A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

EERE-Approved Ten-Year Site Plan / Capital Investment Plan for NREL

FY 2005 – FY 2015

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1 Director's Statement

With the urgency of national and energy security, and our desire for energy sources that do not adversely impact our environment, NREL has a mission of vital importance to the Nation – to develop renewable energy and energy efficient technologies and practices. NREL is recognized as having some of the best scientists in the world working towards that goal. But the best research minds in the world are not enough to accomplish NREL's mission. R&D cannot be done without adequate facilities and equipment. Scientific and engineering progress requires research laboratories, engineering and testing facilities, and process facilities. Technical accomplishments require up-to-date scientific instruments, computer and telecommunication systems, and engineering, testing, and process equipment. Without excellent laboratories and equipment, the best scientists are difficult to attract and retain.

All too often, capital investments are seen as being in competition with other program funding, rather than a necessary element integral to accomplishing the program mission. The National Academy of Sciences recently addressed this issue within the Department of Energy: "This 'zero-sum game' approach may have been relevant 50 years ago, but it has been discarded by most, if not all, successful organizations in government and industry. The intimate integration of missions and management processes applies not only to facilities and infrastructure but also to environmental performance, safety, health, community relations, and other supporting functions. Such elements are not competitors for program resources; rather, they are program enablers that make the program bigger and better than the sum of its parts."[1]

The United States has invested in facilities and equipment at NREL that today has an estimated value of approximately $279 million dollars. The physical assets of NREL, combined with the human assets developed over the 27-year history of the Laboratory, represent a vital national resource base that requires vigilant stewardship in order to maintain it at the peak of its value. One of the most important elements of that stewardship is to integrate into the program strategies each year the necessary portfolio of capital investments, balanced so as to both sustain the current assets and build capabilities that will be needed in the future.

NREL prepared a comprehensive ten-year site plan, dated February 4, 2005, that describes the facilities and equipment that would be needed to accomplish the mission of the Laboratory through 2015. EERE endorsed portions of that plan, and those EERE-approved projects are included in this version.

Dan Arvizu

[1] Intelligent Sustainment and Renewal of Department of Energy Facilities and Infrastructure; December 2004, Committee on the Renewable of Department of Energy Infrastructure, National Research Council of the National Academies, The National Academies Press, Washington, D.C. (www.nap.edu).

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i Preface

The Ten-Year Site Plan is organized as follows:

Section 3. Executive Summary
This section highlights NREL's facility and infrastructure requirements, both construction line item and large general plant projects (including facility-related capital equipment). It also summarizes budget requests for small general plant projects, non-facility-related program capital equipment, and general purpose equipment. The Executive Summary includes the Ten-Year Facilities, Infrastructure, and Equipment Plan (Table 3.1) that summarizes the costs of all capital investments required at the Laboratory FY 2005 – FY 2015.

Section 4. Laboratory Overview
This section introduces the reader to the Laboratory's mission, programs, partnerships, and staff.

Section 5. Capital Investment Principles and Process
This section lays the groundwork for the Laboratory's management approach to capital investments, including roles, goals and outcomes, the various documents and processes related to capital planning at the Laboratory, the internal processes that today result in NREL's Ten-Year Site Plan, and a summary of the DOE project management process.

Section 6. Capital Asset Overview
This section summarizes the value and type of investments DOE has made at NREL, and benchmarks those investments against other organizations. This section also summarizes the value of those investments today, the amounts spent today on maintenance, and the facility condition index for NREL. This section then characterizes the current status of NREL's two major sites, its facilities, and its capital equipment, and summarizes the issues and opportunities relating to each.

Section 7. Capital Investment Plan – Mission (Facilities and Program Capital Equipment)
This section summarizes a concise capital investment plan for each of NREL's major programs, including strategic context, facilities status and requirements, and capital equipment status and requirements. Because each proposed facility project typically benefits more than one program, only a brief description of the proposed facility is included here. A more complete description, by facility, is included in Section 8.

Section 8. Capital Facilities Requests – Mission
This section describes each of the major (large general plant project and construction line item) facility requests that are most directly driven by program (mission) need. Each facility request in this section is a part of one or more program investment strategies in Section 7. Facility and infrastructure requests that are less directly connected to programs, and serve more the institutional needs of the Laboratory, are discussed in Section 10. The facility descriptions and cost estimates in section 8 all include facility-related capital equipment.

Section 9. NREL Site Development / General Development Vision
This section summarizes the Laboratory's goals for sustainable development and its 25-year site plan.

Section 10. Capital Investment Plan and Budget Requests – Institutional Facilities and Infrastructure (General Plant Projects)
This section summarizes the activities and results of NREL's condition assessment process for current facilities, requirements for new capabilities in facilities and infrastructure, the ten-year plan for the small general plant projects pool, and detailed descriptions of facility and infrastructure requests that primarily benefit the entire institution.

Section 11. Capital Investment Plan and Budget Requests – Institutional (General Purpose) Equipment
This section summarizes the condition of institutional equipment (as opposed to program capital equipment), the processes used to plan institutional equipment, a major initiative in institutional equipment, and the ten-year plan for institutional equipment. This section also includes detailed investment plans for each of the three major areas of institutional equipment.

Section 12. Budget Tables
This section repeats the Ten-Year Facilities, Infrastructure, and Equipment Plan (Table 3.1) as Table 12.1, so that it is conveniently adjacent to Table 12.2, which breaks out the estimated cost for each project in detail.

Appendices
The appendices present more detail on NREL's capital assets (A-C) and leased facilities (D). Appendix E includes detail on the maintenance projects that are typically part of the Laboratory's small general plant projects pool, and Appendix F includes detail on representative items of the institutional (general purpose) equipment that are anticipated as requirements in FY 2006 and FY 2007. Appendix G provides a brief summary of each of the FY 2003 and FY 2004 general plant projects and general purpose equipment projects. Appendices H-K provide necessary editorial information for the document.

3 Executive Summary

Since the National Renewable Energy Laboratory (NREL) opened its doors in 1977, the Department of Energy has invested in capital assets at the Laboratory that are today worth $279 million ($176 million replacement plant value for facilities and infrastructure, and $103 million in estimated value today for capital equipment). NREL is committed to managing these assets, and providing additional capabilities, to:

- Accomplish the mission with adequate facilities, infrastructure, and equipment
- Promote mission excellence through the working environment
- Demonstrate sustainable design and practices
- Maintain safe and secure facilities and operations

Achieving these goals requires leadership from program managers and institutional managers at both NREL and DOE. The NREL Ten-Year Site Plan / Capital Investment Plan FY 2005 – FY 2015 (TYSP) forms the overarching strategic link between the mission of NREL and the investments in physical assets that make that mission possible. As such, it is a key management tool for developing and communicating the investment rationale – the business case – for capital investments.

The TYSP is the product of a comprehensive planning process intended to reach a shared understanding among NREL and DOE managers of the future goals and expectations of research and development at NREL as they affect requirements for buildings, infrastructure, and equipment, and identify the capital investments that are needed to successfully meet those goals. This document is intended to communicate this understanding and these proposed investments.

3.1 NREL Facilities and Infrastructure

NREL's first building was constructed in the early 1980s. As a relatively young institution in the DOE system, with no environmental legacies, its challenges with facilities and infrastructure are different from many other DOE laboratories. While the overall facility condition index[1] today of 2% is rated "Good," the oldest facilities are now beginning to require maintenance, sustainment, and recapitalization (refurbishment and modernization). As stewards of the DOE investment, NREL is committed to maintaining these facilities in a "Good" or "Excellent" condition. Maintaining this "Good" rating and working off the current $3.5 million deferred maintenance backlog will require steady attention to capital funding to avoid the large deferred maintenance legacies of other laboratories.

At the same time, however, the Laboratory is challenged by not having enough adequate research space to meet program needs. This problem is particularly acute for bench-scale laboratories at NREL's primary research site, and engineering and testing facilities at both of NREL's sites. Utilization rates of existing facilities are 100% for labs and near that for office space. Such high utilization rates mean that there is little flexibility to set up a new experiment, start a new research project, or accommodate research needs of additional visiting professionals or students. Leased facilities can and are being used, but this solution results in research teams that are

[1] The Facility Condition Index is the value of the deferred maintenance backlog (facility and infrastructure components not replaced at the end of the optimal period of use) as a percent of the total replacement plant value.

scattered among buildings up to 15 miles apart, thwarting efficiency and creativity in scientific progress, increasing costs, and imposing limitations on research because of ES&H requirements.

Today, the Laboratory's primary site has one major research laboratory for solid-state research, one major mixed-use laboratory, and three smaller research buildings; the secondary site has three specialized facilities for wind turbine development and testing. During the period FY 2005 – FY 2015, EERE has endorsed the addition of the following projects:

- The **Science & Technology Facility**, currently under construction and scheduled to be completed in January 2007, will provide the first research capability in the world for developing improved manufacturing techniques for thin-film, large-area devices like solar cells, electrochromic films, and nanostructured and thin-film materials of all kinds. This will help U.S. industry compete in the intensely competitive, rapidly growing world market for solar systems and increase the viability and deployment of renewable energy technologies. This is the first major new research building at NREL since the completion of the Solar Energy Research Facility in 1992, a hiatus of 14 years. Construction and facility-specific capital equipment funding is anticipated to be $13.3 million in FY 2006. Facility-specific capital equipment funding is anticipated to be $2.8 million in FY 2007.
- The **Engineering Test Laboratory** will provide the first research space at NREL that is dedicated to the integration and testing of renewable energy systems, hydrogen and fuel cell systems, and advanced vehicle technologies. Systems research will increase the reliability of electricity generation, delivery, and use, and by integrating hydrogen and advanced vehicles technologies, will reduce dependence on foreign oil. The funding profile for this proposal is $3.6 million, $26.4 million, and $6.0 million in FY 2007 – FY 2009 respectively, including essential capital equipment.
- The **South Table Mountain Roads & Utility Extension** projects will extend the roads and utilities into the undeveloped south central and northeast portions of NREL's primary site. NREL's assumption at this time is that the southern project may be needed first, and is estimated at $2.7 million in FY 2007. The northern project is currently estimated at $3.0 million in FY 2010. The order of these projects may change depending on the final siting decisions made for the Engineering Test Laboratory and the Research Support Facility.
- The **Field Test Laboratory Building HVAC Expansion** project will address the immediate problem of marginal ventilation capacity in the Field Test Laboratory Building, at an estimated cost of $1.1 million in FY 2007.
- The **Research Support Facility** would provide sufficient space (300,000 gsf) to enable NREL and DOE staff in Golden to move from leased office space onto the primary NREL campus. This $60 million-project has been judged "mission critical" and approved by the DOE Office of Program Analysis and Evaluation. A proposal has been made for third-party financing.

NREL's **Small General Plant Projects** pool enables the Laboratory to annually address most of the current, small (less than $1 million) construction projects necessary to maintain and sustain its facilities and infrastructure. This funding also enables the Laboratory to respond quickly each year to the small laboratory reconfigurations and utility modifications needed to meet changing research needs, and carry out safety and security improvements at NREL sites. Both the requirements to sustain assets and the requirement to add new capabilities for research, safety,

and security are increasing every year. The funding request for Small General Plant Projects for FY 2007 is $4.7 million.

3.2 NREL Capital Equipment

While NREL's facility condition index today is 2% or "Good" for facilities and infrastructure, NREL's equipment condition index[2] (ECI) today is 15%, a rating of only "Fair." This means that 15% of the value of NREL's capital equipment today is older than its useful life, and should have been replaced already to avoid technical obsolescence and/or repair downtime. The problem is most acute in the Solar Program, where the ECI is 27% ("Poor") and the average age of the equipment is 13 years compared to an average useful life of 11 years. The amount of equipment that is currently out of date in the Solar Program would require more than $9 million today to replace with upgraded, modern equipment. The next most substantial problem is with General Purpose Equipment (GPE), with an ECI of 20% ("Fair") and a deferred replacement backlog today of $2 million.

Like facilities and infrastructure, capital equipment investments need to be planned not only to replace aging equipment in a timely manner, but also to provide the new capabilities that are constantly required to conduct the highest quality research and respond to new research directions. The new capability equipment that is essential to the functioning of each of the new facilities proposed above is planned and included in the funding estimates for the facilities. However, new research equipment is also needed for today's work in existing facilities. Each NREL program has addressed its capital equipment strategy in the TYSP. For example, Hydrogen, FreedomCAR, and Distributed Energy have not yet invested in substantial capital equipment at NREL. A shortage of capital equipment in a particular programmatic area may put a research program at a disadvantage in needing to borrow time on shared equipment, or limiting its ability to accomplish milestones. Solar, as mentioned above, needs substantial new equipment to replace items beyond their useful life, and new equipment for the Science & Technology Facility. In addition, new instruments (such as an organic semiconductor device bench-scale fabrication system) are needed for ongoing research. In total in FY 2007, NREL programs require $2.8 million for program capital equipment related to specific facilities (S&TF). In addition, NREL anticipates receiving $9.9 million for program capital equipment not related to specific facilities that will include equipment needed to replace obsolete equipment as well as to add new technical capabilities.

General Purpose Equipment includes NREL's information technology (administrative computing) equipment, networks, and telecommunications equipment, as well as shared scientific instrumentation and computational science equipment. The FY 2005 funding level for GPE is assumed, as of January 2005, to be $1.8 million. The FY 2006 funding level for GPE is estimated to be $3.4 million, an increase intended to partially address the GPE deferred replacement problem. An additional increase is needed in FY 2007 to complete the reduction of the deferred replacement backlog in that year and meet the needs for new scientific instrumentation and information technology equipment. Also, the Laboratory proposes a $5-million, two-year initiative ($2.5 million each year in FY 2007 and FY 2008), to significantly increase its capacity for computational science. Computational science -- using computers to

[2] The equipment condition index is the value of the deferred replacement backlog (equipment items not replaced at the end of their strategic useful life) as a percent of the total estimated value of the equipment today.

visualize protein structures, predict photovoltaic device efficiencies, and similar research challenges -- is rapidly becoming the third fundamental technique, along with theory and experiment, in the 21st-century practice of science. The total FY 2007 NREL request for GPE is $8.3 million.

Conclusion

NREL's facilities, infrastructure, and equipment are vital to the success of the Laboratory mission and the nation's energy goals for the future. The Laboratory is committed to working with DOE to determine and pursue the necessary projects and funding to provide the best possible facilities and equipment for NREL scientists and engineers in the conduct of their research.

Table 3.1. NREL Ten-Year Facilities, Infrastructure, and Equipment Plan -- FY 2005 - FY 2015 ($ Millions) (Notes 1,2)

Total Estimated Capital Cost (including facility-specific equipment)

	Project	Primary Beneficiaries	Fund	Prior	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	Total
	Small General Plant Projects	***All***	***Small GPP***		$2.0	$2.4	$4.7	$3.4	$4.8	$2.5	$2.9	$4.1	$9.3	$8.8	$3.9	$48.8
	General Purpose Equipment	***All***	***GPE***		$1.9	$3.4	$8.3	$5.0	$4.4	$6.3	$5.6	$3.8	$7.6	$8.5	$7.9	$62.7
	Program Capital Equipment Not Related to Specific Facilities	***All***	***PCE***		$5.5	$7.3	$9.9	$9.1	$9.5	$10.6	$5.2	$5.2	$5.7	$7.5	$5.4	$81.0
	Project Engineering & Design (PED) (Note 3)	***All***	***PED***	$1.6			$3.6									$5.2
	PED Project Allocation			A			B									
A	***Science & Technology Facility***	***Solar, HFCIT***	***CLI***	$5.5	$7.7	$13.3	$2.8									$29.2
B	***Engineering Test Laboratory***	***HFCIT/FCVT DER***	***CLI***				$3.6	$26.4	$6.0							$36.0
	FTLB HVAC Expansion	***All***	***Large GPP***				$1.1									$1.1
	STM Roads & Utility Extension Phases I and II	***All***	***Large GPP***				$2.7			$3.0						$5.7
	TOTAL			***$5.5***	***$17.1***	***$26.4***	***$33.0***	***$43.9***	***$24.6***	***$22.5***	***$13.6***	***$13.1***	***$22.5***	***$24.8***	***$17.2***	***$264.4***

Note 1 -- This table does not include the Research Support Facility, proposed for third-party financing. (See line below)

Note 2 - All numbers for FY2007 and beyond (excluding S&TF) represent uncertainties of +/- 20%.

Note 3 - Project Engineering & Design (for CLI) (PED) funds are required for CLI projects. The DOE process is normally to establish a PED pool for each program. NREL has chosen to identify PED funds project by project rather than showing a PED pool, but has summarized all the PED funds required here in one line, for information only.

Research Support Facility	***All***	***Third-Party***			$60.0											$60.0

4 Laboratory Overview

NREL is EERE's primary laboratory for energy efficiency and renewable energy research and development. NREL's major emphasis is on the advancement and adoption of renewable energy, energy efficiency, and related technologies and practices. NREL activities include efforts to advance and transfer renewable energy and energy efficient end-use technologies in support of DOE's mission.

NREL is a Federally Funded Research and Development Center (FFRDC), operated under a management and operating contract (M&O) by the integrated Midwest Research Institute and Battelle team on behalf of the Department of Energy. While the Office of Energy Efficiency and Renewable Energy (EERE) is the primary sponsor of work at the Laboratory, NREL performs work for or with other DOE programs; federal, state, or local government entities; private sector companies or research institutions; or academic institutions related to DOE's mission at NREL. To achieve this goal, the Laboratory conducts a wide spectrum of research and development programs and makes its government-funded scientific and technical research results broadly available to the public. NREL also serves as a technical advisor, offering guidance to DOE in support of policy development, program planning, and other DOE activities, while advancing recommendations for new research and development programs designed to achieve DOE mission goals.

NREL Mission
NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovations to address the nation's energy and environmental goals.

4.1 Funding Portfolio

NREL was established by the Solar Energy Research, Development, and Demonstration Act of 1974, and opened its doors in 1977. The often-changing pattern of NREL's funding and staffing is shown in Figure 4.1.1. The DOE Leading Program Secretarial Office for NREL is the Office of Energy Efficiency and Renewable Energy, who provides nearly 90% of NREL's annual funding (Figure 4.1.2). For EERE, NREL's major research programs are in solar, biomass, wind, and FreedomCAR, but other areas are vitally important to NREL's mission (Figure 4.1.3). Hydrogen technologies have been important at NREL since the early 1990s, and are currently a major emphasis under the President's Hydrogen Fuels and FreedomCAR Initiatives. Distributed energy has gained importance in the last several years to address the technical issues of integrating distributed energy technologies such as renewables into the nation's electricity solutions. Geothermal technologies have also been a small but steady part of NREL's expertise. Building energy efficiency has been a strong program for many years in specific areas of expertise, and transportation-related technologies are a growing area of expertise at the Laboratory.

NREL has been steadily funded by the Office of Science in key areas related to EERE applied technologies, including materials science, chemical sciences, and biological sciences. NREL prides itself on demonstrating effective working relationships and collaborations at the interface between the fundamental research mission of the Office of Science and the applied research mission of the Office of Energy Efficiency and Renewable Energy, and hopes to increase its contributions at this vital interface.

NREL also has strong programs directed towards transferring technical successes in renewable energy and energy efficiency to widespread use, working in partnership with industries, government energy users and policy makers, and the general public.

NREL's work for other DOE offices includes work for the Office of Transmission and Distribution and the Office of Nuclear Non-Proliferation for the Initiative for Proliferation Prevention. Non-DOE sources of mission-related work include various organizations in the Department of Defense, environmental Protection Agency, and U.S. Agency for International Development. NREL expects work for others to grow in the future as the Laboratory continues to embrace an ever-widening circle of partners.

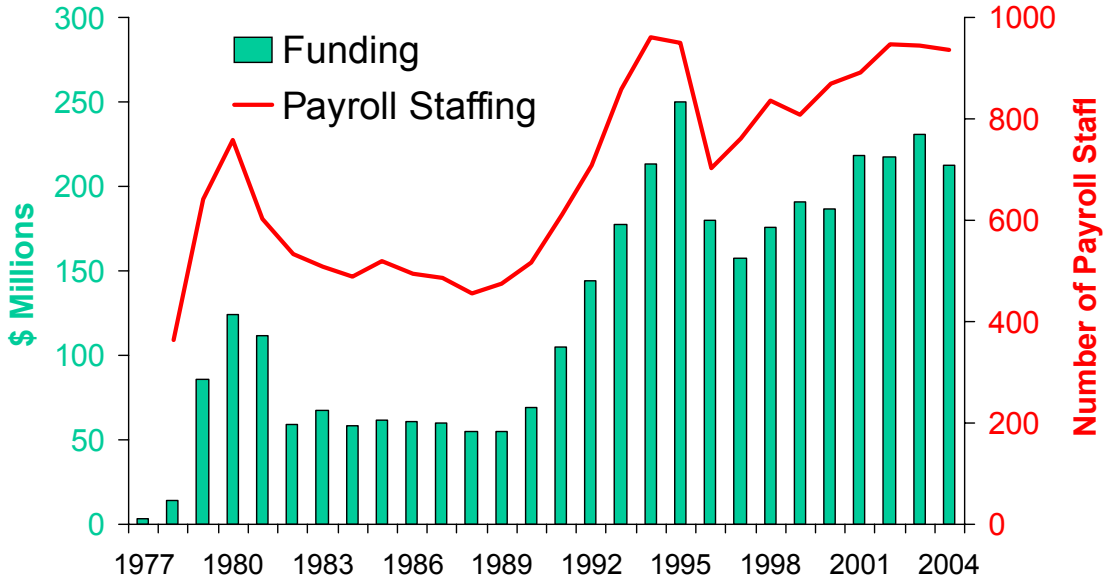


Figure 4.1.1. NREL Funding and Staffing

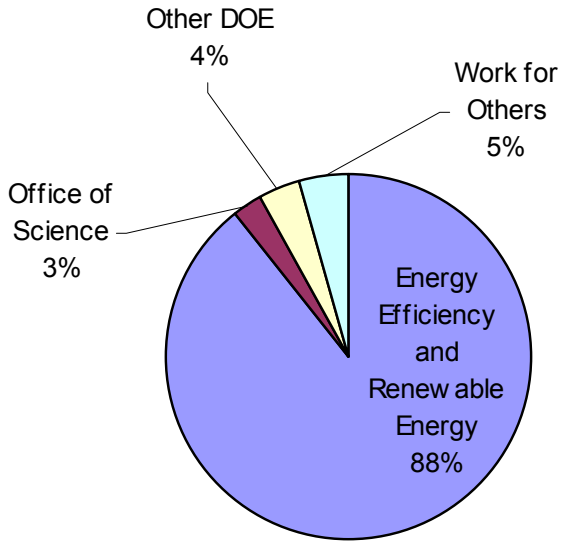


Figure 4.1.2. EERE is the Leading Program Secretarial Office for NREL (FY 2004 Budget Authority = $213 Million)

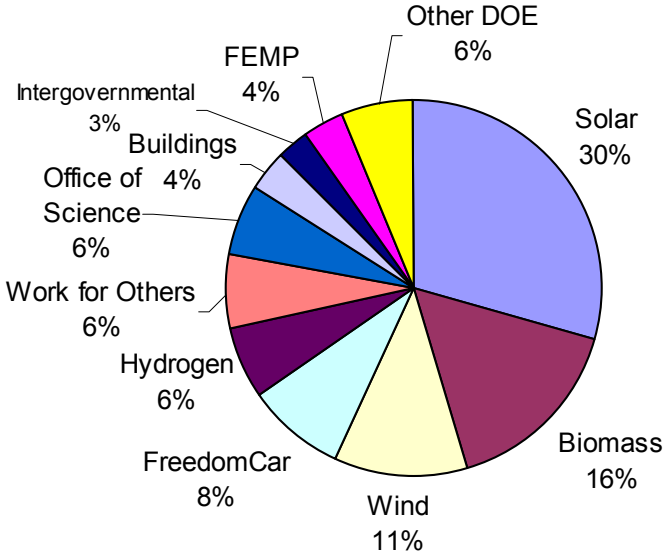


Figure 4.1.3. NREL FY 2004 FTE Distribution by Program

4.2 Partnerships

One of NREL's primary mechanisms for encouraging that research is truly relevant to industry's needs is to partner with companies in subcontracted research. NREL also subcontracts research with many U.S. universities, drawing upon the best minds to work collaboratively with NREL scientists. Figure 4.2.1 compares the total budget authority in FY 2004 with the amount of in-house costs. As seen in this figure, some programs subcontract as much as 50% of their funding to industry and university partners; other programs subcontract less. In FY 2004, 44% overall of NREL's operating costs were subcontract research. Other partnership mechanisms, such as cooperative research and development agreements, complement NREL's subcontracted research.

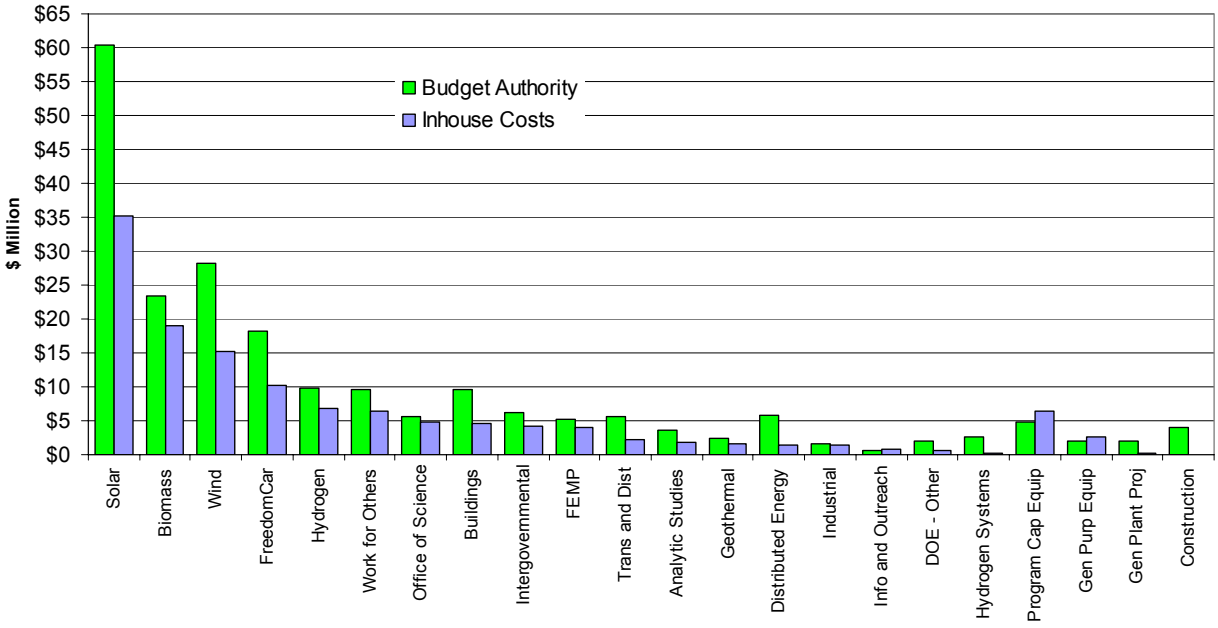


Figure 4.2.1. NREL FY 2004 Funding and In-house Costs by Program

4.3 Staffing Portfolio

Roughly one-quarter of NREL's payrolled staff have a bachelor's degree, one-quarter have master's degrees, and one-quarter have Ph.D.s (Figure 4.3.1). In terms of disciplines or job families, half of the staff are scientists and engineers, one-quarter provide technical support or technical management, and one-quarter are administrators (Figure 4.3.2).

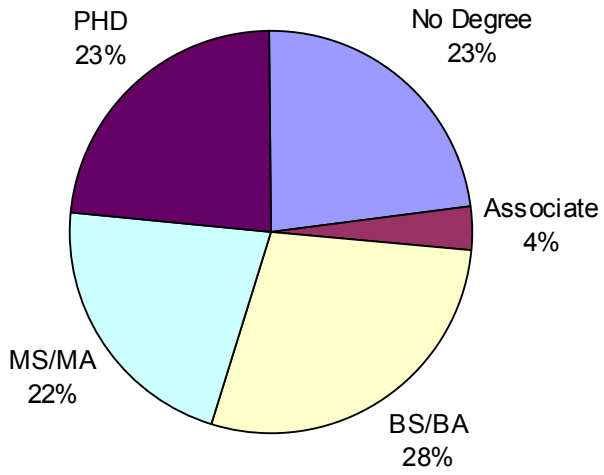


Figure 4.3.1. NREL Degrees (as of 9/30/04)

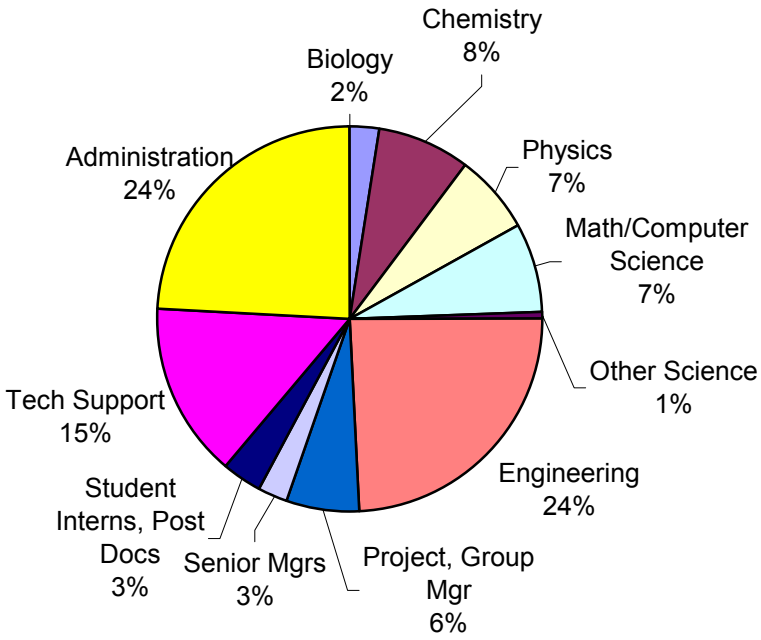


Figure 4.3.2. NREL Disciplines (% of Payroll Staff as of 09/30/04)

5 Capital Investment Principles and Process

5.1 Objective and Scope of the TYSP

The NREL TYSP is the product of a comprehensive planning process. In coordination with NREL's strategic planning processes, the objective of the ten-year site planning process is to reach a shared understanding among NREL and DOE managers of the future goals and expectations of research and development at NREL, and identify the capital investments (facilities, infrastructure, and equipment) that are needed to successfully meet those objectives. The objective of the TYSP itself is to document and communicate these recommendations and the many factors that go into these decisions.

The TYSP is the overarching strategic link between the mission of NREL and the physical assets that make that mission possible. As such, it is a key management tool for developing and communicating the integrated investment rationale – the business case – for capital investments. It also is intended to respond to requirements of DOE Order 430.1B, Real Property Asset Management and fulfills the TYSP requirement of RPAM 430.2.

The scope of the TYSP includes all facilities (buildings), infrastructure (roads, walkways, utilities, etc.), and capital equipment (program-specific and general). It addresses investments necessary over the next 10 years to sustain DOE assets at NREL at the current level of functionality, as well as investments necessary to add or expand mission capabilities. While it focuses on capital investments, related operating costs are also discussed where relevant.

5.2 Leadership

The Assistant Secretary for the DOE Office of Energy Efficiency and Renewable Energy is the Lead Program Secretarial Officer for NREL, and as such "owns the site, manages its own program projects, and acts as a host for tenant program secretarial officers by providing facility and/or infrastructure support." (The DOE Office of Science, Office of Energy Transmission and Distribution, and other DOE offices conduct research at NREL. These offices are tenant program secretarial officers.)

Determining capital investment strategy requires involvement and leadership from both technical managers and institutional managers, at both NREL and EERE. The program managers at NREL include the Technology Managers and Center Directors. The institutional managers at NREL include the NREL Office Directors in Site Operations; Information Services; Environment, Safety, and Security; and Finance. NREL's Associate Director for Science & Technology and Associate Director for Laboratory Operations jointly lead the planning process. NREL's Director and all the Associate Directors together make the final decisions on capital investment recommendations to DOE. The integrated team of MRI and Battelle, who manage and operate NREL under contract to DOE, advise on NREL's plans and in some cases provide the means to implement the plan, such as third-party financing.

5.3 Capital Investment Goals and Outcomes

Goals and Outcomes

Effective planning for capital investments requires clear understanding of the outcome desired. NREL has identified four goals for its capital investments, and several specific outcomes related to those goals:

Goal 1: Accomplish the mission with adequate facilities, infrastructure, and equipment:

- Existing facilities and infrastructure will be maintained in a condition to accomplish its original functionality.
- Existing facilities will be modified, and new facilities and infrastructure will be constructed as necessary, to meet mission requirements and provide new capabilities that will sustain the viability of the Laboratory well into the future.
- Facilities will efficiently and effectively meet specific mission needs, but will also be flexible to adapt to changing research requirements and technologies.

Goal 2: Promote mission excellence through the working environment:

- Activities and organizations will be logically co-located to improve productivity, while cross-program interactions and interdisciplinary science will be encouraged.
- Capital equipment will be added or replaced as necessary to maintain technological relevance and avoid technological obsolescence.
- The laboratories, offices, campus, and research equipment of NREL will significantly contribute to attracting and retaining high-quality staff in a competitive technological job market, and will encourage scientific creativity and discovery.
- State-of-the-art scientific and engineering equipment will be available and maintained. Collaborative use of more expensive items will be encouraged.
- The Laboratory will employ the latest advances in information technology to encourage scientific discovery, enhance worker productivity, and enable convenient interactions with other scientists.
- Visiting professionals and students will be encouraged by providing adequate research and office space.

Goal 3: Demonstrate sustainable design and practices:

- The Laboratory sites and facilities will demonstrate the best principles of sustainability by being cost-effective (efficient to operate and maintain), having minimal impact on the environment, and promoting human wellbeing among the staff and with the surrounding community.
- The Laboratory will be viewed as a good community neighbor.

Goal 4: Maintain safe and secure facilities and operations:

- The Laboratory will provide a safe, healthy, and secure working environment for employees and visitors.
- The visibility of security measures will be minimized to maintain a campus atmosphere consistent with NREL's mission and education and outreach activities.

5.4 Integration and Linkages

Capital investment decisions are integrally linked to many other aspects of an organization's planning and operations. The linkages pertinent to the formulation of NREL's capital investment strategy, and appropriate documents, are enumerated here. Section 10.1 discusses in more detail the strategic directions and capital requirements of the NREL institutional functions introduced here.

DOE Plans and NREL Performance-Based Management

NREL's performance-based management system, which includes capital planning and management, is guided by programmatic strategy, which is documented in documents such as:

- The National Energy Policy
- The DOE Strategic Plan
- The EERE Strategic Plan
- Multiyear program plans for each of EERE's programs

In addition, NREL is guided by the R&D Budget Priorities articulated by the Office of Science and Technology Policy each year, and the current presidential initiatives such as the Hydrogen Fuel Initiative, Networking and Information Technology R&D, and the National Nanotechnology Initiative.

For investment criteria, management practices and expectations, the guiding federal documents include:

- The President's Management Agenda
- Circular No. A 11 Part 7: Planning, Budgeting, Acquisition, and Management of Capital Assets
- DOE Order 430.1B Real Property Asset Management

NREL's performance-based management system provides the overall framework, tools, and systems to define desired outcomes, focus and align Lab resources on these outcomes, provide evidence of performance, and foster organizational learning and improvement. Figure 5.4.1 shows the linkages among the elements of NREL performance-based management, including NREL strategy, the General Development Vision, and Ten-Year Site Plan, and the dependence on DOE programmatic direction.

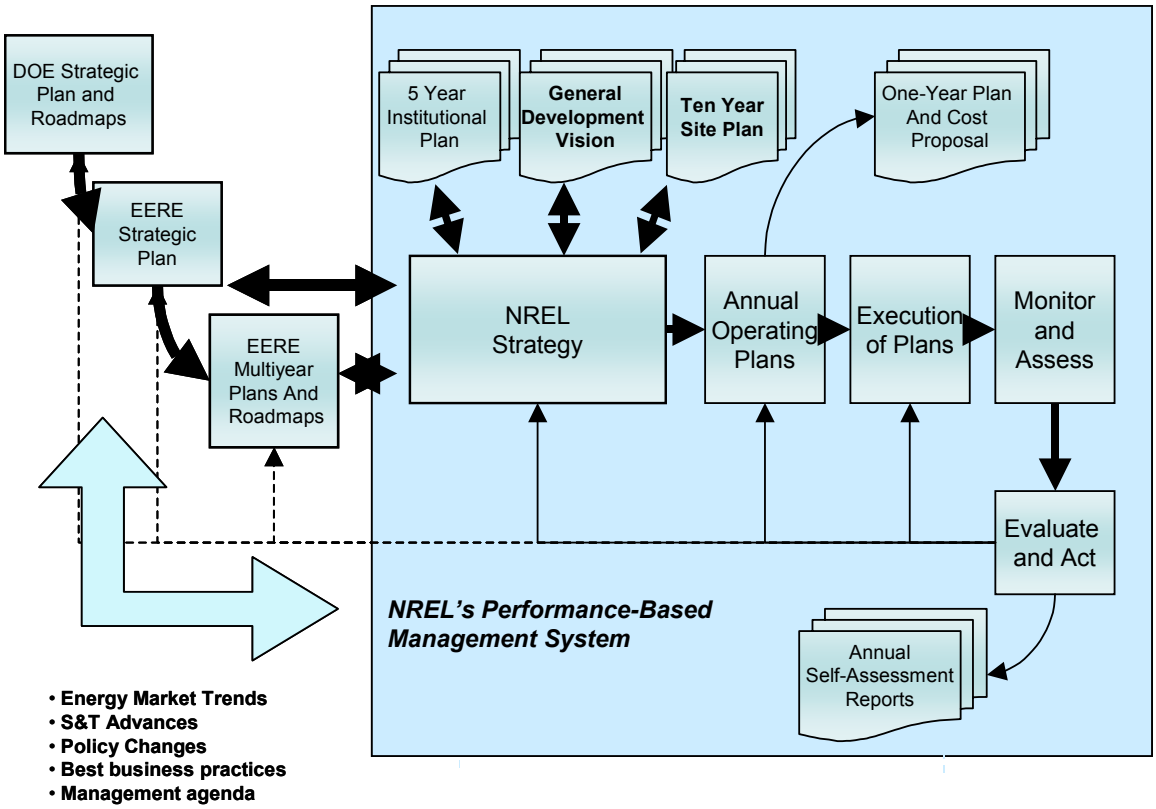


Figure 5.4.1. Integration and Linkages in NREL Planning

DOE Order 430.1B

On September 24, 2003, DOE Order 430.1B Real Property Asset Management was issued which put the Department of Energy on the path to improve the management of its real property assets. The new order integrates various management elements and practices into a holistic, performance-based approach to the life-cycle management of the Department's real property assets. It links real property asset planning, programming, budgeting, and evaluation to the Department's multi-faceted missions. Successful implementation of the Order will enable the Department to better carry out its stewardship responsibilities, and will ensure that its facilities and infrastructure are properly sized and in a condition to meet the DOE mission requirements today and in the future.

DOE Order 413.3B

On October 13, 2000 the DOE Order 413.3 *Program and Project Management for the Acquisition of Capital Assets* was issued which provides the Department of Energy project management direction for the acquisition of capital assets that are delivered on schedule, within budget, and fully capable of meeting mission performance and environmental, safety, and health standards. The order integrates various project management requirements and practices to provide appropriate guidance and critical decision points during the lifecycle of a project in order to ensure the project meets the established budget, schedule, and scope criteria. Successful implementation of the Order will enable the Department to better carry out its responsibilities and will ensure that its

facilities and infrastructure are properly designed and constructed to meet the DOE mission requirements today and in the future. Table 5.5.1 shows the critical decision points for construction line item projects, and Figure 5.5.3 shows the sequence and timing of these critical decision points.

NREL Design Guidelines

The NREL Design Guidelines are a general overview of the codes, standards, and requirements that NREL follows designing new, or modifying existing, facilities and infrastructure. NREL incorporates International Building Code 2000 as the overarching code. In addition, discipline-specific codes and local codes are utilized in all designs. Safety and functionality are the driving factors for design; however, NREL strives to incorporate maximum energy efficiency and to utilize LEED® criteria in its designs without compromising safety and functionality.

NREL Design Advisory Board

The Design Advisory Board (DAB), established in 1993, provides advice and counsel to NREL Executive Management with regard to site planning and facility and infrastructure design and planning. This involves review of building placement and exterior physical environments to develop and facilitate an orderly and architecturally cohesive buildout of the South Table Mountain and National Wind Technology Center sites. DAB members consist of individuals external to NREL, DOE, and EERE who provide advice and counsel. The current members include a leading architect and site developer in the Denver area; a landscape architect and urban planner; a member representing the adjacent community; and a representative from Bechtel, an international construction company. Regular participants also include individuals internal to NREL, DOE, and EERE who provide information as required to the members and address the Board's recommendations.

NREL National Advisory Council

The NREL National Advisory Council (NAC) provides external and independent advice and counsel to the Laboratory Director while monitoring and anticipating changes affecting NREL's mission. Members comprise a diverse group of 15-25 executive-level individuals who represent academia, industry, and at-large stakeholders who personally and actively contribute to Council activities. The Council meets at least two times a year at NREL, usually in spring and autumn to coincide with the Laboratory's planning calendar. The NAC offers recommendations to the Laboratory including advice on the Director's Discretionary Research and Development fund, Lab performance assessment, business and operational issues, initiatives, and capital planning.

NREL Governing Board

The NREL Governing Board provides oversight, policy direction, and assistance to the Director of NREL to ensure that high-quality research is performed by the Laboratory, including requirements for facilities, infrastructure, and equipment; that NREL is operated in a cost-effective manner; that NREL remains a world leader in renewable energy and energy efficiency programs; and that NREL meets the policy, program, and

management objectives of DOE. The members consist of a small number of senior executives from NREL's operating contractors.

Sustainable NREL Master Plan

Sustainability means the simultaneous and balanced pursuit of economic viability, environmental health, and public responsibility over the long term through appropriate investment decisions and operating practices. As such, sustainability is inherently a centerpiece of the work of the Laboratory. It is the Laboratory's stated objective to become more sustainable in its site planning, facilities and infrastructure design and construction, and operations, in synergy with the Laboratory's mission. In the area of sustainable site development, the relevant guidance document is the NREL General Development Vision described below.

The Laboratory has established a formal program, Sustainable NREL, to develop, manage, and implement its sustainability activities. The Sustainable NREL Master Plan describes the Laboratory's sustainability activities (http://www.nrel.gov/sustainable_nrel/), and lists the many DOE Orders and Executive Orders that pertain to the sustainability of Laboratory operations and sustainability impacts of capital investment decisions. These include

- Executive Order 13123, Greening the Government Through Efficient Energy Management
- DOE 430.2A, Departmental Energy and Utilities Management
- Environmental Policy Act of 1992
- Executive Order 13140, Greening the government Through Federal Fleet and Transportation Efficiency
- DOE Compliance Strategy for Executive Order 13149
- Executive Order 13101, Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition
- Resource Conservation and Recovery Act of 1976
- EPA Comprehensive Guidelines
- Executive Order 13146 (DOE Order 450.1) Greening the Government Through Leadership in Environmental Management

This Plan sets Laboratory-wide performance objectives, supporting goals, specific implementation strategies, and an overall management plan. Several of these objectives and goals are directly related to facility planning and building operation, including energy use reduction, water use reduction, new building construction and retrofits, greenhouse gas emissions, and transportation. The Sustainable NREL Master Plan is updated annually.

Environment, Safety, and Security

Environmental, safety, and security (ES&S) planning and management is conducted via an integrated ES&S risk assessment process that utilizes proactive mechanisms to identify risks presented by planned activities on NREL sites. Based on the risk assessment appropriate controls are identified and implemented to maintain the risk

presented by these activities at an acceptable level. The acceptable level of risk is established for all NREL activities via NREL policy.

Components of the risk assessment process may be site wide or activity specific, with significant overlap and interaction between the two types of processes. Site wide activities result in periodic reports such as environmental assessments, fire protection assessments, and security vulnerability analyses that provide ES&S considerations necessary for effective mid to long-range planning. These reports are used in conjunction with other Laboratory planning processes and reports to make informed decisions concerning site development and are updated on a regular basis. Activity specific processes include development of Hazard Analysis Reviews and Fire Hazard Analyses for major facilities, and Safe Operating Procedures for individual research and support tasks. These processes and resultant documentation promote effective planning and management of the ES&S aspects of immediate to mid-term activities and facilities, and are coordinated with the ES&S considerations identified via the site wide processes.

To facilitate proper integration of ES&S considerations in Laboratory-level planning the ES&S Office has direct representation and involvement in all of the planning and management processes described in this section. Conversely, representatives of other Laboratory-level planning processes directly participate in the risk assessment processes managed by the ES&S Office.

ES&S planning is, and will continue to be, an integral part of all capital investments considered at NREL. ES&S active involvement begins when a new construction project is in the earliest stages of conceptual discussion, and continues as projects develop. ES&S staff review all GPP and GPE requests before they come before serious consideration by NREL management. The Laboratory will continue this strong and pervasive involvement by ES&S staff in all capital investment projects.

With regard to the specific projects proposed in this Ten-Year Site Plan, the appropriate and necessary level of ES&S risk assessment has been conducted for all potential facilities and operations. More detailed assessments will be conducted as the development of these facilities and operations proceed. All ES&S hazards presented by the proposed operations already exist within current NREL facilities to some degree. Some limitations may be imposed on specific proposed facilities and operations, such as their location relative to site borders or quantities of hazardous materials allowed, in order to maintain an acceptable level of risk. However, no ES&S hazards have yet been identified that cannot be controlled by application of appropriate codes, standards, and NREL procedures. The acceptable level of risk established by NREL policy can be maintained in all cases, as the proposed projects are understood at the time of publication of this report.

Community Interactions

NREL strives to demonstrate its value as a corporate citizen within the community by interacting positively with community organizations and citizens. The Laboratory's South Table mountain site is bordered by several neighborhoods whose residents have a direct

line of sight to its buildings and daily operational activities. Regular communications with these neighbors, especially about changes on the STM campus that will be visible to the neighbors, is of paramount importance in sustaining NREL's reputation as a good neighbor. This communication occurs through community meetings and newsletters, and by public access to NREL's Visitors Center where information is provided about facilities, construction projects, technologies, and special public events at NREL. Also, a resident of the community involved in Pleasant View's planning activities is also a member of NREL's Design Advisory Board. Thus, the Pleasant View community is given multiple opportunities to participate in NREL's site planning process.

Beyond the local neighborhoods, NREL participates in regional long-range planning activities, neighborhood association meetings, and responds to county information requests about its facilities plans. Representatives of local governments and nearby neighborhoods are members of NREL's Design Advisory Board. The Laboratory works with regional developers, providing technical consultation on sustainable or "green" building projects in nearby cities. NREL technical staff also collaborates with regional governmental entities to facilitate adoption of renewable energy technologies through construction and implementation of renewable energy demonstration projects that benefit local communities.

At the National Wind Technology Center, NREL's interactions with the community include hosting tours and special briefings for community leaders and special interest groups. The Laboratory also works with the Department of Energy and external groups to respond to public concerns about the area surrounding the NREL site where defense weapons production was previously conducted.

Information Technology

The NREL Information Technology Strategic Plan FY 2004 – FY 2008 reflects the long-term goals and priorities of NREL with respect to the role that information technology will have throughout the Laboratory. It is a strategic roadmap for the Laboratory's information technology environment, and guides decisions – including the institutional information technology component of general purpose equipment -- so that the Laboratory can extract maximum value from information technology. The strategic plan serves to help NREL move towards an information technology environment characterized by scientific innovation, high personal productivity, effective inter-and intra-lab collaboration, standards-based management processes, and ubiquitous but secure access to information and high-performance scientific computing and technical computing resources.

5.5 Capital Planning Processes

Internal NREL Processes

The NREL Ten-Year Site Plan focuses on capital investments to maintain, sustain, and recapitalize current assets, as well as investments in new capabilities. The costs of owning a capital asset are shown in Figure 5.5.2 for the life cycle of the asset. The original purchase is usually with capital funds. Mid-life maintenance costs for facilities and infrastructure, at the scale of NREL's operations, are funded through a combination of operating funds and capital (small GPP) funds. Assets are replaced at the end of their

optimum period (also referred to as the strategic useful life) to avoid the rapidly escalating maintenance costs typically incurred as assets pass beyond their useful life.

The maintenance costs incurred during the optimum period are generally covered through Building Maintenance, a component of Laboratory overhead. Replacement of building components or capital equipment at the end of the asset's optimum period (or strategic useful life) is considered regular or on-time maintenance or replacement. Replacement of building components or capital equipment beyond the asset's optimum period is considered deferred maintenance for facilities and infrastructure, and deferred replacement for capital equipment.

Capital investments at NREL are viewed in four different ways, as shown in Table 5.5.1. Some investments are clearly for specific program missions, while other investments must be made that benefit the entire institution. Some investments are for equipment (including installation costs of up to 20% of the total cost), and some for constructing a facility or infrastructure asset. Institutional needs for capital equipment are generally allocated from the approximately $2 to $2.5 million of general purpose equipment funds that the Laboratory has received annually since 2001. At NREL's scale of operations, an item of capital equipment is usually about $1 million or less, although this limitation is likely to change as research equipment costs continue to escalate.

For facilities and infrastructure projects, it has proven practical to fund small (less than $1 million) construction projects of all types out of the approximately $2 million to $2.5 million of general plant projects funds that NREL has received annually since 2001. Construction projects between $1 million and $5 million cannot be accommodated out of the annual GPP funds without a major detrimental affect on NREL's ability to manage its deferred maintenance backlog, and so require an incremental or additional GPP budget request. Projects beyond $5 million are construction line items.

The primary beneficiary (institution or program); the type (equipment or facilities/infrastructure); the magnitude of the investment; and the purpose of the investment (deferred maintenance or replacement, regular (on-time) maintenance or replacement, and new capability) are the principal determining factors in which type of capital funding is used, as shown in Table 5.5.1.

