been simulated as a part of the required GPRA. For light-duty vehicles, two separate analyses were conducted because the FreedomCAR and Fuel Partnership is engaged in R&D of mid-term technologies (e.g., hybridization, high-power-density batteries, lightweight materials, improved combustion, alternative fuels) as well as longer-term technologies (hydrogen and fuel cells). The development of the nearer-term technologies is the focus of the FCVT Program, while hydrogen and fuel cell development is the responsibility of the HFCIT Program. FCVT is also the major Federal R&D organization for commercial truck technology development in the 21st CTP.

The GPRA simulations were developed using two models: 1) the National Energy Modeling System (NEMS) developed by the Energy Information Administration for forecasts to 2025 and 2) for 50-year forecasts, the MARKAL model, developed in a cooperative multinational project over a period of almost two decades by the Energy Technology Systems Analysis Programme of the International Energy Agency.

The DOE/EERE Office of Business Administration (BA) performs a key role in conducting these analyses. Using the program-provided outputs and assumptions, BA works with the Benefits Analysis Team to prepare the technical assumptions needed to run the GPRA-NEMS and GPRA-MARKAL models. These models estimate the economic, energy, and environmental outcomes that would occur over the next 20 and 50 years, respectively, if the program is successful and the future unfolds according to the business-as-usual scenario. BA then compares the outcomes of model runs that include EERE's programs with the outcomes of runs without EERE's programs. The benefits of EERE programs are determined by the improved economic, energy, and environmental outcomes provided by EERE's activities.

In the coming years, BA will extend its benefits estimation tools to address a range of uncertainties. BA is developing alternative scenarios that will be used to illustrate the value of the current EERE portfolio under different futures along with tools and methods to explore how alternative program goals, budgets, and schedules can make EERE's benefits more robust to withstand uncertainties.

Oil Savings in Light-Duty Vehicles.
Oil Savings in Light-Duty Vehicles in a "stand-alone" simulation, the FCVT-supported technologies are commercialized (alone, without any hybrid fuel cell vehicles) by the FreedomCAR and Fuel industrial partners. As indicated in Figure 2-15, initial commercialization will begin by 2010 with modest market penetration in light-duty vehicles as well as heavy trucks. Because the FCVT-supported technologies (components, subsystems, and systems) are commercialized in new vehicles, it takes time for the more efficient vehicles to become a substantial share of the stock of on-the-road vehicles and for the oil savings benefits to accumulate. The technologies that become commercial include accelerated growth in HEVs with advanced batteries, increased use of lightweight materials, and advanced combustion processes. The petroleum reduction is relatively modest until 2025, but then the oil savings grow at a rapid rate. Oil savings nearly double between 2025 and 2030, from 1.1 million barrels per day (MMBD) to 2.0 MMBD. By 2040, petroleum savings are forecast to be nearly five MMBD, continuing to almost seven MMBD by 2050.

A second case that was analyzed is called Integrated Vehicle Technologies, which includes FCVT technologies and hybrid fuel cell vehicles. Results of this analysis are shown in Figure 2-16. Many of the FCVT technologies not only provide oil savings benefits on their own but also facilitate fuel economy improvements in hybrid fuel cell vehicles. For example, hybridization and advanced batteries enable hybrid fuel cell vehicles to take advantage of regenerative braking. Lightweight materials enable any vehicle, regardless of its propulsion system, to be more energy efficient.

Hybrid fuel cell vehicles, because of complexities and hydrogen fueling infrastructure issues, are commercialized later than the FCVT technologies, beginning in about 2020. So the oil savings benefits for the decade between 2010 and 2020 are due to FCVT-supported technologies. Hybrid vehicles with conventional engines are still predominant until 2025, after which both conventional hybrids and hybrid fuel cells share the light-duty vehicle market. This sharing of the market continues for the foreseeable future; although hybrid fuel cells are more energy-efficient, conventional hybrids remain less expensive. In the Integrated Vehicle Technology case, the FCVT light-duty vehicle portion of the oil savings continues to grow, from 0.5 MMBD in 2020 to 1.6 MMBD in 2030 to 3.1 MMBD in 2040. Oil savings still increase after that, but at a slower rate.