Table 5.5.1. Considerations in Managing Capital Asset Investments at NREL

Beneficiary	Institution -- e.g., roads, utilities, support buildings, building maintenance and repair, administrative computers, shared scientific instrumentation, copiers, forklifts		Specific Program(s) -- program-specific buildings, program-specific capital equipment
Type of Asset	Equipment		Facilities/Infrastructure
Magnitude of Facility/Infrastructure Project	Small General Plant Projects -- $25,000 to $1,000,000	Large General Plant Projects -- $1,000,000 to $5,000,000	Construction Line Items -- >$5 million
Purpose	New Capability	Regular (On-Time) Maintenance or Replacement	Deferred (Overdue) Maintenance or Replacement

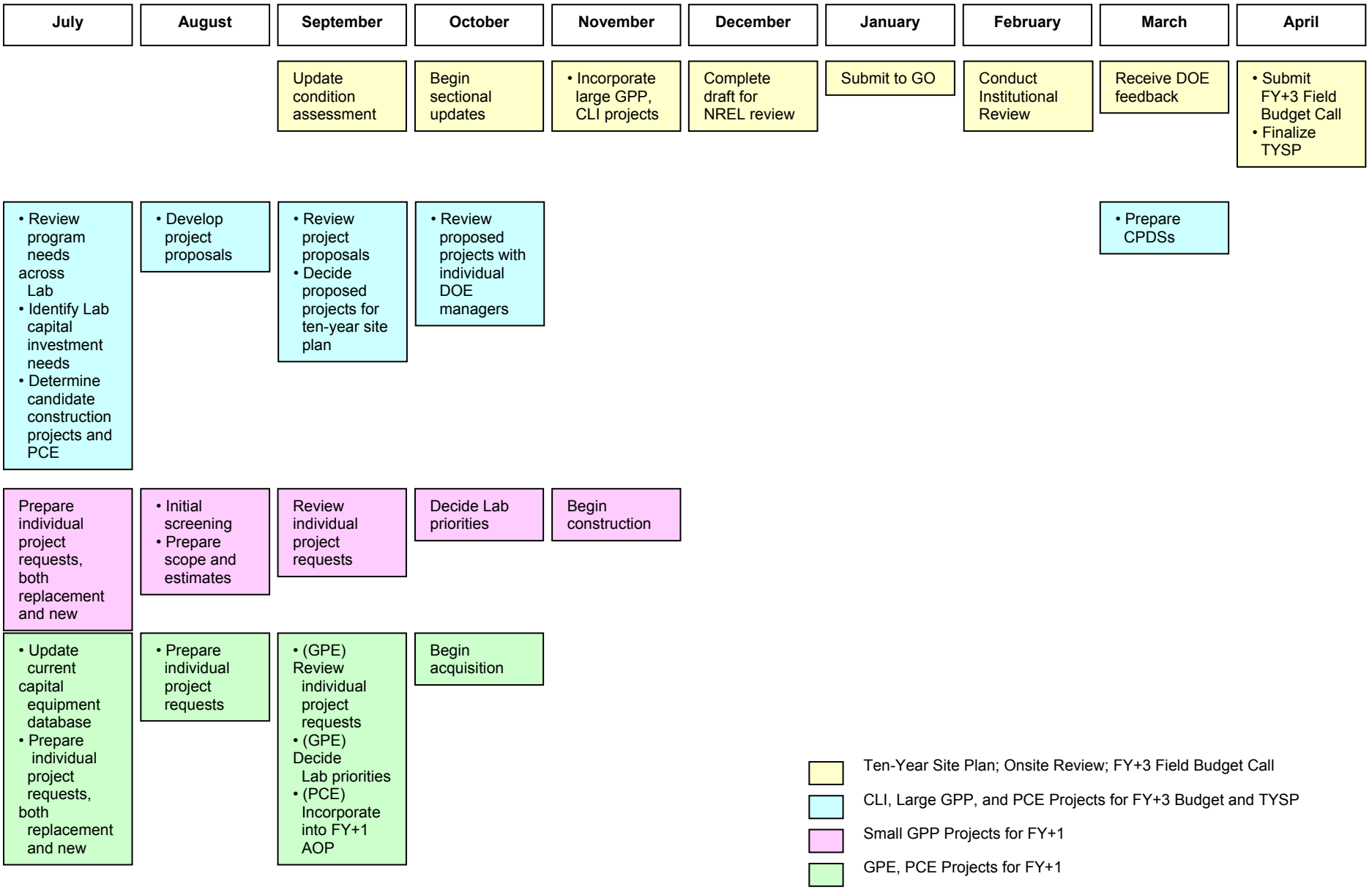


Figure 5.5.1. NREL Internal Capital Planning Process

The actual internal processes at NREL for capital planning are shown in Figure 5.5.1 and discussed below.

Planning Process for Construction Line Items and Large General Plant Projects
NREL's capital planning process begins with the mission needs of its Lead Program Secretarial Office, EERE. With the guidance and input from the DOE documents listed in section 5.4, and ongoing interchanges among NREL and EERE managers, NREL's programmatic facility and equipment strategies and needs are identified. Simultaneously, with guidance and inputs from the NREL Institutional Plan and strategic discussions, the NREL General Development Vision, condition assessments, and consideration of the factors affecting site development, NREL's institutional needs for facilities, infrastructure, and equipment are identified. Joint meetings are then held of technology managers representing each EERE and Office of Science program at NREL, center directors managing the people and capital resources to carry out programmatic work, and laboratory operational managers (including the General Development Vision leader, Site Operations, Environment, Safety, and Security; Finance; and Information Technology) to develop facility and infrastructure solutions to meet mission requirements. These lively forums bring together the individuals needed to work out integrated and practical options and recommendations for the facility and infrastructure challenges facing the Laboratory. Through a series of discussions at various levels, the most critical proposals are identified, sequenced, and prioritized by NREL executive management for discussion with DOE management.

Planning Process for Small General Plant Projects and General Purpose Equipment
Condition assessments, discussed in sections 10.1 and 11.1, are conducted for facilities, infrastructure, and capital equipment. These assessments are key to developing the Laboratory's deferred maintenance backlog reduction plan, Ten-Year Small General Plant Projects Plan, Ten-Year General Purpose Equipment Plan, Ten-Year Program Capital Equipment Plans, and overarching Ten-Year Facilities, Infrastructure and Equipment Plan. These assessments are also key to identifying the individual projects that require upgrade or replacement to sustain functionality. NREL managers also propose projects to provide new capability to support evolving missions. The individual projects proposed by managers are reviewed by Executive Management, who determines the priorities for available funding at the start of each fiscal year.

Planning Process for Program Capital Equipment
The need for capital equipment replacements is informed by the equipment condition assessment information, prepared each July and October. In addition, items are identified during the preparation of the programmatic AOP to extend, expand, or add technical capability. The requests are reviewed and approved by the technology managers, in consultation with the center directors.

DOE Project Management Processes of the DOE Office of Engineering and Construction Management
NREL's construction line item projects are managed in accordance with the DOE project management process directed by the DOE Office of Engineering and Construction Management. Table 5.5.2 describes the steps of that process, and Figure 5.5.3 gives an indication of the timing and duration of the steps.

Table 5.5.2 depicts conceptually the life cycle cost of ownership of an asset. In this example the time in years on the x-axis and the cost on the y-axis are not quantified, since each asset will have a different cost curve. When a new asset is acquired, maintenance costs initially are low. As the asset becomes older, maintenance costs begin to rise. The design or service life of the asset, or optimum period as defined in the Real Property Asset Management (RPAM) order, is eventually reached. Ideally, at the end of the design life, the asset is replaced, and the initially low maintenance cost profile begins anew.

When the old asset is replaced, the rising long-term maintenance cost of the old asset is avoided. If the asset is not replaced the maintenance costs continue to rise. Assets not replaced at the end of their design life become deferred maintenance as defined in the RPAM order. The implication to management is to minimize the total area under the cost curve. The area under the cost curve over the life of the asset represents the total cost of ownership.

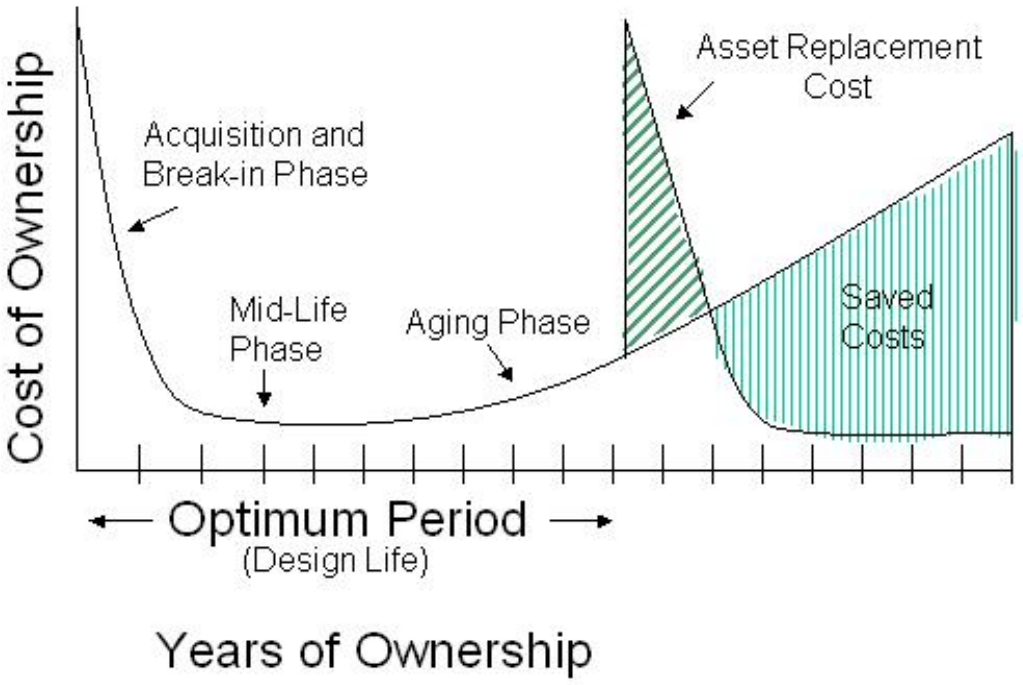


Figure 5.5.2. Life Cycle Cost Curve for an Asset with Replacement

Table 5.5.2. Project Management Process (DOE Order 413.3)

	CD-0	CD-1	CD-2	CD-3	CD-4
Approves	• Mission Need	• Preliminary Baseline Range	• Performance Baseline	• Start of Construction	• Project Acceptance
Launches	• Conceptual Design • Budget Request for PED funds	• Preliminary Engineering Design	• Final Design • Construction Budget Request	• Construction	• Operations
Deliverables	• Conceptual Design Package • Preliminary Project Execution Plan • Preliminary Hazards Report • Preliminary Design Phase Budget & Schedule • NEPA Documentation • Project Data Sheet • Acquisition Plan • Preliminary Baseline Range (cost/scope/ schedule)	• Preliminary Engineering Design Package • Final Project Execution Plan • Construction Project Data Sheet • Independent Cost Estimate • External Independent Review (OECM) ** • Performance Baseline (cost/scope/ schedule)	• Final Design package (Construction Design Documents) • Updated Project Execution Plan • Internal Project Review with OECM ** Review	• Completed Facility Turnover & Startup Plan • O&M Manuals • As-Builts • Operational Readiness Review	
Next Decision	• CD-1 Package to AE* for Decision	• CD-2 Package to AE* for Decision	• CD-3 Package to AE* for Decision	• CD-4 Package to AE* for Decision	
Funding	• Operating Funds	• Capital Project Engineer Design Funds	• Capital Project Engineer Design Funds	• Capital Construction Funds	

*Acquisition Executive
**Office of Engineering & Construction Management

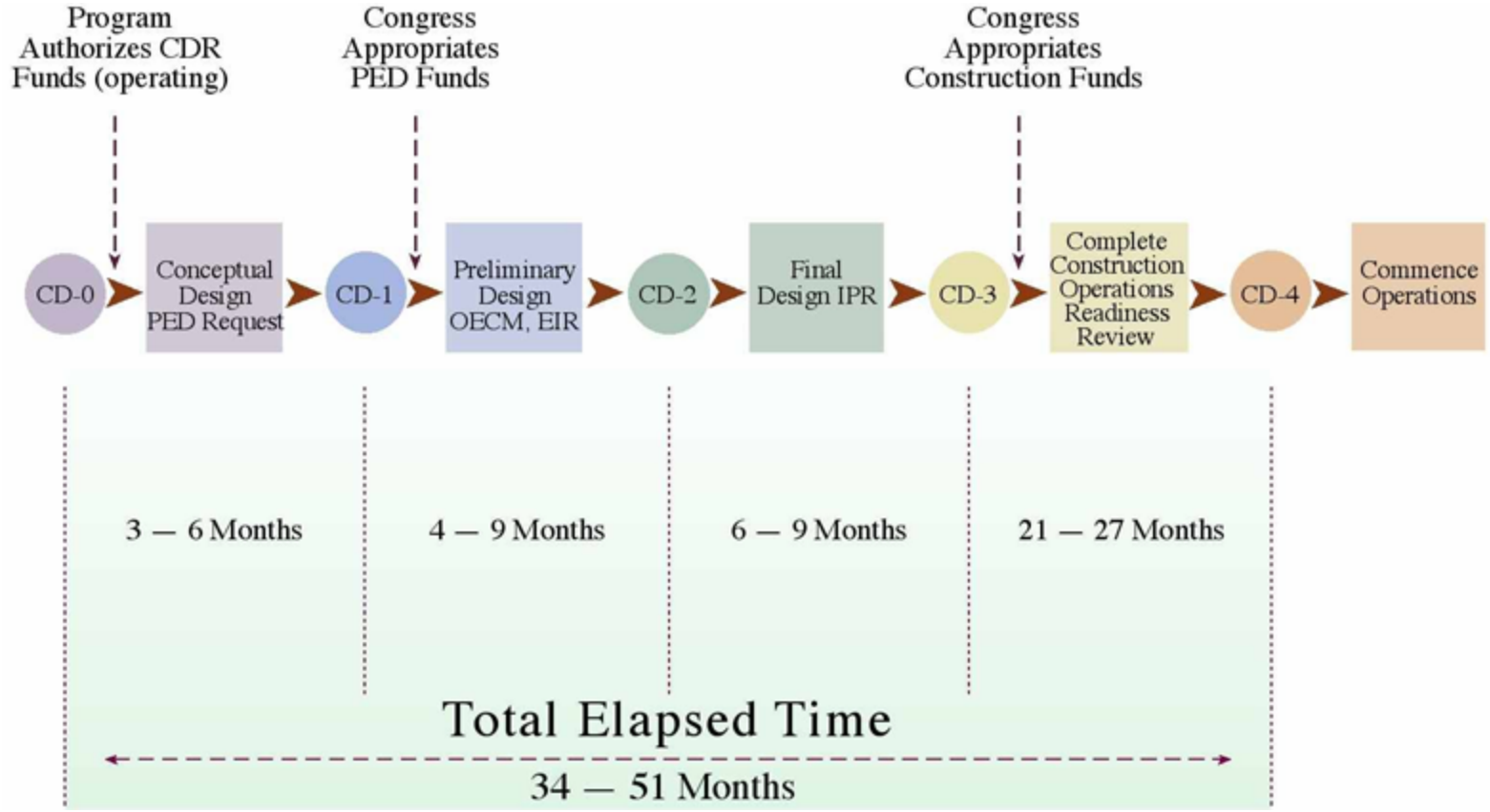


Figure 5.5.3. Approximate Timing of Project Management Steps in DOE Order 413.3

6 Capital Asset Overview

6.1 Capital Investment and Asset Summary

Over the 27-year history of the Laboratory, a total of $192 million in capital funding has been invested at NREL by DOE. (Figure 6.1.1)

Construction line item funding has totaled $45 million (Figures 6.1.1 and 6.1.2). The initial 1979-1980 funding was used to build the first road and utilities and the first two buildings, the older portion of what is now the Alternative Fuels User Facility and the Field Test Laboratory Building. The SERF was built from funding in 1991-1992, and the Alternative Fuels User Facility in 1993. In 1995, DOE invested in an expansion of infrastructure on the STM site. New office space and laboratories were built in part of the FTLB with 1996-1997 funding, while 1998 funding was used to upgrade NREL's information architecture.

General plant projects funding has totaled $24 million (Figures 6.1.1 and 6.1.2). This was used in the early 1990s to build the Outdoor Test Facility, Thermal Test Facility, and other smaller facilities. With 1995 funding, NREL built the Shipping & Receiving facility. Often, general plant projects funds have been used to maintain, replace, and upgrade existing buildings and infrastructure.

Program capital equipment funding has totaled $107 million (Figure 6.1.3). PCE funds were used in the 1979-1981 period to furnish the original FTLB and the early years of research in the solar and wind programs. In 1992-1997, program capital equipment investments were made to support the several CLI projects in this period, largely in solar and biomass areas. In 2003-2004, significant funding was provided for new capabilities in biomass surface characterization and genomics.

General purpose equipment funding, which totals $16 million since the beginning of the Laboratory, was sporadic until 2001 (Figure 6.1.3). Since that year, the annual authorization of $2.0 million -$2.4 million has been instrumental in establishing new capabilities in computational science, upgrading and maintaining administrative computing and information systems, and upgrading and adding instrumentation that serves a wide variety of programs, including spectrometers, microscopes, chromatographs, and calibration equipment.

6.1.1 Comparison to Other Capital Investment Benchmarks

Compared to other benchmarks, NREL's level of total capital funding as a percentage of total funding ranks at or below the lowest level revealed in a literature survey conducted in October 2004 (Figure 6.1.4). In that survey, total capital investments as a percent of total funding for various types of R&D organizations ranged from 7.7% for U.S. private sector R&D service companies, to 17% for all U.S. organizations conducting research, to 22% for recipients of NSF funding. NREL's average over the course of its history is 5.4%.

The percentage of funding specifically spent on capital equipment was also surveyed (Figure 6.1.5). NREL ranked with the U.S. private sector R&D service companies at an average over its history of 3.5%, compared to 5% to 10% for U.S. universities and 13% for universities in the United Kingdom.

Figures 6.1.6 and 6.1.7 compare NREL's total capital investment percentages with figures for other federal agencies and other national laboratories. Again, NREL ranks near or at the bottom of all these comparisons.

6.1.2 Summary of Current Assets and Maintenance Investments

The $192 million that DOE has invested at NREL over 27 years has resulted in a $279-million portfolio of capital assets still actively in use today. Of today's portfolio, 63% of the current value is in facilities and infrastructure, with the balance in equipment (Figure 6.1.8).

NREL has no plans to dispose of any property or facilities in the foreseeable future.

In section 5, a graph of the life-cycle costs of an asset was shown (Figure 5.5.2). For the mid-life maintenance period shown in Figure 5.5, the actual NREL investments (for facilities and infrastructure only) over the last four years are shown in Table 6.1.1 and Figure 6.1.9. DOE Order 430.1 on Real Property Management recommends that at least 2% of the replacement plant value be invested annually in maintenance of facilities and infrastructure. In the last four years, NREL's investments have totaled 1.5% to 2.0%. Of this investment, typically about two-thirds is overhead operating funds, and about one-third is general plant projects capital funds.

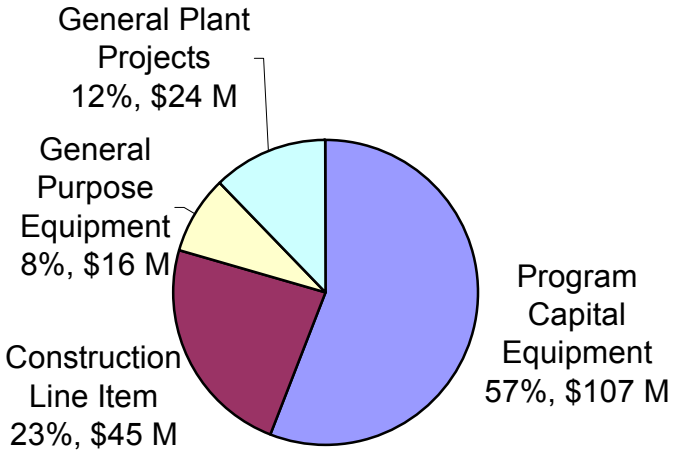


Figure 6.1.1. Distribution of Funding for Total Capital Investments at NREL, 1977-2004 ($192 million total)

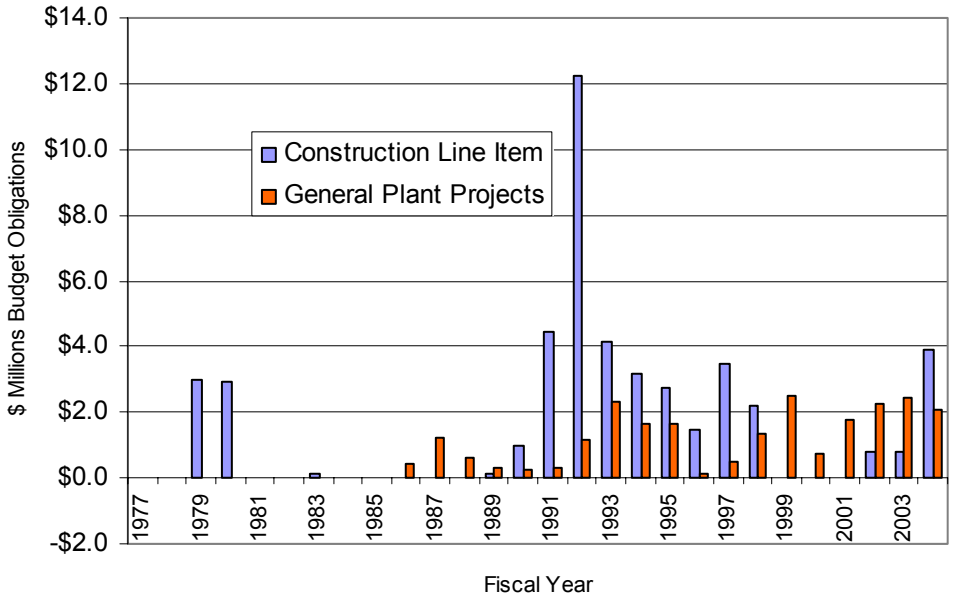


Figure 6.1.2. Capital Facilities & Infrastructure Funding

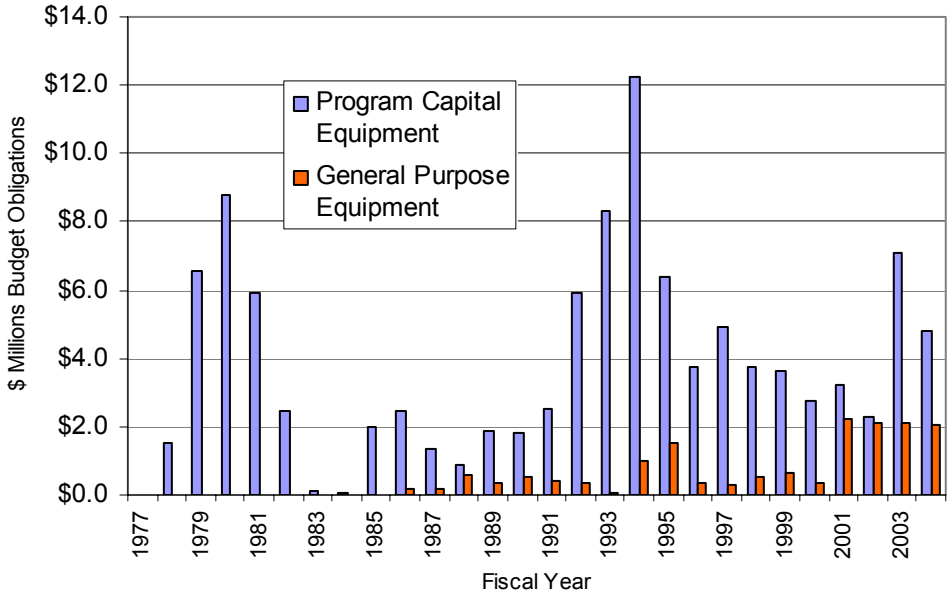


Figure 6.1.3. Capital Equipment Funding

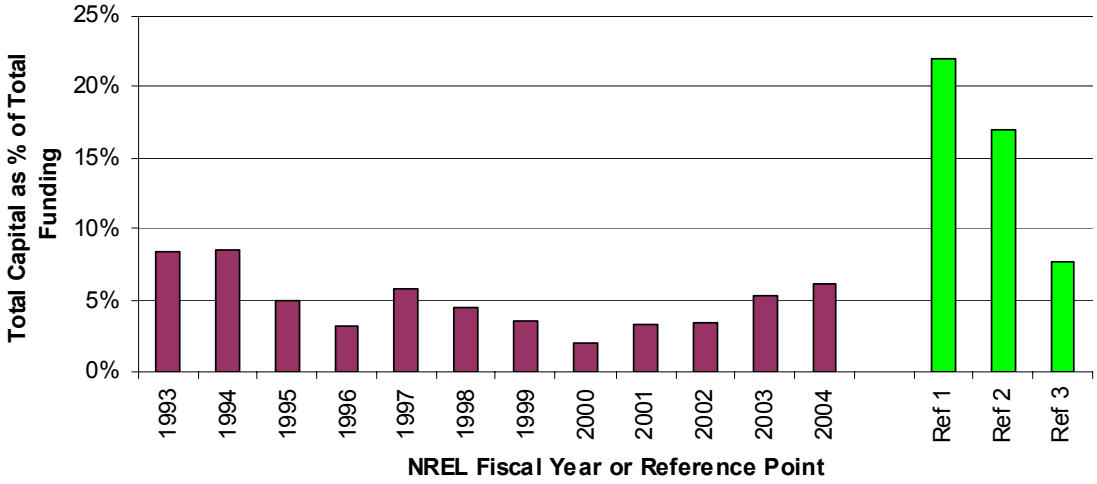


Figure 6.1.4. NREL Vs. Benchmarks: Total Capital as % of Total Funding

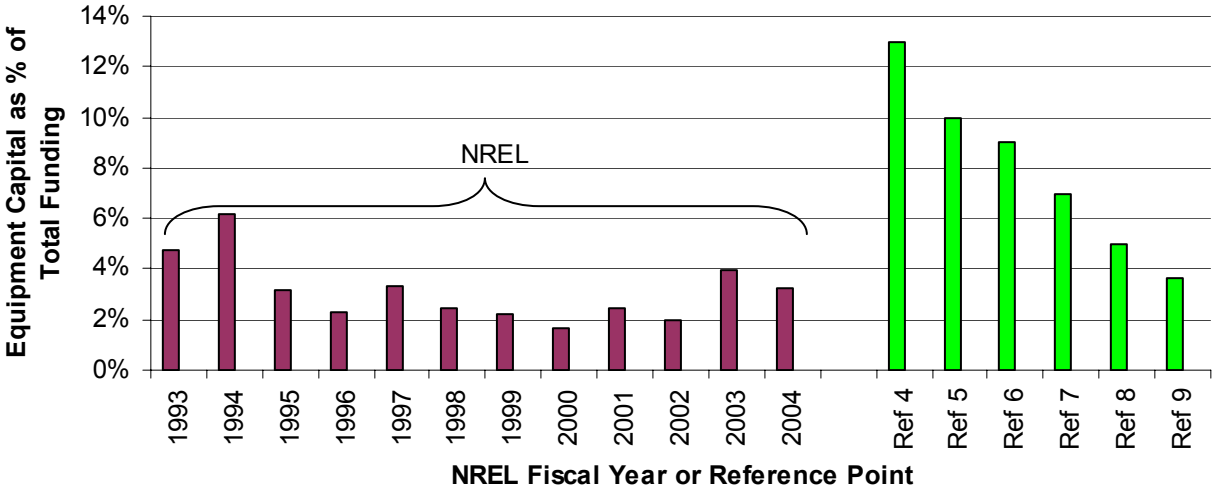


Figure 6.1.5. NREL Vs. Benchmarks: Equipment Capital as Percentage of Total Funding

Figure 6.1.6 and 6.1.7 References

Ref 1 NSF Recipients (2001; Ref Z, p. K-2)
Ref 2 U.S. Average R&D Organizations (2004; Ref X, p. K-2)
Ref 3 U.S. R&D Service Companies (2002; Ref EE. P. K-2)
Ref 4 United Kingdom Academia (2001; Ref E, p. K-1)
Ref 5 U.S. Academia - Chemistry (2001, Ref Y, p. K-2)
Ref 6 U.S. Academia - Physics (2001, Ref Y, p. K-2)
Ref 7 U.S. Academia - Engineering (2001, Ref Y, p. K-2)
Ref 8 U.S. Academia - Biology (2001, Ref Y, p. K-2)
Ref 9 U.S. R&D Service Companies (2002; Ref EE. p. K-2)

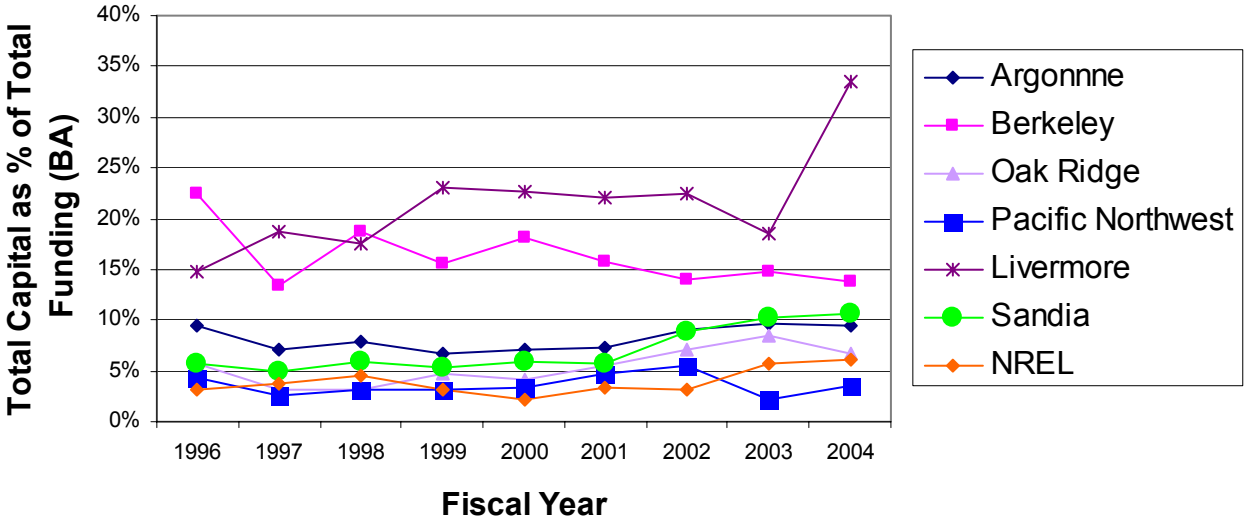


Figure 6.1.6. NREL Capital Investments Compared to Other DOE Labs; Reference: Institutional Plans for each laboratory

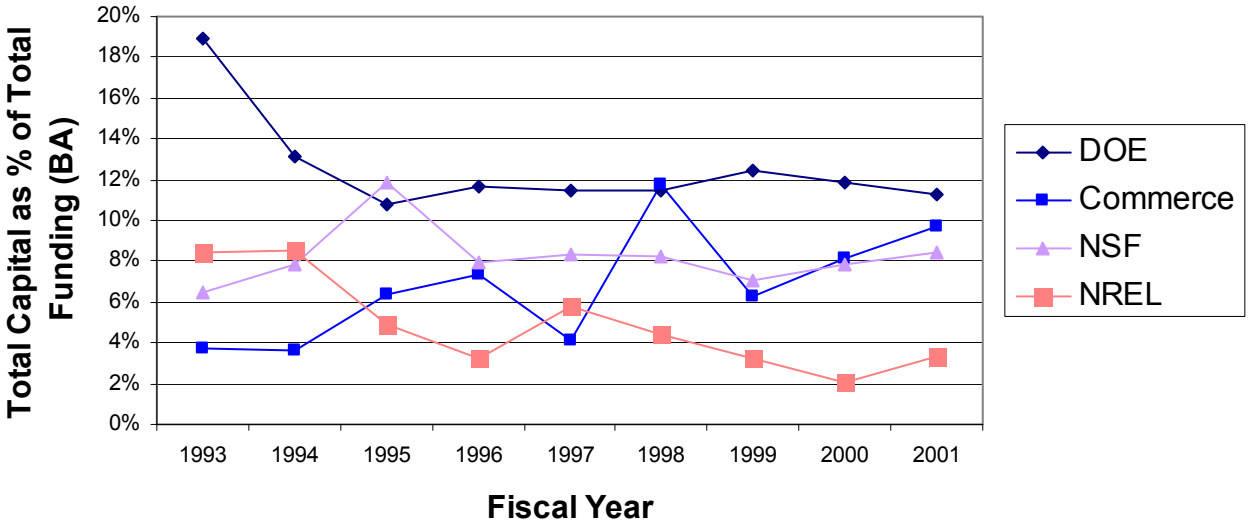


Figure 6.1.7. NREL Capital Investments Compared to Other Federal Agencies; Reference: NSF Science Indicators 2002

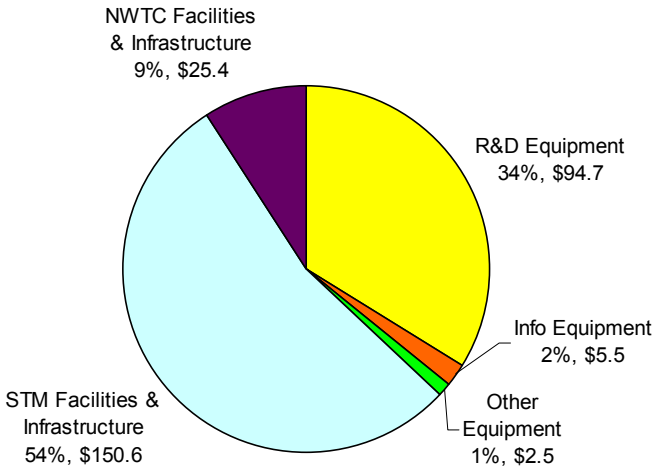


Figure 6.1.8. Distribution of NREL Capital Asset Value, 09/30/04 Total = $279 million

Table 6.1.1. Historical Expenditures for Facilities and Infrastructure Maintenance Real Property Replacement Plant Value (RPV) = $176 million

	Sustainment Maintenance (Overhead Operating Budget)	Deferred Maintenance & Replacement In Kind (GPP Capital Budget)	Maintenance Related Minor Construction (Overhead Operating Budget)	Total $ Millions	% of RPV
FY2001	$1.696	$0.788	$0.083	$2.567	1.5%
FY2002	$1.826	$1.015	$0.161	$3.002	1.7%
FY2003	$1.972	$0.645	$0.047	$2.664	1.5%
FY2004	$2.113	$1.403	$0.169	$3.685	2.0%

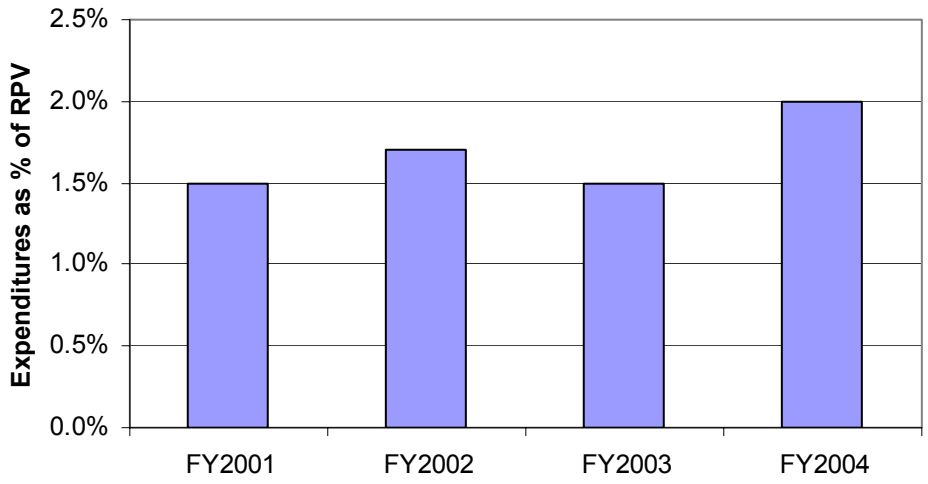


Figure 6.1.9. Operating and Capital Expenditures for Facilities and Infrastructure Maintenance as Percentage of RPV

6.2 Sites Overview

NREL operates in five separate locations in the Denver, Colorado, metropolitan area. DOE-owned sites include the South Table Mountain (STM) site in Golden and the National Wind Technology Center (NWTC) site near Boulder, about 20 miles north of the STM site. Denver locations also include leased facilities in the Denver West Office Park where about half the staff are housed, the Joyce Street Facility warehouse, and the ReFUEL Facility (a small testing facility used for vehicle engine/fuel research). Lastly, NREL maintains a small office in leased space in Washington, D.C. In total, NREL occupies about 670,000 square feet of DOE-owned or leased space. Of this total, about 40% is leased. NREL staff are housed about equally between leased and DOE-owned facilities. NREL's sites have no chemical or radiological legacy. (Figures 6.2.1, 6.2.2, and 6.2.3; Tables 6.2.1 and 6.2.2).

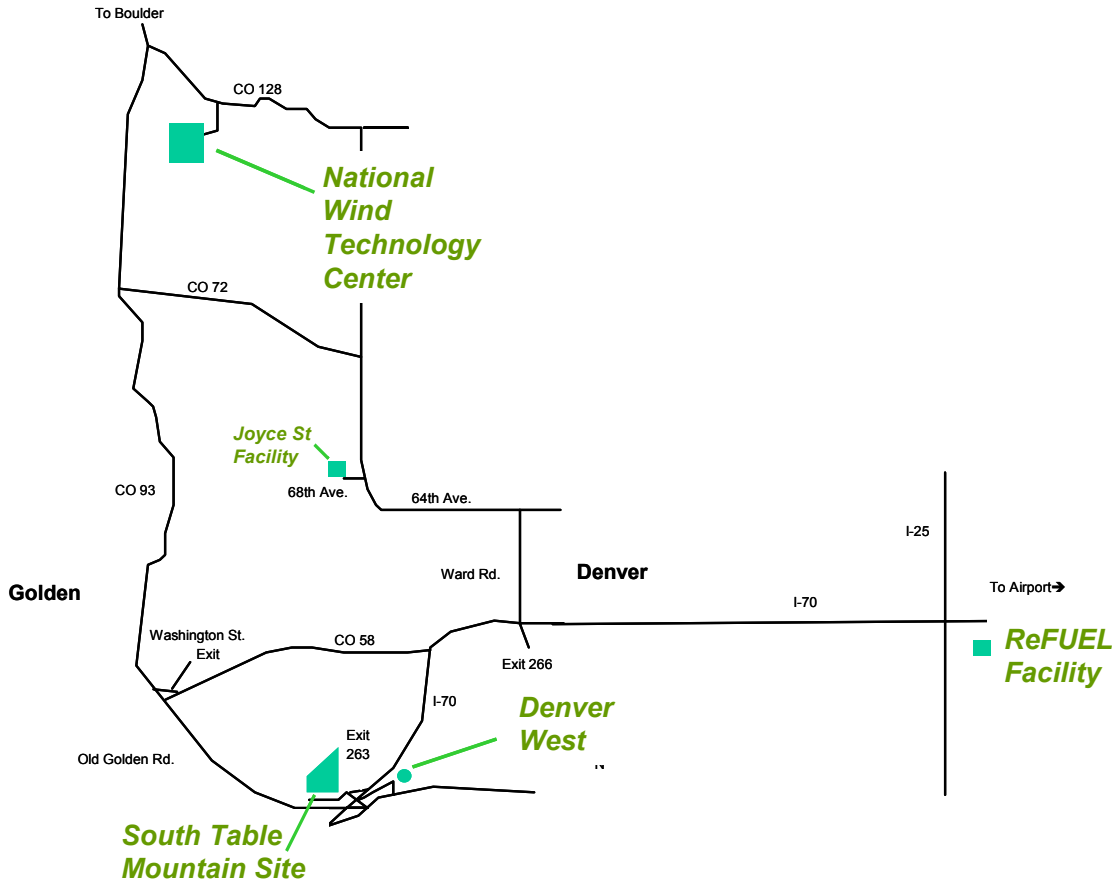


Figure 6.2.1. Location of NREL Sites in the Denver Metro Area

Table 6.2.1. NREL Sites

	Acres	Gross Square Feet of Building Space	Ownership	Occupants as of 12-31-04	Distance from South Table Mountain Site
South Table Mountain*	327	332,000	Owned	426	---
National Wind Technology Center	305	56,000	Owned	91	20 miles
Denver West Office Park**	na	212,000	Leased	515	1.2 miles
Joyce Street Facility	na	56,000	Leased	0	8 miles
ReFUEL Facility	na	4,600	Leased	6	15 miles
Washington, D.C.	na	8,100	Leased	15	---
Total***	632	668,700		1053	
*	Approximately 136 acres of the site can be developed; the balance is in restrictive easements.				
**	Does not include DOE Golden Office and Regional Office space				
***	Includes space tracked in FIMS database (including buildings and trailers) as well as property not tracked in FIMS (e.g., small buildings and leased buildings)				

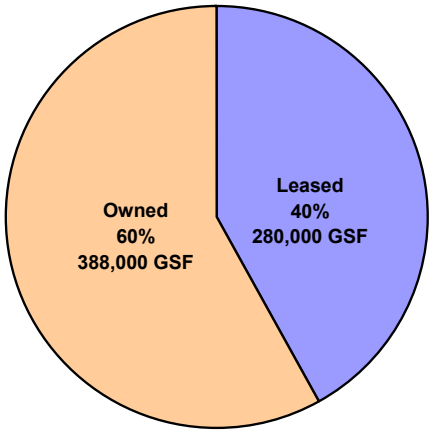


Figure 6.2.2. Distribution of NREL Space (12/30/04)

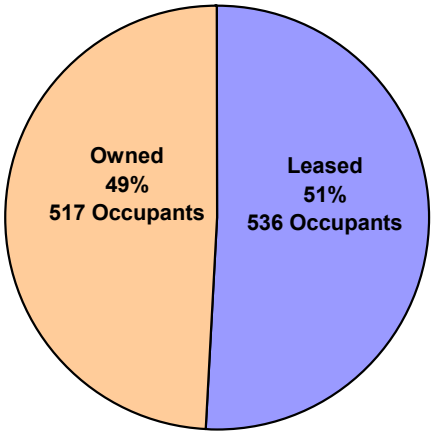


Figure 6.2.3. Distribution of NREL Occupants (12/30/04)

Table 6.2.2. Summary of Issues and Opportunities for NREL Sites

Opportunities

- No environmental legacy issues
- Exceptional physical attractiveness adjacent to western mesa and mountains
- Space available for further development, if capital was available
- Located in Denver, easily accessed by the entire country
- Strong opportunities for collaborations with local universities and governments
- In the Rocky Mountain foothills, sites have six life zones within thirty miles, allowing environmentally specific research and testing (advanced vehicles, building design, etc)
- Sites have excellent solar and wind resources, and access to forest thinnings for biomass
- General Development Vision (2003) delineates land use plans
- Commitment to, and excellent technical expertise in, sustainable development

Issues

- Current facilities are highly utilized, with virtually no research flexibility
- Multiple sites and undesirable separation of activities decrease efficiency and productivity and increase operating costs
- High percentage (50%) of staff in leased facilities
- Primary site (STM) is landlocked
- Secondary site (NWTC, 90 occupants) is far from core NREL activities, with no water or sewer

South Table Mountain Site

The 327-acre STM site is located on the southeast side of South Table Mountain near Golden, Colorado. Appendix B presents a detailed discussion of the STM site.

The STM site supports all research and development areas except wind energy research. These R&D activities include low-bay and high-bay laboratories, process development and pilot-scale facilities, and research support spaces for R&D related to chemistry, biology, physics, thermal sciences and engineering, vehicle engineering, outdoor and field testing, and interdisciplinary activities. The STM site also houses research support facilities such as the Visitor Center, Site Entrance Building, Shipping and Receiving, and maintenance buildings.

Geographically, the STM site has many naturally attractive features. Located on the top, slope, and toe of a western mesa, it lies at the intersection of the natural open space of the mountain to the north and dense man-made developments to the south. The northern half of the site includes the mesa slope, with its pristine hillsides, rock outcroppings, deep drainage channels, and frequent sitings of deer and other wildlife. Most of this area is within a 177-acre conservation easement. With several more acres in utility and trail easements, only 136 acres of the 327-acre total are developable.

Of the 136 developable acres, a long, narrow strip of 18 acres at the western end is only amenable to smaller buildings and field tests because of its difficult topography. The small 13-acre parcel on the mesa top is used only for activities that require unique access to the solar resource, such as concentrated solar research and solar radiation research. These activities

involve a minimum number of people and low, unobtrusive buildings. Because the entire STM site is visible to the surrounding community for several miles, NREL is sensitive to the concerns of its residential neighbors, especially on the Mesa Top. Community action groups and local governments have been working to place the remaining mesa top property in conservation easements. The Laboratory seeks to ensure that research facilities have an acceptable appearance and that research activities on the Mesa Top have minimal visual impact.

The south, east, and west sides of the site are surrounded by a mix of old neighborhoods and rapidly changing residential and commercial development, with increasing growth and rising real estate costs. Further change is expected, including the development of a neighborhood park on NREL's southern border in 2005 and a research and development light industrial park in the southern area at some point in the future. The extent of development around NREL precludes any conceivable expansion of the current property, effectively landlocking the site.

Regional access to the site is excellent with an interchange to Interstate 70 less than a mile away. In the future, a light rail stop is planned a few miles from the STM site, and NREL has discussed shuttle links with NREL in its interactions with community planners and the regional transportation district. The on-going commercialization of the area with the increased traffic due to the number of local residents, office personnel, and shoppers will continue to increase the traffic load on bridges and highway exchanges around the STM site. The mesa top has long been a favorite area for hikers, and the public is allowed to access the mesa via trail easements along the NREL property borders.

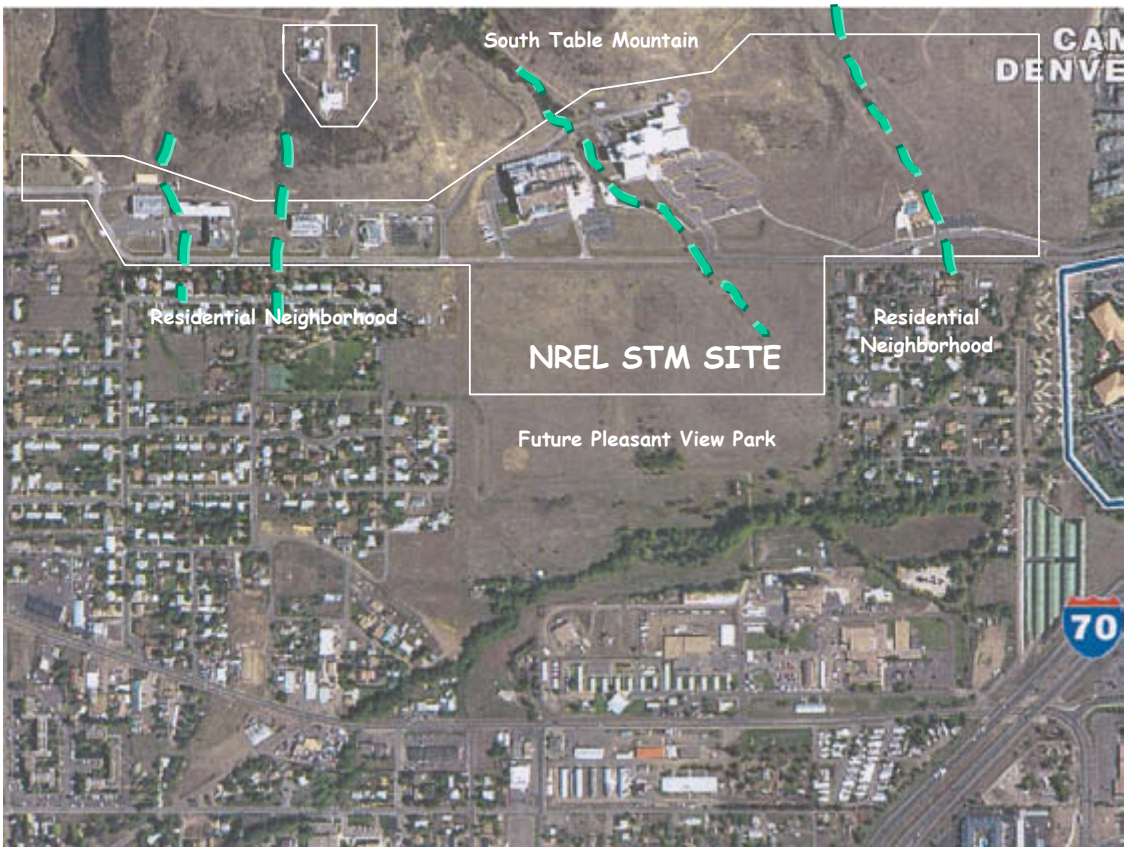


Figure 6.2.4. Satellite View of South Table Mountain Site

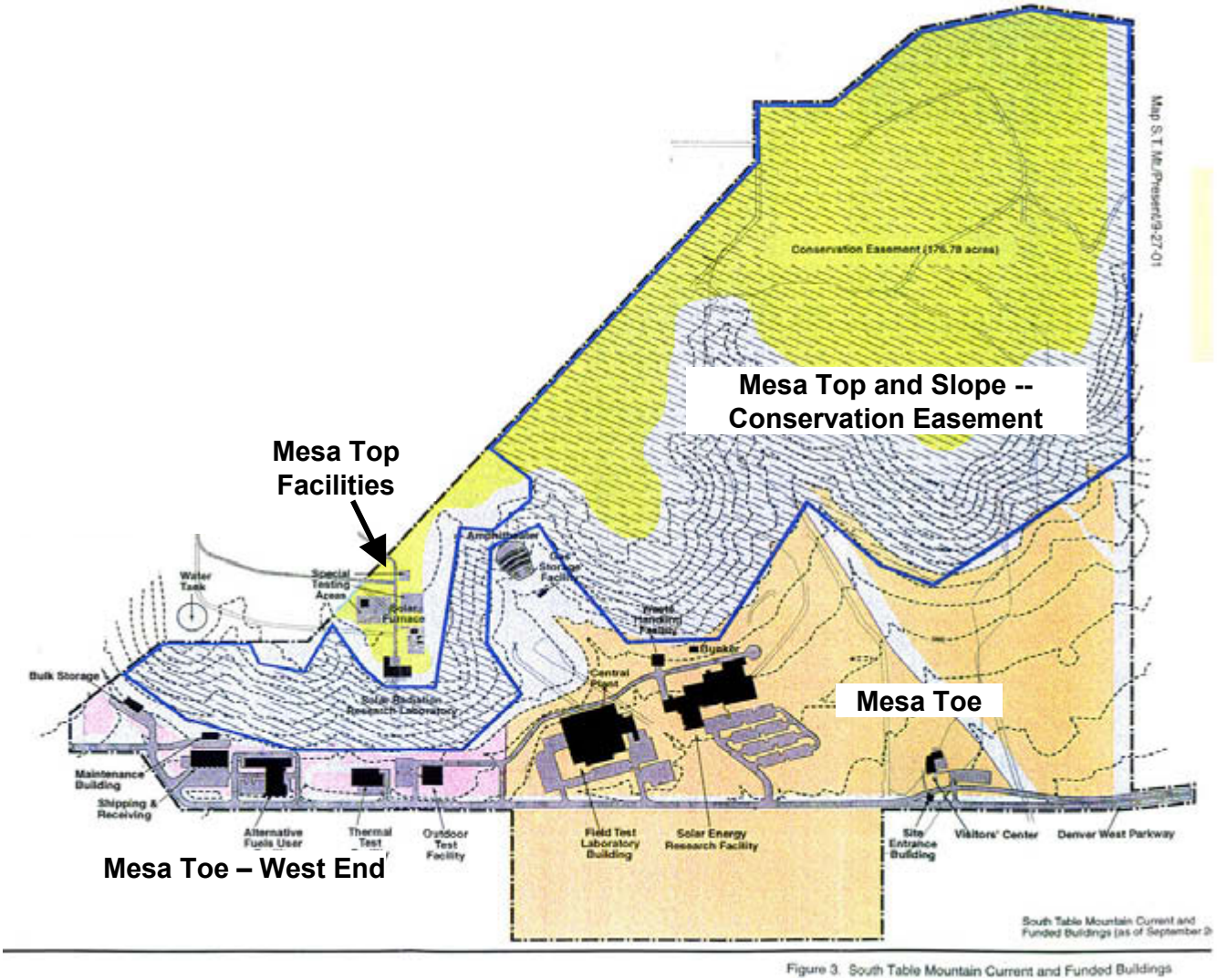


Figure 6.2.5. Mesa Top Facilities

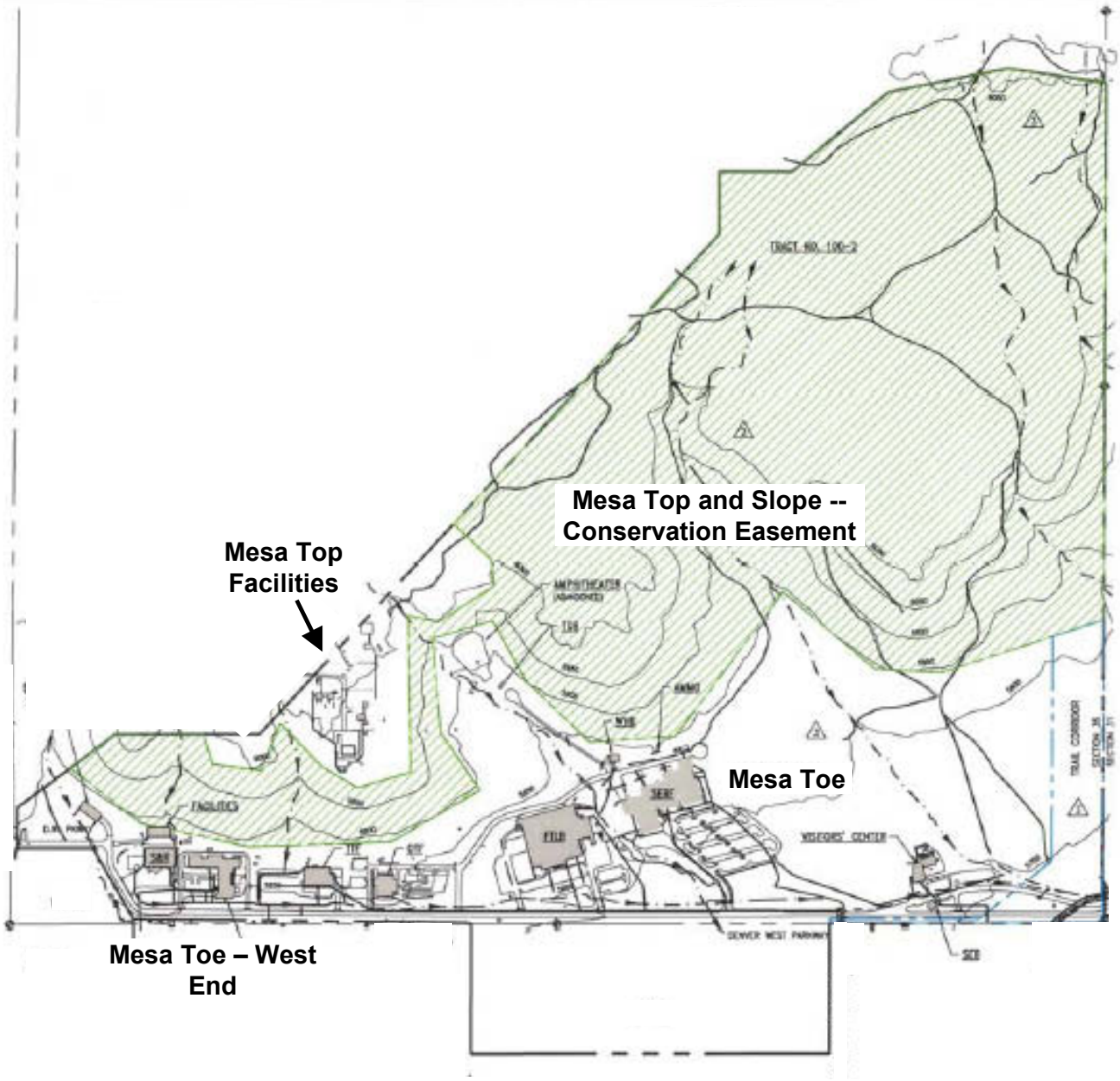


Figure 6.2.6. Mesa Top Topographical Map

Figure 6.2.7. South Table Mountain Site (looking from the east)

Figure 6.2.8. South Table Mountain Site (looking from west)

National Wind Technology Center

The National Wind Technology Center site is adjacent to DOE's Rocky Flats Environmental Technology Site about twenty miles north of the South Table Mountain site. Appendix C presents a detailed discussion of the NWTC site. The topography is flat and accessible. Most developed land at the NWTC is used for outdoor field tests of wind turbines, for which direct access to wind from Eldorado Canyon is needed. The site is ideally suited for a wind research facility because it is subject to intermittent, extremely high-velocity winds, and the site's wind resource is well characterized. It is not well suited for wind power production, however, because the wind patterns are not consistent. In addition to R&D in wind energy, the site supports NREL's R&D in hybrid power technologies and distributed energy resources. The NWTC site was transferred from the Rocky Flats Plant to NREL in 1993, and 25 acres were added in 2002. No radiological operations were conducted on this site, and there are no radiological contamination issues.