Oil Savings in Heavy-Duty Vehicles
Heavy trucks account for about one-fourth of the energy consumed by highway vehicles. Much of the nation's high-value freight is shipped by trucks, and the propulsion system for over-the-road trucks (Class 8) is dominated by relatively efficient diesel engines. Nevertheless, there is room for energy-efficient improvements. The FCVT Program also supports technology development to improve medium- and heavy-duty truck fuel economy. This research is focused on advanced combustion, improved aerodynamics and rolling resistance, heavy hybrid technology (focused on Class 3-6 trucks), and essential power systems. The oil

savings potential of fuel economy improvements in heavy-duty vehicles was also evaluated with the NEMS and MARKAL models. The petroleum savings benefits for heavy-duty trucks remain the same in both the stand-alone and Integrated Vehicle Technology cases. Modest fuel savings begin in 2010 with the introduction of the initial technologies. Oil savings in both cases grow to nearly one million barrels per day by 2035, and continued savings are a little above this level for the out-years, as shown in Figures 2-14 and 2-15.

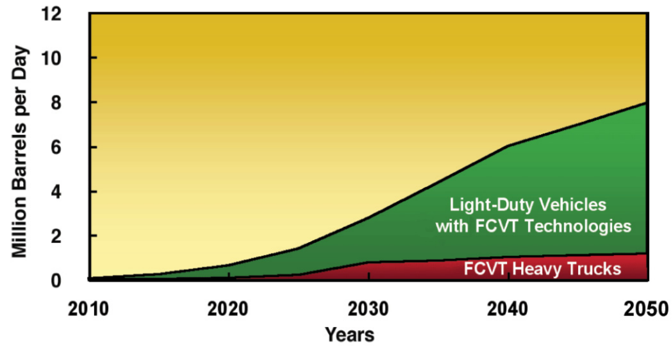

Figure 2-14. Oil Savings due to FCVT if Hybrid Fuel Cell Vehicles are not introduced

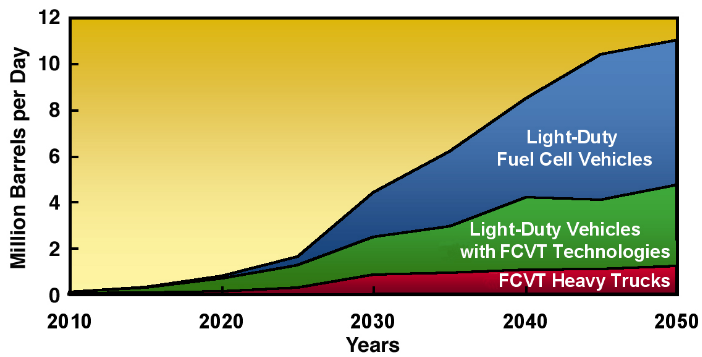

Figure 2-15. Integrated Fuel Savings of FCVT and HFCIT Fuel Cell Technologies

Greenhouse Gas Emissions

Upstream emissions (well to pump or WTP) that occur in the production and distribution of fuels may be as important as vehicle emissions (pump to wheel or PTW). Gasoline and diesel HEVs can have considerable greenhouse gas (GHG) benefits, as illustrated in Figure 2-16. Based on examining the total energy cycle on a per-vehicle basis using the GREET (Greenhouse gas, Regulated Emissions, and Energy use in Transportation) model, hybridization can reduce GHG emissions by nearly 50% compared with conventional vehicles, providing additional environmental benefits of a transition to the goal of hybrid fuel cell vehicles operating on hydrogen. The fuel economy improvements achieved by heavy-duty vehicles will also contribute to a reduction in GHG emissions, as carbon emissions from petroleum are directly related to fuel economy. The MARKAL simulation of the technologies developed with the support of FCVT forecasts carbon emissions reductions of over 300 million metric tons (carbon equivalent) by the year 2050.