The future development of the NWTC is likely to be affected by several internal and external factors. The site has no municipal water supply for staff use or fire protection, and depends on water trucked in to storage tanks from a local supplier. Future development must take into consideration the potential limitations of the existing water supply. Also, the site is buffeted by gale-force (greater than 100 mph) winds at certain times of year, which can cause damage to vehicle windshields and make the site unsuitable for certain kinds of outdoor tests. Suitable windbreak solutions are not yet in place. Other site issues include deterioration of the paved and unpaved roads, which are on the deferred maintenance backlog, and the lack of outdoor areas for staff breaks. Lastly, since most of the acreage is used for wind turbine research, new buildings have to be sited where they will not affect the wind regime in the turbine test areas, nor be damaged by any failure of research turbines.

Externally, private mining companies have operations adjacent to the south and west site boundaries. While DOE owns the surface mineral rights, any future interest from the private owners of subsurface mineral rights may affect site development. The future of the Rocky Flats Environmental Technology Site to the east will also affect the NWTC. Converting the RFETS to a wildlife refuge, as currently planned, may bring visitors into a positive relationship with more public interest in NREL's research, or may bring controversy over the affect of NREL operations. NREL will continue to monitor the various stakeholders who are involved in the future directions of the RFETS.

Other Environment, Safety, and Security Considerations for DOE-Owned Sites

- Conservation easements, environmentally sensitive areas, and other no-build zones are identified in the NWTC Environment Assessment, the STM Environmental Assessment, and in Appendices B and C of this TYSP.
- Environmental Permitting – There may be caps on air emissions, the types and quantities of wastewater discharged, etc., and these are addressed via the ES&S risk assessment processes with necessary permits being obtained.
- Fire Protection –Surveys have been conducted internally and by third-party experts with a determination that there is no unusual threat presented by wildfires on NREL sites, a particular DOE concern after the Los Alamos fires. Fire department services are readily available for both sites.

- Off-Site Exposures – There are no undue threats presented to the NREL sites by neighboring operations. The greatest threat was presented by the Rocky Flats nuclear weapons operations of earlier decades, but NREL lies both upstream and upwind of those activities, and carries no environmental legacy. Limitations on NREL development and operations due to the proximity of neighbors are well known and addressed in the various NREL planning processes.

Figure 6.2.9. National Wind Technology Center

Leased Facilities

Since its inception in 1977, NREL has depended on the Denver West Office Park, a little over a mile from its central South Table Mountain site, for administrative and research support space. Appendix D presents detailed information on NREL's leased facilities. At various times NREL has used part or all of several different buildings in the Office Park, depending on staffing fluctuations. In late 2004, NREL moved out of Building 27 and consolidated most of its operations in Buildings 15, 16, and 17 (with a little space in Building 7). DOE's Golden Field Office and Denver Regional Office are located in the same buildings as NREL. Current leases are summarized in Table 6.2.3.

Building 15, 17, and 7 include offices and support spaces for Laboratory administrative functions, as well as researchers and program management activities for Buildings research, Geothermal research, the Federal Energy Management Program, international deployment activities, state and local deployment activities, and energy analysis activities.

Building 16 is used for research support activities as well as laboratory research. Portions of the research staff supporting basic science, photovoltaics, transportation, industrial processes, resource assessment, geographic information systems, and computational science are also housed in Building 16. About 15% of the Building 16 space is available for or used in laboratory activities. Building 16 contains essentially all of NREL's flex space for labs and offices for new or expanded (overflow) activities and very limited additional staff. Because of its location in an office park, limited ventilation capacity, limited floor loading capacity, and lack of a service elevator, Building 16 has significant challenges for research use. NREL has established a rigorous set of ES&H criteria that bound the type and amount of laboratory operations that can be sited in Building 16. NREL has developed a Building 16 Comprehensive Plan that outlines multiple phases for the remediation and conversion of laboratory space back into office areas as funds become available for this activity. This plan is updated annually to reflect the latest thinking as annual operating plans, research program plans, and budgets become known.

Joyce Street Facility and ReFUEL Facility
The Joyce Street Facility (JSF) and the ReFUEL Facility are leased commercial spaces that provide temporary additional space for NREL's activities. JSF currently provides 56,000 ft^2 warehouse and storage space and has in the past accommodated a small amount of space for limited research experiments. The ReFUEL Facility is used for vehicle engine/fuel research activities, and is discussed further in section 7.5.

Washington, D.C., Office
NREL leases space in the Aerospace Building near DOE's Forrestal Building for NREL staff working closely with DOE and for those activities most effectively managed from this location. In addition, it is used by NREL Golden staff visiting DOE in Washington. There is sufficient space to house the current staff and activities, but no flex space for expansion.

Table 6.2.3. NREL Leased Facilities (as of 12/31/04)

Building	Location	Sq.Ft.	Lease Dates	Annual Cost (Current)	Occupants
Bldg. 7*	Denver West	4,467	04/01-11/08	$45,000	0
Bldg. 15	Denver West	29,100	04/01-11/08	$401,000	78
Bldg. 16	Denver West	85,906	07/94-11/08	$1,475,000	189
Bldg. 17	Denver West	87,744	07//94-11/08	$1,436,000	248
Refuel Facility	Denver, CO	4,576	07//02-07/07	$31,000	6
Joyce Street Facility	Arvada, CO	56,000	09/97-01/08	$227,000	0
L'Enfant Plaza	Washington, D.C.	8,090	10/03-09/07	$365,000	15
* Several staff are planned for Building 7 in early 2005.					

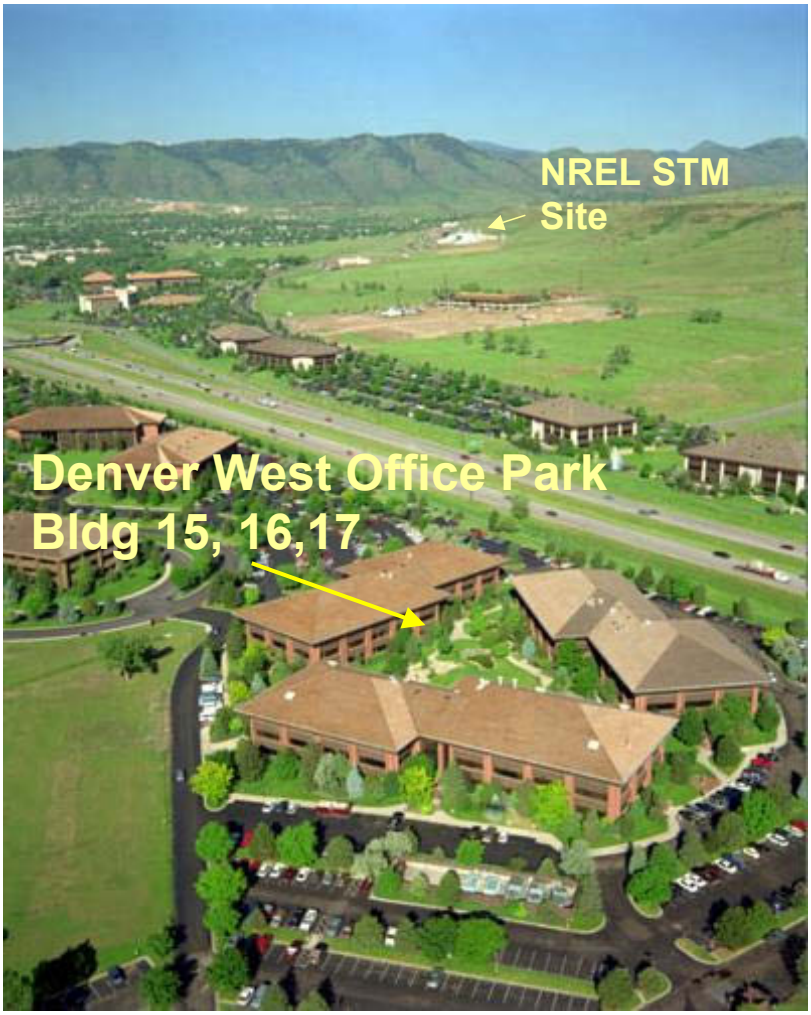


Figure 6.2.10. Denver West Lease Facilities and South Table Mountain Site

6.3 Facilities Overview

NREL conducts no nuclear work, no classified work, and has no remediation legacy, either nuclear or toxic. In contrast, NREL has the advantage, and opportunity, of having relatively young facilities (Figure 6.3.1) compared to other national laboratories. The research facility portfolio today includes two major (more than 100,000 gsf) laboratory buildings on the STM site (the Solar Energy Research Facility and Field Test Laboratory Building), along with three additional research buildings ranging from 10,000 to 30,000 gsf (Alternative Fuels User Facility, Thermal Test Facility, and Outdoor Test Facility), and a Visitor Center and Shipping and Receiving Building. The NWTC site includes the 22,000-gsf Administrative Building 251, which includes computer modeling labs and testing areas; the 5,500-gsf 2.5-MW dynamometer building; and the 11,000-gsf Industrial User Test Facility.

Table 6.3.1 lists the opportunities and issues for NREL's facilities. Today, the facility condition index of 2% (a measure of the adequacy of their physical condition to conduct mission work) is rated as "Good" according to DOE Order 430.1. (Section 10 describes the condition assessment process that resulted in this rating.) NREL therefore has the opportunity to properly maintain these buildings as they age and avoid the problems other national laboratories have with decaying structures after decades of deferred maintenance. However, NREL's oldest major building, the FTLB, is now 20 years old and at the point where significant investments are

needed to repair HVAC systems, the roof, and other building systems at or nearing their optimal periods of service. These issues are further discussed in section 10. Much of the rest of NREL's space falls in the range of 10-11 years old, including the SERF and other smaller research buildings.

Table 6.3.2 and Figure 6.3.2 show the space distribution among the major buildings. Table 6.3.4 and Table 6.3.5 describe in more detail the major facilities that are referenced in this TYSP.

The utilization of NREL facilities, in terms of both laboratories and workstations (offices and cubicles), can be seen in Figures 6.3.3 to 6.3.6. Ideal utilization rates for workstations, to allow practical flexibility for changing research directions, support needs, and visitors, is 85%. NREL's overall rate is 93%. If only standard workstations were included in the count, and substandard workstations were excluded, the overall utilization rate would be 98%. Ideal utilization rates for laboratories, again to allow practical flexibility for changing research directions and new research opportunities, is 90%. NREL's overall rate is 99%, with only four modest laboratories not currently in use located in Building 16, a leased building in an office park.

6.3.1 Programmatic Usage of NREL Facilities

Table 6.3.3 and Figure 6.3.7 indicate the major programmatic users of NREL facilities based on time charged and square footage assignments during FY 2004. Details are given in Section 7 for individual programs.

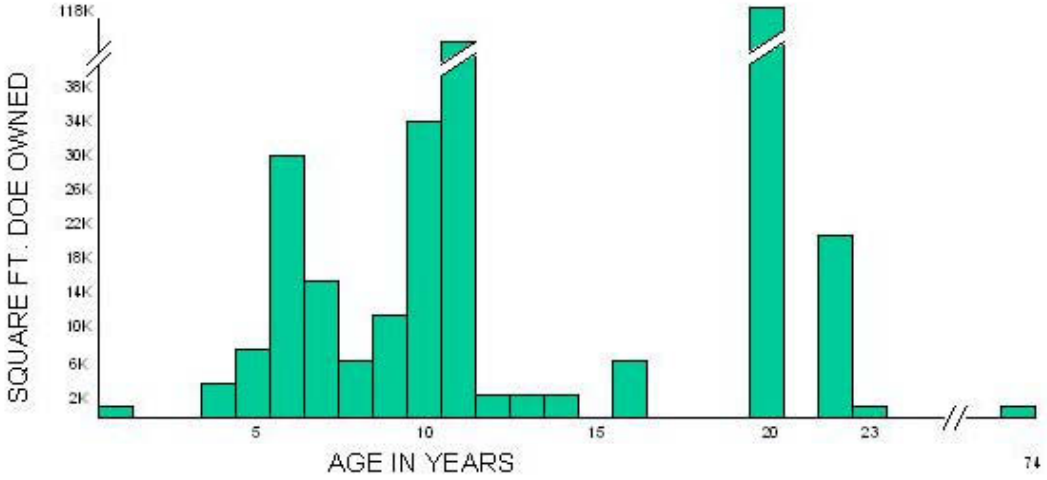
Table 6.3.1. Summary of Issues and Opportunities for NREL Facilities

Opportunities

- Facilities relatively new compared to other national laboratories
- No environmental legacy
- Facility condition index rating is "Good"
- Several unique facilities not available anywhere else in U.S.
- Showcase facilities for energy efficiency
- Commitment to, and excellent technical expertise for, sustainable building design

Issues

- Current laboratories are 99% utilized, with virtually no flexibility for research changes
- Current workstations are 93% utilized, compared to the target of 85%, limiting flexibility to house students and co-locate functional groups.
- Multiple sites and undesirable separation of activities limit efficiency and productivity and increase operating costs
- High percentage (50%) of staff are in leased facilities, which separates them from researchers on campus, increases redundancy and inefficiency in operations, and increases risk from rent increases after the current lease term.



NOTES:
1) DOE owned facilities
2) Gross square feet
3) Age = FY04 – Acquisition Year

Figure 6.3.1. Age of NREL Square Feet

Table 6.3.2 NREL's Major Buildings (as of 12/30/04)

Site	Building	Year Acquired	GSF	Number of Occupants	FY2005 Replacement Plant Value ($ millions as of 09/30/04)*
Leased	DW Building 16	1980	85,906	189	N/A
	DW Bldg 15/17/7	1979	125,808	326	N/A
	REFUEL	2002	4,576	6	N/A
	Joyce St Warehouse	1989	56,000	0	N/A
	Washington DC	2000	7,912	15	N/A
STM	STM Support	various	30,871	32	$7.20
	Alternative Fuels User Facility	1993	32,751	38	$15.30
	Field Test Laboratory Building	1984	125,927	127	$55.30
	Outdoor Test Facility	1994	11,247	14	$5.30
	Solar Energy Research Facility	1992	115,890	199	$54.20
	Thermal Test Facility	1995	10,682	9	$5.00
	Mesa Top Facilities	various	4,882	7	$1.70
NWTC	NWTC Bldg 251	1982	22,026	53	$7.80
	NWTC Industrial User Facility	1994	11,394	9	$4.20
	NWTC Other	various	22,664	29	$5.30
	Total		*668,536*	1053	$161.30
* This RPV includes buildings only, and does not include infrastructure.					

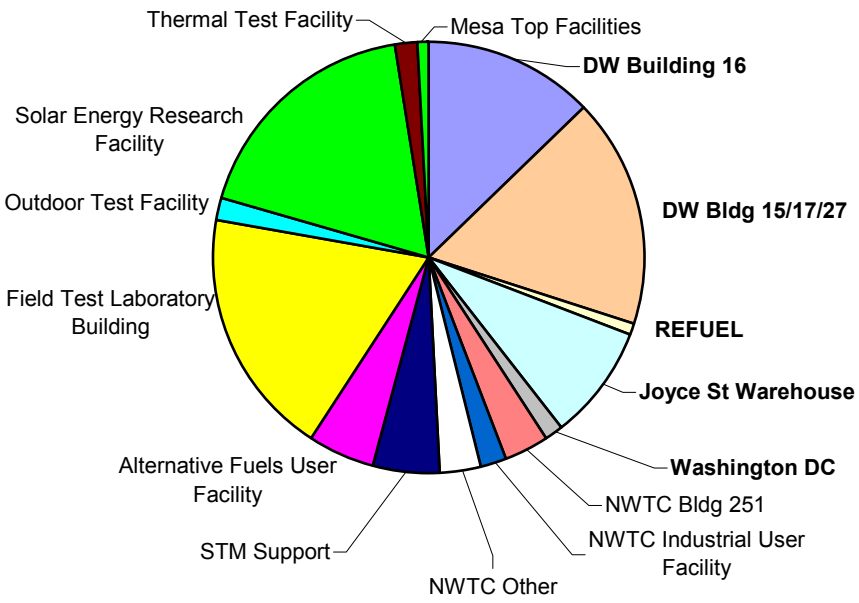


Figure 6.3.2. Distribution of NREL Space by Building (12/30/04)

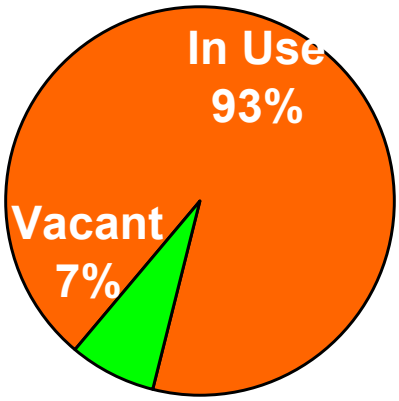


Figure 6.3.3. NREL Workstation Utilization (as of 12/31/04). (In-use rate would be 98% only standard workspaces were counted.)

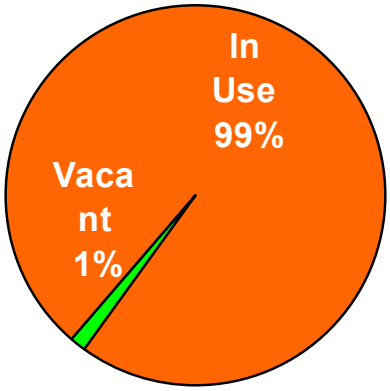
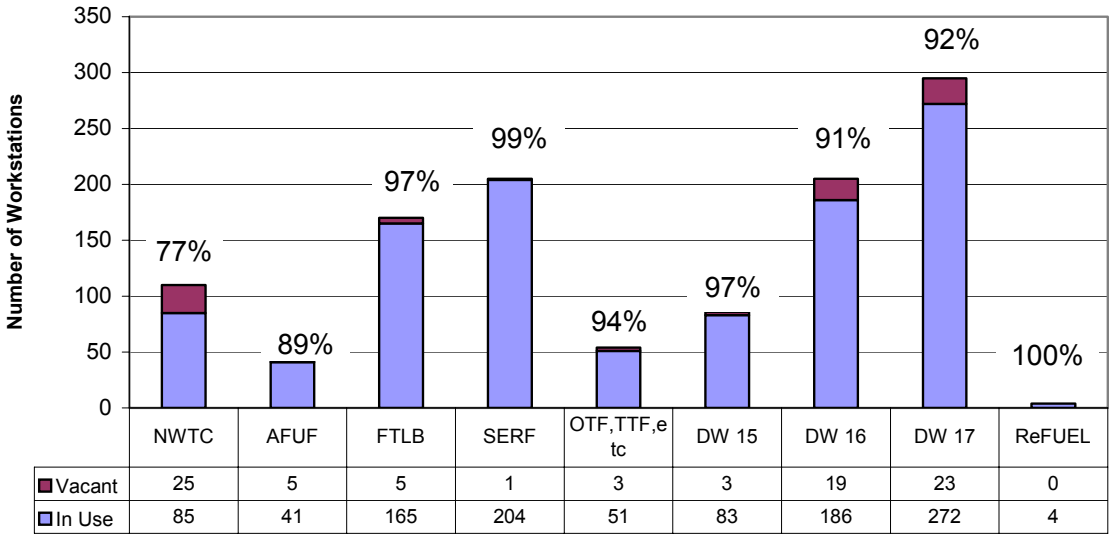
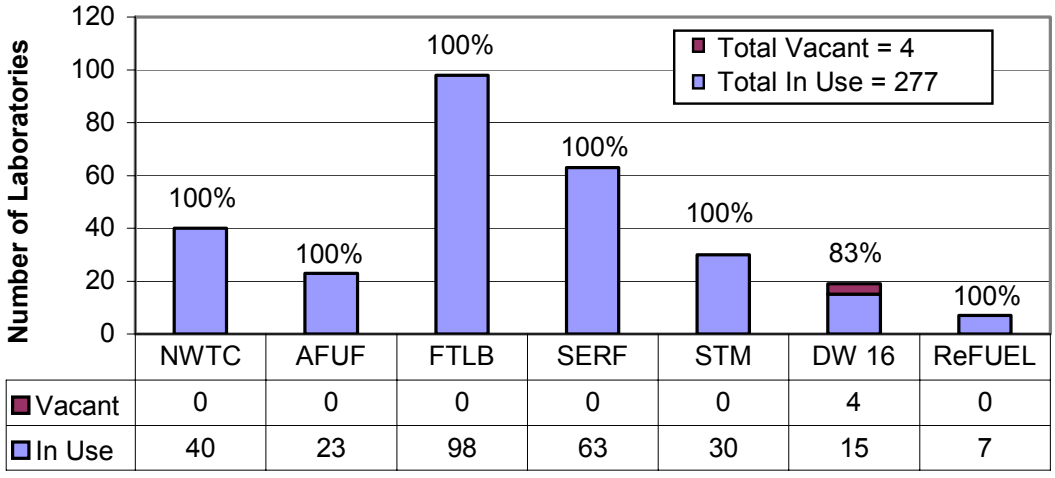


Figure 6.3.4. NREL Laboratory Utilization (as of 12/31/04)



	NWTC	AFUF	FTLB	SERF	OTF,TTF,etc	DW 15	DW 16	DW 17	ReFUEL
Vacant	25	5	5	1	3	3	19	23	0
In Use	85	41	165	204	51	83	186	272	4

Figure 6.3.5. NREL Workstation Utilization (as of 12/31/04)



	NWTC	AFUF	FTLB	SERF	STM	DW 16	ReFUEL
Vacant	0	0	0	0	0	4	0
In Use	40	23	98	63	30	15	7

Figure 6.3.6. NREL Laboratory Utilization (as of 12/31/04)

Table 6.3.3. Distribution of NREL Space by Program as of 9/30/04

Program	*GSF*	
Overhead	229,333	34%
Analytic Studies	1,967	0%
Biomass	102,696	15%
Buildings	19,488	3%
Distributed Power	6,770	1%
FEMP	3,133	0%
FreedomCAR	24,115	4%
Geothermal	4,239	1%
Hydrogen	22,027	3%
Intergovernmental	4,100	1%
Office of Science	22,929	3%
Solar	155,196	23%
Transmission & Dist	4,642	1%
Wind Energy	54,379	8%
Work for Others	13,522	2%
Total	*668,536*	*100%*

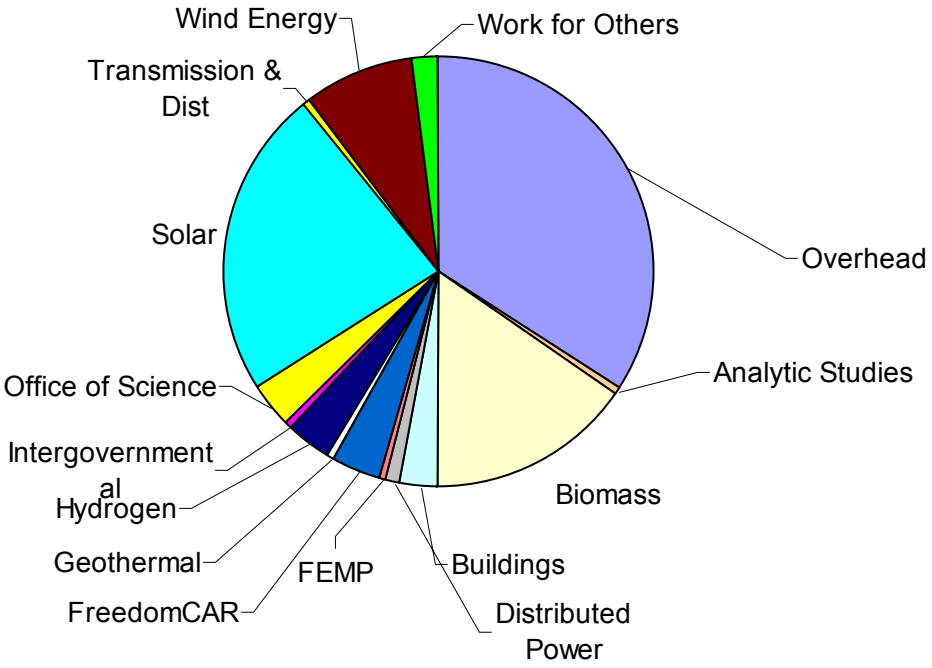


Figure 6.3.7. Distribution of Space by Program (as of 9/30/04) – Total of 670,000 gsf

Table 6.3.4. Summary of DOE-Owned Research Facilities on the South Table Mountain Site

Solar Energy Research Facility – NREL's "signature" building, about 116,000 gsf and completed in 1993, contains low-bay laboratories (some with toxic gas capabilities) and offices to support basic and applied research in many different solid-state materials and devices, with a primary focus on photovoltaic solar cells and modules, hydrogen production and storage technologies, superconducting materials, electrochromic coatings for windows, and nanostructured materials of all types. The work encompasses theoretical studies, material science, device fabrication, process research, and analysis and characterization. The principle focus is on solid-state materials and surfaces, although some liquids and polymers are also studied. Programs supported include EERE programs in Solar; Hydrogen; Distributed Energy & Electricity Reliability; and Buildings; Office of Science programs in Chemical Sciences, Material Sciences, and Biological Sciences; and various CRADAs and work-for-others projects.

Field Test Laboratory Building – NREL's largest and first building, about 126,000 gsf and initially completed in 1984, is a multi-purpose facility that has been modified several times in response to changing research programs. The combination of high-bay and low-bay laboratory space has made this building a versatile and flexible workhorse for virtually every program NREL has supported since its construction. Programs currently supported include Biomass, Hydrogen, Solar, Buildings, FreedomCAR, Geothermal, Industrial Technologies; Office of Science programs in Chemical Sciences, Biological Sciences, and Material Sciences; and various CRADAs and work-for-others projects. The future vision for this facility is to focus its use towards a biosciences research and development facility.

Alternative Fuels User Facility – This facility, about 33,000 gsf and completed in 1994, absorbed the earlier Biotechnology Research Facility built in 1985 and contains biological laboratory and office space, as well as the Biotechnology Process Development Unit. The structure supports the research and development of fuels, chemicals, and other materials from biomass using biological and biochemical conversion processes. Programs supported include EERE Biomass, Hydrogen, Industrial Technologies, and a variety of CRADA projects and work-for-others projects

Outdoor Test Facility -- This facility, about 11,000 gsf and completed in 1995, contains laboratories used to test the performance and reliability of many types of materials for solar applications, including photovoltaic cells and modules, solar films, and other product s. Researchers simulate outdoor conditions to analyze how various devices perform under prolonged exposure to extreme weather conditions. An open field adjacent to the laboratory building is used for outdoor testing. Programs supported include EERE Solar; and various CRADAs and work-for-others projects.

Thermal Test Facility – This facility, about 11,000 gsf and completed in 1996, serves both to house research activities and as a research instrument itself. This structure uses 70% less energy than a similar building of conventional design. Its extensive instrumentation and data collection capabilities help NREL building researchers test and monitor the performance of the building itself, as a research activity. As a functioning laboratory, researchers study advanced cooling, ventilation, ventilation pre-heat, and active solar systems for buildings. The open bay test area houses the Advanced Thermal Conversion Laboratory, which measures realistic performance of desiccant dehumidifiers; air-conditioning components, such as heat exchangers, heat pipes, and evaporators; and entire systems. The facility also houses the Battery Thermal Management laboratory and other transportation-related research activities. Programs supported include EERE programs in Buildings, FreedomCAR, and Distributed Energy & Electricity Reliability; and various CRADAs and work-for-others projects.

Mesa Top Facilities -- The primary mesa top facilities include three small structures. At the Concentrated Solar Radiation User Facility, NREL researchers work with industry partners to discover new ways to reduce manufacturing costs, increase product quality, and reduce pollution using sophisticated equipment that includes a High-Flux Solar Furnace and a UV Concentrator. The High Flux Solar Furnace, completed in 1990, concentrates sunlight up to 50,000 times to study the potential applications of concentrated sunlight on material processing, industrial coatings and surface treatments, chemical synthesis, etc. The Concentrated Solar Test Area includes control rooms and staging areas and outdoor test areas for testing troughs, parabolic dishes, solar trackers, and related equipment. The Solar Radiation Research Laboratory, completed in 2000, supports instrumentation to collect and

analyze solar radiation and meteorological data important to many different programs. Programs supported at the Mesa Top Facilities include Solar; Hydrogen; Industrial Technologies; DOE Initiative for Proliferation Prevention; and various CRADAs and work-for-others projects.

Shipping and Receiving Facility – This facility, about 14,000 gsf and completed in 1997, provides space for shipping and receiving functions and staff.

Visitor Center – This building, about 6,500 gsf and completed in 1994, was built by Midwest Research Institute and donated to DOE. At the east entrance outside the secured area of the Laboratory, it provides technology displays and meeting space. It is open to visitors from the general public and provides meeting space for NREL use.

Site Entrance Building – This small structure houses around-the-clock site security, visitor greeting and badging services, and alarm monitoring.

Table 6.3.5. Summary of DOE-Owned Research Facilities on the National Wind Technology Center Site

Building 251

Building 251, about 22,000 gsf and built in 1982, provides facilities for administrative offices and some high-bay testing capabilities. Researchers also use the latest software to analyze next-generation turbine designs and the data collected from tests and experiments for research and development (R&D) and certification. The high bay at building 251 is used for static and dynamic load testing of small wind turbine blades, small wind turbine generator dynamometer testing, and wind turbine blade component testing. The high bay also houses an environmental chamber that exposes turbine components to extreme ambient temperatures like those found in Arctic environments or hot humid climates.

NWTC Industrial User Facility

The Industrial User Facility, about 11,000 gsf and built in 1996, includes office space for industry researchers working with wind program technical staff, experimental laboratories, computer facilities, a high bay and several test bays. Two testing areas are equipped with stands for blade fatigue testing that shows structural weaknesses in blades. The system is used to perform certification testing for blade design standards. These tests identify problems before they get in the field and helps lower the cost of energy.

Dynamometer Test Bed

The Dynamometer Test Bed (also called the Dynamometer Spin Test Facility), about 5,500 gsf and built in 1999, provides the facility and equipment to conduct lifetime endurance tests on a wide range of wind turbine drivetrains and gearboxes at various speeds, using low or high torque. The 2.5-MW dynamometer helps researchers improve the performance and reliability of wind turbines and ultimately reduce the cost of the electricity they generate. Wear on drivetrains is an important factor in turbine reliability, with many components that work together as a system. By testing full-scale wind turbines, engineers from NREL and industry study the impact of various wind conditions with the goal of improving hardware designs.

Turbine Test Pads

In addition to the two advanced research turbines permanently installed on the site, the NWTC provides outdoor turbine test pads for manufacturers that need to test their prototype machines. Companies that have had turbines tested at the NWTC include the Atlantic Orient Corporation, Bergey, Northern Power Systems, and the Wind Turbine Company. There are currently 21 turbine test sites available. Of those 21 sites, between 12 and 15 generally contain operational turbines or other test equipment; five of the turbines are larger than 100 kW.

6.4 Capital Equipment Overview

NREL has 850-900 individual items of capital equipment. The largest category of NREL capital equipment, approximately $95 million in today's value, is R&D or scientific capital equipment, including sensitive laboratory instruments, large fermentors, dynamometers, and similar items. The next largest category is computer-related or information technology equipment, with a value today of approximately $5.5 million. Last, other equipment (such as machine shop items, large power supplies, radio repeater systems, etc) is worth about $2.5 million today.

Tables 6.4.1 and 6.4.2 characterize NREL's capital equipment portfolio as of June 30, 2004. This data is for all NREL equipment regardless of whether the source of funding was program capital equipment or the general purpose equipment pool. The comparison of average age (10 years) to strategic useful life (12.8 years) gives some indication of the problem of an aging portfolio of equipment. The Equipment Condition Index (see methodology description below) is another measure of the same issue. The ECI of about 15% means that 15% by value of the current equipment portfolio is beyond its strategic useful life, i.e., in the deferred replacement category. Unlike the Facility Condition Index (see section 10.1), DOE has not yet established an "Equipment Condition Index" or category labels of excellent, good, etc. However, if the same categorization is employed, NREL's equipment would be in the "Fair" category (10%<ECI<25%). NREL's target is to have an "Excellent" rating, which requires an ECI of 2% or less.

Information technology equipment includes computer equipment funded through program capital equipment, which serves programmatic missions, and computer equipment funded through general purpose equipment, which is information technology equipment that serves the entire laboratory. Computer equipment faces the greatest challenges of technological obsolescence, with nearly 23% of such equipment beyond its strategic useful life. This is due to the more rapid obsolescence of computer equipment, and the insufficient funding available to keep computer equipment up-to-date. These comments apply to programmatic computer equipment that directly supports programs, institutional information technology equipment that provides the backbone for scientific interchange as well as all administrative computing needs for the Laboratory, and the newest type of computer-related equipment, the very fast processors for computational science (high-performance computing).

Table 6.4.1. Summary of Opportunities and Issues for NREL Capital Equipment

Opportunities

- Strong capabilities in the equipment available for solid-state materials and devices research
- Growing capabilities in equipment for biomass research
- Steady support from Office of Science
- New Computational Science capabilities adding significant value to research programs

Issues

- Deferred replacement status (equipment condition index) is only "fair," with 15% of all equipment beyond its strategic useful life.
- The age of the current portfolio of equipment (average 10.0 years) is nearing the average strategic useful life (12.8 years).
- 23% of all information equipment is beyond its useful life.
- 27% of equipment owned by the Solar Program is beyond its useful life.
- Areas of strategic importance, such as Hydrogen, FreedomCAR, and Distributed Energy, have very little capital equipment to support developing research directions.

For R&D equipment, 14% is beyond its strategic useful life today. The R&D items that are most often beyond their useful life today are items that are more rapidly obsolete, such as microscopes and spectrometers. The R&D items that are not yet beyond their strategic useful life today include long-lasting, less high-technology items, such as heavy-duty fermentors and wind research turbines.

The category of "Other Equipment" includes items such as cranes and forklifts that are used to move heavy items into place; machine shop equipment; safety equipment; security equipment; and such items as compressed natural gas refueling equipment for alternative fuel vehicles used on NREL sites. In this category, 22% of the current value is beyond its useful life.

6.4.1 Programmatic Ownership of Capital Equipment

The major owners of NREL's capital equipment today are the three program areas that have been mainstays at NREL throughout its history – Solar (about $33 million value today), Wind (about $23 million value today), and Biomass (about $14 million today, not including the large purchases at the end of FY03 and FY04 (Figures 6.4.5 and 6.4.6). General purpose equipment, with meaningful levels of investment in FY2001-FY2004, is the next largest owner (about $10 million today). Office of Science is next with $5 million. Buildings program investment has been quite modest at about $2 million. Hydrogen, FreedomCAR, Distributed Energy have not yet invested in substantial capital equipment at NREL. A shortage of capital equipment in a particular programmatic area may put a research program at a disadvantage in needing to borrow time on shared equipment, or limiting its ability to accomplish milestones.

The condition of equipment in individual program areas is shown in Figures 6.4.7 through 6.4.9. As Figure 6.4.8 indicates, the Solar Program has the most severe problem from two different aspects. In Solar, the average age of equipment (13 years) is already well beyond the average strategic useful life (11 years), while the value of the total portfolio of Solar equipment is the

highest in the Laboratory. About 27% of Solar equipment by value is beyond its strategic useful life. The Deferred Replacement Backlog today is about $9 million. These issues were documented in the NREL National Center for Photovoltaics Capital Equipment Plan (April 2004).

The next most severe challenge is in General Purpose Equipment. With a value today of more than $10 million, 20% is beyond its strategic useful life. This is the category that includes most of NREL's administrative computing equipment, networks, and telecommunications equipment, as well as shared scientific instrumentation and computational science equipment.

The Office of Science is an example of a sound strategy for capital equipment investment. Though the total value today is modest at $5 million, the deferred maintenance backlog is very low, resulting in an Equipment Condition Index of about 2%, just into the "excellent" rating. A steady, dependable level of capital equipment funding over several years encourages good planning to balance timely replacement of older equipment with the periodic purchase of an instrument with new capabilities.

Programmatic capital equipment is discussed in more detail in section 7 for each major program. Equipment purchased or intended to be replaced by general purpose equipment is discussed in section 11.1, 11.2 (institutional scientific equipment), 11.3 (computational science), and 11.4 (institutional information equipment).

6.4.2 Equipment Condition Assessment Methodology

The equipment condition index (ECI) given in Table 6.4.2 is the equivalent, for capital equipment, of the replacement plant value used for facilities and infrastructure. This is calculated for R&D equipment as the acquisition cost escalated by the Denver consumer price index. For information equipment, today's value is assumed to be the acquisition cost without escalation, because of the increasing compute power per dollar with time. "Today's value (all items)" includes all items that are still in the asset accounting system at NREL, even though some of those items may be fully depreciated, may be inactive or in a holding status, or be of limited use (e.g., kept for spare parts). This figure correlates the best with the financial accounting of active assets. The items counted as "active, full-use only" excludes items in an inactive or holding status, and items that have been relegated to a "limited use" status. "Limited use" status is a category being used to track instruments that have been replaced by a new, more modern equivalent instrument, but are still actively in limited use for restricted categories of samples, for spare parts inventory, etc. While the "all items" set of equipment items correlates best with financial accounting of active assets, the "active, full-use" portfolio is the set of equipment that needs to be strategically managed, and monitored for replacement at the appropriate time.

Most items that are expected to be replaced at some point have been assigned a replacement year by the research managers who are most familiar both with the instrument or computer and the expected research directions. If the item of equipment was older than its strategic useful life on 09/30/04, and it is intended to be replaced at some point, the value of the item today is counted as part of the deferred replacement backlog and contributes to the Equipment Condition Index. This is the equivalent of the deferred maintenance backlog for facilities and infrastructure. The

Equipment Condition Index is similar to the Facility Condition Index -- the ratio of the value of the deferred replacement backlog to the value of items today that are active and in full use.

Table 6.4.2. NREL Capital Equipment Condition Assessment (06/30/04)

	Units	All Equipment	All R&D Equipment	All Info Equipment	All Other Equipment
Today's Value (all items)	million	$102.7	$94.7	$5.5	$2.5
Today's Value (active, full-use only)	million	$94.1	$86.9	$4.7	$2.5
Deferred Replacement Backlog	million	$13.9	$12.3	$1.1	$0.6
Equipment Condition Index	%	14.8%	14.1%	22.7%	22.3%
Average Strategic Useful Life	Yrs	12.8	13.0	6.4	16.1
Average Age	Yrs	10.0	10.2	5.9	10.7

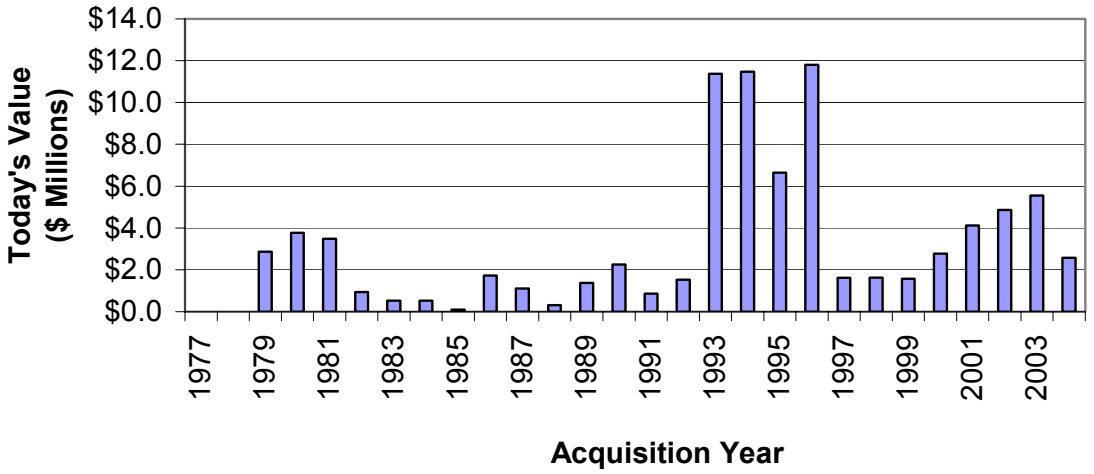


Figure 6.4.1. Age Distribution of R&D Equipment at NREL

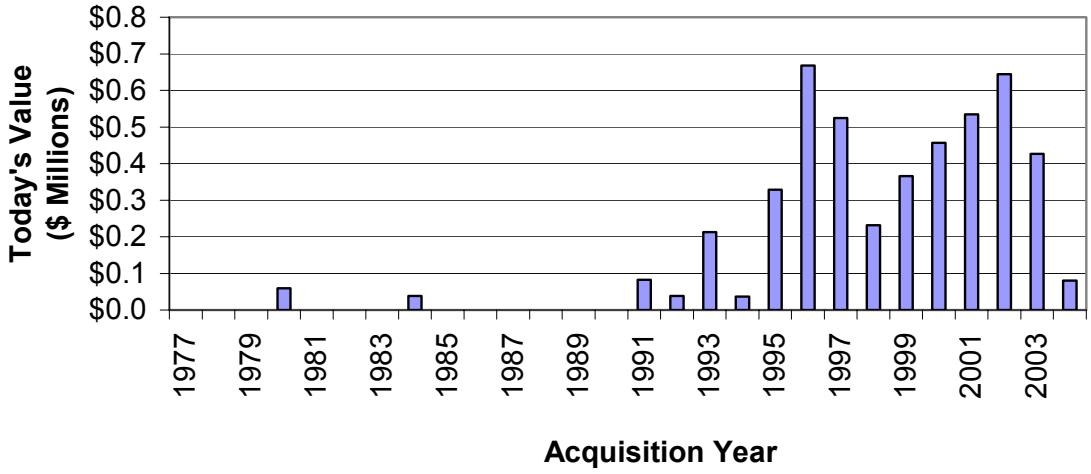


Figure 6.4.2. Age Distribution of Information Equipment at NREL

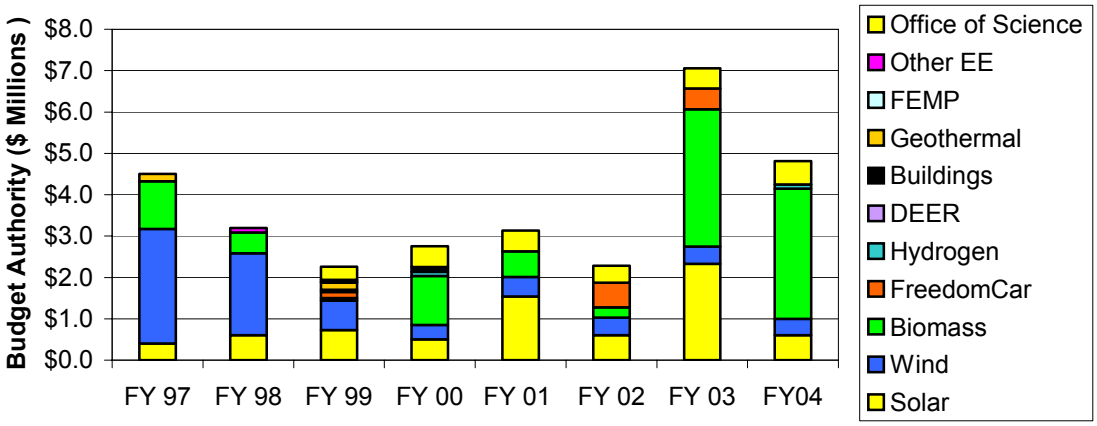


Figure 6.4.3. Program Capital Equipment Funding By Year By Program, 1997-2004

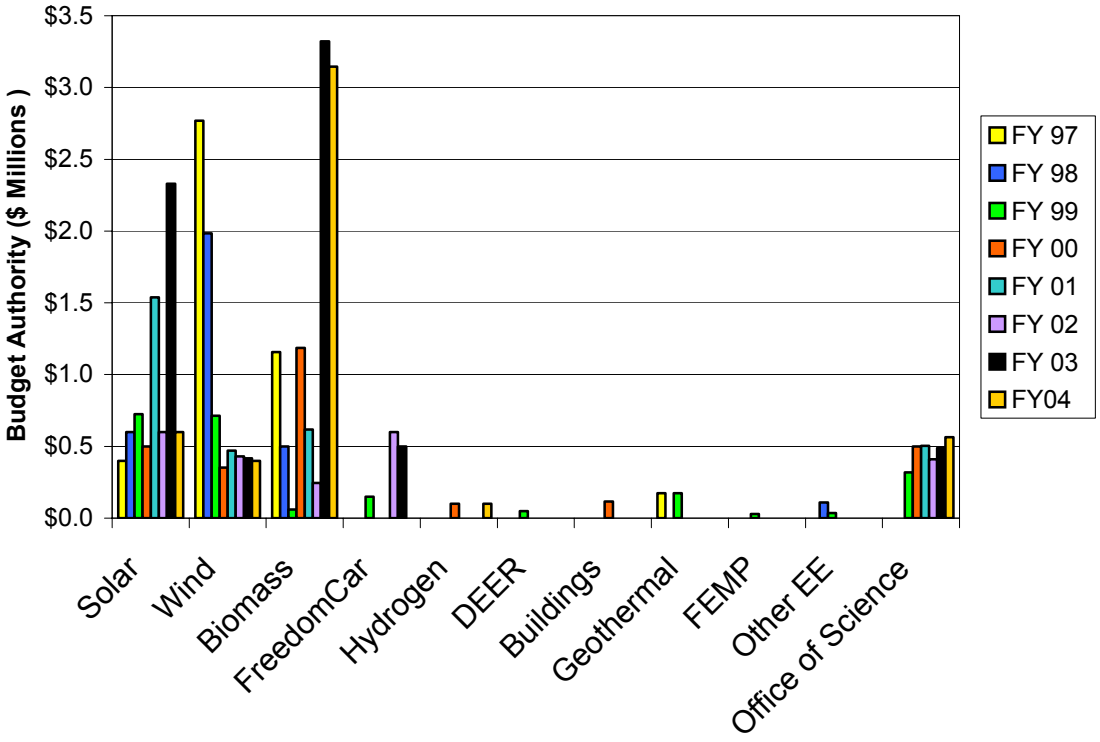


Figure 6.4.4. Program Capital Equipment Funding By Program By Year, 1997-2004

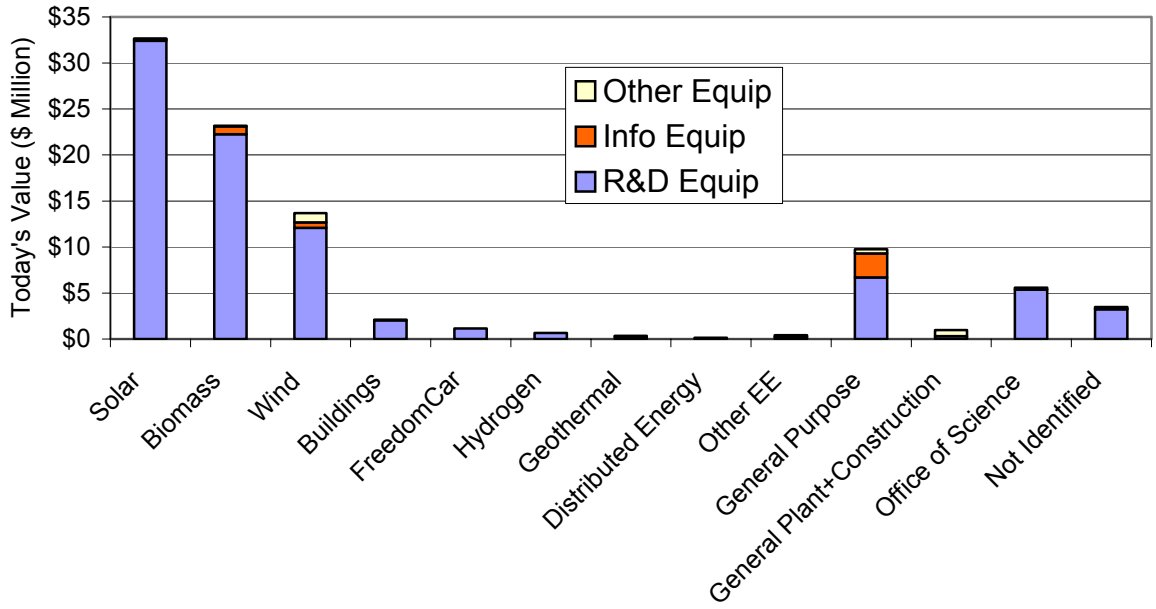


Figure 6.4.5. Ownership of NREL's Capital Equipment (Active, Full Use, as of 06/30/04)

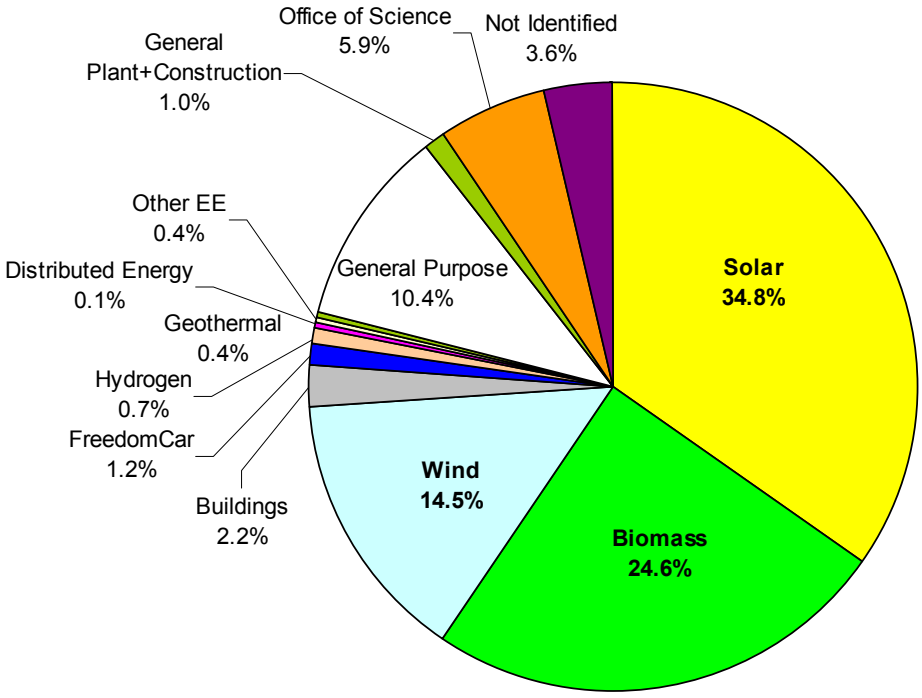


Figure 6.4.6. Distribution of Ownership of NREL Capital Equipment - Today's Estimated Value of $94 Million (Active, Full-Use, as of 6/30/04; 766 Items)

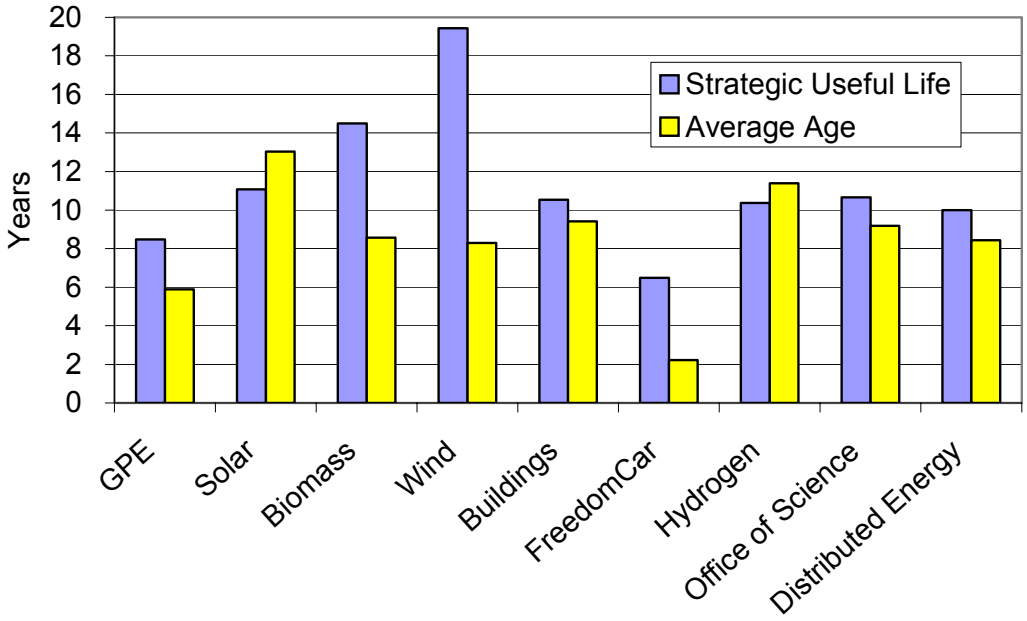


Figure 6.4.7. Average Age of Equipment Compared to Average Strategic Useful Life (Weighted by Today's Value, 06/30/04)

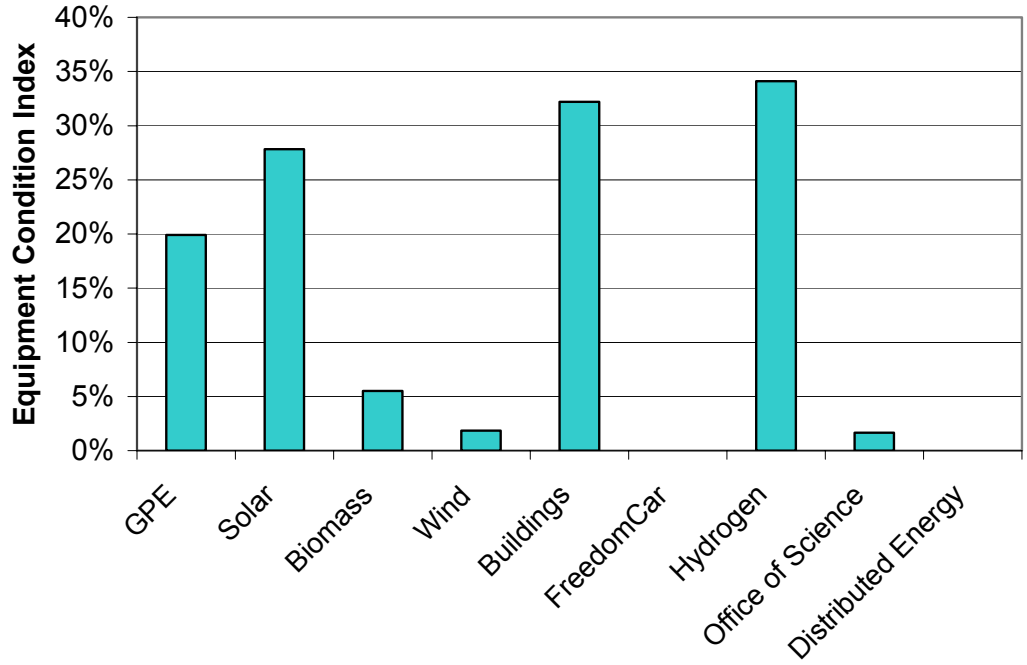


Figure 6.4.8. Equipment Condition Index (Percentage of Active Equipment Beyond Its Strategic Useful Life (Deferred Replacement Category) as of 06/30/04)

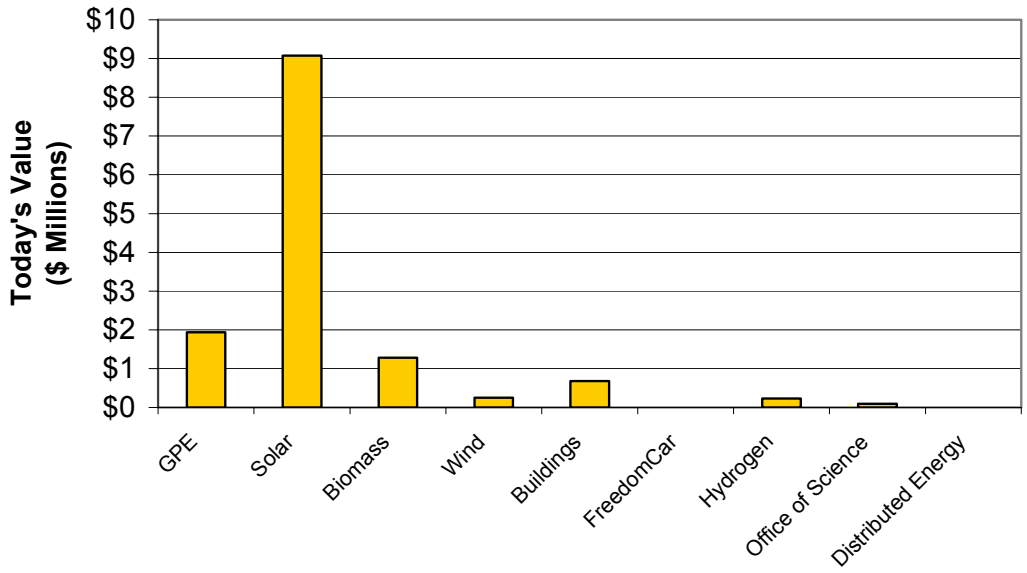


Figure 6.4.9. Value of Capital Equipment Beyond Its Useful Life (as of 06/30/04)

7 Capital Investment Plan – Mission (Facilities and Program Capital Equipment by Program)

7.1 NREL Capital Investment Strategy – Solar Technologies

Strategic Goals

DOE:

Strengthen America's energy security by developing technologies that foster a diverse supply of reliable, affordable, and environmentally sound energy by providing for reliable delivery of energy, guarding against energy emergencies, exploring advanced technologies that make a fundamental improvement in our mix of energy options, and improving energy efficiency.

EERE:

- Increase the viability and deployment of renewable energy technologies
- Increase the reliability and efficiency of electricity generation, delivery, and use

Program:

- Accelerate the development of advanced photovoltaic, solar-thermal electric, solar-heating, and solar lighting technology devices/components leading to integrated systems that are economically competitive, reliable, and adopted by industry.
- Utilize and operate laboratory and engineering facilities in partnership with universities and industry in order to provide viable technology paths that bridge the gaps between the laboratory technologies (research) and the market places.
- Provide world-class R&D facilities and capabilities that will attract highly expert staff and industry/university partners; and, that will maintain and grow NREL's leadership roles in the DOE Solar Energy Technologies Program.

Current Activities at NREL

Table 7.1.1. Solar FY04 Financials and FTEs

FY04 Budget Authorization – Operating	$60.4 million
FY04 Budget Authorization – Capital Equipment	$0.6 million
FY04 In-house Costs	$35.1 million
FY04 Average FTEs	133 FTEs

Planned R&D Activities

- Research on photovoltaic (PV) materials and devices (cells and modules).
- Research on solar thermal materials for converting solar radiation to heat.
- Research on thin-film, highly solar-reflective, materials for producing inexpensive solar mirrors.
- Research on materials suitable for encapsulating photovoltaic and/or solar thermal conversion devices.
- Technology R&D, in partnership with universities and industry partners, to develop advanced solar energy system components: such as; PV modules, solar thermal reflective mirrors and collectors, and solar hot water heating collectors.

- Manufacturing R&D to develop improved and integrated manufacturing processes and equipment.
- Outdoor and accelerated engineering performance and reliability testing on PV and solar thermal systems and components.

Facility Issues and Opportunities

Table 7.1.2. Solar Facility Usage (09/30/04)

Solar Energy Research Facility	89,050	gsf
Joyce St Warehouse	31,091	gsf
Field Test Laboratory Building	59,070	gsf
Outdoor Test Facility	11,219	gsf
DW Building 16	3,702	gsf
Mesa Top Facilities	3,153	gsf
Others	3,010	gsf
Total	*200,294*	*gsf*

Current Facilities

- The Solar Energy Research Facility is the primary research facility for photovoltaic materials research, including deposition systems and measurements and characterization of materials and devices. It provides both well-equipped lab space and office/support space for researchers.
- The Joyce St Warehouse is used for storage of equipment and specialized assembly of components and small systems.
- The Field Test Laboratory Building includes solar thermal materials research and durability testing (e.g. environmental chambers).
- The OTF is used for indoor accelerated and standardized testing of PV modules and outdoor performance and reliability testing of PV modules and small systems.
- Bldg 16 is used for more short-term, specialized, and exploratory materials research.
- Mesa Top facilities are used for outdoor testing and characterization of solar concentrator collectors and systems, and solar radiation measurements.

Manufacturing R&D

A new laboratory, the Science & Technology Facility, will begin actual construction in February 2005, with targeted completion in January 2007. The STF, described in detail in section 8.1, will provide critically needed space for process and manufacturing research for solar modules, and other thin-film and nano-scale materials related to fuel cells, hydrogen storage applications, electrochromic coatings, and optoelectronic applications.

Larger Module R&D

The Outdoor Test Facility currently houses all of NREL's module measurement test beds, environmental test chambers, data acquisition labs, module performance and reliability measurement equipment, and electronics labs in support of the module measurements. These are highly interactive activities that share many common resources as well as modules received by industry. The modules are constructed of tempered glass and can be quite large in size (8-20 square feet). The current trend in PV is to move to larger modules for building integrated PV

applications. In order to maintain the measurement capabilities required by DOE and industry, larger test beds are necessary from program capital equipment, and a larger facility is needed to accommodate them.

Concentrated Solar and Solar Radiation Research
The Mesa Top facilities include one very small (2,688-gsf) building for solar radiation testing and laboratory metrology, approximately 6 years old, which has space for a few small labs and 7 staff. Concentrated solar outdoor experiments are conducted on the mesa involving solar trackers, the Solar Furnace, and other equipment applications. The support buildings for these activities include a collection of sheds and metal buildings that have been added over a period of 27 years. The small lab building does not have the environmental controls, HVAC, or space necessary to accommodate current research needs in solar radiation and metrology. Control rooms are not large enough for new experiments currently being implemented for concentrated solar power components and systems. There are no accommodations for two additional researchers needed, summer students, and visitors. For two of the three major areas of activity on the Mesa, staff and visitors are provided only a port-a-potty.

Inadequate Lab and Office Space
The SERF has been filled well beyond design capacity for several years. In December 2004, there were 199 occupants for a design capacity of 147. In May-August of each year, these numbers increase to accommodate summer student interns. The immediate solution has been substandard workspaces. The completion of the S&TF will allow decompression of the SERF as some labs and researchers will move from the SERF into the S&TF, and will allow some researchers to move from Building 16 to the SERF. However, the overall demand for laboratory space and offices to accommodate other related research activities will ensure that there will continue to be issues with inadequate office and lab space for summer students, post docs, and visiting professionals in the SERF and S&TF combination.

Facility Recommendations
Science & Technology Facility
To address manufacturing R&D problems, complete the new Science and Technology Facility (S&TF) on schedule and within budget, without any compromises to laboratory space and/or capabilities. Prior to moving into the S&TF, develop various forms of joint R&D agreements with selected industry and university partners, with an emphasis on PV manufacturing process R&D. Explore shared funding of specialized equipment and/or staffing.

Equipment Issues and Opportunities

Table 7.1.3. Solar Capital Equipment Status (06/30/04)

Today's Value	$32.7	million
Deferred Replacement Backlog	$9.2	million
Percent of Today's Value Deferred	28%	
Average Strategic Useful Life	11.1	yrs
Average Age	13.1	yrs

As can be seen from Table 7.1.3, the average age of Solar capital equipment is far older at 13 years than its average useful life of 11 years. More than $9 million worth of Solar equipment today is older than its useful life. This is the most difficult challenge of any program at NREL.

The success of the Solar Program relies on (i) state-of-the-art measurement and characterization laboratories that directly assist these industry, university, and laboratory partners in the critical evaluation of their products; and (ii) materials and device research facilities that provide both fundamental and applied research support for the Solar Program. The Program is in danger of losing its key leadership and a critical technical resource that has been more than 25 years in the making. The capital equipment investments in the PV Program have declined to insignificant levels since 1994, and these levels have only allowed for the replacement of a few critical components. Maintenance and service costs have also escalated on existing major equipment due to age. In fact, several major systems are in jeopardy of becoming decommissioned because critical components are unavailable.

NREL's laboratories are the DOE leads for standards, measurements, and tests with the world photovoltaics community. But it is difficult to maintain technological and scientific leadership as investments in required capital equipment steadily erode. It has not been possible to invest in many newly available techniques and processes that have been developed since the last major capital equipment infusion in 1992. Much of the equipment is one or more generations removed from the state-of-the-art.

In the current world context, these centralized activities are key to maintaining the strategic and competitive edge for the U.S. PV industry over the growing foreign competition, including laboratories in Europe and Asia that have established facilities analogous to the DOE/NREL operations to assist their own industries and economies. To ensure the U.S. advantage *in* photovoltaics technology, it is critical to maintain support facilities, providing state-of-the-art equipment that can meet the growing needs of the U.S. Program toward meeting the performance and reliability goals of the U.S. PV Industry 20-Year Roadmap and the DOE EERE Multi-Year Technical Plan.

The strategy for the period of 2005-2010 is to:

1. Replace and upgrade seriously deficient and aging equipment that is several generations old and/or has become "cost ineffective" based on maintenance considerations
2. Provide new equipment that provides capabilities introduced in the past 10 years that are essential to the competitiveness of the U.S. PV Program

3. Provide the capital equipment necessary to fully outfit the Science and Technology Facility (S&TF) so that we can meet our goal of reducing the time it takes to move a technology from the lab to the marketplace.

Each of these approaches is critical to meeting the EERE key strategic goal of "Reducing the cost of PV to $0.06/KWh by the year 2020" and CSP electricity to $0.09/kWh by the year 2010. This plan follows the last major capital equipment investment by some 10 years, about 4-6 years beyond the expected lifetime of the majority of techniques. Continued neglect will jeopardize the U.S. PV leadership and its existing investment in its resources.

Current expectations of Solar program budget suggests that the level of funding available for non-facility-related capital equipment of all types (regular replacement, deferred replacement, and new capability) will be about $600,000 per year for the foreseeable future (Figure 7.1.4), compared to the need of $4 million to $7 million per year (Figure 7.1.3). The Laboratory continues to examine several options with the Solar program to mitigate this shortfall.

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the Solar Energy Technologies Program. There is a general need for increased computational modeling, simulation and data handling of materials, devices and processes used in photovoltaics and solid state lighting. Specific examples include the quantum mechanical simulations of solid state and organic materials, fluid dynamics simulation of metal-organic vapor phase epitaxy reactors, and mining of experimental data for hidden correlations to improve stability of Cadmium Telluride high performance solar cells.

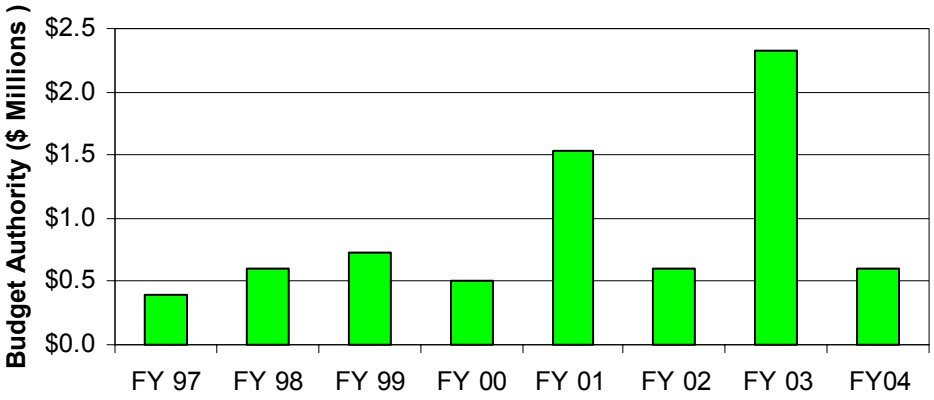


Figure 7.1.1. Solar Program Capital Equipment Funding 1997 – 2004

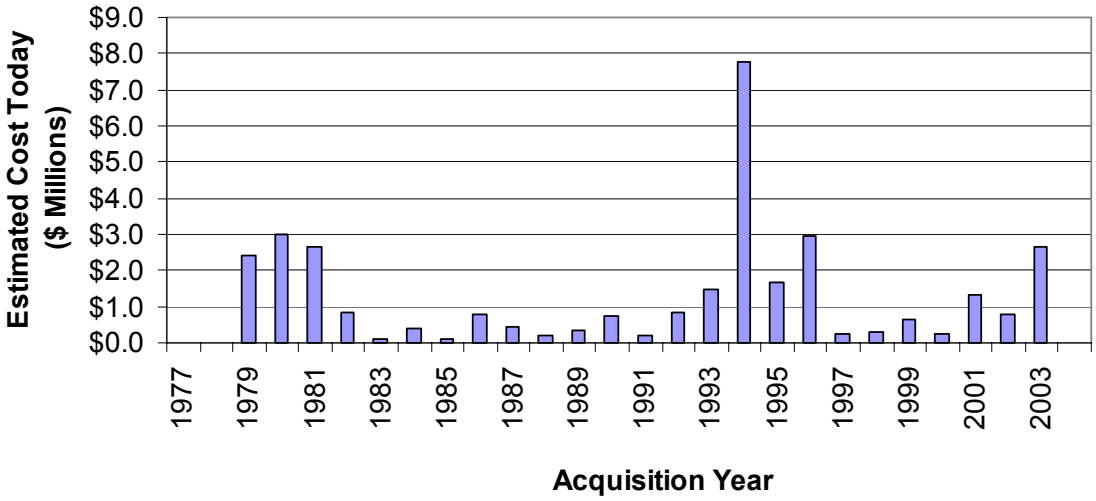
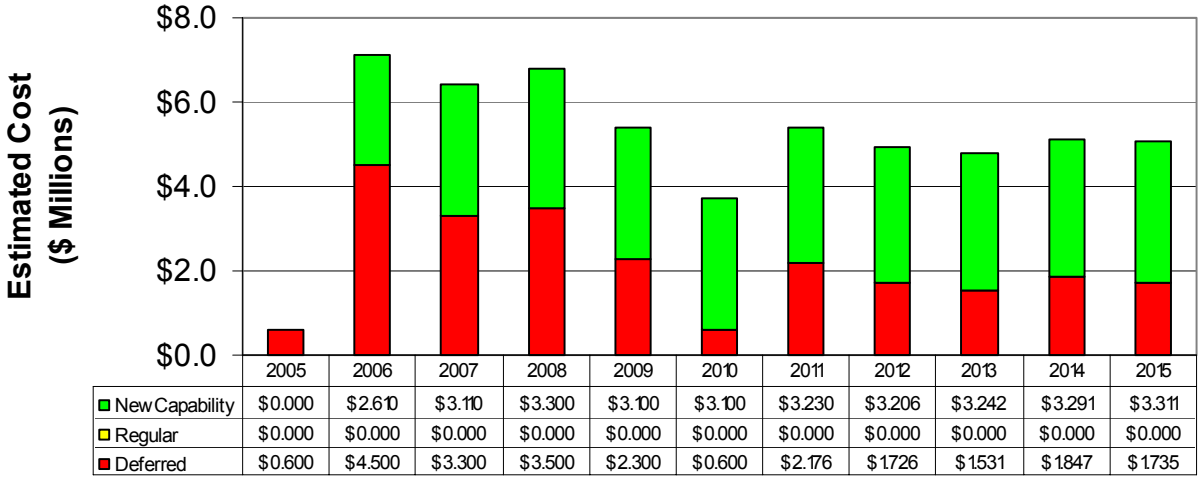
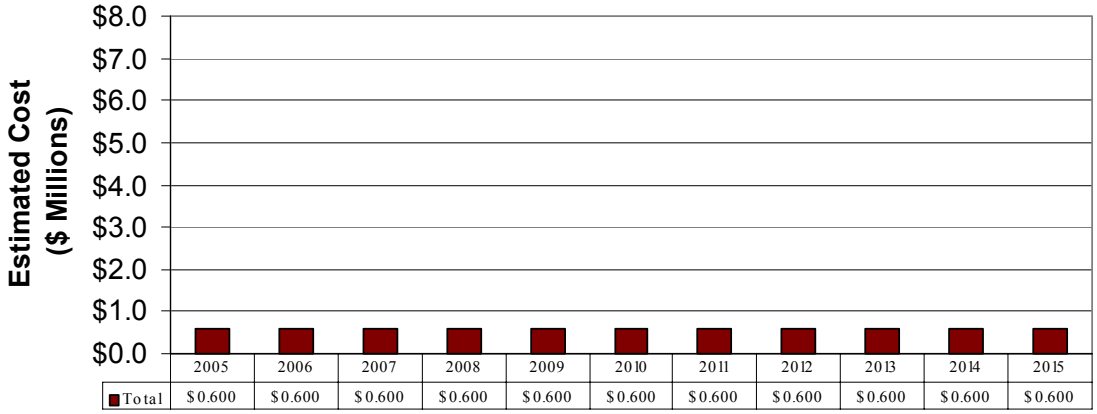


Figure 7.1.2. Age Distribution of Solar Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	$0.000	$2.610	$3.110	$3.300	$3.100	$3.100	$3.230	$3.206	$3.242	$3.291	$3.311
Regular	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Deferred	$0.600	$4.500	$3.300	$3.500	$2.300	$0.600	$2.176	$1.726	$1.531	$1.847	$1.735

Figure 7.1.3. Projections of Equipment Requirements for Solar (Excluding Facility-Specific Equipment, FY05 – FY15)



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	$0.600	$0.600	$0.600	$0.600	$0.600	$0.600	$0.600	$0.600	$0.600	$0.600	$0.600

Figure 7.1.4 Projections of Equipment Funding for Solar (Excluding Facility –Specific Equipment, FY05-FY15)

Table 7.1.4. Projections of Capital Equipment Requirements for Solar FY2005-FY2007

Replacement Year	Replacement Category	Item	Estimated Replacement Cost	In Service Year (if available)
2005	Deferred	Turbo pump stations	$30,000	1989
2005	Deferred	Dicing tool	$25,000	
2005	Deferred	Optical reflectance monitor	$75,000	
2005	Deferred	Replacement Pumping System	$30,000	1992
2005	Deferred	Scanning spectroscopic ellipsometer with autoretarder	$220,000	
2005	New Capability - Facility Related	Film Crystal Silicon Deposition System	$550,000	
2005	New Capability - Facility Related	Polycrystalline TF PVD Workstation- I (4 chambers)	$1,200,000	
2005	New Capability - Facility Related	Multi-target Sputtering system (TCO/metallization)	$550,000	
2005	New Capability - Facility Related	X-ray and Ultraviolet Photoelectron Spectrometer (XPS/UPS) Workstation	$800,000	
2005	Regular	Silicon Combi PECVD	$145,000	
2005	Regular	Electron-Beam Source (Wire Fed)	$45,000	2001
2005	Regular	Thermal atomic hydrogen source	$30,000	2001
2006	Deferred	MOCVD upgrade	$200,000	
2006	Deferred	Automation of the EPI930 MBE system	$45,000	1994
2006	Deferred	UHV ion-beam assisted hot-wire CVD	$90,000	
2006	Deferred	Electron Back Scattered Diffraction (EBSD) / Energy Dispersive Spectrsocopy (EDS) X-ray system for SEM	$240,000	1984
2006	Deferred	Portable spectral radiometer for outdoor use	$60,000	1985
2006	Deferred	Dynamic Secondary Ion Mass Spectrometer (SIMS)	$1,900,000	1980
2006	Deferred	X-ray and Ultraviolet Photoelectron Spectrometer (XPS/UPS)	$950,000	1994
2006	Deferred	Closed-cycle He Refrigerator	$60,000	1990
2006	Deferred	Tracker for PV Modules and Data Acquisition	$200,000	
2006	Deferred	Updated Multitracers for PERT (Performance and Energy Rating Testbed)	$150,000	
2006	New Capability	Bench-top atomic force microscope	$100,000	
2006	New Capability	Spectral ellipsometry system for the Riber Compact21 MBE system	$75,000	
2006	New Capability	Micro-Raman measurement system	$170,000	
2006	New Capability	Organic Semiconductor Device Fabrication System	$300,000	
2006	New Capability	Pulsed Electron Beam Deposition Tool	$255,000	
2006	New Capability	Multijet inkjet printing system	$250,000	
2006	New Capability	Hot press	$100,000	
2006	New Capability	Machine Shop Tools for the machine shop in the S&TF	$100,000	
2006	New Capability	Vacuum deposition system	$90,000	
2006	New Capability	Time-of-Flight-Mobility Measurement Setup	$50,000	
2006	New Capability	Atomic Absorption Spectroscopy System	$100,000	
2006	New Capability	Optical Probe Workstation phase I (PL, TRPL, Raman, rf-PCD)	$700,000	
2006	New Capability	Dispersive Micro-Raman System	$290,000	
2006	New Capability	Microwave Reflection Based Lifetime Scanner	$250,000	
2006	New Capability	3D semiconductor device simulation package	$80,000	
2006	New Capability	Cryostat for spectroscopic ellipsometer	$70,000	
2006	New Capability	Extended wavelength-range CCD camera, 0.4 ñ 2 µm, for Reflectometer	$50,000	
2006	New Capability	Absorption equipment	$60,000	
2006	New Capability	Zeta Potential Analyzer	$50,000	
2006	New Capability	Surface Profiler with Stress Analysis Package	$80,000	
2006	New Capability	Spectroradiometer for PERT (Performance and Energy Rating Testbed)	$40,000	
2006	New Capability - Facility Related	a-Si CVD Workstation (3 chambers- p, i, n)	$1,200,000	
2006	New Capability - Facility Related	Thin Film Analyzer Auger Electron Spectrometer (TFA-AES) Cart	$460,000	
2006	New Capability - Facility Related	Stationary Transfer Platform	$230,000	
2006	Regular	Phase III Multi-chamber, combinatorial deposition tool	$300,000	
2006	Regular	Upgrade Dimension 3100/Nanoscope IV to incorporate close-loop head, conductive AFM and SCM capability.	$130,000	2000
2006	Regular	2-axis, 0.02 degree accuracy tracker for concentrator module efficiency measurements	$120,000	2002
2006	Regular	2D semiconductor device simulation package	$55,000	2003
2006	Deferred	Large area PLD heater	$50,000	
2007	Deferred	S&TF compatibility	$100,000	1994
2007	Deferred	Temperature measurement system for the EPI930 MBE system	$75,000	1994

7.2 NREL Capital Investment Strategy – Wind Program

Strategic Goals

DOE: Strengthen America's energy security by developing technologies that foster a diverse supply of reliable, affordable, and environmentally sound energy by providing for reliable delivery of energy, guarding against energy emergencies, exploring advanced technologies that make a fundamental improvement in our mix of energy options, and improving energy efficiency.

EERE:

- Increase the viability and deployment of renewable energy technologies
- Increase the reliability and efficiency of electricity generation, delivery, and use

Current Activities at NREL

Table 7.2.1. Wind Program FY04 Financials and FTEs

FY04 Budget Authority - Operating	$28.1	million
FY04 Budget Authority – Capital Equipment	$0.4	million
FY04 In-house Costs	$15.3	million
FY04 Average FTEs	52	FTEs

- Advance the development and deployment of low wind speed turbines for land and offshore applications by helping industry produce machines capable of generating electricity at 3 cents/kilowatt-hour (kWh) in a low wind speed Class 4 (13.4 mph) wind site by 2012
- Improve performance and reduce the costs of wind energy technologies by investing in wind energy R&D and conducting field tests
- Facilitate market adoption of wind energy technologies by partnering with private companies to demonstrate technologies in commercial energy systems.

Planned R&D Activities

The Program's highest priority goal is to further reduce the cost of electricity from large onshore wind systems in Class 4 winds to 3 cents/kWh, and to 5 cents/kWh for offshore systems by 2012. These goals are important elements of the Department's strategy to support the National Energy Policy objective for increasing the Nation's sources of clean, domestically produced, affordable energy. Studies have shown that the new multi-megawatt wind turbine designs will produce this cost competitive energy in wind resource areas that are 20 times more abundant and five times closer to major load centers than the wind resource areas that are in use today.

For the U.S. Wind and Hydropower Program to meet these goals, it will be necessary to support the development of these large-scale wind turbines in the multi-megawatt scale for both onshore and offshore applications.

Facility Issues and Opportunities

Table 7.2.2. Wind Program Facility Usage (09/30/04)

NWTC Other	22,666	gsf
NWTC Bldg 251	21,454	gsf
NWTC Industrial User Facility	11,291	gsf
Other Facilities	758	gsf
Total	*56,169*	*gsf*

- All of the research for the Wind Program at NREL is conducted at the National Wind Technology Center, about 20 miles north of the main NREL South Table Mountain Site. This 305-acre site contains 20-30 test sites for turbines and a variety of buildings used for research. 25 acres of the 305 is planned for installation and R&D testing of a megawatt-class wind turbine
- Building 251 houses offices for program administration and computer labs for wind turbine systems electrical and mechanical dynamics modeling, computer code development and wind turbine computer control system development and modeling.
- The Industrial User Facility, also known as the Blade Test Facility, is used to test wind turbine blades up to 32 meters in length
- The Hybrid Power Test Bed (HPTB)/Distributed Energy Research (DER) Facility is used for testing and development of controllers of off-grid and grid connected renewable energy devices used to decrease use of fossil fuels and provide cost effective supplemental/replacement electricity.

Facility Recommendations

Temporary 50-Meter Test Stand
Construct a large concrete base as a test stand for 50-meter blades outside the perimeter of the existing 32-meter blade test facility at the National Wind Technology Center. Placing the end of the blade on this temporary test stand and extending the blade inside the interior of the existing facility will allow some limited critical testing. The estimated cost is $400,000 – $500,000 in FY2005.

Equipment Issues and Opportunities

Table 7.2.3. Wind Program Capital Equipment Status (06/30/04)

Today's Value	$13.7	million
Deferred Replacement Backlog	$0.3	million
Percent of Today's Value Deferred	2%	
Average Strategic Useful Life	19.4	yrs
Average Age	8.3	yrs

In 1996, the Wind Program purchased a 2.5-MW dynamometer for $5.5 million. Other large-value items in the Wind Program equipment portfolio include the advanced research wind

turbine; wind tower systems; the hybrid power system of electrical connection, switching and computer control equipment used in the Hybrid Power Test Bed, an aerial work platform, crane truck, manlift, and other equipment for moving large wind components for testing; data acquisition systems; and other computer equipment. The nature of this equipment results in a longer average strategic useful life compared to other programs' equipment at NREL. The equipment needs to be maintained, repaired, upgraded and sometimes replaced by larger capacity equipment as the wind industry grows, producing the evolution of new R&D challenges and its associated technical issues (much larger drive trains and blades, off-shore in a marine environment, land-based low wind speed development, hydrogen production, etc.).

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the Wind & Hydropower Technologies Program through more aeroacoustics research. It will support efforts to develop physics-based aeroacoustics codes for both design and problem solving applications. These will enable more slender blades and higher tip speeds, enhancing cost, performance, and long-term reliability of future designs.

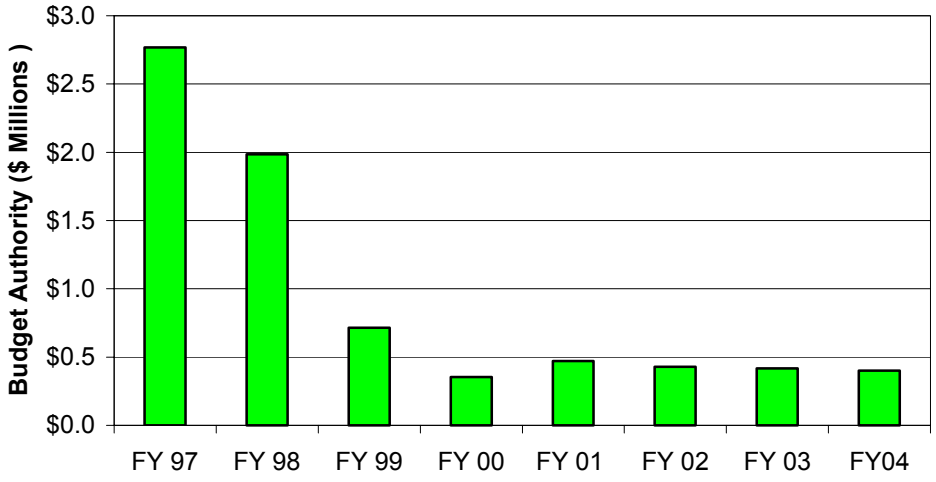


Figure 7.2.1. Wind Program Capital Equipment Funding (1997-2004)

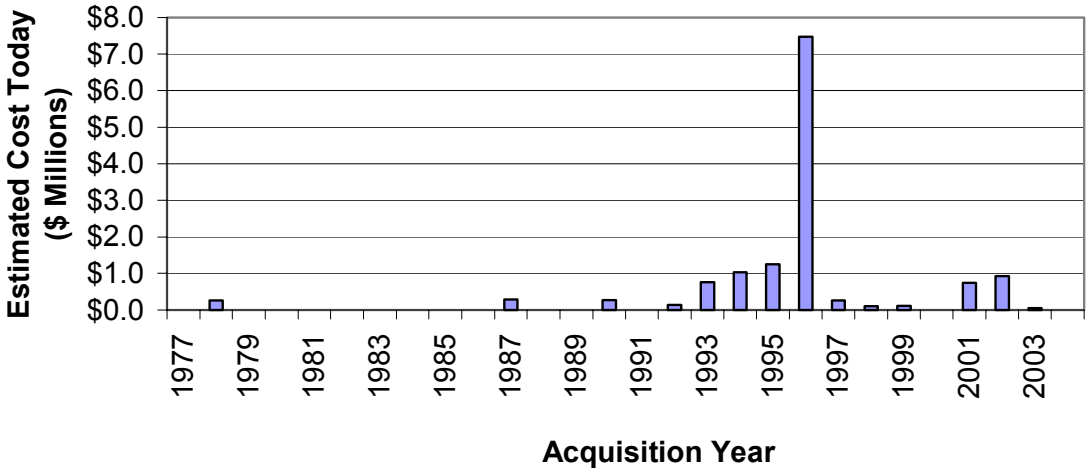


Figure 7.2.2. Age Distribution of Wind Equipment at NREL

Table 7.2.4. NWTC Wind Program Capital Equipment Requests - FY2005-FY2011 ($ in 1000's)

Option 1 Assumptions:	No Congressional Line Item for NWTC Large Wind Turbine Test Facilities Program Capital Augmentation to Maximize Existing 50m Blade Test Stand and 2.5 MW Dyno Program Capital Augmentation for Offshore Technology								
Description	**Type**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Total**
New NWTC 50m Blade Testing Capability		**$370**	**$200**	**$100**	**$0**	**$50**	**$100**	**$150**	**$1,200**
50m Blade Test Stand & Foundation	PCE	$200	$0	$0	$0	$0	$0	$0	$430
Fatigue Test Apparatus for 50m Stand	PCE	$50	$50	$0	$0	$0	$50	$50	$200
Static Test Apparatus for 50m Stand	PCE	$70	$100	$0	$0	$50	$0	$0	$220
Blade Movement & Positioning Apparatus	PCE	$50	$50	$100	$0	$0	$50	$100	$350
NWTC 2.5 MW Dyno Testing Capabilities		**$0**	**$50**	**$100**	**$200**	**$100**	**$0**	**$50**	**$500**
Fault Ride Through Test System	PCE	$0	$0	$100	$150	$0	$0	$0	$250
Radial Loading Capability	PCE	$0	$0	$0	$50	$100	$0	$0	$150
Condition Monitoring Equipment	PCE	$0	$50	$0	$0	$0	$0	$50	$100
Maxmize 50m Blade Testing & 2.5 MW Dyno		**$0**	**$0**	**$500**	**$500**	**$0**	**$0**	**$0**	**$1,000**
Add NPS 1.5 MW direct drive to Dyno	PCE			$250	$250				$500
Outdoor fatigue testing on 2nd 50m stand face	PCE			$250	$250				$500
New NWTC Offshore Technology Development Capabilities		**$0**	**$0**	**$1,700**	**$3,100**	**$2,700**	**$1,200**	**$700**	**$9,400**
Wave/Wind Simulator Platform	PCE	$0	$0	$1,000	$2,000	$100	$0	$0	$3,100
Offshore Shallow Water Instrument System	PCE	$0	$0	$300	$500	$500	$100	$100	$1,500
Offshore Deep Water Instrument System	PCE	$0	$0	$100	$400	$2,000	$1,000	$500	$4,000
Met Ocean Ecological Measurement System	PCE	$0	$0	$300	$200	$100	$100	$100	$800
New Grid Integration Test Support Capabilities		**$0**	**$50**	**$50**	**$70**	**$150**	**$0**	**$0**	**$320**
Utility Grid Fault Generator	PCE	$0	$0	$0	$70	$150	$0	$0	$220
Power Quality Test Equipment (Low Voltage)	PCE	$0	$50	$0	$0	$0	$0	$0	$50
Power Quality Test Equipment (High Voltage)	PCE	$0	$0	$50	$0	$0	$0	$0	$50
New NWTC Field Test & Operations Support Capabilities		**$30**	**$100**	**$250**	**$230**	**$200**	**$400**	**$300**	**$1,510**
Modal Test Equipment	PCE	$0	$0	$0	$50	$0	$50	$0	$100
Component Vibration System	PCE	$0	$0	$0	$50	$50	$0	$0	$100
Small Turbine Data Acquistion Systems	PCE	$0	$20	$0	$30	$0	$50	$0	$100
Large Turbine Data Acquisition Systems	PCE	$0	$0	$50	$0	$50	$0	$50	$150
Optical Strain Measurement System	PCE	$30	$30	$0	$0	$0	$0	$0	$60
LIDAR Inflow Measurement System	PCE	$0	$50	$50	$0	$50	$0	$0	$150
120 ft. Manlift	PCE	$0	$0	$150	$100	$0	$0	$0	$250
Turbine Service Vehicle	PCE	$0	$0	$0	$0	$0	$100	$0	$100
Multi-megawatt research turbine test site	PCE	$0	$0	$0	$0	$50	$200	$250	$500
Total Program Capital Equipment		**$400**	**$400**	**$2,700**	**$4,100**	**$3,200**	**$1,700**	**$1,200**	**$13,930**

7.3 NREL Capital Investment Strategy – Biomass

Strategic Goals
EERE Goals:

- Dramatically reduce or even end dependence on foreign oil
- Create the new domestic bioindustry

Sugar Platform: To develop the capability for using lignocellulosic biomass to produce inexpensive sugar streams that can be utilized for the production of fuels, chemicals, and materials.

Thermochemical Platform: To develop the capability of thermo-chemically converting biomass into simple building blocks for the production of fuels, power, chemicals, and materials.

Products: To develop the capability to produce fuels, power, chemicals, and/or materials utilizing intermediates from thermochemical and sugar platform intermediates.

Integrated Biorefinery: To support the establishment of integrated biorefineries that utilizes both conversion platforms through partnerships with industry.

Table 7.3.1. Biomass FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$23.4	million
FY04 Budget Authorization - Capital Equipment	$3.1	million
FY04 In-house Costs	$19.1	million
FY04 Average FTEs	72	FTEs

Current Activities at NREL

- Partnerships with industry, universities, and other national laboratories
- Biomass characterization
- Development of new analytical tools for biomass conversion
- Thermochemical and biochemical biomass conversion technologies
- Biobased products development
- Biomass process engineering and analysis

Planned R&D Activities
Sugar Platform
R&D includes analyzing various feed stocks and their effects on process performance; developing more cost-effective methods for pretreatment and enzymatic hydrolysis; developing more effective catalysts; determining how to produce useful products from lignin; understanding the complex interactions among the process steps; and understanding the fundamentals of biomass structure as it affects biomass process economics.

Thermochemical Platform
R&D centers converting biomass and/or the residue from the sugar platform into useful intermediate chemical building blocks, cleaning and conditioning the gas from biomass/residue gasification to meet strict quality standards for downstream fuel/chemical applications; treating and upgrading pyrolysis oils to make other products; ways to integrate intermediates with existing refineries and chemical plants; and addressing the problems that affect sustained performance in a fully integrated process plant.

Products
R&D focuses on maximizing the value of all components produced by the Sugar and Thermochemical Platforms, by converting them to a slate of fuels, chemicals, materials, heat, and power and developing specific unit operations required to do this.

Integrated Biorefinery
R&D addresses how the specific unit operations can be combined to create different biorefineries, requiring significant advances in process integration R&D. In support of the emerging biomass conversion industries, new low cost, high throughput analytical tools are being developed specifically for the integrated biorefinery.

Facility Issues and Opportunities
Current Facilities
Biomass research is accomplished in two primary research facilities at NREL. The Field Test Laboratory Building, currently devoted 65% to Biomass research, provides chemistry and biology laboratories and offices for researchers and program management staff. Some of the key Biomass Program facilities housed in the FTLB include a Nuclear Magnetic Resonance Facility, a Biomass Surface Characterization Facility, and a Genomics Laboratory. The FTLB also houses the 6,000-gsf ThermoChemical Process Development Unit (TCPDU). The Alternative Fuels User Facility is used exclusively by the Biomass program, providing chemistry and biology laboratories, the 6,800-gsf BioChemical Process Development Unit (BCPDU), and offices for researchers and analysts.

Table 7.3.2. Biomass Facility Usage (09/30/04)

Field Test Laboratory Building	76,703	gsf
Alternative Fuels User Facility	30,944	gsf
DW Building 16 and others	3,176	gsf
Total	*110,823*	gsf

Chemical Analysis and Applied Biology Laboratories
NREL requires state-of-the-art chemistry and biology laboratories to support the Biomass Program's strategic plan and to meet industrial partners' needs in these areas. While NREL has excellent facilities in this area, all currently built laboratories within the FTLB and AFUF are continuously in use at near 100% utilization. The chemical analysis equipment used for biomass characterization is spread across a large number of labs with little relationship between the type of research and the analytical support for that research. This reduces the NREL's effectiveness

and productivity in a critical area. Although we frequently receive requests for lab-based training related to biomass analysis, no laboratory teaching/training facilities exist at NREL. Also, the Applied Biology research today completely fills available facilities, and there is no space to conduct new work expected in this area.

Integrated Biorefinery Facility
Neither the TCPDU nor the BCPDU can be operated as a fully integrated biorefinery. Neither facility currently has any room for expansion to develop new processing options for the future. In addition, the current height of the TCPDU, and the floor-loading capacity, limit the types of research that can be done. These unique pilot plants were developed in two separate buildings under the earlier biomass-related program structures. The two pilot plants are heavily used by both the Biomass Program and industry partners. Adding the capability to operate the BCPDU and the TCPDU as an integrated facility would most effectively provide the process R&D needed to develop integrated biorefinery technology, and create a truly unique and much needed capability for DOE. There is no such capability available in the U.S. for this type of fully integrated biorefinery research.

Biobased Polymers & Composites R&D Facility
NREL's facilities are not adequate to support the anticipated and desired growth in biobased products R&D, especially in the area of biobased polymers and composites research. A new laboratory dedicated to this work will better equip DOE to support industry, and catalyze the exploration of unique biobased polymers that have cost & performance characteristics that are superior to the established petroleum-derived incumbents.

Offices, cubicles, and workstations
The utilization rate for offices, cubicles, and workstations is about 97% in the FTLB and 89% in the AFUF as of December 2004, compared to the desired practical utilization rate for workspaces of 85%. Workstations are even more crowded, and are of substandard size, when students and teachers are added in the summer. In addition, about half of the workstations in the FTLB consist of large blocks of cubicles in interior spaces that have absolutely no windows. These crowded and substandard conditions overall make it difficult to attract and retain senior scientists in the highly competitive biotechnology field.

Facility Options
In considering facility needs, the following options should be included:
Chemical Analysis and Applied Biology Laboratories
- Limit R&D at NREL to that which can be accomplished with the current facilities
- Temporarily lease commercial laboratory space, duplicate services and equipment as necessary at the leased facility, and accept the decrease in productivity inherent in split locations.
- Improve the utilization of the FTLB by moving offices out of interior spaces and building out unused or underutilized space in the interior of the FTLB, adding walls and casework, and upgrading and expanding building ventilation and drains.

- Improve the utilization of the FTLB by a major project that will reconfigure and remodel the poorly utilized interior spaces into modern laboratories. Redistribute existing laboratory space in the AFUF and FTLB to consolidate current activities. Define separate AFUF and FTLB activities to focus on specific research areas and different customers.
- Combine Biomass needs with other programs' needs for laboratories at NREL in a new Chemical and Material Sciences Laboratory.

Integrated Biorefinery Facility
- Limit R&D at NREL to that which can be accomplished with the current facilities
- Explore options to use/lease laboratory capabilities at another location and accept the decrease in productivity inherent in split locations (Planned option for FY05-06)
- Expand one and/or both of the PDUs in their current locations to allow it to be integrated operationally with the other facility (Preferred long- term option)
- Move the TCPDU to the AFUF and expand the AFUF structure to house an integrated biorefinery R&D pilot plant
- Build a totally new integrated biorefinery R&D pilot plant, at NREL or another location

Biobased Polymers & Composites R&D Facility
- Continue to inadequately serve the emerging biobased products industry
- Explore options to use/lease laboratory capabilities at another location and accept the decrease in productivity inherent in split locations (possible short-term option)
- Improve the utilization of the FTLB by moving offices out of interior spaces and building out unused or underutilized space in the interior of the FTLB, adding walls and casework, and upgrading and expanding building ventilation and drains.
- Improve the utilization of the FTLB by a major project that will reconfigure and remodel the poorly utilized interior spaces into modern laboratories.
- Combine Biomass needs with other programs' needs for laboratories at NREL in a new Chemical and Material Sciences Laboratory.