Overall Summary

The FCVT Program mission and activities contribute directly to EERE's and DOE's mission of improving National Energy and Economic Security. Its mission and activities address the President's National Energy Policy call for reducing dependence on oil imports and modernizing conservation technologies and practices. President Bush observed that ". . . any effort to reduce (oil) consumption must include ways to safely make cars and trucks more fuel efficient. New technology is the best way to do

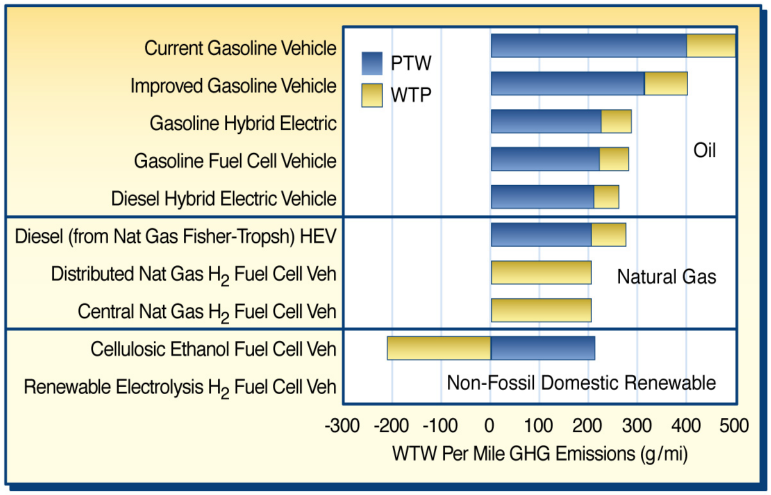

Figure 2-16. Comparative Total Energy Cycle Greenhouse Gas Emissions from Selected Vehicle Technologies

so." In fact, highway vehicles alone account for 54 percent of total U.S. oil use, more consumption than U.S. domestic oil production. Cost competitive and more energy-efficient vehicles will enable U.S. citizens and businesses to accomplish their daily tasks while reducing their consumption of gasoline and diesel fuels, thus reducing demand for petroleum, lowering carbon emissions, and decreasing energy expenditures.

If implemented and fully successful, the FCVT Program integrated activities will improve the energy efficiency and productivity of our economy. These improvements are planned to reduce susceptibility to energy price fluctuations and potentially lower energy bills; reduce EPA criteria pollutants; reduce greenhouse gases; enhance energy security by increasing the diversity of domestic fuel use; and provide greater energy security and reliability by reducing reliance on imported oil. In addition to these "EERE business-as-usual" benefits, realizing the FCVT Program goals would provide the technical potential to reduce conventional energy use even further if warranted by future energy needs. Estimates of annual non-renewable energy savings, energy expenditure savings, carbon emission reductions, and oil savings that result from the realization of FCVT Program benefits are shown overall in Table 1 as shown in Section 1.10 through 2050. These benefits are achieved by targeted Federal investments in technology research and development in partnership with auto manufacturers, commercial heavy-duty vehicle manufacturers, equipment suppliers, fuel and energy companies, other Federal agencies, state government agencies, universities, national laboratories, and other stakeholders. These partnerships facilitate the technical coordination of activities and attract cost sharing to provide leveraged benefits for the American taxpayer.

The assumptions and methods underlying the modeling efforts have significant impact on the estimated benefits, and results could vary significantly if external factors, such as future energy prices, differ from the "baseline case" assumed for this analysis. EERE's baseline case is essentially the same as the EIA "business-as-usual" case presented in its Annual Energy Outlook. In addition, possible changes in public policy and disruptions in the energy system which may affect estimated benefits are not modeled. The external factors such as unexpected changes in competing technology costs could also affect the Program's ability to achieve its goals. A summary of the methods, assumptions, and models used in developing these benefit estimates that are important for understanding these results are provided at:

http://www.eere.energy.gov/ba/pba/gpra.html.