Offices and Support Space
- Continue in inadequate space, with overflow to leased office buildings in another location, accepting the decrease in productivity inherent in split locations.
- Expand the FTLB outside the current footprint to add office spaces if needed late in the 10-year time frame.
- Install "temporary" office trailers nearby

Equipment Issues and Opportunities

Table 7.3.3. Biomass Capital Equipment Status* (06/30/04)

Today's Value	$23.2	million
Deferred Replacement Backlog	$1.3	million
Percent of Today's Value Deferred	5.5%	
Average Strategic Useful Life	14.5	yrs
Average Age	8.6	yrs
* FY03 and FY04 additions for BSCL and Genomics Lab not yet included in these figures		

In FY03, NREL and the DOE Biomass Program committed to establishing a very unique facility at NREL for the advanced characterization of biomass surfaces and materials. NREL used $2.2 million in capital funds provided by the Biomass Program to purchase microscopy equipment to build a world-class Biomass Surface Characterization Laboratory. These new surface characterization tools greatly enhance NREL's resources for developing improved biomass pretreatment technology and improved enzymes for cellulose and hemicellulose hydrolysis. In addition, the Laboratory is investing $865,000 in small general plant projects funds in FY2004 to construct a suite of environment-controlled laboratories in underutilized space in the FTLB to house the equipment. The new equipment included:

- Scanning electron microscope for compositional analysis of samples, topographical imaging, and structural micro-characterization.
- Transmission electron microscope for high-resolution imaging, and structural, compositional, and cross-sectional analysis.
- Near-field optical microscope for fundamental material and nanoscale studies.

The Biomass Surface Characterization Laboratory and Process Chemistry Laboratory will keep NREL at the cutting edge of botany, biochemistry, chemistry, and material and computer sciences. It will also help DOE achieve the long-term goal of developing biorefineries to produce fuels, chemicals, and biobased products from lignocellulosic biomass that are cost competitive with petroleum-derived.

In FY04, the DOE Biomass Program provided $1.3 million for a capital investment in genomics capability at NREL. The ongoing revolution in biotechnology research includes new techniques to characterize gene expression, protein expression, and metabolite accumulation in organisms. NREL's new equipment will allow the study of gene expression at the whole organism level. The proteomic equipment will allow direct measure of protein expression in a microorganism or secreted by a microorganism. The metabolite-related equipment will complement existing capabilities for measuring metabolites. This instrument is particularly suited to non-volatile, small molecules such as are found in central metabolism, and further understanding of these metabolites will improve the ability to develop new strains.

Other major investments in equipment include the original components for the BCPDU, originally purchased about 1993; components for the TCPDU, purchased in the mid-1990s; and periodic upgrades and additions to laboratory instrumentation such as mass spectrometers, nuclear magnetic resonance spectrometers, liquid chromatographs, etc.

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the Biomass Program through more detailed molecular dynamical and quantum chemical simulations. It would enable realistic molecular modeling for enzyme technology and biomass conversion. It would also greatly increase our ability to use quantum chemical calculations for inorganic catalytic materials research. Examples include molecular dynamical and quantum chemical simulations of enzymes and catalysts to study biomass recalcitrance and cellulose binding domains, fluid dynamics simulations of biomass reactors, and bioinformatics.

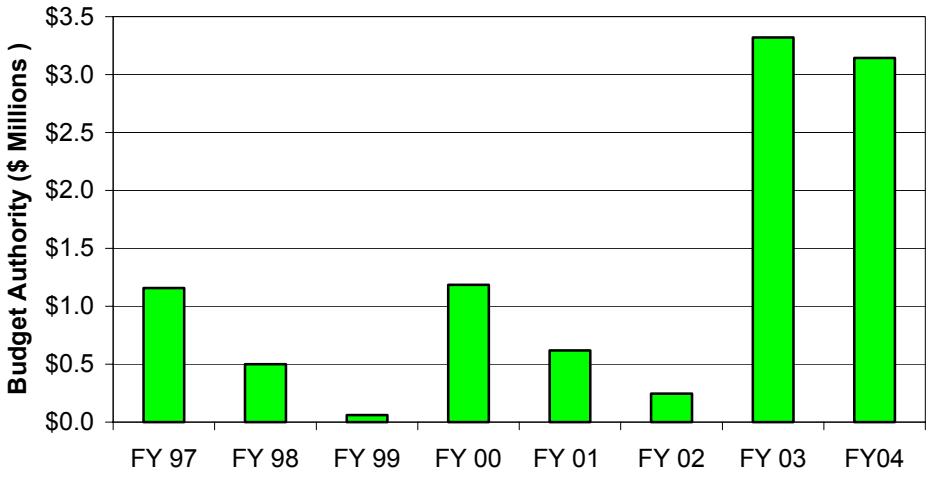


Figure 7.3.1. Biomass Program Capital Equipment Funding 1997-2004

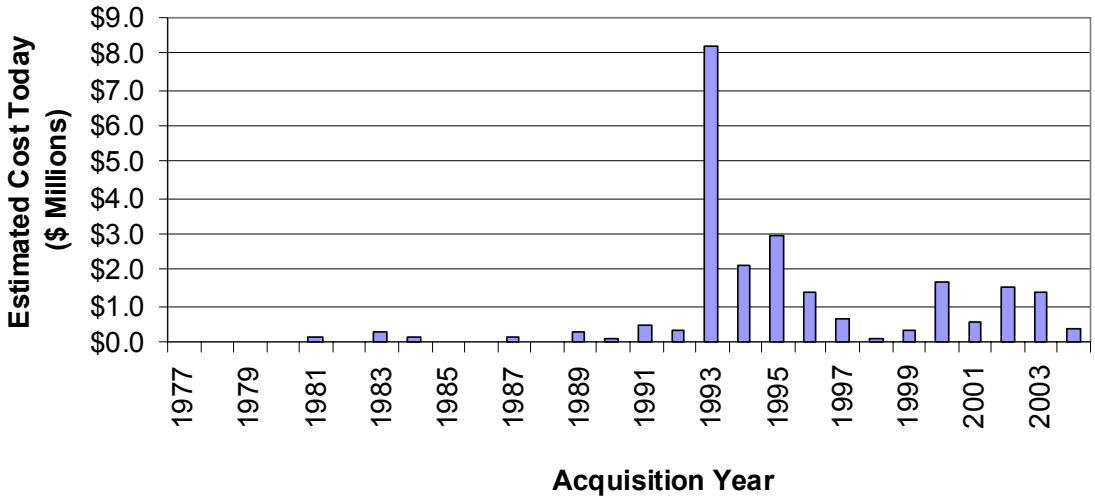
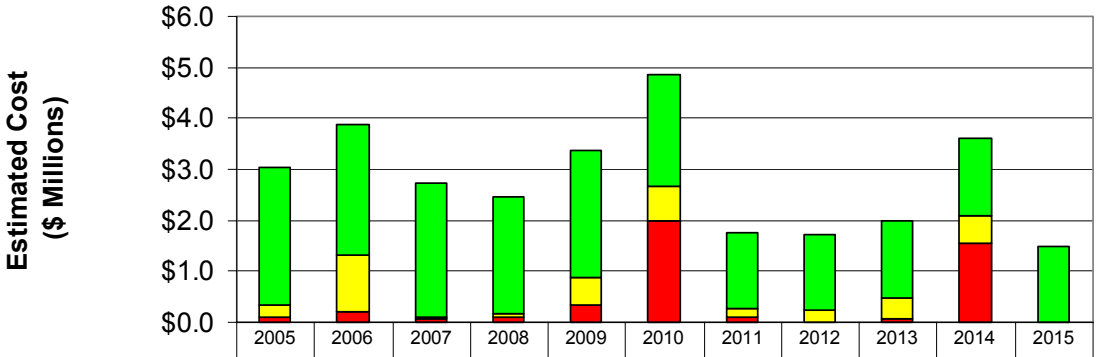


Figure 7.3.2. Age Distribution of Biomass Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	$2.700	$2.559	$2.605	$2.300	$2.477	$2.204	$1.500	$1.500	$1.500	$1.500	$1.500
Regular	$0.230	$1.099	$0.034	$0.066	$0.551	$0.680	$0.156	$0.232	$0.420	$0.553	$0.000
Deferred	$0.108	$0.205	$0.076	$0.100	$0.334	$1.984	$0.104	$0.000	$0.066	$1.553	$0.000

Figure 7.3.3. Projections of Equipment for Biomass (Excluding Facility-Specific Equipment, FY05-FY15)

Note: New Capability $ for out years 2011 – 2014 are based on an assumption of $1.5M/year. Table A-1in Appendix A shows replacement costs to 2017 - 2022 not reflected in this graph.

Table 7.3.4. Projections of Replacement Equipment for Biomass

Replacement Year	Replacement Category	Asset Description	Estimated Replacement Cost	In Service Date	Age as of 09/30/04 (Years)	Age as of 09/30 of Replacement Year	Useful Life (Years)
2004	Regular	Fermentor	$144,040	1/21/2002	2.69	2.69	10
	2004 Reg Total		**$144,040**				
2005	Deferred	Gas Chromatograph	$25,532	8/20/1992	12.12	13.12	7
2005	Deferred	Leak Detector	$40,000	6/1/1994	10.34	11.34	10
2005	Deferred	Pump And Control Package	$42,912	8/20/1997	7.12	8.12	7
	2005 Def Total		**$108,444**				
2005	Regular	Micro Calorimeter	$88,770	11/20/2003	0.86	1.86	15
2005	Regular	Fermentor	$141,217	1/21/2002	2.69	3.69	3
	2005 Reg Total		**$229,987**				
2006	Deferred	Cooling Tower	$204,881	6/20/1995	9.29	11.29	10
	2006 Def Total		**$204,881**				
2006	Regular	Liquid Chromatograph - Als	$51,885	7/31/2003	1.17	3.17	15
2006	Regular	Fermentation System	$77,065	12/20/1995	8.79	10.79	15
2006	Regular	Emissions Measurement System	$122,151	7/26/1999	5.19	7.19	12
2006	Regular	Fermentation System Custom	$245,015	12/20/1996	7.78	9.78	15
2006	Regular	Bioreactor System	$602,780	10/20/1994	9.95	11.95	15
	2006 Reg Total		**$1,098,896**				
2007	Deferred	Gas Flow Control System	$28,476	12/20/1994	9.79	12.79	8
2007	Deferred	Laser Defraction Particle An	$47,112	6/20/1993	11.29	14.29	10
	2007 Def Total		**$75,588**				
2007	Regular	Incubator Shaker	$33,777	7/25/2003	1.19	4.19	5
	2007 Reg Total		**$33,777**				
2008	Deferred	Mass Selective Detector	$100,491	3/20/1999	5.54	9.54	7
	2008 Def Total		**$100,491**				
2008	Regular	Smartsystem/UPEAK	$65,901	12/20/1992	11.79	15.79	15
	2008 Reg Total		**$65,901**				
2009	Deferred	2100 Bioanalyser For Ts Profiling	$28,701	4-Dec	N/A	5	5

Replacement Year	Replacement Category	Asset Description	Estimated Replacement Cost	In Service Date	Age as of 09/30/04 (Years)	Age as of 09/30 of Replacement Year	Useful Life (Years)
2009	Deferred	Fermentation System 2.5l	$31,955	4/20/1996	8.45	13.45	5
2009	Deferred	Fermentation System 10.0l	$32,153	4/20/1996	8.45	13.45	5
2009	Deferred	Capillary Electrophoresis Ms For Metabolite Profiling	$241,301	5-Sep	N/A	4	4
	2009 Def Total		**$334,110**				
2009	Regular	Microarray Sys Transc Profiling	$393,449	5-Sep	N/A	4	4
2009	Regular	Monitor Biotage Density	$29,093	7/20/1994	10.21	15.21	15
2009	Regular	(Maldi) Expanding MS Capability	$60,910	1/15/2005	N/A	5	5
2009	Regular	Chemical Analyzer Rtpcr	$38,374	5-Sep	N/A	4	4
2009	Regular	Chemo Doc	$29,396	5-Sep	N/A	4	4
	2009 Reg Total		**$551,222**				
2010	Deferred	Mini Prep Robotics For Ts Profiling	$259,270	5-Sep	N/A	5	5
2010	Deferred	Proteome Work System – Typhoon, Software, Spot Cutter, Gel Setup, Peripherals	$233,842	5-Sep	N/A	5	5
2010	Deferred	Reservoir Sterilizable	$28,099	6/15/1983	21.31	27.31	6
2010	Deferred	Fermentation System 2.5l	$31,961	4/20/1996	8.45	14.45	6
2010	Deferred	Fermentation System 2.5l	$32,648	4/20/1996	8.45	14.45	6
2010	Deferred	Fermentation System 2.5l	$42,841	3/20/1996	8.54	14.54	6
2010	Deferred	Chromatograph Liquid	$63,365	7/20/1994	10.21	16.21	15
2010	Deferred	Fermentor	$86,013	8/20/1993	11.12	17.12	6
2010	Deferred	Fermentor Industrial	$89,156	4/15/1983	21.48	27.48	6

Replacement Year	Replacement Category	Asset Description	Estimated Replacement Cost	In Service Date	Age as of 09/30/04 (Years)	Age as of 09/30 of Replacement Year	Useful Life (Years)
2010	Deferred	Spectrometer Mass Exm 750	$166,420	10/20/1991	12.96	18.96	10
2010	Deferred	ESEM – Quanta 400 FEG	$600,000	12/15/2004	N/A	6	6
2010	Deferred	NSOM	$100,000	12/15/2004	N/A	6	6
2010	Deferred	Confocal Laser	$250,000	1/15/2005	N/A	6	6
	2010 Def Total		**$1,983,615**				
2010	Regular	Robotic Arm	$77,212	7/3/2001	3.25	9.25	10
2010	Regular	Advanced Liquid Handling Sta	$99,123	7/3/2001	3.25	9.25	10
2010	Regular	Auto Picker System	$159,430	5/25/2001	3.35	9.36	10
2010	Regular	Automated Plate Handling Sta	$171,483	11/14/2000	3.88	9.88	10
2010	Regular	Centrifuge Microtiter Plate J-E & Allegra 25r	$80,000	11/30/2004	N/A	6	6
2010	Regular	DNA Sequencer AB13100	$93,499	1/30/2005	N/A	5	5
	2010 Reg Total		**$680,747**				
2011	Deferred	Scintillation System	$71,022	1/20/1993	11.7	18.7	10
2011	Deferred	Module Programmable Solvent	$32,682	3/28/1989	15.52	22.52	8
	2011 Def Total		**$103,704**				
2011	Regular	Fluidized Bed Tar/Steam Refo	$156,169	4/6/2004	0.48	7.49	10
	2011 Reg Total		**$156,169**				
2012	Regular	Shaking Incubator	$43,076	1/21/2002	2.69	10.7	10
2012	Regular	Shaking Incubator	$43,076	1/21/2002	2.69	10.7	10
2012	Regular	Multi-Pippeting Robot	$145,883	1/21/2002	2.69	10.7	10
	2012 Reg Total		**$232,035**				
2013	Deferred	Cytoflour Ii Scanner	$31,280	6/20/1995	9.29	18.29	10
2013	Deferred	Chromatograph Gas Series Ii	$34,856	9/20/1991	13.04	22.04	10
	2013 Def Total		**$66,136**				

Replacement Year	Replacement Category	Asset Description	Estimated Replacement Cost	In Service Date	Age as of 09/30/04 (Years)	Age as of 09/30 of Replacement Year	Useful Life (Years)
2013	Regular	Liquid Chromatograph - ALS	$38,206	7/17/2003	1.21	10.21	10
2013	Regular	Nsom Head Unit	$381,717	12/16/2003	0.79	9.8	10
	2013 Reg Total		**$419,923**				
2014	Deferred	AFM	$400,000	12/15/2004	N/A	10	10
2014	Deferred	TEM – Techni G2 T20	$800,000	12/15/2004	N/A	10	10
2014	Deferred	Lab Glass Washing System	$32,799	10/20/1995	8.95	18.96	10
2014	Deferred	Lab Glass Washing System	$32,799	10/20/1995	8.95	18.96	10
2014	Deferred	Bioflo3 2.5l	$33,948	11/20/1991	12.87	22.88	20
2014	Deferred	Bioflo3 5.0l	$34,167	11/20/1991	12.87	22.88	20
2014	Deferred	Sterilizer Package	$64,881	10/20/1995	8.95	18.96	10
2014	Deferred	Spectrometer Mass	$83,485	5/20/1991	13.38	23.38	20
2014	Deferred	Tetred	$71,022	5-Sep	N/A	9	9
	2014 Def Total		**$1,553,101**				
2014	Regular	Fermentation System 1 Liter	$94,688	10/20/1995	8.95	18.96	20
2014	Regular	Fermentation System Compact	$105,856	12/20/1995	8.79	18.79	20
2014	Regular	Basic Unit	$158,719	9/20/1995	9.04	19.04	20
2014	Regular	50 Liter Fermenter System	$193,305	10/20/1995	8.95	18.96	20
	2014 Reg Total		**$552,568**				
2017	Deferred	Automated Plate Handling Sta	$69,473	11/14/2000	3.88	16.89	15
2017	Deferred	Liquid Chromatography System	$97,856	9/20/1997	7.03	20.04	15
	2017 Def Total		**$167,329**				
2017	Regular	Control Unit	$46,933	7/17/2003	1.21	14.22	15
2017	Regular	Pressure Belt Filter	$509,690	4/15/2002	2.46	15.47	15
	2017 Reg Total		**$556,623**				
2020	Regular	Air Compressor	$46,617	11/20/1995	8.87	24.88	25
	2020 Reg Total		**$46,617**				
2022	Regular	Spectrophotometer	$42,287	1/21/2002	2.69	20.7	20

Replacement Year	Replacement Category	Asset Description	Estimated Replacement Cost	In Service Date	Age as of 09/30/04 (Years)	Age as of 09/30 of Replacement Year	Useful Life (Years)
	2022 Reg Total		**$42,287**				

Table 7.3.5. Projections of New Capability Equipment for Biomass

Equipment Description	PGM2	CODE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
NBC Genomics Lab	BB	NC	$0.700	$0.600									
Biomass Compositional Analysis Lab	BB	NC	$0.900	$0.800									
Cleanup Catalyst Regeneration System	BB	NC		$0.500									
Additional TMBMS Instrument for TC R&D	BB	NC	$0.400										
PDU Enhancements - Pretreatment & Hydrolysis	BB	NC			$1.750	$0.550							
Biobased Polymer and Composites Facility	BB	NC	$0.000	$0.000	$0.000	$0.000	$1.354	$1.055					
Biorefining Technology Research Facility	BB	NC	$0.700	$0.659	$0.855	$1.750	$1.123	$1.149					
			$2.700	$2.559	$2.605	$2.300	$2.477	$2.204	$1.500	$1.500	$1.500	$1.500	$1.500

Note: New Capability $ for out years 2011 – 2014 are based on an assumption of $1.5M/year

Table 7.3.5. NBC GPE FY06/FY07 Equipment List

Equipment description	Cost (k)	Requestor
LC/MS Triple Quadruple	$250	Zhang
IC-MS	$180	Zhang
Dionex HPLC System for Metabolites	$100	Zhang
2 HPLCs (HP 1100s) (one for sugar and one for organic acids)	$80	Zhang
2 Bench top fermentors (20 l)	$95	Vinzant
Atomic Force Microscope	$215	Ding
Fermentation gas analysis instrumentation	$360	McMillan
Particle size analyzer	$120	McMillan
LIMS	$80	McMillan
Bench scale DACS	$90	McMillan
Serpentine heat exchanger	$60	McMillan
Carbon/Nitrogen Analyzer for gram samples	$75	Chum/Hames
Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FT-ICR-MS)	$800	Nimlos/Chum
Automated Surface Area Analyzer	$80	Magrini/Chum
Pilot scale pellet mill	$150	Philips
Total (to be competed during the FY06 / FY07 funding cycle)		$2.7 million

7.4 NREL Capital Investment Strategy – Hydrogen

Strategic Goals
EERE Goals:

- Dramatically reduce dependence on foreign oil
- Promote the use of diverse, domestic, and sustainable energy resources
- Reduce carbon emissions from energy production and consumption
- Increase the reliability and efficiency of electricity generation

The mission of DOE's and NREL's Hydrogen, Fuel Cells & Infrastructure Technologies Programs is to research, develop and validate fuel cells and hydrogen production, delivery, and storage technologies for transportation and stationary applications.

Current Activities at NREL

Table 7.4.1. Hydrogen FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$9.7	Million
FY04 Budget Authorization - Capital Equipment	$0.1	Million
FY04 In-house Costs	$6.9	Million
FY04 Average FTEs	28	FTEs

- Partnerships with industry, universities, and other national laboratories
- Hydrogen production from renewable energy: electrolysis, photoelectrochemical and photobiological systems, fermentation, solar-driven high temperature chemical reaction cycles and thermochemical conversion of biomass.
- Hydrogen delivery and resource analysis
- Hydrogen storage on nano-structured, carbon-containing materials
- Fuel cell research in transportation systems, distributed generation systems, and components
- Technology evaluation and validation for DOE's controlled hydrogen fleet and infrastructure demonstration and for fuel cell buses
- Codes and Standards development and underlying R&D
- Safety sensors
- Information development about fuel cell and hydrogen systems

Planned R&D Activities

- *Production* -- Research and develop low-cost, highly efficient hydrogen production technologies from diverse, domestic, renewable sources of energy.
- *Delivery* -- Develop hydrogen fuel delivery technologies that enable the introduction and long-term viability of hydrogen as an energy carrier for transportation and stationary power.
- *Storage* -- Develop and demonstrate viable hydrogen storage technologies for transportation and stationary applications.
- *Fuel Cells* --Develop and demonstrate fuel cell power system technologies for transportation and stationary applications.

- *Technology Validation* --Validate integrated hydrogen and fuel cell technologies for transportation, infrastructure, and electric generation in a systems context under real-world operating conditions.
- *Hydrogen Codes and Standards* --Facilitate the creation and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential, and transportation applications. Provide technical resources to harmonize the development of international standards among the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO), and the Global Regulation on Pollution and Energy (GRPE) Program. Test components of hydrogen systems under development to verify performance with respect to equipment standards.
- *Hydrogen Safety* --Develop and implement the practices and procedures that will ensure safety in the operation, handling, and use of hydrogen and hydrogen systems.
- *Cross-Cutting Analysis* -- Provide analysis of energy and cost elements of hydrogen electric systems.

Facility Issues and Opportunities

Table 7.4.2. Hydrogen Facility Usage (09/30/04)

Field Test Laboratory Building	9,783	gsf
Denver West Building 16	7,404	gsf
Solar Energy Research Facility	4,447	gsf
Others	392	gsf
Total	*22,027*	*gsf*

- Hydrogen research is conducted in several different facilities at NREL. Building 16 is a leased office building that has been partially converted to laboratories. It houses research for photoelectrochemical hydrogen production and fuel cell materials and components.
- Hydrogen storage research is done in both the SERF and the FTLB.
- Hydrogen systems engineering and testing, such as testing of fuel cells and electrolyzers is conducted at the National Wind Technology Center 20 miles north of the other hydrogen activities.
- Fragmented locations – NREL does not have dedicated facilities for hydrogen research. As a result, today's pressing needs are being accommodated with creativity, but having the various R&D activities scattered over five different buildings and a distance of twenty miles creates management and productivity inefficiencies and discourages research integration and synergy.
- *Photoelectrochemical Hydrogen Production Research* - Future directions in this research will be limited by its current facilities in Building 16. The four currently unassigned laboratory spaces in Building 16 have significant restrictions on ventilation, levels of hydrogen and toxic materials, and physical access because of their location in a leased office building. The research labs in the FTLB and SERF are fully and continuously in use, compared to the desired practical utilization rate for research labs of 90%. This 100% utilization rate results in no practical flexibility to quickly respond to changing research priorities or directions, or accommodate the additional research activities of students, visiting professionals, or industry partners.

- *Hydrogen Storage Research* - Future directions in this research will be limited by the lack of available laboratories in the SERF and FTLB, as noted above.
- *Photobiological Production Research* - At the laboratory scale, this research will also limited by the lack of available laboratories in the SERF and FTLB, as noted above.
- *Other Laboratory-Scale Research* - Research in hydrogen permeation and separations, fuel cell materials and components, and sensors will be similarly restricted due to the absence of available laboratories.
- *Photobiological Research Scale-Up* - Projections for the scale-up of photobiological hydrogen production will require such facilities as a clean room, temperature-controlled environmental chambers, and several bioreactors. These facilities are not currently available.
- *Hydrogen Production from Concentrated Solar* - This research requires the NREL High Flux Solar Furnace (HFSF), located on NREL's mesa top. The current facility does not include a simple laboratory, so that samples need to be driven to another location for testing. The current facility will not accommodate a laboratory or additional research.
- *Engineering and Testing* - This includes system-level R&D in both mobile and stationary fuel cells, electrolyzers, and photoelectrochemical systems to generate hydrogen. Engineering and testing at a small scale for electrolysis and wind and PV systems is conducted in two locations.

Facility Options

In considering facility needs, the following options should be included:

Laboratory-Scale Research of all Types --photoelectrochemical production, hydrogen storage, fuel cell components, and separations

- Limit R&D at NREL to that which can be accomplished with the current facilities.
- Temporarily lease more commercial space, duplicate services and equipment as necessary, and continue to accept the decrease in productivity inherent in split locations.
- Improve the utilization of the FTLB by moving offices out of interior spaces and building out unused or underutilized space in the interior of the FTLB by adding walls and casework, and upgrading and expanding building ventilation and drains.
- Combine Hydrogen needs with other programs' needs for laboratories at NREL in a new Chemical and Material Sciences Laboratory.

Photobiological Research Scale-Up

- Limit R&D at NREL to that which can be accomplished with the current facilities
- Temporarily lease more commercial space, duplicate services and equipment as necessary, and continue to accept the decrease in productivity inherent in split locations.
- Conduct near-term research in the 1,300-gsf existing glass-enclosed research area currently available in the FTLB. In addition, remodel 3,000 gsf of space in the FTLB to provide a temperature-controlled room for growth chambers for growing research organisms; a clean room for computer-controlled high-throughput screening of algal colonies; and wet laboratory space for anaerobic protein purification. A temporary trailer is likely to be needed for office space.
- Construct an addition to the FTLB to provide space designed to accomplish this work now and in the future. Required space includes 4,000 gsf of glass-enclosed research space for bioreactors and 3,000-4,000 gsf of lab space for temperature-controlled rooms and growth chambers for growing research organisms; clean rooms for computer-controlled high-

throughput screening of algal colonies; wet laboratory space for anaerobic protein purification; offices; and support space. Three options have been studied – the minimum addition (12,600 gsf) projected to be needed at this time; a larger addition (19,000 gsf) that would provide more flexibility for the future with additional offices and labs that could benefit other programs as well; and a full, two-story addition (30,000 gsf) that would provide significant new space for several programs.

Hydrogen Production from Concentrated Solar
Because of the uniqueness of NREL's High Flux Solar Furnace (HSFS), the only viable option is to expand the support space adjacent to the furnace itself. Three options have been studied to construct new integrated Mesa Top Facilities at NREL that would address the various needs of the Hydrogen Program, the Solar Program, the Office of Science, and the various other work-for-others partners who use the HFSF. All three options propose some degree of construction and build-out of two new facilities on the mesa top, the Mesa Solar Research Laboratory and Mesa Solar Optics Laboratory. The Hydrogen program would benefit from the Mesa Solar Research Laboratory in each option, and may contribute a reasonable portion of the cost.

- Option 1 – Full build-out of a total of 10,500 gsf (7,500 gsf for the Mesa Solar Research Laboratory and 3,000 gsf for the Mesa Solar Optics Laboratory), for a total cost of $6.0 million in FY2007, including estimated capital equipment essential to this facility. Hydrogen would pay only a portion of this cost.
- Option 2 – Full shell and partial build-out of the proposed 10,500 gsf for a total cost of $3.5 million in FY2007, including estimated capital equipment essential to this facility. Hydrogen would only pay a portion of this cost.
- Option 3 – Full build-out of a portion of the proposed building (2,800 gsf for the Mesa Solar Research Laboratory and 3,000 gsf for the Mesa Solar Optics Laboratory) at this time, with additional construction at some time in the future. Hydrogen would only pay a portion of this cost.

Engineering and Testing
- Limit R&D at NREL to that which can be accomplished with the current facilities
- Temporarily lease more commercial space, duplicate services and equipment as necessary, and continue to accept the decrease in productivity inherent in split locations.
- Construct a new facility of about 11,000 gsf that will meet the needs today for engineering and testing of Hydrogen, Distributed Energy, and Transmission and Distribution systems using renewable energy.
- Combine today's Hydrogen needs with other current engineering and testing needs related to FreedomCAR, Distributed Energy, and Transmission and Distribution programs and construct a new, approx 60,000-gsf integrated Engineering Test Laboratory. This would accommodate the same functions as the 11,000-gsf facility proposed and add flexibility and efficiency by sharing equipment and resources with other programs.

Manufacturing R&D – The new Science & Technology Facility, to be completed in 2007, will have some capabilities to assist in manufacturing and process research for thin-film components of fuel cells, and photoelectrochemical systems.

A full analysis of these options is not included here due to space limitations.

Facility Recommendations

Engineering Test Laboratory
This 60,000-gsf facility would accommodate critical engineering and testing activities in support of the Hydrogen, FreedomCAR, Distributed Energy, and Transmission and Distribution programs, including electrical interconnection research and testing, general engineering performance and testing of hydrogen renewable systems, and vehicle engineering research activities such as the 21st-century truck research from ReFUEL, auxiliary load and power electronics research from Bldg 16, and battery thermal management. Estimated cost is $36 million in the FY2007 – FY2009 budgets. This includes $6.0 million for new capital equipment related to the facility. The Hydrogen Program would contribute only a portion of this cost.

Equipment Issues and Opportunities

Table 7.4.3. Hydrogen Capital Equipment Status (06/30/04)

Today's Value	$0.7	million
Deferred Replacement Backlog	$0.226	million
Percent of Today's Value Deferred	34.1	%
Average Useful Life	10.4	yrs
Average Age	11.4	yrs

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the Hydrogen, Fuel Cells & Infrastructure Technologies Program. There is a general increased need for computational modeling, simulation and data handling of materials, devices and processes used in hydrogen production and storage, and in fuel cells. Specific examples include the quantum mechanical simulations of solid state materials for photoelectrochemical hydrogen production, detailed biomolecular simulations for enzyme engineering for biological hydrogen production, and mining of data for optimizing high throughput experimental design of materials.

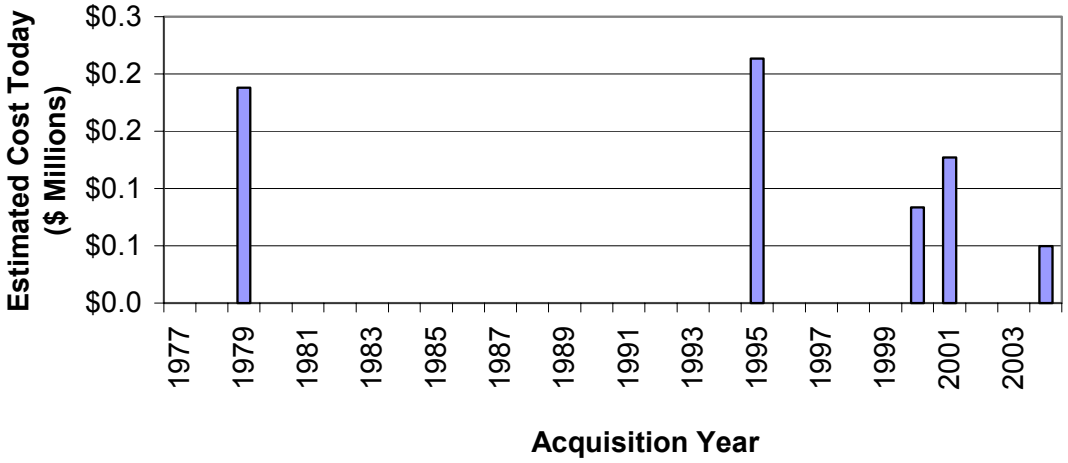
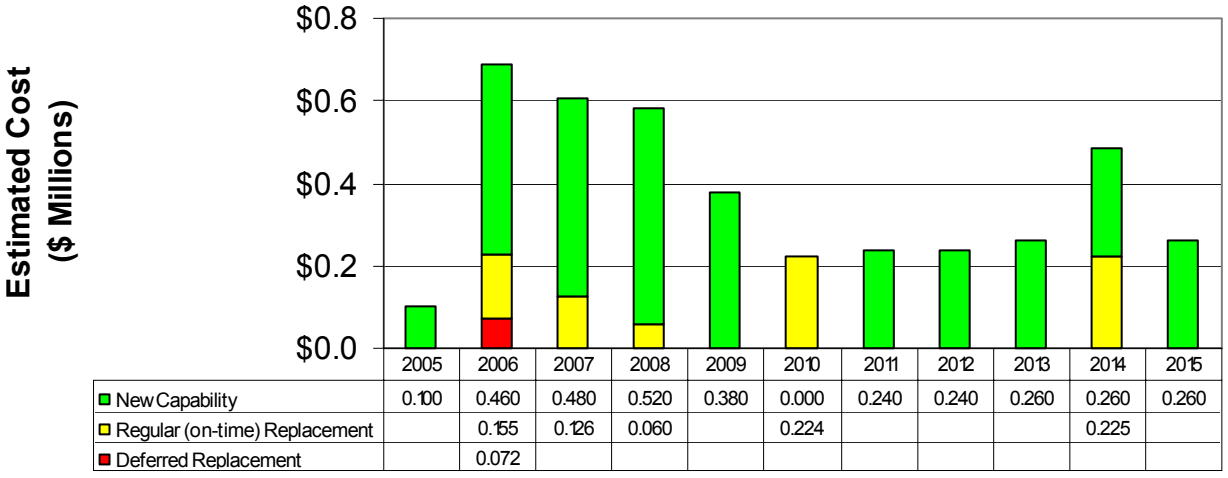


Figure 7.4.2. Age Distribution of Hydrogen Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	0.100	0.460	0.480	0.520	0.380	0.000	0.240	0.240	0.260	0.260	0.260
Regular (on-time) Replacement		0.155	0.126	0.060		0.224				0.225	
Deferred Replacement		0.072									

Figure 7.4.3. Projections of Equipment for Hydrogen Excluding Facility-Specific Equipment FY05-FY15

Table 7.4.4. Projections of Replacement Equipment for Hydrogen

Replacement Year	Replacement Category	Asset Description	Estimated Replacement Cost	In-Service Date	Age as of 09/30/04 (Years)	Age as of 09/30 of Replacement Year	Useful Life (Years)
2006	Deferred	Compressor High Pressure Gas	$29,023	10/20/1995	9	9	7
2006	Deferred	Control	$42,732	6/20/1995	9	10	10
2006	Regular	Coy Anaerobic glove box, big size	$25,000	1/1/1980	25	10	10
2006	Regular	Hewlett Packard High Pressure Liquid Chromatograph	$80,000	6/17/1995	10	10	10
2006	Regular	Hewlett Packard Gas chromatograph	$50,000	6/2/1980	25	20	20
2007	Regular	Hewlett Packard Gas chromatograph	$50,000	6/2/1980	25	20	20
2007	Regular	Oxygen Permeation	$26,000	9/1984 (est)	20	22	15
2007	Regular	Conviron Growth chamber	$50,000	7/1/1979	25	25	25
2008	Regular	Amsco Steris Autoclave	$60,000	10/1/1998	6	10	10
2010	Regular	Quadruppole MSD	$74,251	5/20/1992	12	17	10
2010	Regular	Photobioreactor systems	$150,000	1/1/2000	4	10	10
2014	Deferred	System Basic Laser YAG	$80,194	3/15/1979	26	36	10
2014	Regular	Coy Anaerobic glove box, big size	$25,000	6/26/2004	0	10	10
2014	Regular	Beckman centrifuge and rotors	$40,000	2/1/2001	4	15	15
2014	Regular	Beckman Ultra-centrifuge and rotors	$80,000	2/1/2001	4	15	15

Table 7.4.5. Projections of New Capability Equipment for Hydrogen ($ Millions)

Equipment Description	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Calibration system for hydrogen sensors		$0.10									
Storage measurement equipment	$0.10										
Anaerobic glove box		$0.03									
Solar simulator			$0.04								
Electrochemical impedance spectrometer		$0.05									
35kW alkaline electrolyzer		$0.05									
Outdoor integrated photovoltaic test pad			$0.25								
100kW electrolyzer			$0.13								
Photoelectrochemical test apparatus				$0.20							
Photobiological test apparatus				$0.25			$0.09	$0.09	$0.09	$0.09	$0.09
Photolytic test apparatus					$0.30		$0.10	$0.10	$0.11	$0.11	$0.11
High-throughput adsorption testing station		$0.08									
Reactor for growing hydrogen storage materials		$0.09									
Optical spectroscopy equipment			$0.06								
Anaerobic glove box for hydrogen storage		$0.06									
System for large-scale growth of hydrogen storage materials				$0.07			$0.02	$0.02	$0.03	$0.03	$0.03
Scale-up test apparatus for hydrogen storage materials					$0.08		$0.03	$0.03	$0.03	$0.03	$0.03
	$0.100	$0.460	$0.480	$0.520	$0.380	$0.000	$0.240	$0.240	$0.260	$0.260	$0.260

7.5 NREL Capital Investment Strategy – FreedomCAR and Vehicle Technologies

Strategic Goals
EERE Goal: Dramatically reduce or even end dependence on foreign oil

Mission: Develop more energy-efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum

FreedomCAR Partnership: Enable the full spectrum of light-duty passenger vehicles to operate without using petroleum or producing harmful emissions while sustaining freedom of mobility and vehicle choice.

21st Century Truck Partnership: Dramatically improve the energy efficiency and safety of trucks and buses while maintaining a dedicated concern for the environment.

Current Activities at NREL

Table 7.5.1. FreedomCAR FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$18.2	million
FY04 Budget Authorization - Capital Equipment	$0.0	million
FY04 In-house Costs	$10.3	million
FY04 Average FTEs	38	FTEs

- Partnerships with industry, other federal agencies, and other national laboratories
- Advanced vehicle systems research
- Technology integration and utilization
- Fuels performance research

Planned R&D Activities
Advanced Vehicle Systems
Conduct R&D on ancillary loads reduction, vehicle systems analysis, energy storage, power and propulsion systems, and advanced power electronics. NREL supports these R&D areas through program planning and technical oversight as well as experimentation, modeling and analysis, development, and demonstration of advanced vehicle enabling technologies.

Technology Integration & Utilization
Evaluate the performance of new vehicle and fuel technologies as they move into commercial use, and work with industry to develop technical solutions and support to overcome problems that may result. Analysis of market and industry trends helps shape future technical programs and identify promising opportunities and supports DOE in policy review relative to transportation sections of EPAct. Information in print and electronic format helps educate users and enable informed decision-making.

Fuels Performance
Apply expertise in fuels, lubricants, and emission control system technologies to guide relevant R&D in support of activities such as the Advanced Petroleum Based Fuels project. NREL also works on renewable fuels and lubricants, alternative fuel vehicle, engine, and infrastructure R&D, demonstration, and deployment. *NREL has a facility (the ReFUEL laboratory) to support fuels research as well as the capabilities to evaluate the environmental impacts of conventional and advanced vehicles.*

Facility Issues and Opportunities

Table 7.5.2. FreedomCAR Facility Usage (09/30/04)

DW Building 16	13,219	gsf
REFUEL	4,386	gsf
Field Test Laboratory Building	4,151	gsf
Thermal Test Facility	1,482	gsf
Solar Energy Research Facility and others	877	gsf
Total	*24,115*	*gsf*

- FreedomCAR research is done in several different facilities at NREL: Building 16 is a leased office building that has been partially converted to laboratories; it houses all activities of Technology Integration and Utilization, as well as program management, analysis, and modeling. Building 16 also houses the Ancillary Loads Reduction Laboratory, which focuses on improving fuel economy and reducing emissions by decreasing vehicle auxiliary loads, such as air conditioning, while maintaining passenger comfort; the Power Electronics Laboratory which evaluates thermal aspects of automotive components and the Fuels Chemistry Laboratory, which focuses on characterizing the effect of molecular structure on the ignition properties of various fuel molecules.
- The ReFUEL (Renewable Fuels and Lubricants) Laboratory is a unique high-altitude, heavy-duty engine and vehicle laboratory located in a leased building 15 miles from the primary NREL campus. This is the first laboratory in the United States dedicated to researching and developing renewable and synthetic fuels and lubricants for heavy-duty transportation applications.
- The Thermal Test Facility provides space for Energy Storage research, which helps battery developers and automobile manufacturers improve battery module and pack designs by enhancing performance and extending battery life.

Fragmented Locations
Because NREL's unique capabilities in transportation-related research have evolved in the past several years, there has not been capital investment in long-term, dedicated facilities for this work. As a result, today's pressing needs are being accommodated with creativity, but having the various R&D activities scattered over several miles and multiple locations creates management and productivity inefficiencies and discourages research integration and synergy.

Full Utilization and Inflexibility
The research labs in the ReFUEL, TTF, FTLB, and SERF are fully and continuously in use, compared to the desired practical utilization rate for research labs of 90%. This 100% utilization

rate results in no practical flexibility to quickly respond to changing research priorities or directions, or accommodate the additional research activities of students, visiting professionals, or industry partners. In addition, the four currently unassigned laboratory spaces in DW Building 16 have significant restrictions on ventilation, floor loading, and physical access because of their location in a leased office building, and would be unsuitable for much of the work of the FreedomCAR program.

Facility Options

In considering facility needs, the following options should be included:

- Limit R&D at NREL to that which can be accomplished with the current facilities
- Temporarily lease more commercial space, duplicate services and equipment as necessary, and continue to accept the decrease in productivity inherent in split locations.
- Consolidate selected engineering research activities (the 21st-century truck research from ReFUEL, auxiliary load and power electronics research from Bldg 16, battery thermal management from the TTF, etc) in a dedicated, 20,000-gsf facility on the STM site. This would require moving NREL's shipping and receiving function, modifying the current Shipping & Receiving Facility, and expanding it to accommodate selected activities.
- Combine today's FreedomCAR needs with other current engineering and testing needs related to Hydrogen, Distributed Energy, and Transmission and Distribution programs and construct a new, approx 60,000-gsf Integrated Engineering Facility. This would accommodate the same functions as the 20,000-gsf facility proposed for a remodeled Shipping & Receiving Facility and add flexibility and efficiency by sharing equipment and resources with other programs.

A full analysis of these options is not included here due to space limitations.

Facility Recommendations

NREL's recommendations are as follows.

Engineering Test Laboratory

This 60,000-gsf facility would accommodate critical engineering and testing activities in support of the FreedomCAR, Hydrogen, Distributed Energy, Transmission and Distribution, and other renewable energy programs, including engineering research activities such as the 21st-century truck research from ReFUEL, auxiliary load and power electronics research from Bldg 16, battery thermal management from the Thermal Test Facility, electrical interconnection research and testing, and general engineering performance and testing of renewable energy systems. This facility would also provide space for program management, Alternative Fuels Data Center, analysts, computer scientists, communications staff, and other researchers for the FreedomCAR program. Total estimated cost is $36 million in the FY2007 – FY2009 budgets. This includes about $6 million for new capital equipment related to the facility. FreedomCAR would bear only a portion of this cost.

Equipment Issues and Opportunities

Table 7.5.3. FreedomCAR Capital Equipment Status (06/30/04)*

Today's Value	$1.1	million
Deferred Replacement Backlog Today	$0.096	million
Percent of Today's Value Deferred	0.0%	
Average Useful Life	6.5	yrs
Average Age	2.2	yrs

* Equipment investments have also been made that do not appear in the table or graphs because they are not technically program capital equipment for various reasons. However, this equipment is very important to the success of the research program, and includes experimental equipment such as the manikin, general purpose equipment purchases important to the program such as ABC 1000, or equipment gained from hybrid subcontract closeouts with the automotive companies such as calorimeters.

The DOE FreedomCAR Program invested in over $1 million of capital equipment to enable research in the ReFUEL facility. ReFUEL is a test facility for advanced fuels in heavy-duty engines and vehicles and advanced heavy hybrid vehicles, and houses the following specialized testing and measurement equipment:

- Heavy-duty chassis dynamometer for testing advanced trucks and buses, simulation capability from 8,000 - 80,000 lbs
- Heavy-duty engine transient test cell (up to 400 hp) for fuels research and development
- Emissions measurement capability sensitive enough to be compliant with Federal certification procedures required in 2007.

NREL acquired the lab in 2002 and this equipment in 2002 and 2003 to increase the use of renewable diesel through research and development that removes barriers to a wider use of these non-petroleum based fuels. The investment made by NREL and DOE in the ReFUEL facility makes the lab available to the research community that is capable of testing advanced fuels, prototype engines, and hybrid powertrains in development for the next ultra-clean generation of heavy-duty vehicle technologies.

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the FreedomCAR & Vehicle Technologies Program through more fluid dynamics research and development. It would enable more detailed modeling of airflow and thermal loads in vehicle cabins to improve air-conditioning effectiveness and reduce vehicles auxiliary loads. It would also provide computing capability to study components used in more fuel efficient hybrid vehicles such as spray cooling for high power electronics in heavy hybrid vehicles and improved road load prediction simulations with an accurate tire model to assists in reducing vehicle weight while maintaining a durable vehicle structure.

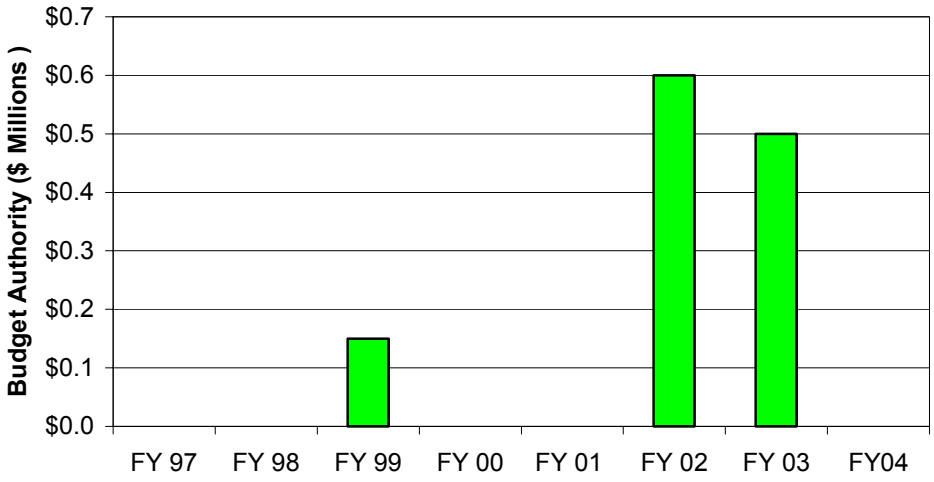


Figure 7.5.1. FreedomCAR Program Capital Equipment Funding 1997-2004

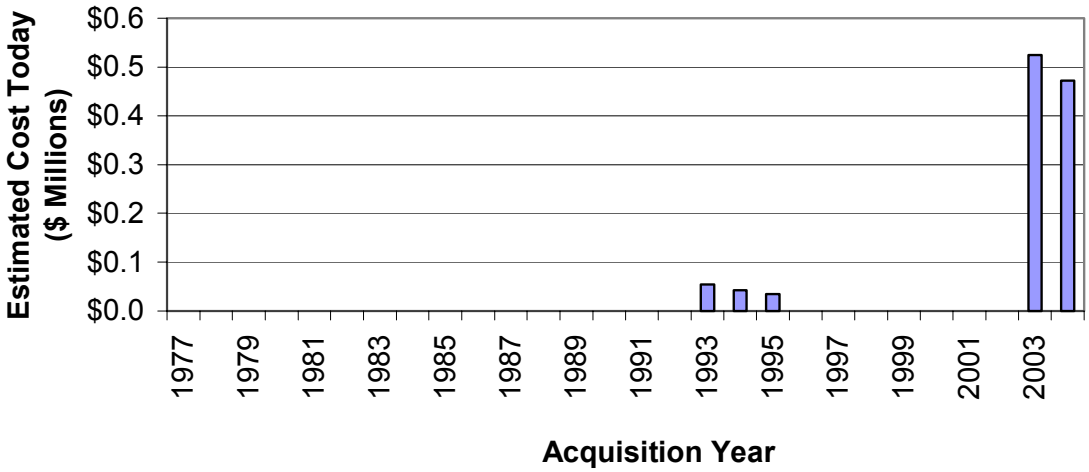
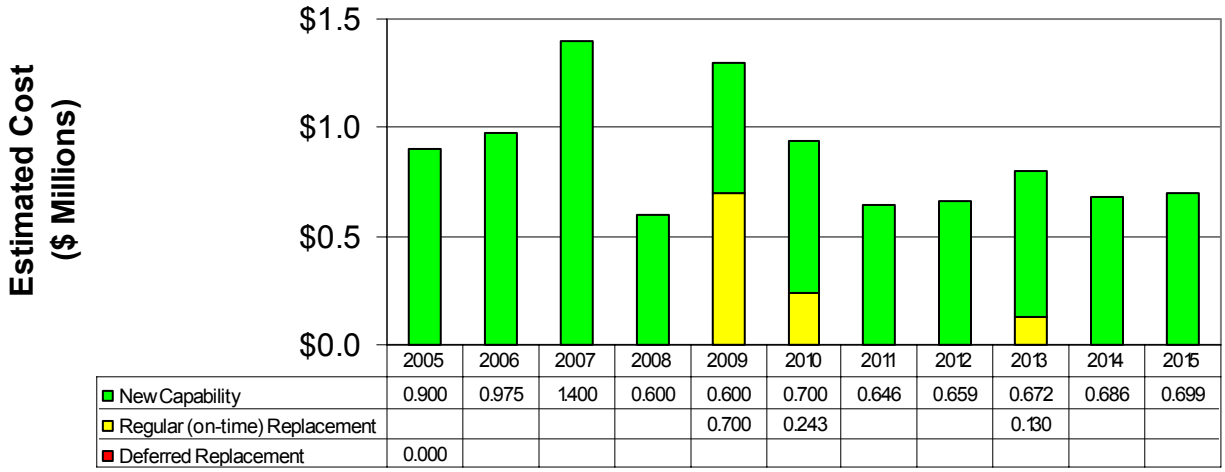


Figure 7.5.2. Age Distribution of FreedomCAR Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	0.900	0.975	1.400	0.600	0.600	0.700	0.646	0.659	0.672	0.686	0.699
Regular (on-time) Replacement					0.700	0.243			0.130		
Deferred Replacement	0.000										

Figure 7.5.3. Projections of Equipment for FreedomCAR (Excluding Facility-Specific Equipment, FY05-FY15)

The projections for equipment purchases for the FreedomCAR program include replacing major components in the ReFUEL laboratory.

Table 7.5.4. Projections of Replacement Equipment for FreedomCAR

Replace-ment Year	Replace-ment Category	Asset Group	Asset Description	Replace-ment Cost	In Service Date	Age as of 09/30/04 (years)	Age as of 09/30 of Replace-ment Year	Strategic Useful Life
2009	Regular	R&D	CONTROLLER / DATA ACQUISITIO	$32,705	3/24/2004	0.52	5.52	5
2009	Regular	R&D	FUEL SYSTEM	$45,895	3/23/2004	0.52	5.53	5
2009	Regular	R&D	CONTROLLER / DATA ACQUISITIO	$103,885	3/24/2004	0.52	5.52	5
2009	Regular	R&D	COMBUSTION ANALYZER	$108,166	3/24/2004	0.52	5.52	5
2009	Regular	R&D	CHASSIS DYNAMOMETER	$199,522	2/6/2003	1.65	6.65	5
2009	Regular	R&D	CONTROLLER	$210,130	3/23/2004	0.52	5.53	5
2010	Regular	R&D	ELECTRICAL CABINET	$59,309	2/6/2003	1.65	8.65	7
2010	Regular	R&D	ENGINE DYNAMOMETER	$183,859	2/6/2003	1.65	8.65	7
2013	Regular	R&D	INGITION QUALITY TESTER	$130,000	1/24/2003	1.68	11.69	10

Table 7.5.5. Projections of New Capability Equipment for FreedomCAR ($ Millions)

Equipment Description	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Advanced Power Electronics B&R# VT0302											
Test loop for spray and jet cooling	$0.100										
Integrated Heat transfer Loop		$0.100									
Carbon Nano-tube heat sink test loop			$0.150								
Integrated nano-technology and micro system equipment				$0.100			$0.034	$0.035	$0.035	$0.036	$0.037
On-Board Emissions Measurement System	$0.300										
Particulate Matter Emissions Characterization	$0.200										
Hydrogen Internal Combustion Engine Test Equipment		$0.600									
Multi-Axle Heavy Hybrid Vehicle Test Equipment			$1.000								
Emissions Measurement for post-2010 Regulations				$0.500			$0.170	$0.173	$0.177	$0.180	$0.184
Advanced Engine After treatment Test Equipment					$0.300		$0.102	$0.104	$0.106	$0.108	$0.110
Heavy Hybrid Fuel Cell Vehicle Test Equipment						$0.700	$0.238	$0.243	$0.248	$0.253	$0.258
Calorimeter for 42 V Modules	$0.250										
Subtotal New Capability PCE	$0.000	$0.000	$0.000	$0.000	$0.300	$0.000	$0.102	$0.104	$0.106	$0.108	$0.110
Anemometer and Power Analyzer	$0.050										
Environmental Chamber		$0.025									
Single Cylinder Research Engine and Test Bench		$0.250	$0.250								

7.6 NREL Capital Investment Strategy – Distributed Energy and Electric Reliability (DEER) Program

The NREL DEER Program activities are carried out in support of the Department of Energy (DOE) Office of Electric Transmission and Distribution (OETD), and the Office of Energy Efficiency and Renewable Energy (EERE) Distributed Energy (DE) Program.

- OETD NREL R&D Activities include: Distributed Power Systems Integration (Electric Distribution); Transmission; High Temperature Superconductivity; and Energy Storage.
- EERE DE NREL R&D Activities include: Thermally Activated Technologies; DOE DE Website; and DE Electrical System Integration. Also includes CEC collaboration.

Strategic Goals

- Increase the reliability and efficiency of electricity generation, delivery, and use
- Increase the viability and deployment of renewable energy technologies
- Develop non-vacuum High Temperature Superconductors (HTS) for wires and tapes and support for electric power systems.
- Reduce stress on the grid by limiting peak demand through the advancement of thermally activated cooling and demand-controlled ventilation and ventilation credit strategies

Current Activities at NREL

Table 7.6.1. Distributed Energy (EERE) and Electric Reliability (OETD) FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$11.4	million
Distributed Energy (EERE)	*$5.7*	million
Transmission & Distribution (OETD)	*$5.7*	million
FY04 Budget Authorization - Capital Equipment	$0.0	million
FY04 In-house Costs	$3.7	million
Distributed Energy (EERE)	*$1.4*	million
Transmission & Distribution (OETD)	*$2.3*	million
FY04 Average FTEs	13	FTEs
Distributed Energy (EERE)	*5*	FTEs
Transmission & Distribution (OETD)	*8*	FTEs

- Distributed Power Systems Integration - Electrical Distribution (OETD)
    - Interconnection Standards and Technology Development and Validation
    - Interconnection Systems Characterization and Operational Field Testing
    - Stakeholder and Institutional Adoption
- High Temperature Superconductivity (OETD)
    - Development of buffer layers for YBCO superconductor by non-vacuum electrodeposition technique
    - Preparation and characterization of YBCO superconductor by non-vacuum techniques.
    - Work with industries, national laboratories and universities

- Thermally Activated Technologies (EERE)
    - Research and develop thermal conversion systems that convert waste heat from onsite prime movers to heating/cooling work, thereby more than doubling source energy utilization efficiency in buildings from approximately 30% to over 70%
    - Assist in the design, analysis and evaluation of packaged, combined cooling, heating and power systems for buildings

Planned R&D Activities

Distributed Power Systems Integration - Electrical Distribution

- Development of national and international standards for interconnection and integration of distributed resources and electric power systems and to develop advanced technologies that integrate distributed resources with distribution systems.
- Characterization and testing of advanced technologies for interconnection, integration, and control of distributed resources. This is done by conducting system characterization on prototype DR interconnection systems, test procedure validation, and examining the effects of DR on distribution systems.
- Working to ensure the understanding, adoption or reference, and maximum impact of the interconnection and communication standards work of the program by relevant operating, regulatory and related institutions, such as authorities having jurisdiction over the electric power system. This is done by identifying, analyzing, and developing solutions to reduce institutional and infrastructural barriers to the development and commercialization of distributed power systems and the deployment of next generation communications, controls and other technical innovations.
- Develop multiyear power electronics program plan and testing activities for interconnection technologies, micro-grid designs, and standard testing protocols with the California Energy Commission in collaboration or concert with the EERE DE DOE program.

High Temperature Superconductivity

- Prepare electrodeposited biaxially textured buffer layer (innovative and simplified) for YBCO HTS.
- Demonstrate $J_c > 10^6$ A/cm^2 at 77 K for YBCO using the NREL developed buffer layer.
- Investigate non-vacuum techniques (specially electrodeposition technique) for producing YBCO superconductor.
- Work on YBCO-coated conductor in collaboration with IGC SuperPower Corporation. Establish new CRADA agreement with IGC SuperPower.
- Technical communications for the DOE Headquarters' staff.
- NREL and University of Colorado working together on electrodeposition and spray deposition process. NREL established new collaborative effort with SuperPower Corporation. NREL is also working with other national laboratories; especially ORNL and LANL, on YBCO coated conductors.

Thermally Activated Technologies

- Research and develop advanced desiccant materials that enhance energy efficiency, durability, and performance in emerging applications.

- Develop accurate and fast air quality sensors and low-concentration test protocols to support evaluation of the indoor environmental quality benefits of desiccant systems and other air-cleaners.
- Assist industry in market entry of novel packaged systems for improved humidity control and indoor air quality

Facility Issues and Opportunities

Table 7.6.2. Distributed Energy and Electric Reliability Facility Usage (09/30/04)

Thermal Test Facility	3,048	gsf
DW Building 16	2,620	gsf
Hybrid Power Test Bed	1,790	gsf
SERF	1,000	*gsf*
Total	8,458	*gsf*

- Researcher offices for Distributed Energy and Electric Reliability are in Buildings 16 and 17. Research work at this time is limited to the very small Hybrid Power Test Bed at the NWTC site, and a small portions of laboratories in the Solar Energy Research Facility for HTS research and the Thermal Test facility for TAT work.

Because NREL's unique capabilities in distributed energy and electric reliability research has evolved in the past several years, there has not been significant capital investment in dedicated facilities for this work. As a result, today's needs are being accommodated with "seed" spaces resulting from creative reconfigurations of available space using general plant projects funds.

Facility Options

In considering facility needs, the following options should be included:

- Limit R&D at NREL to that which can be accomplished with the current facilities
- Temporarily lease commercial space, duplicate services and equipment as necessary, and accept the decrease in productivity inherent in split locations.
- Combine today's Distributed Energy and Transmission & Distribution needs with other current engineering and testing needs related to Hydrogen, Fuel Cells, and Infrastructure technologies, and mobile fuel cells in FreedomCAR and Vehicle technologies, and construct a new, approx 60,000-gsf Engineering Test Laboratory. This would accommodate the same functions as the HRDEIL and add flexibility and efficiency by sharing equipment and resources with other programs.

A full analysis of these options is not included here due to space limitations.

Facility Recommendations

NREL's recommendations are as follows.

Engineering Test Laboratory

This 60,000-gsf facility would accommodate critical engineering and testing activities in support of the Hydrogen, FreedomCAR, Distributed Energy, and Transmission and Distribution

programs, including electrical interconnection research and testing, general engineering performance and testing of hydrogen renewable systems, and vehicle engineering research activities such as the 21st-century truck research from ReFUEL, auxiliary load and power electronics research from Bldg 16, and battery thermal management. Estimated cost is $36 million in the FY2008 budget. This includes $6.0 million for new capital equipment related to the facility.

Equipment Issues and Opportunities

Table 7.6.3. Distributed Energy and Electric Reliability Capital Equipment Status (06/30/04)

Today's Value	$0.137	million
Deferred Replacement Backlog	$0.0	million
Percent of Today's Value Deferred	0%	
Average Strategic Useful Life	10.0	Yrs
Average Age	8.4	Yrs

Distributed Energy and Electric Reliability (or the equivalent earlier programs) purchased two instruments currently in active use at NREL, one of which will need to be replaced in FY2005 (Squid Magnetic System for HTS R&D). In addition, the Distributed Energy program has benefited from four items purchased through general purpose equipment funds before the program was established. These should be replaced in the future by program funds, as noted in the graph below.

Several pieces of equipment can be utilized at Thermal Conversion Laboratory to meet current and future DE and industry goals. The TCL was designed and constructed to handle larger airflow conditioning loads than its existing thermal plant can support. Industry initial product offerings in commercial air cleaners are targeted within the TCL's enhanced design envelope and can be accommodated by an enlarged thermal plant. Particulate loading and measurement equipment is also needed to fully characterize the abilities of cutting edge air cleaners.

Table 7.6.4. Capital Equipment Needs for DE Thermally Activated Technology for FY2005

Capital Equipment Item	Project Area	Cost $K	Justification
Thermal plant upgrade	Thermal Conversion Component Development/Integration	50	Increase DE Test Capacity
Particulate Seeding/Sensing upgrade	Contaminant Capture	100	Expand Ventilation Credit Test Capability

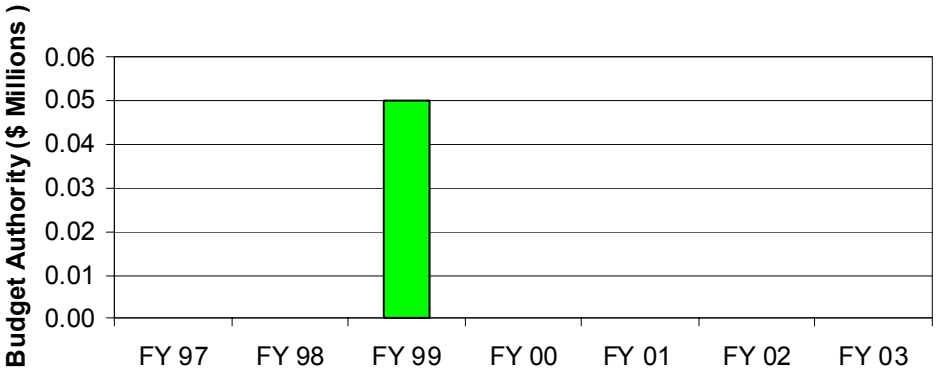


Figure 7.6.1. Distributed Energy and Electric Reliability Program Capital Equipment Funding 1997-2004

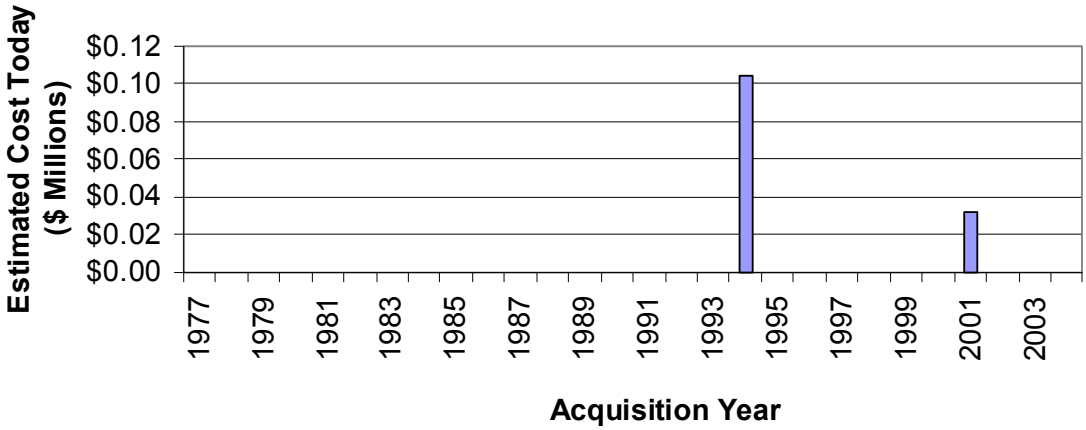
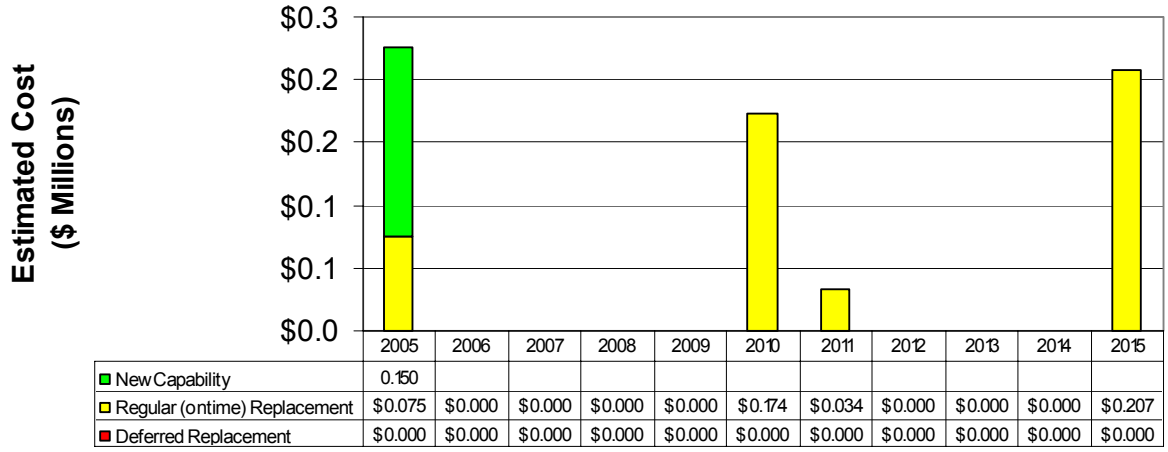


Figure 7.6.2. Age Distribution of Distributed Energy Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	0.150										
Regular (ontime) Replacement	$0.075	$0.000	$0.000	$0.000	$0.000	$0.174	$0.034	$0.000	$0.000	$0.000	$0.207
Deferred Replacement	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000

Figure 7.6.3. Projections of Equipment for Distributed Energy (Excluding Facility-Specific Equipment, FY05-FY15)

Table 7.6.5. Projections of Replacement Equipment for Distributed Energy and Electric Reliability

Replacement Year	Replacement Category	Asset Description	Replacement Cost	In Service Date	Age as of 09/30/04 (years)	Age as of 09/30 of Replacement Year	Strategic Useful Life
2005	Regular	SQUID MAGNETIC SYSTEM	$75,429	10/20/1994	9.95	10.95	10
2010	Regular	POWER ANALYZER	$34,627	2/21/2001	3.61	9.61	10
2010	Regular	SURGE TESTER	$139,228	6/5/2001	3.32	9.33	10
2011	Regular	SIMULTANEOUS DSC-TGA TESTER	$33,556	3/22/2001	3.53	10.53	10
2015	Regular	POWER CONTROLLER	$207,249	11/7/2001	2.90	13.90	15
2025	Regular	LOAD BANK	$152,663	4/17/2002	2.46	23.47	25
2010	Regular	DEWPOINT HYGROMETERS	$100,000	5/15/2000	4.33	10	10

7.7 NREL Capital Investment Strategy – Buildings

Strategic Goals

- Improve the energy efficiency of residential and commercial buildings and the energy-using equipment in these buildings
- Integrate renewable energy technologies into building systems to enable net-zero energy buildings at low incremental cost by 2025.

Mission: Develop and validate technologies, techniques, and tools to make residential and commercial buildings more energy efficient, productive, and affordable.

Building America R&D
The technical goal is to reduce the energy consumption in residential buildings and integrate renewable on-site energy in a whole building systems approach optimized for specific climate zones across the country. Building America works in partnership with leading production builders and energy consulting teams for field testing and validation of advanced energy efficiency and renewable energy technologies and construction practices.

High Performance Commercial Buildings R&D
The technical goal is to reduce the energy consumption in commercial buildings and integrate renewable on-site energy in a whole building systems approach optimized for specific commercial building types across the country. Advanced energy analysis tools are developed and validated through well-documented case studies of high performance commercial buildings from conceptual design and construction through operation for at least two years.

Emerging Technologies R&D
Advanced energy efficiency technologies including building equipment, appliances, lighting, windows and thermal envelope systems are developed and tested in laboratory and building environments.

Current Activities at NREL

Table 7.7.1. Buildings FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$9.7	million
FY04 Budget Authorization - Capital Equipment	$0.0	million
FY04 In-house Costs	$4.6	million
FY04 Average FTEs	16	FTEs

- Building America
- High Performance Commercial Buildings
- Emerging Technologies

Planned R&D Activities
Building America R&D
NREL provides the field technical management and R&D support for the Building America program. The FY05-06 goals are validation by production builders of cost competitive whole

building energy savings of 30% in the 6 major U.S. climate zones. The energy savings goals increase to 40% whole building energy savings (including building integrated on-site renewable energy) by 2010 and net zero energy buildings by 2020. NREL develops the program benchmark, analysis tools, energy monitoring protocols, and laboratory test data supporting the field tests.

High Performance Commercial Building R&D
NREL works with building developers, architects and owner/operators to design, construct, and operate a range of commercial building types that achieve at least 50% energy savings and incorporate on-site renewable energy sources. Well-validated and documented case studies provide the basis for design packages for different building types for various climate zones. In addition, NREL develops energy analysis tools, performs opportunity analysis and optimization methodology for to meet the EERE goal of zero net energy commercial buildings by 2025.

Emerging Technologies
NREL's primary role is the testing the durability and failure mechanisms of advanced windows. In addition, the Laboratory develops advanced material systems to improve the performance and life-cycle cost of dynamic windows.

Facility Issues and Opportunities

Table 7.7.2. Buildings Facility Usage (09/30/04)

DW Bldg 15/17/27	10,855	gsf
Thermal Test Facility	4,504	gsf
Field Test Laboratory Building	2,342	gsf
Solar Energy Research Facility	1,293	gsf
Others	494	gsf
Total	*19,488*	*gsf*

- Researcher offices for Building Technologies were in Building 27 of the Denver West Office Park, and moved in November 2004 to Building 17.
- R&D for the Building America and High Performance Commercial Buildings activities is conducted primarily in the Thermal Test Facility. The Thermal Test Facility is shared with the battery thermal management research for FreedomCAR and Vehicle Technologies, and there is insufficient space for both programs' activities. Additional laboratory space is required for building component and subsystems testing in support of the residential and commercial buildings R&D activities.
- R&D on advanced window testing and materials development is conducted in the Field Test Laboratory Building. There is currently adequate space for the planned activities.

Facility Options
In considering facility needs, the following options should be included:

- Limit R&D at NREL to that which can be accomplished with the current facilities.
- Construct the proposed Engineering Test Lab, which would provide space for FreedomCAR activities currently in the Thermal Test Facility, allowing more space for Buildings research in the Thermal Test Facility.

Facility Recommendations

Construct the proposed Engineering Test Lab, which would provide space for FreedomCAR activities currently in the Thermal Test Facility, allowing more space for Buildings research in the Thermal Test Facility.

Equipment Issues and Opportunities

Table 7.7.3. Buildings Capital Equipment Status (06/30/04)

Today's Value	$2.1	million
Deferred Replacement Backlog	$0.7	million
Percent of Today's Value Deferred	32%	
Average Strategic Useful Life	10.5	yrs
Average Age	9.2	yrs

The Building Technologies Program has invested very little in capital equipment at NREL over the past seven years. Some items currently need replacement and there are some additional capital items needed for new capabilities to meet program goals. The status of current capital equipment items for the Buildings Technology Program is summarized below.

Capital equipment items that will be replaced in FY2005-FY2008 have been determined, as shown in the Table 7.7.4. The replacement plans for some other items have not yet been determined and are shown as “TBD” – to be determined.

NREL proposes adding equipment for a Daylighting Test Laboratory within the Thermal Test Facility. The Daylighting Test Lab will add the capability to measure and validate the light distribution, performance, and energy savings for daylighting options. For example, it will be able to quantify and measure side-by-side the performance of options such as a skylight with a fresnel lens, a light tube, and a light shelf. This capability will be added in two increments. The first in 2008 will be accommodated in existing space in the Thermal Test Facility; the second phase in 2010 will require space that is currently occupied by the Battery Test equipment for the FreedomCAR program. This FreedomCAR research is anticipated to move to the new Engineering Test Laboratory. The primary cost of the Daylighting Test Laboratory will be program capital equipment. Some modification of the existing space, and possible roof penetrations will be required, but the cost of the modifications will be less than 20% of the cost of the equipment.

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the Building Technologies Program through enhancing the speed and efficiency to complete more detailed modeling and simulation. Specifically the EnergyPlus whole building energy simulation program, the BeOpt optimization meta-program, and our computational fluid dynamics modeling would benefit significantly from high

performance computing hardware. In addition efforts to link ground heat transfer models and CFD models to whole building simulation models would also become much more viable with advanced computing hardware.

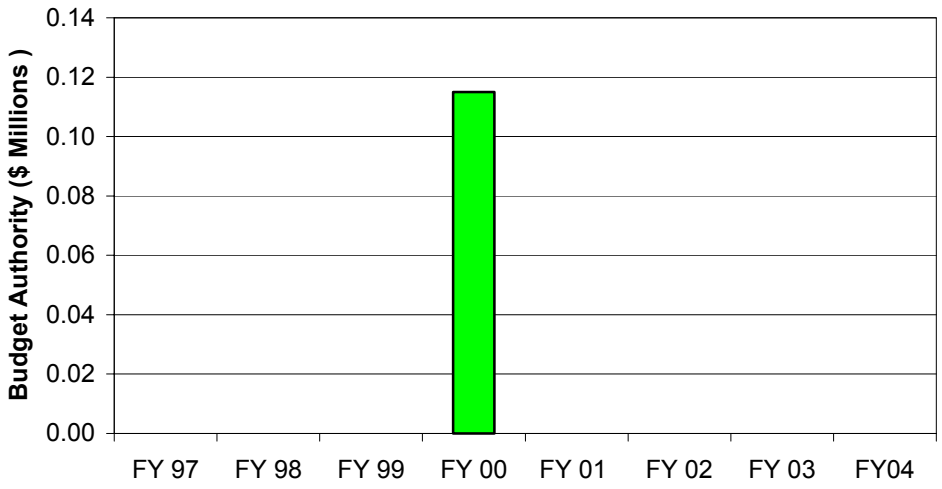


Figure 7.7.1. Buildings Program Capital Equipment Funding 1997-2004

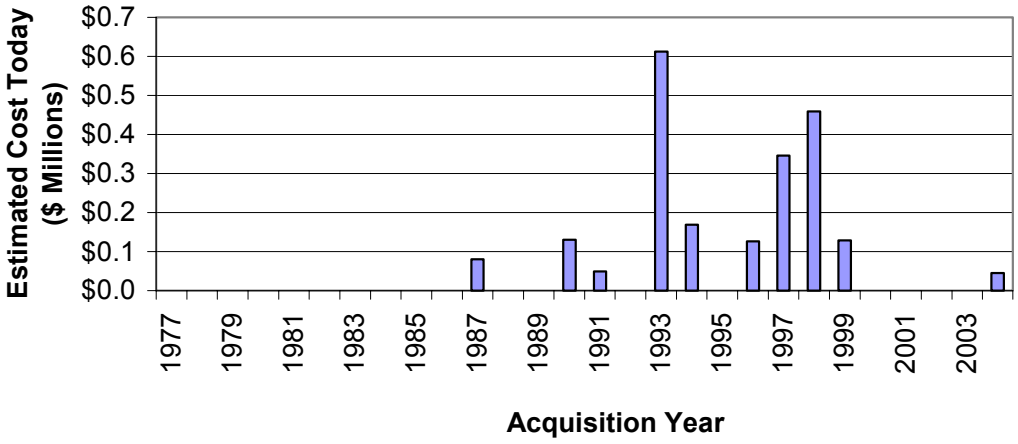


Figure 7.7.2. Age Distribution of Buildings Equipment at NREL

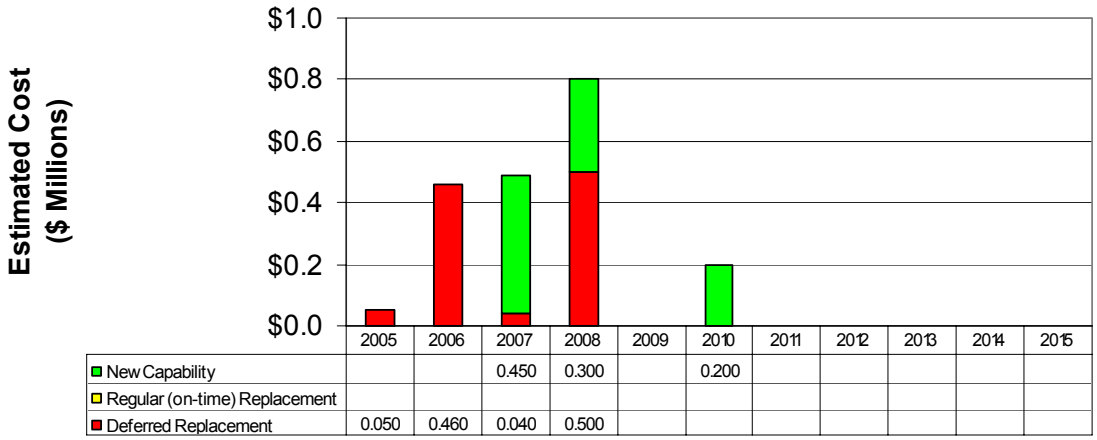


Figure 7.7.3. Projections of Equipment for Buildings (Excluding Facility-Specific Equipment, FY05-FY15)

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Table 7.7.4. Projections of Replacement Equipment for Buildings Technologies

Replacement Year	Replacement Category	Asset Description	Replacement Cost	In Service Date	Age as of 09/30/04 (years)	Age as of 09/30 of Replacement Year	Strategic Useful Life
2005	Deferred	Impedance Analyzer for Window Durability Testing	$50,000	4/20/1993	11.45	12.45	6
2006	Deferred	Test Chamber for Advanced Window Durability Testing	$400,000	1/20/1998	6.70	7.70	6
2006	Deferred	Work Station for Residential Building Optimization Analysis	$60,000	1/20/1994	10.70	12.70	10
2007	Deferred	Multi Stat System for Window Durability Testing	$40,000	1/20/1996	8.70	9.70	6
2008	Deferred	ARBIN TESTING SYSTEM	$50,000	4/20/1997	7.45	10.45	9
TBD	TBD	Weatherometer	$109,490	1/20/1999	5.70	6.70	6
TBD	TBD	MULTIPOINT SAMPLER	$34,425	9/20/1996	8.03	10.03	10
TBD	TBD	THERMAL CAMERA	$70,679	10/20/1997	6.95	8.95	10
TBD	TBD	MULTIGAS MONITOR	$26,837	9/20/1996	8.03	11.03	10
TBD	TBD	SPECTRORADIOMETER	$81,145	12/20/1997	6.78	9.78	10
TBD	TBD	MULTIGAS PHOTOCOUSTIC ANALYZ	$38,523	10/20/1993	10.95	14.96	15
TBD	TBD	FLOW VELOCIMETER SYSTEM	$114,562	3/20/1994	10.54	20.55	20

Table 7.7.5. Projections of New Capability Equipment for Buildings Technologies ($Millions)

Equipment Description	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dedicated 100 Node Parallel Processor for Commercial Building Analysis			$0.450								
Daylighting Test and Validation Laboratory				$0.300		$0.200					

7.8 NREL Capital Investment Strategy – Geothermal Program

Strategic Goals

DOE: Strengthen America's energy security by developing technologies that foster a diverse supply of reliable, affordable, and environmentally sound energy by providing for reliable delivery of energy, guarding against energy emergencies, exploring advanced technologies that make a fundamental improvement in our mix of energy options, and improving energy efficiency.

EERE:

- Increase the viability and deployment of renewable energy technologies
- Increase the reliability and efficiency of electricity generation, delivery, and use

Current Activities at NREL

Table 7.8.1. Geothermal FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$2.5	million
FY04 Budget Authorization - Capital Equipment	$0.0	million
FY04 In-house Costs	$1.5	million
FY04 Average FTEs	4	FTEs

- Research to enhance the performance and decrease the cost of air-cooled condensers via air side surface alteration with tabs or other protuberances to disrupt and renew the boundary layer on the heat transfer surface, while maintaining or even reducing the energy expenditure on the air side. These developments can substantially enhance geothermal energy production.
- Development and field-testing of advanced doped polymeric coatings that can be applied to inexpensive base metals to provide the corrosion and abrasion resistance of exotic metals, while reducing the cohesion of fouling layers. The coatings can substantially reduce the cost of geothermal equipment such as piping and heat exchangers.
- Define and develop advanced conversion technology to increase the efficiency and decrease the cost of geothermal power. This includes analytical evaluation and field-testing of conversion processes and components.
- Provide technical integration support to the Geothermal Technologies Program, with activities ranging from planning and managing, to analysis, to outreach.

Planned R&D Activities

- The heat transfer developments will be perfected and will be taken to large scale field-test at a geothermal operating facility.
- Field-testing of doped polymeric coatings will be expanded, with continued development of polyphenylene sulfide based coatings, and development and testing of organo-metallic type coatings. One area of emphasis will be to provide fouling and corrosion efficient coatings that are thermally conductive for use on the air side of air-cooled condensers that are sprayed with brine in the summer to significantly enhance the rate of condensation and to reduce the condenser pressure to increase turbine output.

- Enhance the adoption of new processes and components for geothermal energy conversion via field-testing, with emphasis on development of the conversion technology necessary to make enhanced geothermal systems technically feasible and economically viable.

Facility Issues and Opportunities

Table 7.8.2. Geothermal Facility Usage (09/30/04)

Field Test Laboratory Building	2,304	gsf
Thermal Test Facility and others	1,935	gsf
Total	*4,239*	*gsf*

The NREL Geothermal Technology Program will continue to use the current facilities in the TTF and the FTLB.

Equipment Issues and Opportunities

Table 7.8.3. Geothermal Capital Equipment Status (06/30/04)

Today's Value	$0.4	million
Deferred Replacement Backlog	$0.1	million
Percent of Today's Value Deferred	24%	
Average Strategic Useful Life	10.0	yrs
Average Age	6.5	yrs

The existing capital equipment is barely adequate to perform the required work in heat transfer and materials testing. The existing heat transfer equipment needs to be upgraded to allow more efficient fabrication of test items, more cost-effective testing, and more rapid and in some cases in-situ analysis of materials performance.

The enhanced heat exchanger test module fabrication will require a numerically controlled punch coupled with an automated positioning table for formation of fin specimen. The transient and the steady state heat transfer test apparatus need to be upgraded with better data collection devices and with better auxiliaries to enable closer control of variables. The materials testing will require a dedicated boroscope to allow in-situ visual inspection of piping and tubing interiors, along with a fouling instrument to characterize the deposition of salts and corrosion products on the surfaces of geothermal equipment. Field-test of the enhanced air-cooled condenser will require a full-scale air-cooled condenser, essentially 1 bay of an industrial condenser located on a geothermal power plant. The air-cooled condenser test specimen will be a custom fabrication.

A significant investment in NREL's Computational Sciences expertise and high performance computing capabilities would benefit the Geothermal Technologies Program through more fluid dynamics research and development. For example, it would help reduce cost of geothermal electricity via research and development to identify and simulate improved, innovative air-cooled heat exchanger designs in collaboration with industry partners.

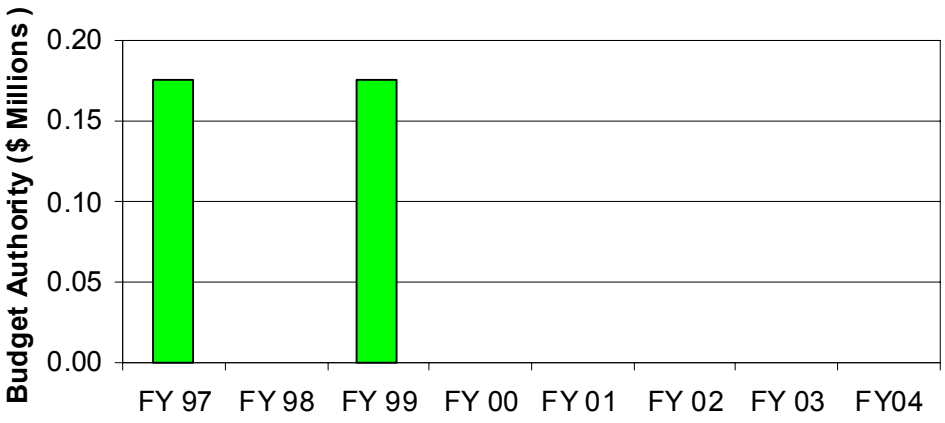


Figure 7.8.1. Geothermal Program Capital Equipment Funding 1997-2004

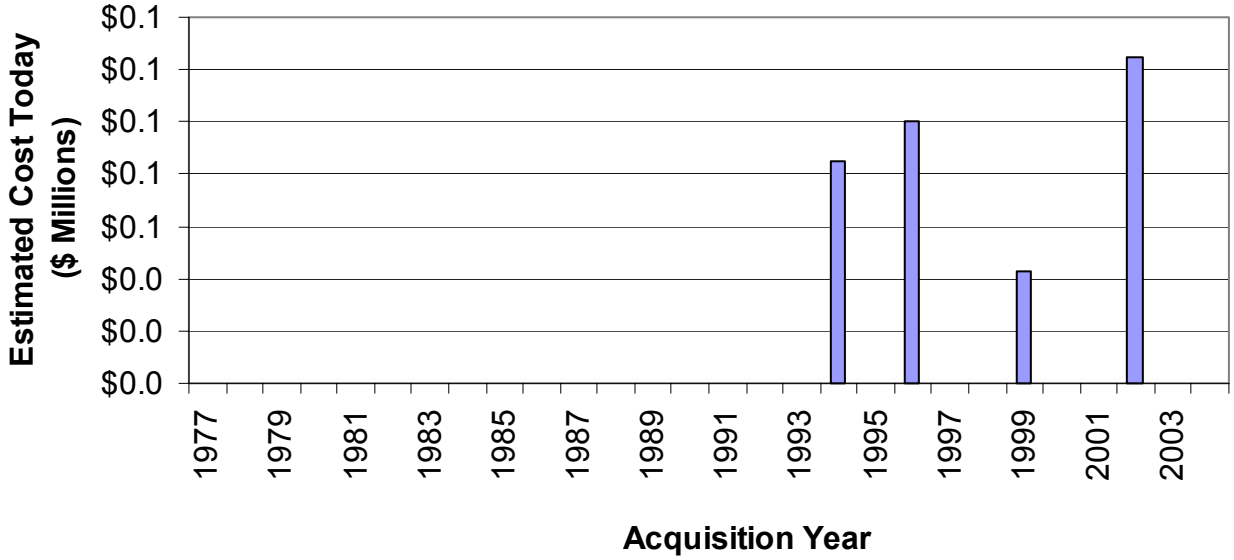
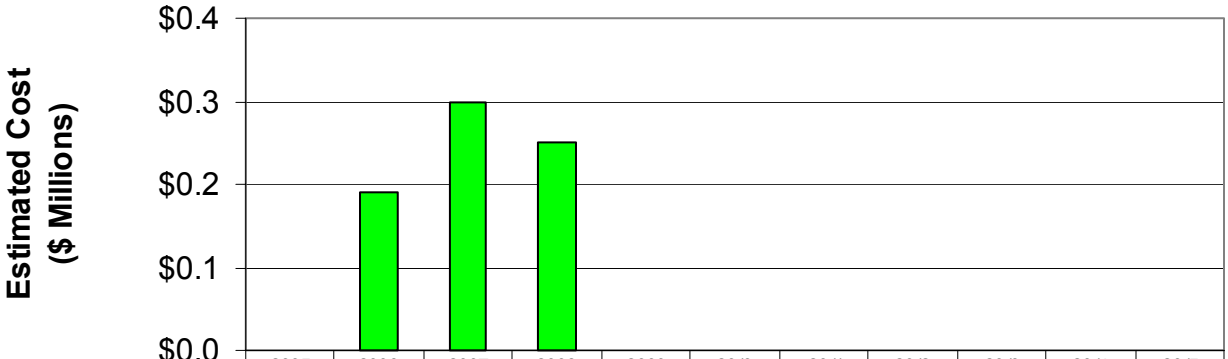


Figure 7.8.2. Age Distribution of Geothermal Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	$0.000	$0.190	$0.300	$0.250	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Regular	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Deferred	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000

Figure 7.8.3. Projections of Equipment for Geothermal (Excluding Facility-Specific Equipment, FY05-FY15

Table 7.8.4. Projections of Replacement Equipment for Geothermal Program

None, existing equipment is serviceable for the foreseeable future.

Table 7.8.5. Projections of New Capability Equipment for Geothermal Program ($ Millions)

Equipment Description	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Condenser Test Module		$0.150	$0.300	$0.250							
Materials Characterization Equipment		$0.040									

Rationale:
Condenser Testing Module: $50K to enhance the transient test loop at NREL and $50K to enhance the steady state test loop at NREL, with the test loops used to characterize air-cooled heat transfer surfaces. $50K for a numerically controlled punch to enhance fabrication of fins for test specimen. $300K for a field test of the enhanced air-cooled condenser in FY07. $250K to build a state-of-the-art condensation test rig at NREL.

Materials Test Loop – expansion of materials test capabilities, with optical characterization equipment and a heat exchanger fouling instrument ($40K)

7.9 NREL Capital Investment Strategy – Office of Science

Strategic Goals

Office of Science Goals:

- Advance the basic sciences for energy independence
- Harness the power of our living world
- Deliver Computing for the frontiers of science
- Provide the resource foundations that enable great science

Programs:

- The goal of the SC/BES/Materials Sciences projects is to study the structural, optical, electrical, and defect properties of some exciting, new semiconductors and related materials for photovoltaics and other energy-related applications by using the state-of-the-art theoretical and experimental techniques.
- The goal of the SC/BES Chemical Sciences program at NREL is to advance the basic understanding of the relevant science in chemistry, photochemistry, photoelectrochemistry, catalysis, materials chemistry, and semiconductor physics and chemistry that supports evolving solar photochemical conversion technologies; efforts are also made to integrate the advances in the basic chemical sciences into relevant technology development activities.
- The goal of the SC/BES Biological Sciences program at NREL is to advance basic understanding of bacterial and plant photosynthesis, including relevant metabolic pathways, and to apply that knowledge to develop renewable fuels, chemicals, and materials, as well as address environmental problems.

Current Activities at NREL

Table 7.9.1. Office of Science FY04 Financials and FTEs

FY04 Budget Authorization - Operating	$5.5	million
FY04 Budget Authorization - Capital Equipment	$0.6	million
FY04 In-house Costs	$4.9	million
FY04 Average FTEs	28	FTEs

NREL performs fundamental research for DOE's Office of Science. The mission is to provide fundamental knowledge in the basic sciences and engineering that will underpin new and improved renewable energy technologies. In support of this mission, NREL executes research in three areas— materials sciences, chemical sciences, and energy biosciences. NREL also integrates its fundamental research with applied R&D in several projects. Core activities are shown in Figure 7.9.1.

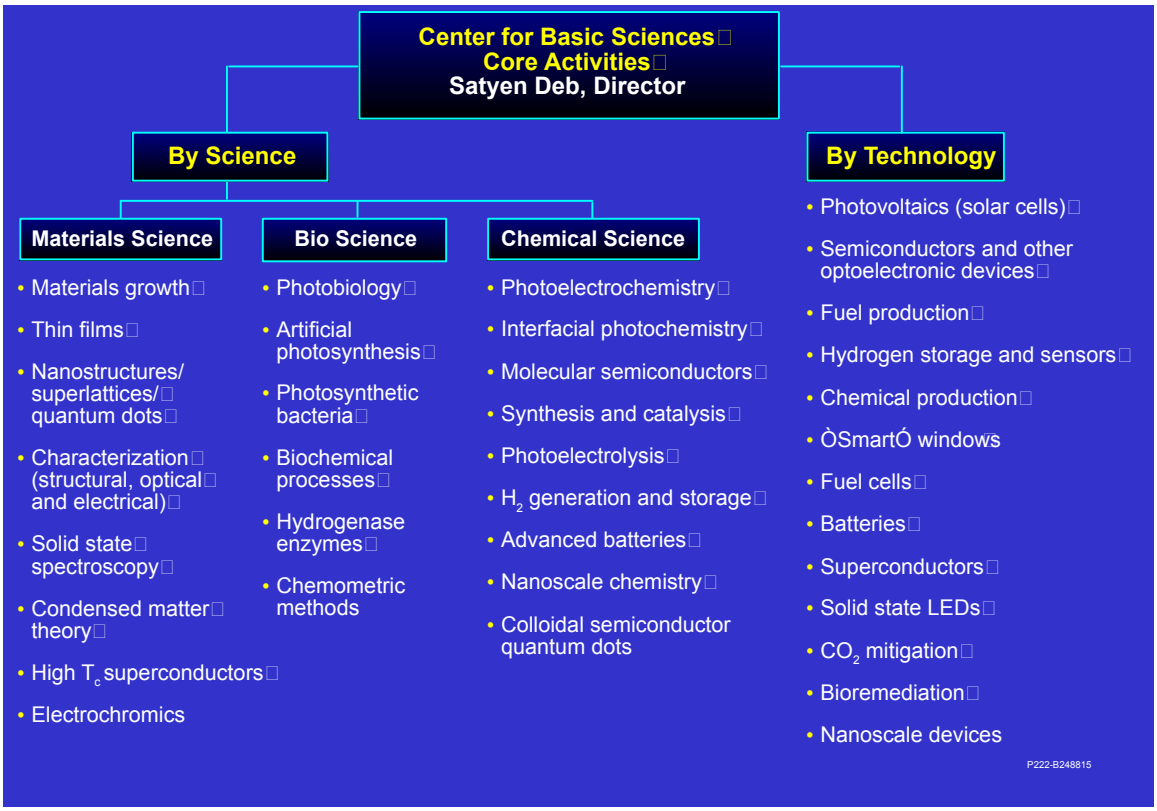


Figure 7.9.1. Center for Basic Sciences Core Activities

Planned R&D Activities

Materials Science –

- Ordering in III-V semiconductor alloy materials
- Physics of isoelectronic co-doping
- Doping bottlenecks in semiconductors
- Carbon nanotubes membranes
- Solid state theory
- Nanostructure materials
- Novel semiconductor materials (e.g., III-V nitrides)

Chemical Sciences

- Synthesis and characterization of novel semiconductor quantum dots and quantum dot structures
- Dye-sensitized photochemical solar cells
- Synthesis of new molecular catalysts for C1 chemistry (for example, CO2 reduction)
- Carrier dynamics and quantization effects at semiconductor-molecule interfaces
- Interfacial photochemical processes
- Self-organized films of liquid crystalline molecular semiconductors

Biological Sciences

- Basic studies of photosynthetic water-splitting in plants and algae
- Regulating H2 and CO2 metabolism in algae

Facility Issues and Opportunities

Current Facilities – Research for the Office of Science is conducted in portions of NREL's largest laboratory buildings. To take advantage of synergies with EERE program areas, Materials Science R&D is generally conducted in the SERF near Solar Program and Hydrogen staff, and Chemical and Biological Sciences R&D is generally conducted in the FTLB near Biomass and Hydrogen staff.

Table 7.9.2. Office of Science Facility Usage (09/30/04)

Solar Energy Research Facility	11,870	gsf
Field Test Laboratory Building and others	11,058	gsf
Total	*22,928*	*gsf*

Chemical and Biological Laboratories

Both the SERF and the FTLB are filled to capacity (see section 6.3 on utilization rates). While NREL has excellent facilities in this area, all currently built laboratories within the FTLB and SERF are continuously in use at near 100% utilization, compared to the desired utilization rate of 80%. This crowded condition leaves no flexibility to add new research projects or change research directions.

Office, Cubicles, and Support Space

The utilization rate for offices, cubicles, and workstations is about 97% in the FTLB and 100% in the SERF as of December 2004, compared to the desired practical utilization rate for workspaces of 85%. Workstations are even more crowded, and are of substandard size, when students and teachers are added in the summer.

All of the offices and cubicles available to scientists in the FTLB supporting the Office of Science consist of odds and ends of interior spaces that have been added ad hock over the long life of the building, and have absolutely no windows. These crowded and substandard conditions overall make it difficult to attract, incentivize, and retain senior scientists in these highly competitive technical fields. With no flexibility, finding any space for summer interns and visiting professionals requires an inordinate amount of researcher and management time.

The SERF has been filled well beyond design capacity for several years. In December 2004, there were 199 occupants (Solar, Office of Science, Hydrogen, and others) for a design capacity of 147. In May-August of each year, these numbers increase to accommodate summer student interns. The immediate solution has been substandard workspaces. The completion of the S&TF will allow decompression of the SERF as some labs and researchers will move from the SERF into the S&TF, and will allow some researchers to move from Building 16 to the SERF. However, the overall demand for laboratory space and offices to accommodate other related research activities will ensure that there will continue to be issues with inadequate office and lab space for summer students, post docs, and visiting professionals in the SERF and S&TF combination.

Facility Options

As a Program Secretarial Office for NREL, the Office of Science is a tenant at NREL sites that are primarily owned and managed by EERE, the Lead Program Secretarial Office. Until now, the Office of Science has contributed a steady amount of capital equipment funds to NREL (see below), but has not contributed to facility needs. NREL is interested in exploring changes to this situation so that Office of Science needs for new and expanded laboratory space can be better addressed.

Chemistry and Biology Laboratories

- Limit R&D at NREL to that which can be accomplished with the current facilities
- Temporarily lease commercial laboratory space, duplicate services and equipment as necessary at the leased facility, and accept the decrease in productivity inherent in split locations.
- Improve the utilization of the FTLB in small increments as needed, by moving offices out of interior spaces and building out unused or underutilized space in the interior of the FTLB, adding walls and casework, and upgrading and expanding building ventilation and drains.
- Improve the utilization of the FTLB by a major project that will reconfigure and remodel the poorly utilized interior spaces into modern laboratories.
- Expand the FTLB outside the current footprint to provide additional laboratories and office space.
- Combine Office of Science needs with other programs' needs for laboratories at NREL in a new Chemical and Material Sciences Laboratory.

Offices and Support Space

- Continue in inadequate space, with overflow to leased office buildings in another location, accepting the decrease in productivity inherent in split locations.
- Expand the FTLB outside the current footprint to provide additional office spaces.
- Install "temporary" office trailers nearby

Equipment Issues and Opportunities

Table 7.9.3. Office of Science Capital Equipment Status (06/30/04)

Today's Value	$5.6	million
Deferred Replacement Backlog	$0.1	million
Percent of Today's Value Deferred	2%	
Average Strategic Useful Life	10.7	yrs
Average Age	9.2	yrs

The Office of Science is an example of a sound strategy for capital equipment investment. Though the total value today is modest at $5 million, the deferred maintenance backlog is very low, resulting in an Equipment Condition Index of about 2%, just into the "excellent" rating. A steady, dependable level of capital equipment funding over several years encourages good planning to balance timely replacement of older equipment with the periodic purchase of an instrument with new capabilities.

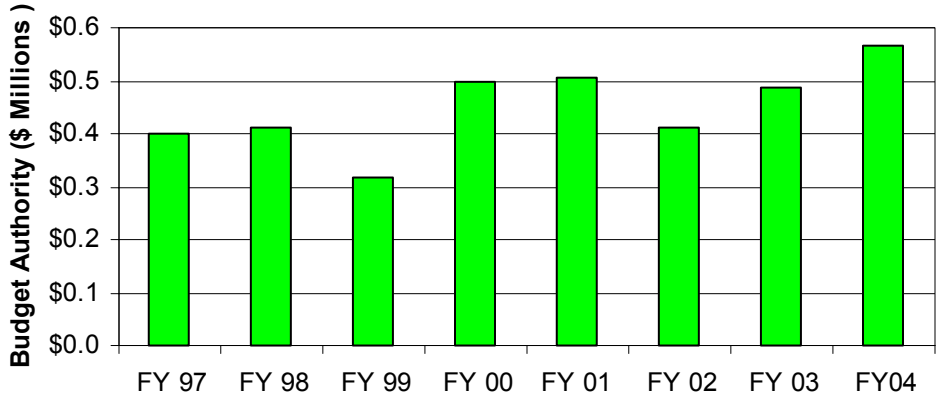


Figure 7.9.2. Office of Science Equipment Funding 1997-2004

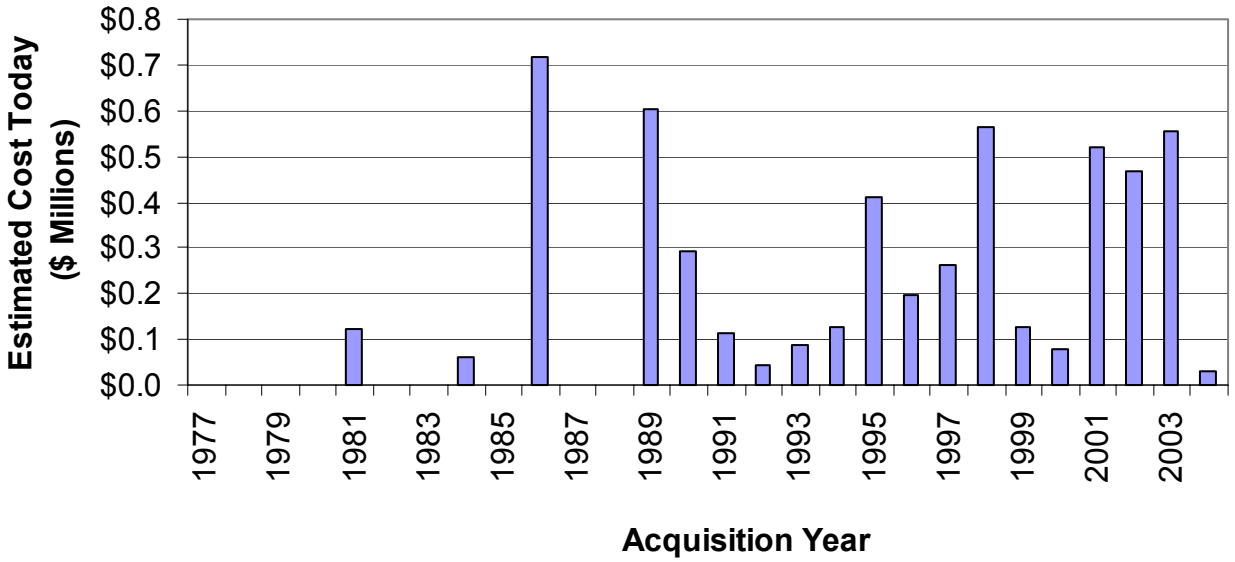


Figure 7.9.3. Age Distribution of Office of Science Equipment at NREL

Table 7.9.4. FY2005 - Capital Equipment

ER20	$160K	Replace Ar ion laser + upgrades for MBE growth system.
EROK	$40K	Upgrading the computers and other supporting facilities.
ER62	$120K	Urgent need to add processors to our in-house SGI system as well as memory.
EROL	$100K	Infrared emission spectrometer.
ER2B	$40K	Closed cycle refrigerator for 4.2K operation.