Uncertainties are larger for longer term estimates. The results shown in the long term benefits tables are preliminary estimates based on initial modeling of some of the possible program production technologies; nonetheless, they provide a useful picture of growing national benefits over time.

FY 2006 GPRA Benefits Estimates for the FCVT Program are provided in Section 1.10 Program Outcomes, of this plan.

2.8 Relationship to Other EERE, DOE and Federal Programs

FCVT coordinates its research with its industrial partners, and with other offices within EERE, with other offices within DOE, and with others outside DOE. Unique relationships are formed as a part of the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership. Additional relationships within EERE are formed as a part of crosscutting research and development efforts and outside EERE as a part of implementation of the Energy Policy Act of 1992.

The Program leads, along with the HFCIT, the FreedomCAR and Fuel Partnership, a collaboration among the DOE, the U.S. Council for Automotive Research and five energy companies to support the FreedomCAR goals. The USCAR member companies are Ford, General Motors and DaimlerChrysler. The energy partners are BP PLC, Chevron Corporation, ConocoPhillips, Exxon Mobil Corporation, and Shell Hydrogen (U.S.). HFCIT, within EERE, is responsible for R&D in the areas of hydrogen production, storage, and utilization for the purpose of making hydrogen a cost-effective energy carrier for transportation applications; and research, development and validation of fuel cells for transportation applications. Therefore, FCVT collaborates closely with HFCIT to ensure that the FCVT transportation vehicle technologies and the HFCIT hydrogen and fuel cell technologies are implemented in a synergistic fashion. The Programs share responsibility for the development of hydrogen fueled internal combustion engines.

FCVT is also the lead government office for 21st CTP. This partnership between the trucking industry and the government has the objective of significantly reducing the petroleum dependence of medium- and heavy-duty trucks. In the 21st CTP DOE teams with the Department of Defense, the Environmental Protection Agency and the Department of Transportation to sponsor coordinated efforts towards this objective. Industry partners are Allison Transmission, BAE Systems Controls, Caterpillar, Cummins, DaimlerChrysler, Detroit Diesel, Eaton Corporation,

Freightliner, Honeywell International, International Truck and Engine, Mack Trucks, NovaBUS, Oshkosh Truck, PACCAR, and Volvo Trucks North America.
A number of technologies or research areas pursued by FCVT are of interest to other EERE programs. Prominent among these are materials, power electronics, and new fuels. Crosscutting teams, with technical representatives from each program, have been formed to coordinate efforts and share information and knowledge. FCVT participates in several crosscutting teams.

EERE-managed research activities are often leveraged with Office of Science research. These leveraged activities include co-funding of the Combustion Research Laboratory, using Office of Science–procured massively parallel computers for vehicle crash modeling, and performing applied research in the Advanced Photon Source. Many technologies discovered in the Office of Science BES Program are carried through applied research by this program and others within EERE. As an example, capacitors discovered under funding from the BES are now undergoing applied research funded by the FCVT Program to determine their applicability to hybrid vehicle inverters. Similarly, combustion technologies coming out of the basic research program are now being applied to engines for transportation vehicle applications. Ceramic materials invented in the BES program, were the subject of EERE funded applied research and are now commercialized in heavy truck engines.

As a part of implementation of EPAct, DOE (and FCVT as the Program with responsibility) has a distinctive relationship with all other Federal agencies including the White House. The EPAct fleet programs require selected covered fleets (as well as the Department) to procure alternative fuel passenger vehicles annually. DOE tracks and reports on Federal Fleet compliance according to Executive Order 13149. The FAST (Federal Automotive Statistical Tool) system is used and made available to facilitate the review and analysis of their own fleet data by agencies.