Table 7.9.5. FY2006 – Capital Equipment

ER20	$160K	Replace Ar ion laser
EROK	$40K	Upgrading the computers and other supporting facilities.
ER62	$120K	Urgent need to add processors to our in-house SGI System, as well as memory.
EROL	$100K	Laser for materials synthesis.
ER2B	$45K	Ion Laser

8 Capital Facility Requests - Mission

8.1 Candidate Construction Project (CLI) – Science & Technology Facility

Project Description

Construct the Science & Technology Facility (S&TF) at the South Table Mountain site immediately east of the SERF. This 71,347-gsf, multi-story building will house nine laboratories for advanced material synthesis, characterization, and general support; an 10,170-gsf Process Development and Integration Laboratory specifically designed to accommodate a new class of thin-film deposition, processing and characterization tools for process research; and support space for about 55 occupants. An elevated bridge will connect the SERF and the S&TF by linking their service corridors. The LEED™ goal for the building is certification at the Gold level, with expectations of a 42% reduction in energy use compared to the standard ASHRAE 90.1 Budget Building DOE-2 Model through daylighting, energy efficient lighting, energy recovery technologies for ventilation air, and other features. The building will house surface characterization equipment that will be re-located from the SERF, and several new capital equipment items that will be purchased to support the process research mission of the facility, including specialized manipulation tools for polycrystalline and amorphous silicon thin film process research, an x-ray and ultraviolet photoelectron spectrometer, a film crystal silicon deposition system, a multitarget sputtering system, an optical probe, a thin-film analyzer Auger spectrometer, a stationary transfer platform, a spectroscopic ellipsometry vacuum workstation, and an ambient deposition system.

Program Beneficiaries

- EERE Office of Solar Technologies
- EERE Office of Hydrogen, Fuel Cell, and Infrastructure Technologies
- Other programs involved with thin-film and nanostructured technologies, such as Buildings and DOE Office of Science.

Project Justification / Program Requirements

The S&TF will provide a transformational research capability and approach to developing thin-film and nano-scale devices and low-cost, high-throughput manufacturing processes that does not exist in the United States at this time. When commissioned, the S&TF will combine process integration, diagnostics, and simulation with the fundamental and applied research and development that is currently conducted in the adjacent NREL Solar Energy Research Facility (SERF) in ways that have not been done before. As such, EERE capitalizes on the existing research equipment and capability in the SERF thereby improving performance and reducing costs.

The research and development conducted in the S&TF will provide vital process research information that is needed by U.S. industry in the highly competitive international marketplace. This will enable the United States to maintain a leadership position in the international marketplace for near-term and next-generation thin-film and nanostructured technologies. The S&TF will provide the capability to accelerate renewable energy technology advancement through performance-based R&D programs and public-private partnerships involving solar technologies, hydrogen technologies, fuel cell components, and distributed energy technologies.

The S&TF will also allow EERE to meet key milestones from the National Energy Policy such as *"Providing clean and affordable electricity ($0.06/kWh) to all Americans by the year 2020."*

With the construction of the Science and Technology Facility at NREL and the process improvement knowledge that will be gained, the time from laboratory to marketplace is expected to be significantly shortened (from 25% to 65%) for these technologies. U.S. industry will have a totally new capability to aid them in competing in the international energy marketplace. The research that can only be accomplished in the S&TF will fill a critical knowledge gap that will help accelerate the introduction of new thin-film and nanostructured technologies into the marketplace and lower their cost.

Alternatives Considered to Meet Program Requirements

The following options were considered and documented in the OMB-300 report (July 2004):

1. No action.
2. Build the S&TF and conduct the research as planned, on DOE property at the NREL adjacent to the existing SERF.
3. Lease, renovating as necessary, sufficient space to conduct equivalent research.
4. Conduct research as planned at a private sector R&D facility without federal capital investment.
5. Build a new laboratory similar to the S&TF with sufficient space to conduct equivalent research at another location.

Table 8.1.1. Current Proposed (or Actual) Project Schedule

	Month -Year
CD-0 Approve Mission Need (authorizes the CDR start)	July 1999
CD-1 Approve Preliminary Baseline Range (requires completion of CDR and Baseline Range)	June 2002
CD-2 Approve Performance Baseline (requires completion of Preliminary Design and Independent Cost Estimate)	Sept. 2003
CD-3 Approve Start of Construction (requires completion of Final Design and Budget and Congressional Authorization and Appropriation)	Dec. 2003
CD-4 Approve Start of Operations or Project Closeout (requires beneficial occupancy, completion of construction and commissioning)	Jan. 2007

Table 8.1.2. Current Proposed (or Actual) Funding Profile Funding Profile ($ millions)

		Prior	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY 2008 and Beyond	Total
Conceptual Design	Operating	$0.4								$0.4
Project Engineering & Design	Capital		$0.8	$0.8						$1.6
Construction	Capital				$3.9	$6.7	$10.5			$21.1
Program Capital Equipment	Capital					$1.0	$2.75	$2.75		$6.5
Subtotal Building Construction	Capital									$22.7
Total Estimated Capital	Capital									$29.2

8.2 Candidate Construction Project (CLI) – Engineering Test Laboratory

Project Description

Construct a new Engineering Test Laboratory on the South Table Mountain site. This 60,000-gross square foot facility will provide space for 110 researchers, and will meet the immediate needs for engineering research and testing space for NREL's activities in Hydrogen, Fuel Cells, and Infrastructure Technologies; Distributed Energy; and FreedomCAR and Vehicle Technologies. This facility will house the activities currently being done in the ReFUEL leased facility, in the Hybrid Power Test Bed at the National Wind Technology Center, in low-bay labs in a leased building in an office park, and in space borrowed from the Buildings program in the Thermal Test Facility. It will also provide space for expanded testing in electrolytic hydrogen production systems, advanced distributed power applications, power electronics, electric reliability, and unique distributed generation concepts such as intentional electrical islands, microgrids and grid-connected hybrid propulsion systems. It will also provide space for about 78 researchers related to FreedomCAR and 30 researchers related to Hydrogen. These researchers will be able to move out of shared space in Building 16. The initial estimated cost for this facility and facility-specific capital equipment is $36 million (including $6 million for the initial capital equipment), assuming full construction funding in FY2008 and completion in FY 2009. This cost does not include the cost of road and utility extensions. The facility will be designed to meet a LEED silver rating.

The new facility will have several specialized test areas, including a drive-through high-bay space for testing biodiesel, diesel, and alternatively fueled trucks with a full-chassis dynamometer; a power electronics and motor laboratory for development of advanced power electronics interfaces and study of thermal issues, a high-bay test lab with an environmental chamber; low-bay labs for power system testing, battery and other energy storage research, and auxiliary load research; and an isolated lab for high-voltage surge testing, hydrogen systems testing, and electrolyzer testing. In addition, five outdoor pads will be available for testing larger equipment up to the multi-megawatt scale. Several of the labs will be designed for testing electrolyzers for hydrogen production and integrated hydrogen systems (renewable energy based production through end-use). Plans include an area for storage of biodiesel, diesel, hydrogen, and other fuels for testing. Initial conceptual drawings are attached. Several items of capital equipment will be required, including an environmentally controlled test chamber for testing hydrogen production equipment and alternative fuel vehicles, alternating and direct current (AC/DC) electrical test busses, AC and DC load banks, a motor load bank, a utility grid simulator, and heavy-duty vehicle (chassis) and engine dynamometers.

Program Beneficiaries

- EERE Office of Hydrogen, Fuel Cell, and Infrastructure Technologies
- EERE Office of Distributed Energy
- EERE Office of FreedomCAR and Vehicle Technologies

Project Justification / Program Requirements

EERE's strategic goals include the following: "Dramatically reduce, or even end, dependence on foreign oil;" and, "Increase the reliability and efficiency of electricity generation, delivery, and use." Reducing the dependence on foreign oil requires (1) research on both light-duty and heavy-duty vehicles, their engines and drivetrains, and their fuels (liquid hydrocarbons, blends and hydrogen) and emissions and (2) development of a clean and affordable path to a hydrogen energy future. Increasing the reliability and efficiency of electricity usage requires addressing the technical challenges of safely and reliably interconnecting distributed generators, including all types of renewables, with utility grids. In addition to these EERE goals, the Administration has focused on hydrogen as a cornerstone of its energy policy. As President Bush noted in his Hydrogen Initiative, hydrogen will help to power a more secure America, both in vehicles replacing foreign petroleum and in stationary power applications.

The key to successful research of this nature is a focus on the energy system. The energy systems central to these programmatic areas all require multidisciplinary (electrical, thermal, and mechanical) engineering expertise, equipment, and specially designed facilities for research success. Individual components need to be designed and tested, including hydrogen production units, electrical generation devices (photovoltaics, wind turbines, microturbines, fuel cells, gas turbines, and internal combustion engines), power electronics (i.e. inverters, converters), electric motors, interconnection and interface hardware, batteries or other energy storage devices, and electrical controls. Entire systems need to be tested; for hydrogen systems, this includes electrolytic production through end-use using actual or simulated inputs of renewable energy (e.g., wind and solar). For vehicles, this includes heavy-duty truck/non-road engines, heavy-duty powertrains, and vehicles. For distributed energy, systems-level testing includes advanced control strategies and distribution system operating concepts such as microgrids, intentional islands, and hybrid systems.

Today this research is conducted in five different research facilities at four different locations in the Denver metro area, with the farthest sites being approximately forty miles apart. Co-locating this research, and providing space for the expansion of electrical interconnection and hydrogen systems engineering and testing on the immediate horizon, will provide the following benefits:

- Improved likelihood of research breakthroughs via closer interaction and synergy among engineers from all three program areas
- More efficient use of space and equipment, shortening the time to milestones
- Reduction of capital and operating expenses through elimination of redundant infrastructure systems, fuel storage facilities, and inter-site transportation and deliveries that are required by multiple sites
- Enhancing the application of integrated safety management concepts by co-locating activities having similar ES&H hazards in a single facility designed for the efficient control of these hazards
- More research capabilities available to each programmatic area by sharing equipment and human resources, which will leverage expertise, reduce overall cost and achieve research milestones

- More effective research in DOE-owned, specially designed facilities, compared to the limitations imposed by occupying leased facilities in less-than-ideal industrial or office park settings
- Greater stability in the research programs over time by conducting the research in DOE-owned facilities, compared to disruptions of lease terminations and startups.
- Ability to upgrade measurement capability consistent with upcoming 2010 emission requirements
- Improved ability to conduct cooperative R&D projects with industry partners.

Alternatives to be Considered to Meet Program Requirements

The following options will be explored, estimated, and /or documented as part of the development of the Conceptual Design Report (CDR):

1. Continue the limited scale of research possible in today's facilities.
2. Conduct research as planned at a larger leased facility, if available.
3. Conduct research as planned at a private sector R&D facility without federal capital investment.
4. Conduct research as planned at a different federal facility with existing space.
5. Build two smaller facilities at NREL.

Table 8.2.1. Current Proposed (or Actual) Project Schedule (Phase I)

	Month-Year
CD-0 Approve Mission Need (authorizes the CDR start)	May 2005
CD-1 Approve Preliminary Baseline Cost Range (requires completion of CDR and Cost Estimate)	Oct. 2006
CD-2 Approve Performance Baseline (requires completion of Preliminary Design and Cost Estimate)	Oct. 2007
CD-3 Approve Start of Construction (requires completion of Final Design and Cost Estimate)	Feb. 2008
CD-4 Approve Start of Operations (requires beneficial occupancy, completion of construction and commissioning)	Sept. 2009

Table 8.2.2. Current Proposed (or Actual) Funding Profile ($ millions)*

		FY2005	FY2006	FY2007	FY2008	FY2009	Total
Conceptual Design Report	Operating		$0.8				$0.8
Project Engineering & Design	Capital			$3.6			$3.6
Construction	Capital				$26.4		$26.4
Program Capital Equipment	Capital					$6.0	$6.0
Subtotal Building Construction	Capital						$30.0
Total Estimated Capital	Capital						$36.0

* All numbers represent mid-point with uncertainty of +/- 20%

9 NREL Site Development / General Development Vision

9.1 Sustainability Goals

NREL relies upon its Sustainable NREL Master Plan to guide the design of individual buildings and infrastructure projects, and overall Lab operations, towards specific goals of environmental sustainability. Sustainability is defined as "the simultaneous and balanced pursuit of economic viability, environmental health, and public responsibility over the long term through appropriate investment decisions and operating practices." Sustainability goals are considered in the identification and development of all NREL construction projects and equipment purchases, whether to maintain the functionality of current assets or to acquire new assets for expanded capabilities. Sustainability goals include:

- Manage the impact on the environment caused by the placement and general design of Laboratory structures including buildings, roads, parking, storm water management, etc.
- Maintain, protect, and restore natural and landscaped environments to sustain natural and native ecological systems.
- Reduce water consumption and manage water discharges from the site.
- Reduce energy use in all building designs and operations.
- Reduce the impact of local Laboratory travel (within sites, between sites, or to local destinations) on the environment through choices leading toward pedestrian campuses, the use of advanced vehicles and bicycles, walking, and public transportation.
- Reduce the use of materials and the creation of waste by reducing, reusing, and recycling materials needed for Laboratory operations.
- Increase the purchase and use of environmentally sensitive products, such as products with the highest recycled content, bio-based products and products made from energy efficient materials and processes.
- Provide an environment, both indoors and outdoors adjacent to Laboratory facilities, that promotes efficiency and effectiveness, and encourages the creativity and personal motivation required for excellence in scientific, engineering, technology development, and support functions.

9.2 NREL Site Development

NREL prepared a 25-year site plan called the NREL General Development Vision to guide the development of both the STM and NWTC sites. The NREL General Development Vision assumes a 3% annual growth in NREL staff at both DOE-owned sites, resulting in 2,500 employees working at the STM site and 160 employees working at the NWTC in 2027. The plan also assumes that all NREL staff will be accommodated with adequate space on DOE property during this 25-year period.

9.2.1 South Table Mountain

Each improvement proposed at DOE-owned sites is considered in light of this 25-year plan. In addition, all improvements are subject to review by the NREL Design Advisory Board (DAB). The DAB process addresses consistency of a proposed project with the results of the ongoing site planning effort defined in the General Development Vision and the applicable programs, policies, and procedures NREL has established for sustainable development. The ongoing site planning effort and the DAB process are expected to minimize negative land use impacts from

future improvements on NREL sites. Also, no improvements are or will be proposed within conservation easements or in designated historic areas.

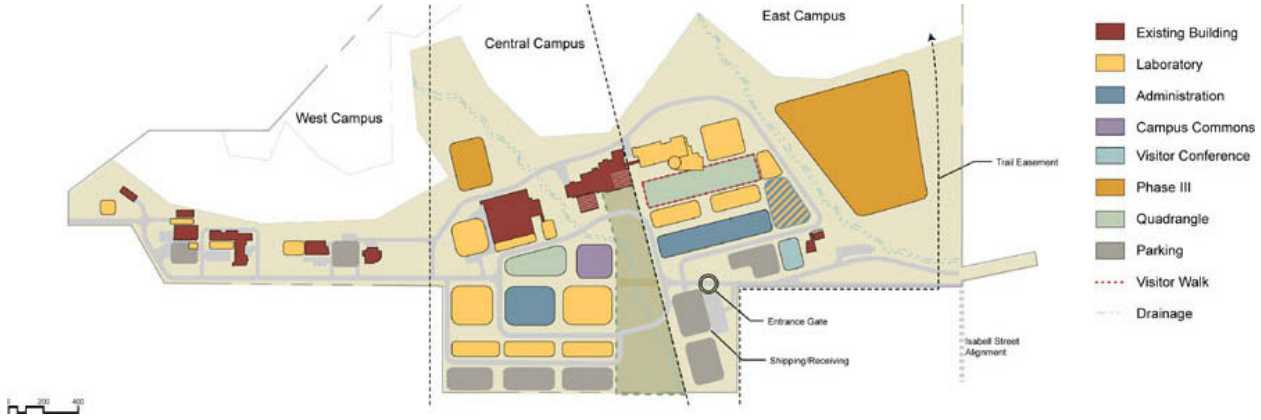


Figure 9.2.1. South Table Mountain Site

Figure 9.2.1 provides a land use plan for South Table Mountain. The plan depicts building sites to support just under 1.7 million square feet to house staff (including personnel currently located off-site in Denver West leased space). The building sites are intentionally clustered to create a pedestrian-friendly environment with open spaces between the buildings. Future development is divided into three zones: the east, central and west campus.

East Campus Plan

The East Campus is designated as the "visitor interaction" potion of the site. Buildings sited in this portion of the campus should have some need for public access, such as an expanded visitors center and a conference center. Laboratory buildings in this zone will be clustered around a quadrangle. The buildings will be oriented so that visitors could have escorted access to some of them to learn about research activities through displays and examples. Research functions grouped on the East Campus could include solid-state R&D, surface science, photovoltaics, nanotechnologies, computational sciences, solid-state lighting and discovery areas. An administrative complex development site would be located south of the east quadrangle. It is proposed to be the location of the Directors office and other administrative functions with a public orientation.

Central Campus Plan

The Central Campus contains the heart of the research activities at South Table Mountain. Anchored by the existing Solar Energy Research Facility (SERF) and the Field Test Laboratory Building (FTLB), the Central Campus contains five additional laboratory building sites and a site for an administration building. Research areas such as biomass, fuel cells, hydrogen, energy storage, and transportation are likely candidates for additional facilities in this zone. Additions to the FTLB are also contemplated. The administration building in the Central Campus would contain internal campus functions such as accounting, planning, etc. At the core of this development zone is a site for a Campus Commons building, centrally located to provide

common internal campus services such as a food service area, meeting rooms, a wellness center, child care and the like.

West Campus
The West Campus is envisioned to be an infill development area with building sites contemplated as additions to existing laboratory buildings. Because this area is relatively narrow, future development opportunities are somewhat limited. Building sites may include additions to the Thermal Test Facility, the Alternative Fuels User Facility and the existing Shipping and Receiving building. In addition, there are sites south of the existing Bulk Storage building at the far west end of the campus. The west end of campus would also be well suited for expansion of outdoor test areas if building additions are not planned. Future West Campus development is characterized through the following criteria:

- Additional facilities growth that supports research affinities
- Facilities that have a low density of personnel
- Facilities that have a low impact on adjacent residential development (i.e. low noise impact, little to no after-hours usage, preservation of site lines to the mesa, low light levels, etc.)
- Smaller size buildings that work with the existing topography, easements, and drainage

Mesa Top Plan
Development on top of the Mesa is anticipated to include modifications to existing facilities to improve efficiency of land use and operations, and to improve access and information for visitors to this unique test site. Other changes in this area could include the placement of different and/or additional outdoor renewable energy devices within the area designated for development.

Open Space Plan
Open spaces for employee use are located in three different locations. The east quadrangle provides access to outdoor rejuvenation for the East Campus. The central open space area preserves a major drainage zone, while a small open space area in front of the SERF is intended to provide outdoor access for researchers in the northern part of the Central Campus.

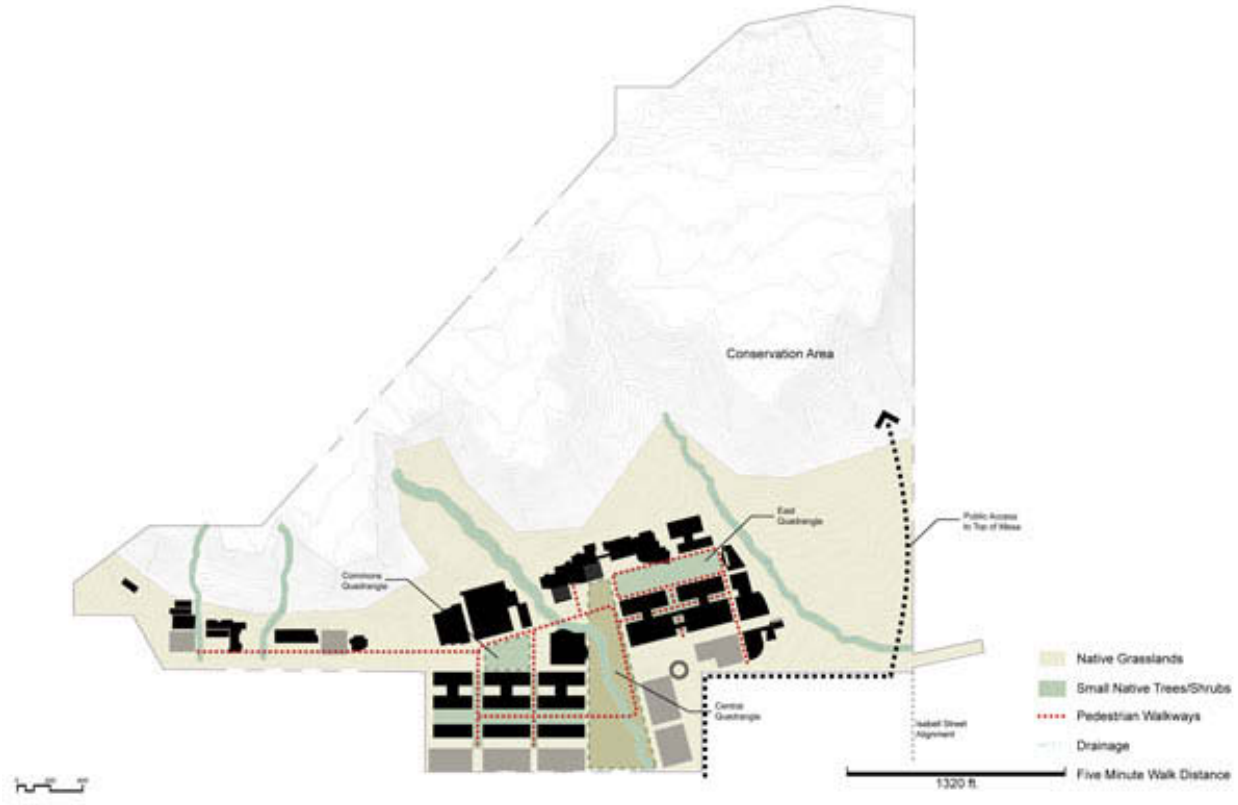


Figure 9.2.2. STM Open Space Plan

Transportation and Parking Plan
A strategy for road development on the NREL campus identified in the GDV provides for an internal roadway network and coordinated parking areas. The roadway plan is based on a loop organization and is shown in Figure 9.2.3. An outer loop runs around the perimeter of the central development area, and is primarily intended to be a service and parking access road. The northern portion of the outer loop is an extension of a service road that currently runs north of the FTLB and the SERF. The southern portion will extend south along the east and west property lines of the former Camp George West property; it then will run east and west between the laboratory building development pads and the parking areas at the south edge of the property. The inner loop runs south of the FTLB and SERF buildings and between the laboratory and administrative office sites on the southern half of the property. This roadway is intended to be primarily a pedestrian and internal shuttle route to connect the various facilities on campus. The plan suggests eliminating Denver West Parkway, which currently runs east-west through the center of the site. Because of the large number of utilities running under the road, the right-of-way will continue to be an easement.

As an overall goal for the development, parking supply should be reduced over time and incentives should be created to encourage employees to reduce automobile commuting. While some parking on campus will always be required for deliveries and handicapped spaces, the intent of the transportation plan is to reduce employee commuting in individual vehicles. On the East Campus, parking is intercepted in two primary locations near the Visitor Center and along the east edge of the southern 25-acre block. On the Central Campus, parking areas are planned at the southern edge of the property. Due to its relative remoteness and small employee population,

parking in the West Campus will be accommodated in existing and potentially modified surface parking lots.

Changes in parking areas would be phased over time. Initially, surface parking lots would be built to accommodate the parking needs associated with new development. As the population of the campus increases, the surface lots could be converted to parking structures. The topography of the campus lends itself to two-level decks that could be accessed from grade at both levels, providing for an efficient and cost-effective way of adding capacity. If the parking as shown is fully developed with two-level decks, approximately 1,500 cars could be accommodated on site.

Currently, the primary entrance to the site is from the east on Denver West Parkway. There is also a gate at the west end of the site, but it is infrequently used. The potential increase of occupants on the STM site from the current level of about 425 to the possible buildout of 2,500 suggests that site access from primarily one location may become congested. Additional roadway connections to the regional transportation network may need to be developed. Options for additional connections to the campus include an extension of Isabel Street to the north to connect into Denver West Parkway, which would provide access from the south off Colfax near the Colorado Mills shopping development. Also, roadways could be extended from South Golden Road to the north on the east and west sides of the park in the former Camp George West property. If the extension of Isabel Street is developed in the future, the location of the site entrance station and security checkpoint might be relocated west to coincide with intersection at Denver West Parkway. This would allow easy security access to a relocated Shipping and Receiving facility as well as allowing additional facilities beyond the Visitors Center to be outside the security zone if desired.

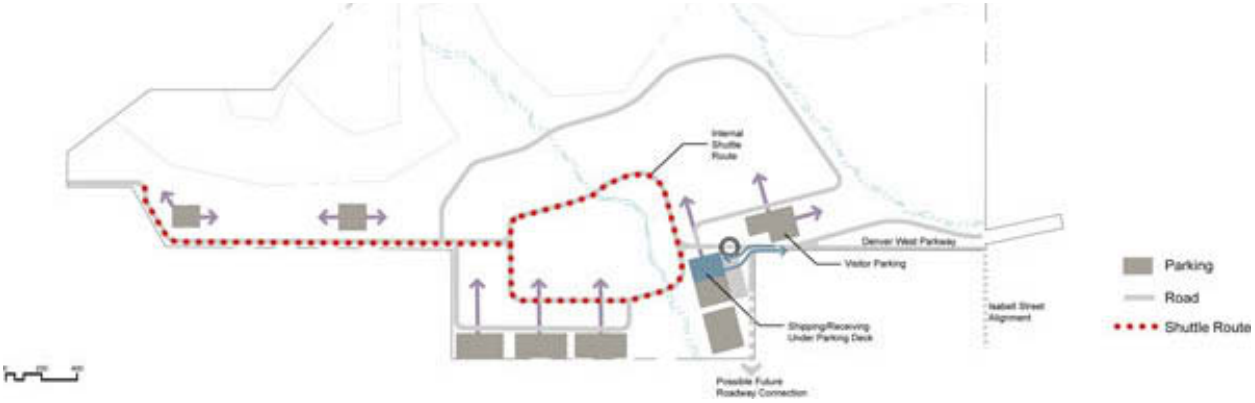


Figure 9.2.3. STM Transportation and Parking Plan

Local Impacts

Although development would increase the scale and intensity of office and research and development uses adjacent to residential areas, proposed facilities would be consistent with existing facilities and the mix of residential and office-related land uses in the area. Preservation of the existing trail easement along the eastern boundary of the site will provide a substantial setback between STM site development and the Camden Denver West condominiums. Access via the trail easement corridor through the unsecured portions of the site between the mesa top and off-site residential and park areas will remain open to the public. Development in the

southern areas of the Central Campus is not expected to adversely affect recreational use at the planned park to the south, particularly considering that use of the park would likely be most intense during the evening and on weekends when the STM site would be least active. A section of land located east of the current visitor's center is intended to remain undeveloped as open space in the 25-year planning horizon.

9.2.2 National Wind Technology Center

The assumed planning scenario for the NWTC at this time is continued use as a wind research facility. Figure 9.2.5 shows the 25-year general development vision for the NWTC. With the NWTC continuing to operate as a wind research site, additional building development is limited to the extreme northern portion of the site due to the safety area and wind fetch required for the turbines. It is possible to expand the buildable area approximately 100 feet south of the existing east/west road that runs through the site. As such, the plan suggests relocating the road to the southern development limit, providing more contiguous land for building development north of the road to the property line. Building site areas are indicated on the plan, generally clustered in four areas.

Figure 9.2.4. NWTC Land Use Plan

At the east end of the site, there is space for an additional building or buildings just west of the existing entrance gate. This would be an ideal location for a visitor center at this site, depicting the research activities that occur on the site, the natural features and wildlife of the area, as well as exhibits related to NREL research conducted at South Table Mountain. There is currently a relatively high number of visitors that come to the NWTC for tours and the visitor center would help raise public awareness of NREL activities and capitalize on the existing high public interest in the site.

Just west of the entrance station, north of the reconfigured road, is a site for additional building development. The site is relatively flat up to the existing drainage arroyo. Because of the high exposure and intense wind on site, it is preferable to use the buildings to surround parking and open space areas to protect pedestrians.

Surrounding existing Building 251 is another opportunity for additional facilities development. Again, the buildings should be used to screen the parking and open space from the predominant northwest winds. This building development could become the administrative core for the campus, expanding on the uses within Building 251.

West of Row 1 is a conservation management area that, due to its location in the wind fetch for the turbines, should remain undeveloped. The added 25 acres on the southeast side of the property will provide the NWTC with space to test the next generation of megawatt class turbines.

10 Capital Investment Plan and Budget Requests – Institutional Facilities and Infrastructure (General Plant Projects)

NREL's institutional facilities and infrastructure encompasses all the real property assets of the Laboratory. (Institutional capital equipment assets are discussed in section 11.) All of the facilities and infrastructure at NREL have been funded through the Laboratory's Lead Program Secretarial Office, the Office of Energy Efficiency and Renewable Energy. As the Lead Program Secretarial Office, EERE is responsible for maintaining and sustaining the institutional capital assets such as roads, utilities, and general purpose buildings such as security buildings, Visitors Center, and Shipping & Receiving Facility.

Real property assets also include the R&D buildings. The programs within EERE, such as Solar, Wind, etc, generally sponsor the development of the R&D facilities needed to provide adequate facilities for research. Maintaining and sustaining each R&D building in good working order for the technical mission of the Laboratory becomes a part of EERE's overall institutional responsibility for NREL. NREL uses FIMS (DOE Facility Information Management System) for real property asset information.

Section 10.1 discusses the nature, extent, and projected requirements for maintaining, sustaining, and recapitalization of all Laboratory real property.

NREL also requires funding to add new facilities and infrastructure capabilities to the Laboratory. Section 10.2 discusses the nature and extent of construction projects adding new capability.

Whether the intent is to maintain, sustain, and/or recapitalize an existing asset, or add a new asset, four types of funds are used for all institutional facility and infrastructure projects.

- Activities to maintain an asset are funded from NREL's building maintenance overhead operating budget.
- Individual projects under $1 million are funded from the Small General Plant Project pool. While the size of the pool is planned two years in advance as part of the DOE budget cycle, the individual projects are prioritized and selected at the start of each fiscal year. The use of this pool for small projects gives the Laboratory flexibility to respond to immediate needs.
- Individual projects over $1 million but less than $5 million, termed Large General Plant Projects, are identified and planned individually two years in advance in the budget cycle.
- Construction line item projects are more than $5 million, and are planned through the project management process of the DOE Office of Engineering and Construction Management (DOE Order 413.1).

Section 10.3 presents the Laboratory's Small General Plant Projects Plan. This plan consolidates small projects needed for sustaining current assets derived from the condition assessment survey work discussed in section 10.1, and small projects needed for new capabilities in facilities or infrastructure discussed in section 10.2.

10.1 Sustainment of Current Facilities and Infrastructure

Real property assets (facilities and infrastructure) must be managed in a manner that promotes operational safety, worker health, environmental compliance, property preservation and cost-effectiveness while meeting the program missions. This requires a balanced approach to managing the assets and also provide for their modernization.

Sustaining Current Assets

Sustainment consists of maintenance and repair activities necessary to keep the inventory of facilities in good working order. Sustainment includes regularly scheduled maintenance and anticipated major repairs or replacement of components that occur periodically over the expected service life of the facilities. Lack of sufficient levels of sustainment can result in a reduction in service life.

Condition Assessment Summary

In September 2003, NREL contracted with an independent and experienced firm to perform an on-site, comprehensive condition assessment survey (CAS) consisting of inspections for 375,000 square feet of DOE owned facilities and other structures and facilities (OSF), and populating deficiency data from CAS inspections into the Department of Energy's Condition Assessment Information System (CAIS). The CAIS provides a comprehensive evaluation that is used to make informed facilities management decisions. Deficiency data, optimum replacement forecasts, facility, built-in equipment, and system condition were entered in CAIS for all NREL facilities, systems, and site infrastructure. Condition assessment management reports were provided such as the Recapitalization Plan, Deferred Maintenance List, and the Ten-Year Maintenance Plan.

In summary, the NREL replacement plant value (RPV) for real property has been determined to be $176,000,000 as of 09/30/04. The NREL Facilities Condition Index (FCI) is 2.0%, which has a FCI rating characterized as "Good." The NREL Asset Condition Index (ACI) is 0.98, which has an ACI rating characterized as "Good."

Condition Assessment Process

In September 2003 Parsons Brinckerhoff, a subcontractor, assisted NREL Site Operations personnel to develop, and again in December 2004 to update the CAIS data base as a result of the intervening year of inspections and operational transactions.

Data collected during the project included:

- Identify the inspection item found deficient
- Location of the work required
- Nature and extent of each deficiency found
- Quantity affected
- Overall condition of the item
- Out-year in which the renewal work should be performed.

Condition assessments were performed consistent with the guidance provided in the DOE Real Property Asset Management (RPAM) DOE Order 430.1B, as applicable to the established DOE

Condition Assessment Survey/CAIS process. Subcontractor teams consisting of architectural, electrical, mechanical, and civil/structural inspectors performed the condition assessments. The work involved the Condition Assessment Survey of approximately 375,000 square feet of the South Table Mountain site in Golden, Colorado and the National Wind Technology Center site at NREL. The survey data was entered into the DOE's CAIS program and database for costing and reporting purposes, including prioritization of corrective projects.

The assets surveyed consisted of facilities such as office, storage, research, research support, and service/support facilities of various sizes, construction types, age, and use. The systems and subsystems included:

- Mechanical -- conveying systems; plumbing systems; fire protection; heating, ventilating, and air conditioning (HVAC) systems
- Electrical -- service and distribution (e.g. transformers, switchgear, main control centers); lighting; generators; uninterruptible power supplies (UPS); lightning protect; fire alarm panels
- Structural -- foundations and footings; substructure; superstructure; exterior closure; roofing (actual invasive inspections of the roofing system will not be required); interior finishes
- Other structures and facilities -- roads, walks and paved areas; exterior lighting; storm water lines; fiber optic cables; fencing

Replacement Plant Value

The project team determined and validated the NREL's real property Replacement Plant Value (RPV), the site's mainline utility systems, and other structures and facilities. The RPV for facilities and infrastructure was determined to be $176,000,000. See Table 10.1.1.

Table 10.1.1. NREL Replacement Plant Value and Deferred Maintenance

	Replacement Plant Value	Deferred Maintenance
South Table Mountain Site	$150,612,000	$2,957,000
National Wind Technology Center Site	$25,368,000	$550,000
Overall	$175,980,000	$3,507,000
NREL Facility Condition Index = $3,507 / $175,980 = 2.0%		

Deferred Maintenance Backlog

The deferred maintenance backlog is the list of replacements that were not completed when they should have been or were scheduled to be performed, and which were deferred or delayed for a future period. The total NREL deferred maintenance backlog is $3,507,000. A five-year plan to eliminate the deferred (replacement in kind) maintenance backlog is shown in Table 10.1.2.

Table 10.1.2. Deferred Maintenance Backlog Reduction Plan

YEAR	STM	NWTC	TOTAL
2005	$791,022	$37,293	$828,315
2006	$9,754	$2,773	$12,527
2007	$1,093,785	$170,000	$1,263,785
2008	$530,000	$170,000	$700,000
2009	$532,894	$169,840	$702,734
TOTAL	$2,957,455	$549,906	$3,507,361

Facility Condition Index (FCI)

The Facility Condition Index (FCI) is the ratio of the current deferred maintenance backlog in dollars divided by the current real property replacement plant value in dollars. The NREL FCI is 2.0% (Table 10.1.3). The goal is for the FCI to approach zero as the backlog of deferred maintenance decreases at a site. Therefore, the smaller the FCI, the more favorable the maintenance condition.

Table 10.1.3 Facility Condition Index Ratings

Excellent < 2% (0 to 1.9)
Good < 5% (2.0 to 4.9)
Adequate < 10% (5.0 to 9.9)
Fair < 25% (10.0 to 24.9)
Poor < 60% (25.0 to 59.9)
Fail < 100% (60.0 to 99.9)
Reference: DOE Order 430.1B

Asset Condition Index (ACI)

The Asset Condition Index (ACI) is the Department's corporate measure of the condition of its facility assets. The ACI reflects the outcomes of real property maintenance and recapitalization policy, planning, and resource definitions. The Asset Condition Index is one (1) minus the Facility Condition Index (FCI).

$$ACI = 1 - FCI$$

Ratings are assigned to ACI range measures. The goal is for the ACI to approach unity (1). The ACI increases and approaches unity as the condition of facilities improves at a site. ACI ranges and ratings are also shown in Table 10.1.4. NREL's ACI is (1.0 – 0.02) = 0. .98 or Good.

Table 10.1.4. Asset Condition Index (ACI) Ratings

ACI Range	ACI Rating
1.00 > 0.98	Excellent
0.98 > 0.95	Good
0.95 > 0.90	Adequate
0.90 > 0.75	Fair
0.75 > X	Poor

Condition Assessment Information System (CAIS) Database
A standardized, documented inspection Condition Assessment Information System (CAIS) database that provides accurate, consistent and repeatable results was developed. Standardized cost data is attained by using the CAIS to determine repair and replacement costs. This report provides NREL with the capabilities to break out the deferred maintenance cost by asset components or systems, and reports the five highest Facility Condition Index (FCI) deficient systems for all assets in FIMS. It allows NREL to calculate an FCI by asset system, report system deficiencies, and prioritize current and anticipated deferred maintenance and repair requirements by asset system. Summary reports documenting general building conditions, system and component deficiencies, including life safety code deficiencies and general accessibility deficiencies, and recommendations for repair or replacement of the deficient components or systems are generated using the CAIS database.

Deferred Maintenance List
A list of deferred maintenance items has been developed (Appendix E-1 and EH-2) with an estimate of costs including a Golden, Colorado-based site factor and an NREL site factor. The costs were based on a national cost estimating system developed by R.S. Means and are embedded into the CAIS.

Ten-Year Maintenance Plan
A ten-year maintenance plan has been developed (Appendix E-3 and E-4) based on projections of serviceability, economic life, and the mission of the each facility. The ten-year maintenance plan summary (Table 10.1.5) for the National Renewable Energy Lab for FY 2004-2015 consists of all replacement actions regardless of deferred maintenance status. Consequently, in addition to actions currently classified as deferred maintenance, it includes those for components not yet at the end of useful design life, but projected to reach the end during the next ten years.

Maintenance is "..work that is required to sustain property in a condition suitable for it to be used for its designated purpose(s).." while repair is the "restoration of failed or malfunctioning equipment, system, or facility to its intended function or design condition." For the purpose of the planning process, replacement of components or systems constitutes a repair action normally at the end of the useful design or service life.

The year in which the replacement action is recommended is the end of the optimum period. The optimum period is defined in the DOE O 430.1B as ".. that time in the life cycle of an asset when maintenance actions should be accomplished to preserve and maximize the useful life of the asset. The determination is based on engineering/maintenance analysis and is independent of funding availability." It corresponds to the optimum year field in the CAIS2000 database.

Annual, asset, optimum year, real property replacement costs for both the South Table Mountain (STM) and the National Wind Technology Center (NWTC) sites are noted in Table 10.4 as well as the total overall ten year costs.

Sustaining real property is, in practice, an ongoing series of planned projects to replace building components as they age. In the near term, each of these projects at NREL is expected to be

typically under $1 million. As mentioned in the section 10 introduction, two funding mechanisms are used today for these smaller projects. NREL's Small General Plant Project pool is used for planned expenditures for sustainment including both deferred and regular (on-time) maintenance (section 10.3). Some maintenance is funded through Laboratory overhead (Building Maintenance) and is used for operating projects, as is shown in Table 10.1.5.

It should be noted, however, that in the later years of this plan, NREL's sustainment activities may not be able to be funded out of the Small General Plant Project pool. It is expected that as NREL's real property approaches the end of its optimal period, a larger investment will be necessary requiring the identification of a separate Large General Plant Project or Construction Line Item project. This can be seen on the horizon for NREL in the large planned costs in FY2012-2014 in Table 10.1.4, which are arising from the aging of the Solar Energy Research Facility, Outdoor Test Facility, Thermal Test Facility, and Alternative Fuels User Facility, all built in the early 1990s.

Table 10.1.5. Infrastructure Maintenance Projected Requirements

	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15
(A) Real Property Replacement In Kind at End of Optimum Period	$83K	$211K	$553K	$375K	$1,305K	$68K	$228K	$1,030K	$4,367K	$3,739K	$494K
(B) Deferred Maintenance Backlog Reduction	$828K	$12K	$1,264K	$700K	$703K						
(C) Escalation (5% per year)	0	$11K	$186K	$166K	$432K	$18K	$77K	$419K	$2,085K	$2,061K	$310K
(A)+(B)+(C)	$911K	$234K	$2,003K	$1,223K	$2,440K	$86K	$305K	$1,449K	$6,452K	$5,800K	$804K
Building Maintenance (Overhead)	$2,067K	$2,170K	$2,279K	$2,392K	$2,512K	$2,638K	$2,769K	$2,908K	$3,053K	$3,206K	$2,164K

10.2 Institutional Requirements for New Capabilities in Facilities and Infrastructure

As mentioned in the introduction to section 10, NREL frequently needs capital funds to develop new capabilities in facilities and infrastructure. The need for projects to add new capability arises from several reasons:

1) NREL does not yet have several key institutional structures which are taken for granted at other DOE facilities, including an administrative or research support building, a cafeteria, a conference center, a data center, or a warehouse.
2) NREL's sites are only partially developed, and periodically roads or utilities need to be changed or extended, pathways and outdoor areas need to be constructed, parking lots needs to be constructed, and landscape maintenance systems need to be added.
3) NREL's research changes directions frequently, requiring modifications to existing laboratories or reconfiguring of space inside existing buildings.
4) Safety, security, and/or energy and water efficiency requirements frequently change, necessitating capital improvements to facilities and infrastructure.
5) Technology improvements offer opportunities to improve building management, such as new energy management systems or new liquid or gas utility distribution systems.

Examples of FY05 projects planned to build new capabilities include extending the new natural gas line at the NWTC to a research building; expanding a small existing laboratory building; adding an electrical connection between a small dynamometer and a main electrical bus at the NWTC; and remodeling space within the FTLB to form a new Genomics Laboratory.

Like sustainment projects, the funding for new capability projects depends on the magnitude of the project. Projects under $1 million are generally accomplished through NREL's Small General Plant Project pool; projects larger than $1 million are planned and justified individually two years in advance; and projects larger than $5 million are planned as construction line item projects.

10.3 Small General Plant Projects Plan

As mentioned above, NREL's Small General Plant Projects pool addresses the smaller (<$1M) projects needed to sustain current facilities and infrastructure as well as to build new capabilities. Figure 10.3.1 shows the historical funding for Small General Plant Projects, and Appendix G summarizes the individual projects that were funded from the Small General Plant Projects pool in FY03 and FY04. The planned expenditures for FY2005-FY2015 are shown in Table 10.3.1 and Figure 10.3.2.

A comparison of the timely replacement-in-kind maintenance, deferred replacement-in-kind maintenance, and new capability requirements determined by NREL's condition assessment survey and internal planning process, and the latest information on potential GPP funding for FY2005, indicates a shortfall. This means that some items intended to be addressed in FY2005 will roll forward to FY2006, and similarly for FY2006 to FY2007. Analysis shows that the net impact of the funding shortfalls in FY2005 and FY2006 results in the need for an additional $0.6 million of GPP funding in FY2007 to replace items on the deferred replacement list.

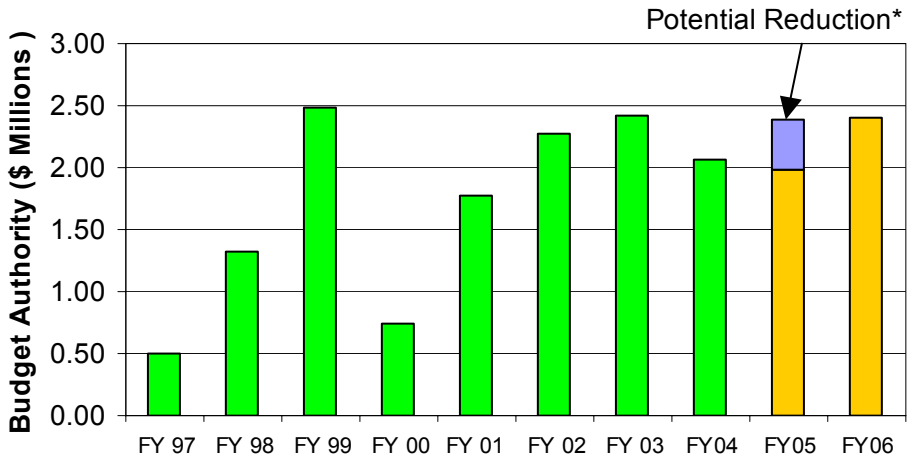


Figure 10.3.1. Institutional Small General Plant Projects Funding 1997-2004 (2005, 2006 estimate)

* Although Congress appropriated $2.4 million for NREL's General Plant Projects and General Purpose Equipment funds in FY05, there is a likelihood that there will be a $1 million reduction in actual funds received when compared to that approved by Congress. Of that $1 million, $0.4 is assumed to affect Small General Plant Projects funding.

Table 10.3.1. NREL FY 2005 – FY 2015 Small General Plant Projects Plan ($ million)

	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015
Planned Expenditures											
Deferred Maintenance	$0.229	$0.400	$1.971	$0.810	$0.855	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Regular Maintenance	$0.000	$0.000	$0.610	$0.434	$1.586	$0.087	$0.306	$1.449	$6.452	$5.800	$0.805
New Capability	$1.801	$2.000	$2.100	$2.205	$2.315	$2.431	$2.553	$2.680	$2.814	$2.955	$3.103
Total	$2.030	$2.400	$4.681	$3.449	$4.756	$2.518	$2.858	$4.130	$9.266	$8.755	$3.907

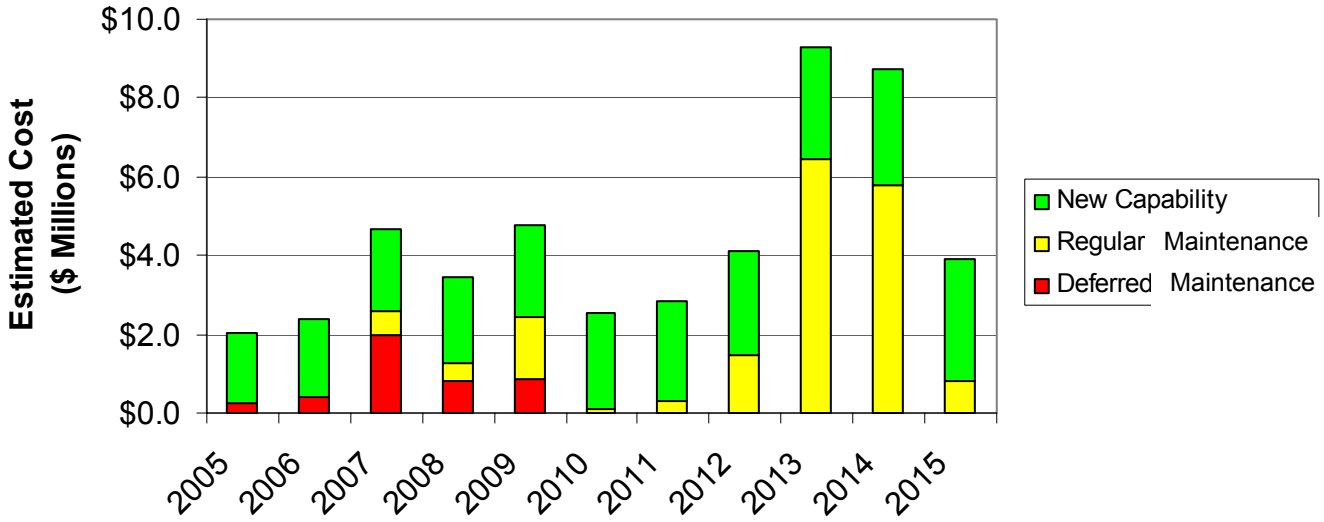


Figure 10.3.2. Small General Plant Project Plan (excluding Facility-Specific Equipment, FY05-FY15)

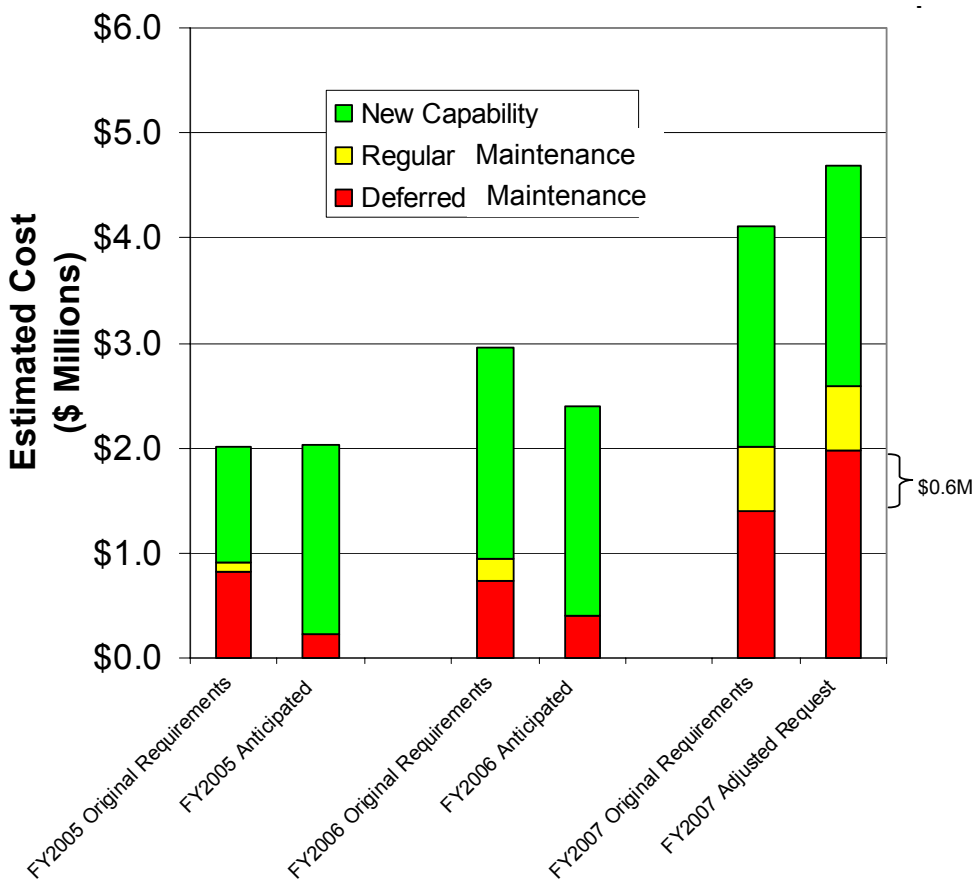


Figure 10.3.3. Reductions in FY2005-FY2006 GPP Funding Add $0.6 Million for Deferred Maintenance to 2007 Request

Large (>$1 million) Projects (Including General Plant Projects, Construction Line Item Projects, and Third-Party Financed Projects)

In addition to the small (<$1 million) facilities and infrastructure projects required as described in sections 10.1-10.3, several larger projects will also be needed in the ten-year planning period. These include Large GPP projects, Construction Line Item Projects, and one Third-Party Financed project. These large projects can be driven by program needs, as described in section 8, or institutional needs, as described here in section 10.

Large projects can serve to add new capabilities to the Laboratory, similar to Small GPP projects described above. Or, large GPP or CLI projects may be necessary to recapitalize facilities. Facilities eventually wear out or become outdated and incapable of supporting mission needs. These facilities will need to be replaced, recapitalized, or disposed of if they are excess to needs. Recapitalization extends the service life of facilities or restores lost service life, and consists of alterations and betterments needed to keep existing facilities modern and relevant in an environment of changing standards and missions. Recapitalization investments do not sustain facilities and will, therefore, be complemented by an effective sustainment program to protect the facility. Therefore, recapitalization is defined as major renovations or reconstruction activities, including facility replacements needed to keep existing facilities modern and relevant in an environment of changing standards and missions.

10.4 Candidate Construction Project (Third-Party Financed): Research Support Facility

Project Description

NREL's administrative functions and several major programmatic activities, including R&D, are conducted in leased office space more than a mile from NREL's primary South Table Mountain site. NREL proposes constructing a facility of one to three individual buildings as much as 300,000 total gsf to house administrative and research support functions, including space for approximately 900 occupants. Current plans are that the facility will be financed, designed, and constructed by a private-sector developer on land within the South Table Mountain site. The facility is intended to be consistent with the principles of LEED Platinum certification using as much EERE technology as possible, while demonstrating that this can be done in a manner to create occupancy costs competitive with non-LEED-designed buildings in the Denver market. The estimated total project cost of $60 million in private financing does not include the cost of extending roads and utilities to the building site chosen for the facility.

Program Beneficiaries

- All EERE programs

Project Justification / Program Requirements

NREL currently (12/31/04) pays $3.4 million/year for leasing more than 200,000 gsf of office and administrative space in the Denver West Office Park for NREL operations. In addition, the DOE Golden Field Office and Denver Regional Office occupy 48,000 gsf of leased office space also in Denver West Office Park. The proposed Research Support Facility would provide leased space for approximately equivalent functions and expected growth into the future, but with the following advantages compared to the present leases:

- Currently administrative functions are located 1.5 miles away from the major research activities. This project would co-locate all administrative functions for NREL with research activities at the South Table Mountain Site.
- Co-location will improve both administrative and research productivity, reduce the duplication of services, reduce lost time in commuting, reduce loss of real-time information sharing, and improve the efficiency of environmental, safety, and security management.
- The Research Support Facility will be a showcase for energy efficiency and sustainable design, in accordance with EERE's vision that "The Federal government will lead the Nation in conserving energy and using renewable energy resources."
- Federal funds will not be required for design and construction.

Alternatives to be Considered to Meet Program Requirements

The following options have been considered and documented:

1. Continue the present leases in Denver West Office Park.
2. Find alternative leased office space at a location even further away from research activities.
3. Seek congressional line item funding for such a facility

Current Proposed (or Actual) Project Schedule
The project authorization, design, and completion is dependent upon the issuance of DOE's policy on third-party financing.

Current Proposed Federal Funding Profile ($ million)
Federal funding is required to extend roads and utilities to the intended building site. Assuming that the building will be sited in the south central campus area of the South Table Mountain site, roads and utilities will be extended through the large GPP project, STM Roads and Utilities Southern Extension, at an estimated cost of $2.7 million in FY2007. See section 10.5 for a description of this project.

10.5 Candidate Construction Project (Large GPP) - HVAC Expansion

Project Description

This project will provide additional HVAC capability to the Field Test Laboratory Building. A new 1,400-gsf penthouse will be added to the north central area of the building. The new penthouse would house mechanical equipment, such as, one air handling unit and two exhaust fans, which would service the future research laboratories. This project will provide the HVAC infrastructure to the future remodeling of approximately 20,000 gsf of interior space into new laboratories. The new penthouse will be located just north of the future renovated offices to laboratories and just west of the Central Plant. The estimated capital cost, including necessary HVAC equipment, is $1.1 million in FY2007.

Program Beneficiaries

- All NREL programs

Project Justification / Program Requirements

All of the FTLB laboratories are currently 100% utilized. NREL needs additional laboratories in several programmatic areas. The FTLB is the only DOE-owned research building, which currently has space under roof that can be remodeled in a reasonable timeframe to provide urgently needed additional bench-scale laboratory space for changing and growing program areas including Biomass, Hydrogen, and the Office of Science. While the ultimate strategy for the FTLB is to focus on biosciences, in the short-term, the FTLB could accommodate some engineering-scale research and testing for Solar, Geothermal, and other programs that have nowhere else to conduct their experiments. However, the current HVAC system already limits the types and extent of work that can be done in existing research spaces. No additional space can be remodeled for additional research work until additional HVAC is provided.

This expansion of the HVAC system will support the remodeling of 20,000 gsf of interior space to laboratories. It will also broaden the types and extent of research that can be conducted in existing laboratories.

Table 10.5.1. Current Proposed Project Schedule

	Month-Year
Start design and construction	Jan. 2008
Complete construction	Jan. 2009

Table 10.5.2. Current Proposed Funding Profile ($ millions)*

		FY2007	Total
Detailed Design and Construction	Capital	$1.1	$1.1

* All numbers represent mid-point with uncertainty of +/- 20%

10.6 Candidate Construction Project (Large GPP): South Table Mountain Road and Utility Southern Extension

Project Description

A significant portion of the South Table Mountain Site has not yet been developed. In 2003, NREL prepared a General Development Vision (GDV) that outlines the intended usage of various portions of the South Table Mountain site. The GDV transportation plan optimizes usage of the central portion of the South Table Mountain site, and replaces the single east-west road traversing the center of the site with a central loop configuration. The loop configuration is necessary to connect buildings planned for the southern portion of the central campus, and to allow the reconfiguration of access and parking to buildings on the northern portion of the central campus.

This project describes three separate subprojects that are the minimum required to support the first proposed building on the undeveloped southern portion of the site. The next two facility projects that may be sited on the south central campus are the Research Support Facility and / or the Engineering Test Lab. Siting decisions for these buildings have not yet been made. However, for the purposes of this FY2005-FY2015 Ten-Year Site Plan / Capital Investment Plan, both the Research Support Facility and the Engineering Test Lab are assumed to be sited on this south central campus.

The three subprojects include: Lower Inner Loop Road (LILR) Subproject, Lower Parking Access Road (LPAR) Subproject, and one Parking Lot Subproject. Figure 10.5.1 locates each subproject on the STM campus vision. The Lower Inner Loop Road would build a new road and extend utilities to the south central campus. The Lower Parking Access Road will allow access to the southern parking lots in accordance with the General Development Vision. The Parking Lot subproject is a representative project that estimates the cost of one of the three surface parking lots at the southern boundary of the site. This much parking may be just enough for the proposed 110 occupants of the Engineering Test Laboratory, but not nearly enough for the Research Support Facility. Parking solutions for the Research Support Facility have not yet been developed in this plan. The two subprojects affecting the eastern campus development (Upper Loop Connector Road and Upper Inner Loop Road) are described in section 9.2, Road and Utility Infrastructure for the East Campus.

This set of three subprojects is estimated at $2.7 million in FY2007. However, the extension of the utility services, roads, and parking lots can be completed in segments as funding becomes available. Any necessary roads, parking lots, and utility extensions will need to be completed prior to beneficial occupancy of future buildings.

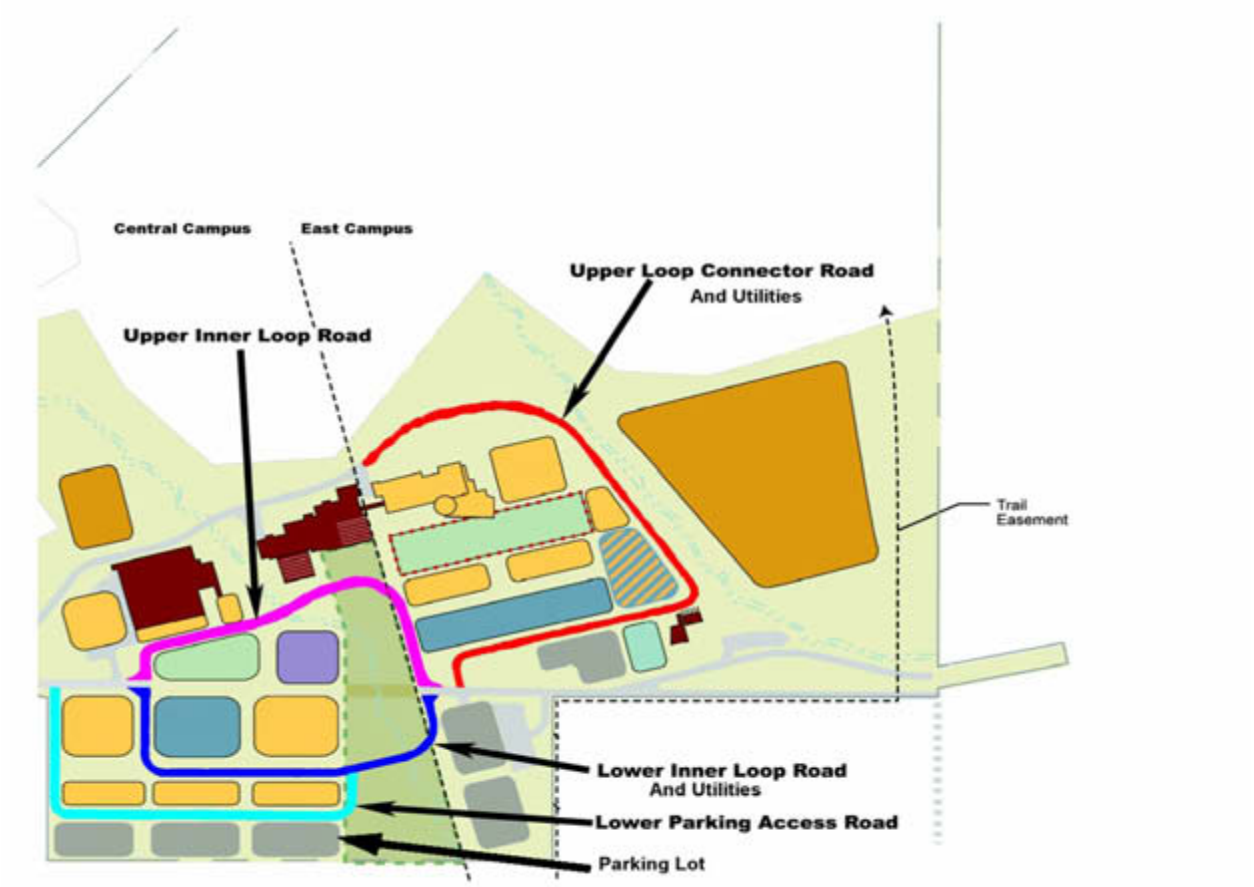


Figure 10.6.1. Map of Road and Utility Infrastructure of the Central and East Campus

Lower Inner Loop Road (LILR) Subproject
The cost of this subproject in FY2007 is estimated at $1,677,000.
Road description:

The road construction will include approximately 1400 LF of new 2-lane roadway that will be designed and constructed to be similar to other NREL roads. It will be paved with asphalt, and be approximately 23 feet wide. Concrete curbs and gutters are included in the road construction. The LILR will tie-into the existing road as illustrated on Figure 10.5.1. When the Upper Inner Loop Road is completed, the existing road between the tie-in points will be demolished. The road can be constructed in segments (e.g., 500 - 700 feet) to access specific buildings as they are constructed.

Mechanical Utility description:
The Mechanical Utilities will include Domestic Cold Water (DCW), Natural Gas (NG), and Sanitary Sewer (SS). Fire Line and Storm Line costs will not be included in this project and will be associated with the individual building costs. The new services will tie into the existing services located along the main road that runs in the East/West direction.

The mechanical cost estimate is based on the installation of approximately 1400 LF of 12" DCW ductile iron pipe, 1400 LF of 4" NG polyethylene (PE) pipe, and 1400 LF of 8" SS

polyvinylchloride (PVC) pipe. The new 12" DCW pipe will tie into the existing 12" DCW main in the main road. The new 4" NG pipe will tie into the existing 4" NG main before the existing SERF 4" NG pipe branch takeoff. The new 8" SS pipe will tie into the existing 8" SS main in the main road. These new utilities will be extending from the existing main road and will follow the lower inner loop road. Buildings built on either side of this road will have access to these utility services. Each facility in the lower inner loop of the Central Campus has the ability to tie into the natural gas service to provide its own building heating plant, as well as tie into the electrical power service to provide its own building cooling plant. However, it does not preclude the option of servicing the heating and cooling of these facilities from its own lower inner loop Central Plant (refer to Option 2 of Sustainable Options section) or tying these facilities to the two existing Central Plants located at the SERF and the FTLB to conform to a STM Central Plant (refer to Option 3 of Sustainable Options section).

The underground mechanical utilities can be installed in segments (e.g., 500 – 700 feet at a time) to serve specific buildings, as they are constructed in the south portion of the Central Campus area. The mechanical utility services would be installed by their respective utility company. The natural gas utility would be installed by Xcel Energy, the domestic water utility would be installed by Consolidated Mutual Water and the Sanitary Sewer lines would be installed by Pleasant View Water and Sanitation.

Electrical & Telecommunication Utilities description:
The underground electrical infrastructure will be expanded to serve the LILR (Central Campus) area by extending one of the three existing 13.2KV primary distribution underground system loops. The LILR electrical feeder will originate from these loops at the STM site service entrance (south of the FTLB at the main road at outdoor pad mounted switch). The existing underground telecommunication (voice & data) will be expanded to serve the Central Campus by extending the existing underground telecommunication infrastructure.

The electrical cost estimate is based on the installation of six (6) pad-mounted switches and 1400 feet of underground electrical cable in 5-inch PVC conduit. The underground electrical cables are sized to carry a 10MVA load. The cost estimate for the Central Campus underground telecommunication infrastructure is based on 2-each 4-inch PVC conduits with 3 - each 1-inch inner ducts. The conduit will carry 3,000 feet of 600 pair voice cable and 3,000 feet of fiber cable (48sm/48mm). No new telecommunication manholes were included in the estimate.

The underground electrical and telecommunication utilities can be installed in segments (e.g., 500 - 700 feet at a time) to serve specific buildings as they are constructed in the Central Campus Area. The underground utilities will be strategically routed to effectively serve the Central Campus area. The underground electrical utility shall be designed to provide the capability for a redundant loop in case of underground electrical failure. The electrical underground utility, after being installed by NREL's contractor, shall be part of NREL's property (the new utilities tie to NREL's side of the existing STM electrical service meter).

Lower Parking Access Road (LPAR) Subproject
The cost of this project in FY2007 is estimated to be $630,000.
Road description:
The road construction will include approximately 1600 LF of new 2-lane roadway that will be designed and constructed to be similar to other NREL roads. It will be paved with asphalt, and be approximately 23 feet wide. Concrete curbs and gutters are included in the road construction. On the east, the LPAR will tie-in to the Lower Inner Loop Road. On the west, it will join the existing road (Figure 10.5.1). The road can be constructed in segments (e.g., 500 - 700 feet) to access specific buildings as they are constructed.

Mechanical Utility description
No mechanical utilities will be incorporated in this project.

Electrical & Telecommunication Utilities description
No electrical or telecommunication utilities will be incorporated in this project.

Parking Lot Subproject
The cost of this subproject in FY2007 is estimated to be $360,000.
Parking Lot description:
The surface parking lot construction will consist of a rectangular area that is approximately 285 feet by 130 feet. Space will be available for approximately 112 vehicles. It will be paved with asphalt, with concrete curbs and gutters. The parking lot can be constructed in segments to accommodate buildings as they are constructed and available funding. Other similar surface parking lot projects may be necessary to accommodate building projects in this Ten-Year Site Plan.

Mechanical Utility description
No mechanical utilities will be incorporated in this project.

Electrical & Telecommunication Utilities description
No electrical or telecommunication utilities will be incorporated in this project.

Program Beneficiaries
- All EERE Programs

Sustainable Options
The following options can be explored as part of the development of future infrastructure:

1. Gravel Roads - The construction costs for a gravel road are estimated to be approximately one-third less than for a paved roads. However, gravel roads are not recommended for the following reasons:
    - Heavy vehicles routinely travel over NREL roads. The vehicles include delivery trucks and those associated with laboratory testing. Hard surface roads withstand this type of loading much better than gravel roads.
    - Maintenance costs for snow removal and upkeep are higher for gravel roads.

- Airborne particulate matter (dust) in the relatively high wind area of Golden will be substantially higher than with roads paved with asphalt. Dust will have an adverse impact on employees, laboratory instruments and equipment, and nearby residents.

2. Central Plants within the South Central Campus and the East Campus – This option would consider having a central plant located in the South Central Campus and in the East Campus to service the South Central facilities and East Campus facilities, respectively. The Central Plant within each campus would tie into the natural gas and electrical power service utility mains to provide the heating and cooling plant, respectively. The underground heating and cooling lines from the Central Plant would be distributed to the facilities within each campus and can be installed in segments (e.g., 500 – 700 feet at a time) to serve specific buildings, as they are constructed.

3. STM Central Plant with Biomass – The STM Central Plant with biomass option will have the heating and cooling for all existing and future facilities on the STM site centrally located between the FTLB and SERF. FTLB has an existing heating and cooling plant that services all existing facilities west of the FTLB and the SERF has a heating and cooling plant that will service the SERF and S&TF (located east of the SERF). The STM Central Plant will tie the two cooling plants together and incorporate the proposed Renewable Fuel Heating Plant (RFHP) to provide the cooling and heating, respectively, for all of facilities (existing and future) on the STM site. The RFHP is a wood chip fueled boiler plant that would provide the heating to the existing and future facilities on the South Table Mountain Site. If the RFHP proposal is not approved, it does not preclude having the heating serviced by the two existing central plants. The cost estimate includes heating and cooling pipes to extend from the STM Central Plant to service the South Central Campus and the North portion of the East Campus. The underground heating and cooling lines can be installed in segments (e.g. 500 – 700 feet at a time) to serve specific buildings, as they are constructed.

Table 10.6.1. STM Road and Utility Extension (Southern) Project Schedule

	Month-Year
Start Design/Construction*	November 2007
Complete Construction	May 2008
*Assumes receipt of funding in October 2007	

Table 10.6.2. STM Road and Utility Extension (Southern) Project Funding Profile ($ million)

		FY2005	FY2006	FY2007	FY2008 and beyond	Total
Conceptual Design	Operating		$0.093			$0.093
Detailed Design and Construction – Lower Inner Loop Road	Capital			$1,670		$1.677
Detailed Design and Construction – Lower Parking Access Road	Capital			$0.630		$0.630
Detailed Design and Construction – Parking Lot	Capital			$0.360		$0.360
Total Capital	Capital			$2.667		$2.667

10.7 Candidate Construction Project (Large GPP): South Table Mountain Road and Utility Northern Extension

Project Description

A significant portion of the South Table Mountain Site has not yet been developed. In 2003, NREL prepared a General Development Vision (GDV) that outlines the intended usage of various portions of the South Table Mountain site. The GDV transportation plan optimizes usage of the central portion of the South Table Mountain site, and replaces the single east-west road traversing the center of the site with a central loop configuration. The loop configuration is necessary to connect buildings planned for the southern portion of the central campus, and to allow the reconfiguration of access and parking to buildings on the northern portion of the central campus.

This project describes two separate subprojects related to extending the road and utility infrastructure through the South Table Mountain north central section in accordance with the NREL General Development Vision. The next two projects for construction on the South Table Mountain site are the Research Support Facility and / or the Engineering Test Lab. Siting decisions have not yet been made. However, for the purposes of this FY2005-FY2015 Ten-Year Site Plan / Capital Investment Plan, both the Research Support Facility and the Engineering Test Lab are assumed to be sited on the south central campus. Therefore, the northern extension is planned in the outyears, shown in this plan in FY2010.

The two subprojects include: Upper Loop Connector Road (ULCR) Subproject and Upper Inner Loop Road (UILR) Subproject. Figure 10.6.1 locates each subproject on the STM campus vision. The Upper Loop Connector Road would build a new road and extend utilities to new areas of the northeast STM campus. The Upper Inner Loop Road would provide shuttle and pedestrian access from peripheral parking lots to the FTLB, SERF, STF, and other future buildings on the east campus. The three subprojects affecting the south central campus development (Lower Inner Loop Road (LILR) Subproject, Lower Parking Access Road (LPAR) Subproject, and one of the three southern parking lots) are described in section 9.2, Road and Utility Infrastructure for the South Central Campus.

This set of two subprojects is estimated at $3.0 million in FY2010. However, the extension of the utility services, roads, and parking lots can be completed in segments as funding becomes available. Any necessary roads, parking lots, and utility extensions will need to be completed prior to beneficial occupancy of future buildings.

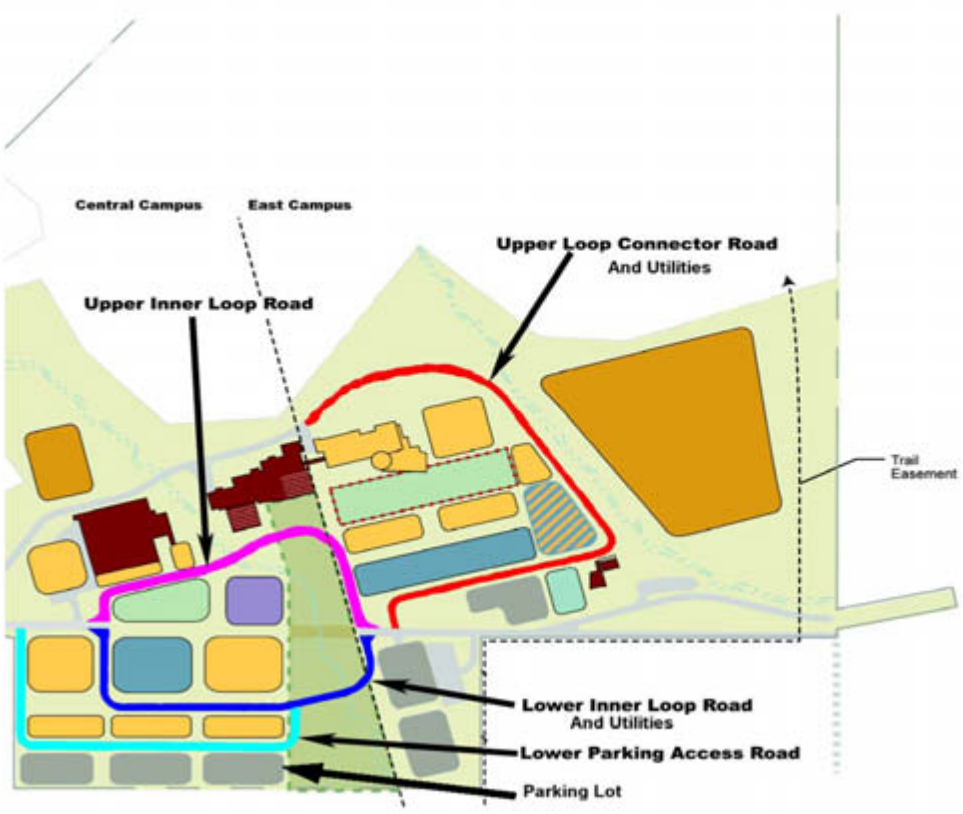


Figure 10.7.1. Map of Road and Utility Infrastructure of the Central and East Campus

Upper Loop Connector Road (ULCR) Subproject
The cost of this subproject in FY2010 is estimated to be $2,327,000.
Road description:
The road construction will include approximately 2400 LF of new 2-lane roadway that will be designed and constructed to be similar to other NREL roads. It will be paved with asphalt, and be approximately 23 feet wide. Concrete curbs and gutters are included in the road construction. The ULCR will tie-into the existing roads as illustrated on Figure 10.6.1. On the north, the ULCR will tie-in to the road behind the SERF. On the southeast, it will join the existing road. The road can be constructed in segments (e.g., 500 - 700 feet) to access specific buildings as they are constructed.

Mechanical Utility description
The mechanical utilities include Domestic Cold Water (DCW), Natural Gas (NG), and Sanitary Sewer (SS). Fire Line and Storm Line costs will not be included in this project and will be associated with the individual building costs. The new utility services will tie into the existing services located along the main road that runs in the East/West direction.

The mechanical cost estimate is based on the installation of approximately 1400 LF of 12" DCW ductile iron pipe, 1400 LF of 4" NG polyethylene (PE) pipe, and 1400 LF of 8" SS

polyvinylchloride (PVC) pipe. The new 12" DCW pipe will tie into the existing 12" DCW main in the main road. The new 4" NG pipe will tie into the existing 4" NG main before the existing SERF 4" NG pipe branch takeoff. The new 8" SS pipe will tie into the existing 8" SS main in the main road. These new utilities will be extending from the existing mechanical utility infrastructure located in the main road to service the North portion of the East Campus. Each facility in the upper loop of the East Campus has the ability to tie into the natural gas service to provide its own building heating plant, as well as tie into the electrical power service to provide its own building cooling plant. However, it does not preclude the option of servicing the heating and cooling of these facilities from its own East Campus Central Plant (refer to Option 2 of Sustainable Options) or tying these facilities to the two existing Central Plants located at the SERF and the FTLB to conform to a STM Central Plant (refer to Option 3 of Sustainable Options).

The underground mechanical utilities can be installed in segments (e.g. 500 – 700 feet at a time) to serve specific buildings, as they are constructed in the north portion of the East Campus area. The mechanical utility services would be installed by their respective utility company. The natural gas utility would be installed by Xcel Energy, the domestic water utility would be installed by Consolidated Mutual Water and the Sanitary Sewer lines would be installed by Pleasant View Water and Sanitation.

Electrical & Telecommunication Utility description
The underground electrical infrastructure will be expanded to serve the ULCR (East Campus) area by extending one of the three existing 13.2KV primary distribution underground system loops. The ULCR (East Campus) electrical feeder will originate from the existing underground loops at a pad-mounted switch located adjacent to the SERF Energy Center. The existing underground telecommunication (voice & data) will be expanded to serve the East Campus by extending the existing underground telecommunication infrastructure.

The electrical cost estimate is based on the installation of six (6) pad-mounted switches and 1400 feet of underground electrical cable in 5-inch PVC conduit. The underground electrical cables are sized to carry a 10MVA load. The cost estimate for the East Campus underground telecommunication infrastructure is based on 2-each 4-inch PVC conduits with 3 - each 1-inch inner ducts. The conduit will carry 1,600 feet of 600 pair voice cable and 1600 feet of fiber cable (48sm/48mm). No new telecommunication manholes were included in the estimate.

The underground electrical and telecommunication utilities can be installed in segments (e.g. 500 - 700 feet at a time) to serve specific buildings as they are constructed in the East Campus Area. The underground utilities will be strategically routed to effectively serve the East Campus area. The underground electrical utility shall be designed to provide the capability for a redundant loop in case of underground electrical failure.

Upper Inner Loop Road (UILR) Subproject
The cost of this subproject in FY2010 is estimated to be $676,000.
Road description
The road construction will include approximately 1400 LF of new 2-lane roadway that will be designed and constructed to be similar to other NREL roads. In addition, approximately 900 feet

of the existing road will be demolished. On Figure 10.6.1, the existing road is already shown to have been removed.

It will be paved with asphalt, and be approximately 23 feet wide. Concrete curbs and gutters are included in the road construction. The UILR will tie-into the existing road as illustrated on Figure 10.6.1. On the east and west, it will join the existing road. The road can be constructed in segments (e.g., 500 - 700 feet) to access specific buildings as they are constructed.

Mechanical Utility description:
No mechanical utilities will be incorporated in this project.

Electrical & Telecommunication Utilities description:
No electrical or telecommunication utilities will be incorporated in this project.

Program Beneficiaries

- All EERE Programs

Sustainable Options

The following options can be explored as part of the development of future infrastructure:

1. Gravel Roads - The construction costs for a gravel road are estimated to be approximately one-third less than for a paved roads. However, gravel roads are not recommended for the following reasons:
   - Heavy vehicles routinely travel over NREL roads. The vehicles include delivery trucks and those associated with laboratory testing. Hard surface roads withstand this type of loading much better than gravel roads.
   - Maintenance costs for snow removal and upkeep are higher for gravel roads.
   - Airborne particulate matter (dust) in the relatively high wind area of Golden will be substantially higher than with roads paved with asphalt. Dust will have an adverse impact on employees, laboratory instruments and equipment, and nearby residents.

2. Central Plants within the South Central Campus and the East Campus – This option would consider having a central plant located in the South Central Campus and in the East Campus to service the South Central facilities and East Campus facilities, respectively. The Central Plant within each campus would tie into the natural gas and electrical power service utility mains to provide the heating and cooling plant, respectively. The underground heating and cooling lines from the Central Plant would be distributed to the facilities within each campus and can be installed in segments (e.g., 500 – 700 feet at a time) to serve specific buildings, as they are constructed.

3. STM Central Plant with Biomass – The STM Central Plant with biomass option will have the heating and cooling for all existing and future facilities on the STM site centrally located between the FTLB and SERF. FTLB has an existing heating and cooling plant that services all existing facilities west of the FTLB and the SERF has a heating and cooling plant that will service the SERF and S&TF (located east of the SERF). The STM Central Plant will tie the two cooling plants together and incorporate the proposed Renewable Fuel Heating Plant (RFHP) to provide the cooling and heating, respectively,

for all of facilities (existing and future) on the STM site. The RFHP is a wood chip fueled boiler plant that would provide the heating to the existing and future facilities on the South Table Mountain Site. If the RFHP proposal is not approved, it does not preclude having the heating serviced by the two existing central plants. The cost estimate includes heating and cooling pipes to extend from the STM Central Plant to service the South Central Campus and the North portion of the East Campus. The underground heating and cooling lines can be installed in segments (e.g. 500 – 700 feet at a time) to serve specific buildings, as they are constructed.

Table 10.7.1. STM Road and Utility Extension (Northern) Project Schedule

	Month-Year
Start Design/Construction*	November 2009
Complete Construction	May 2010
*Assumes receipt of funding in October 2007	

Table 10.7.2. STM Road and Utility Extension (Northern) Project Funding Profile ($ million)

		FY2009	FY2010	Total
Conceptual Design	Operating	$0105		$0.105
Detailed Design and Construction – Upper Loop Connector Road	Capital		$2.327	$2.327
Detailed Design and Construction – Upper Inner Loop Road	Capital		$0.676	$0.676
Total Capital	Capital		$3.003	$3.003

11 Capital Investment Plan and Budget Requests – Institutional (General Purpose) Equipment

11.1 Institutional (General Purpose) Equipment Summary

Institutional equipment serves the needs of the entire institution, as opposed to any particular program. NREL's institutional equipment is typically funded through general purpose equipment funds, and consists of four categories of capital equipment items that serve most or all of the Laboratory:

- Institutional Scientific Instrumentation (including computers used by researchers associated with instruments)
- Computational Science Equipment (i.e., high-performance computers)
- Institutional Information Technology Equipment
- Institutional Other Equipment

The strategic investment plans for the first three of these categories are discussed in the individual sections following this institutional equipment summary.

Table 11.1.1. NREL Institutional Capital Equipment Condition Assessment (6/30/04)

	Units	All Institutional Equipment	Institutional Scientific Instrumentation	Computational Science Equipment	Institutional Information Equipment	Institutional Other Equipment
Today's Value (all items)	million	$10.927	$6.805	$0.604	$3.065	$0.452
Today's Value (active, full-use only)	million	$10.400	$6.677	$0.604	$2.667	$0.452
Deferred Replacement Backlog	million	$2.105	$1.072	$0.000	$0.919	$0.114
Percent of Today's Value Deferred		21.5%	16.1%	0.0%	34.4%	25.3%
Average Strategic Useful Life	yrs	8.3	9.6	3.0	4.0	14.6
Average Age	yrs	5.9	6.4	0.1	4.1	8.9

Table 11.1.1 characterizes NREL's institutional capital equipment portfolio as of June 30, 2004. The term "deferred" refers to equipment that is older than its strategic useful life today, or will be when it is planned to be replaced. The deferred replacement backlog is the total value of active equipment currently beyond its strategic useful life. As of 06/30/04, this was $2.1 million for NREL. The "Percent of Today's Value Deferred," also called the Equipment Condition Index (ECI; see section 6.4), is the value of the equipment in active use that is beyond its strategic useful life (deferred replacement backlog) as a percentage of the total value of the equipment pool today. Unlike the Facility Condition Index (see section 10.1), DOE has not yet formally established an "Equipment Condition Index" or category labels of excellent, good, etc. However, it is reasonable to assume the same qualitative descriptors for equipment as are already in use for facilities and infrastructure. The qualitative descriptors of the ECI is given in Table 11.1.2.

Table 11.1.2. Equipment Condition Index Qualitative Descriptors

Excellent < 2% (0 to 1.9)
Good < 5% (2.0 to 4.9)
Adequate < 10% (5.0 to 9.9)
Fair < 25% (10.0 to 24.9)
Poor < 60% (25.0 to 59.9)
Fail < 100% (60.0 to 99.9)

NREL's ECI of 21.5% for institutional equipment gives NREL only a "Fair" rating (10%<ECI<25%). NREL's target is to have an "Excellent" rating, which requires an ECI of 2% or less.

Information technology equipment (computers, servers, etc) faces the greatest challenges, with more than 34% of such equipment beyond its strategic useful life. This is due to the more rapid obsolescence of computer equipment, and the need to direct available funding to even higher priorities. Institutional information technology provides the backbone for scientific interchange as well as all administrative computing needs for the Laboratory.

Figure 11.1.1 shows the pattern of general purpose equipment funding, including the estimated level for FY2005. Figure 11.1.2 shows the distribution of the current equipment by age. Much of this equipment was purchased in 2001-2004 because of the increased availability of general purpose equipment funding during those years.

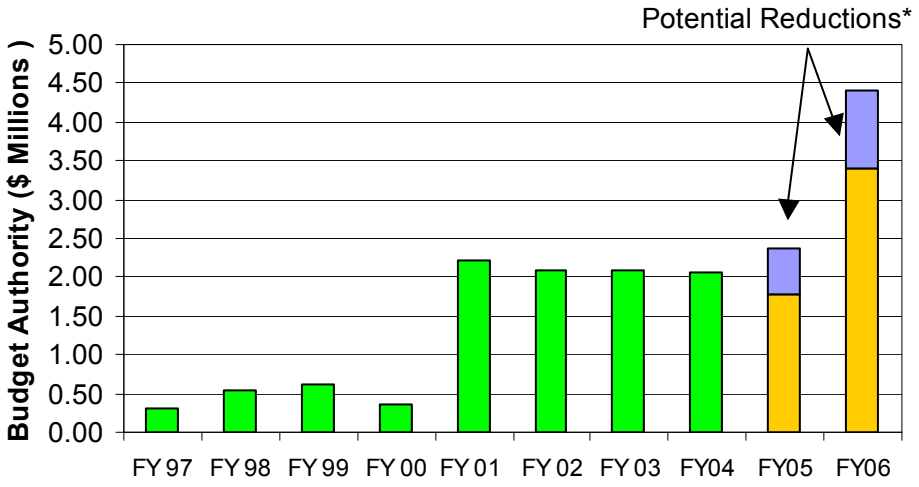


Figure 11.1.1. Institutional (General Purpose) Equipment Funding 1997-2004 (2005, 2006 estimate)

* Although Congress appropriated $2.4 million for NREL's General Plant Projects and General Purpose Equipment funds, there is a likelihood that there will be a $1 million reduction in actual funds received when compared to that approved by Congress. Of that $1 million, $0.6 is assumed to affect General Purpose Equipment funding.

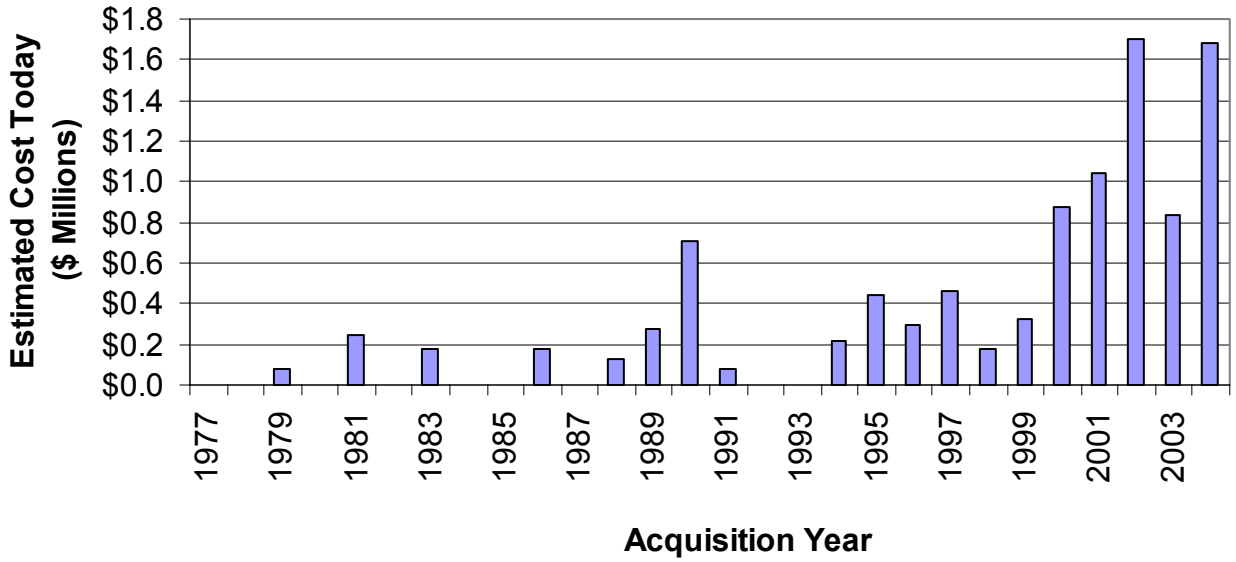


Figure 11.1.2. Age Distribution of Institutional Equipment at NREL

Institutional Equipment Planning Process

A very different internal process was used for developing these requirements compared to projections prepared for previous budget cycles. The deferred and regular replacement requirements were developed by examination of the replacement plans for each individual item developed by the equipment owner, compared to the strategic useful life projected by each owner. This approach has yielded considerably more accurate information about the Laboratory's equipment needs. The process is not yet perfect, as the Laboratory is testing various methods of educating equipment owners and managers, and collecting and verifying new types of data about 900-1000 individual items of capital equipment. However, the process to date has been invaluable at raising levels of awareness of the strategic importance of planning ahead for capital equipment replacements, and sustaining the value of asset and the research capabilities of the Laboratory.

Projections of funding for institutional equipment needed for new capabilities were estimated more broadly, based on historical trends. The Laboratory does not ask researchers or computer scientists to determine their requests for equipment that will add new capabilities until just before the start of the fiscal year. This allows the researchers to take advantage of the latest developments in their respective fields, and allows the Laboratory to make just-in-time decisions to optimize new capability purchases.

Computational Science Initiative

NREL's institutional equipment plan includes one major new initiative in computational science. This new initiative is needed to meet the rapidly growing demand for high-performance computing in areas such as aero acoustic simulations necessary to address wind turbine tip noise challenges; more realistic fluid dynamics and heat transfer simulations necessary to optimize air-cooled heat exchanger designs used in the efficient generation of geothermal electricity; and large-scale classical and quantum mechanical simulations needed to study electron transfer and protein dynamics in hydrogenase complexes that are part of photobiological hydrogen

production. This initiative requests $0.4 million additional GPE funds in FY06, $2.5 million additional in FY07, and $2.5 million additional in FY08. More detail is presented in section 11.3.

General Purpose Equipment Plan

Table 11.1.3 and Figure 11.1.3 summarize the Laboratory's GPE plan for FY2005-FY2015 with separate projections for deferred replacement, regular (on-time) replacement, and new capability items. These data were developed from the subplans in sections 11.2, 11.3, and 11.4 for Institutional Scientific Instrumentation, Computational Science Equipment, and Institutional Information Technology, respectively, plus some allowance for Other Equipment.

Table 11.1.3. NREL FY2005-FY2015 Institutional (General Purpose) Equipment Plan ($millions) – Total Laboratory

NREL FY2005-FY2015 General Purpose Equipment Plan ($ millions) - By Equipment Category

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Planned Expenditures											
Deferred Replacement	$0.700	$1.800	$2.497	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Regular Replacement	$0.285	$0.000	$1.560	$0.714	$2.401	$4.402	$3.598	$1.827	$5.549	$6.484	$5.818
New Capability	$0.933	$1.567	$1.544	$1.587	$1.954	$1.881	$2.010	$1.939	$2.068	$1.999	$2.130
Computational Science Initiative	$0.000	$0.000	$2.500	$2.700	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Total	$1.918	$3.367	$8.101	$5.001	$4.355	$6.283	$5.608	$3.766	$7.617	$8.483	$7.948

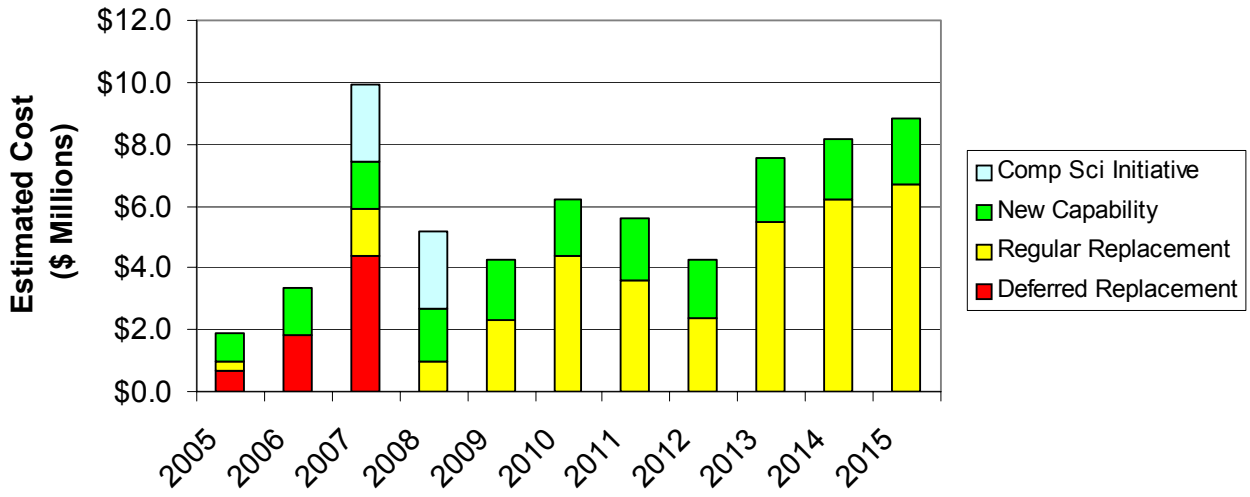


Figure 11.1.3. Institutional (General Purpose) Equipment Plan (Excluding Facility-Specific Equipment, FY05-FY15

Impact of Funding Shortfalls in FY2005 and FY2006
Figure 11.1.1 shows the historical funding for Institutional (General Purpose) Equipment, and Appendix G summarizes the individual items that were funded from GPE in FY03 and FY04.

A comparison of the deferred replacement, regular replacement, and new capability requirements determined by NREL's internal planning process, and the latest information on potential GPE funding reductions as shown in Figure 11.1.4 for FY2005 and FY2006, indicates a considerable shortfall. This means that some items intended to be replaced in FY2005 will roll forward to FY2006, and similarly for FY2006 to FY2007. Analysis shows that the net impact of the funding shortfalls in FY2005 and FY2006 is that $1.7 million more will be required in FY2007 to replace items on the deferred replacement list than if the required funding had been available when needed (Figure 11.1.4).

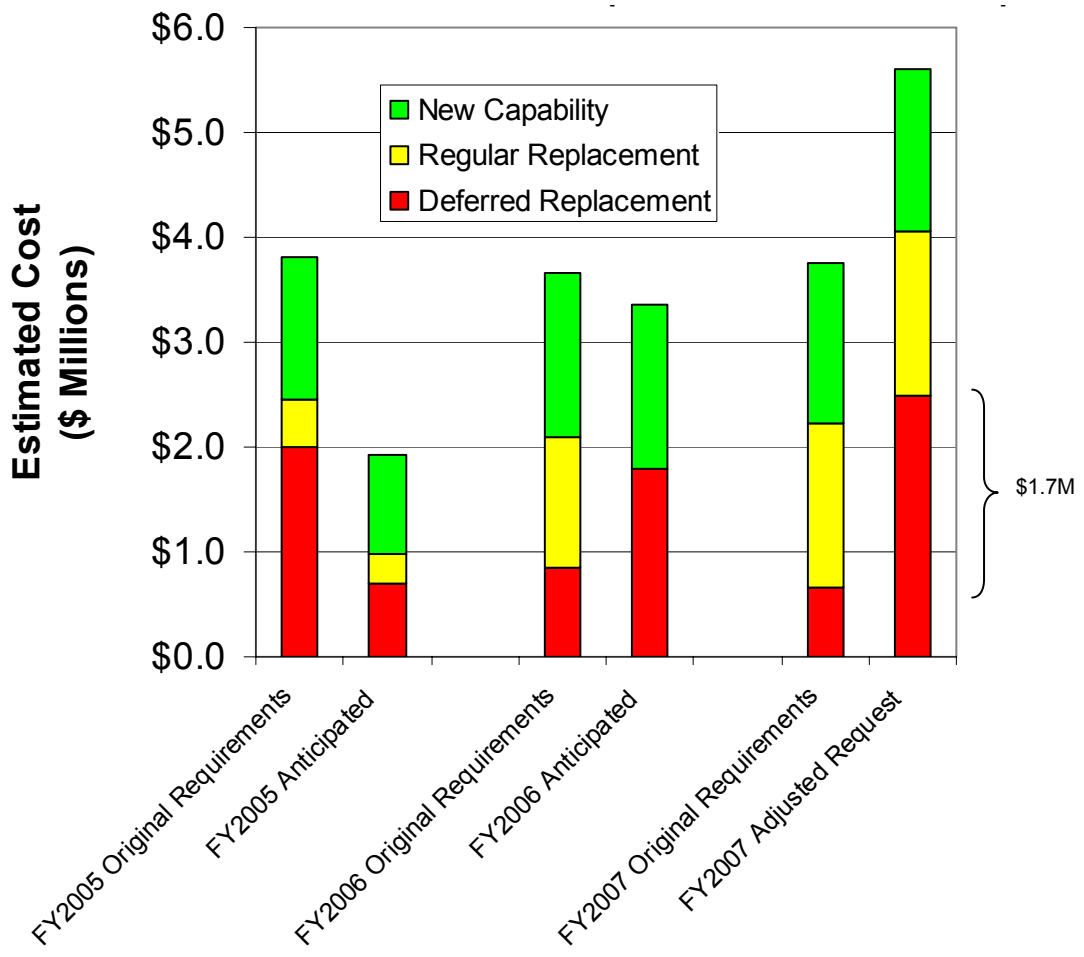


Figure 11.1.4. Reductions in FY2005-FY2006 GPE Funding Add $1.7 Million for Deferred Replacements to 2007 Request

11.2 Institutional Scientific Equipment

Strategic Goals

- Provide state-of-the-art scientific instrumentation that can be used by multiple programs across the Laboratory
- Provide the metrology and calibration equipment necessary to maintain scientific excellence
- Assist programs to meet technical milestones
- Encourage new areas of scientific discovery

Current Activities at NREL

- Scanning electron, transmission electron, atomic force, and other microscopes for surface studies of all solid-state materials including thin-films, nanostructures, and organic solids
- X-ray diffraction, Auger, photoelectron, and other spectrometers for solid-state surface studies
- Ion-beam milling instruments for solid-state sample preparation
- Deposition and solid-state growth equipment for thin-film and nanostructure preparation
- Nuclear magnetic resonance spectrometers for organic materials
- Chromatographs, mass spectrometers, and combination instruments for organic material separation and characterization
- Metrology and calibration equipment
- Calorimeters, infrared cameras, and other thermal measurement instrumentation
- Lasers, centrifuges, sterilizers, autoclaves, and other general instrumentation and equipment
- Accessories to upgrade existing instrumentation such as vacuum pumps and chambers, autosamplers, and microprobes.

Planned R&D Activities

NREL is evolving from more isolated programmatic R&D to more integrated, interdisciplinary, and multidisciplinary approaches to science and technology development. NREL expects to continue emphasizing integrated R&D wherever possible.

- Integrated approaches to science encourage greater creativity, more effective problem-solving, increased likelihood of breakthroughs, and more rapid research progress.
- Shared instrumentation avoids duplication, lowers costs, and improves flexibility.

Management and Facility Plan

While it is sometimes effective for programs to pool capital funding and jointly purchase a particular instrument needed by both, it has proven most effective to purchase shared instrumentation through the use of general purpose funds and manage the equipment to benefit the entire Laboratory. This management solution establishes a laboratory or instrument owner who oversees issues of use, maintenance, training, and fair distribution of operating costs for the benefit of all potential users at NREL

General purpose scientific instrumentation is typically located where the greatest numbers of users are clustered. No specific new facilities are planned for general purpose scientific instrumentation.

Equipment Issues and Opportunities

Table 11.2.1. NREL Institutional Capital Equipment Condition Assessment (6/30/04)

	Units	Institutional Scientific Instrumen-tation
Today's Value (all items)	million	$6.805
Today's Value (active, full-use only)	million	$6.677
Deferred Replacement Backlog	million	$1.072
Percent of Today's Value Deferred		16.1%
Average Strategic Useful Life	yrs	9.6
Average Age	yrs	6.4

The field of scientific instrumentation for micro-, nano-, and atomic-scale characterization has exploded in the last ten years. Instrumentation for genomics and biological science of all types has advanced rapidly as well. Miniaturization of computers and the geometric progression of their capabilities continue to increase the effectiveness of all instruments.

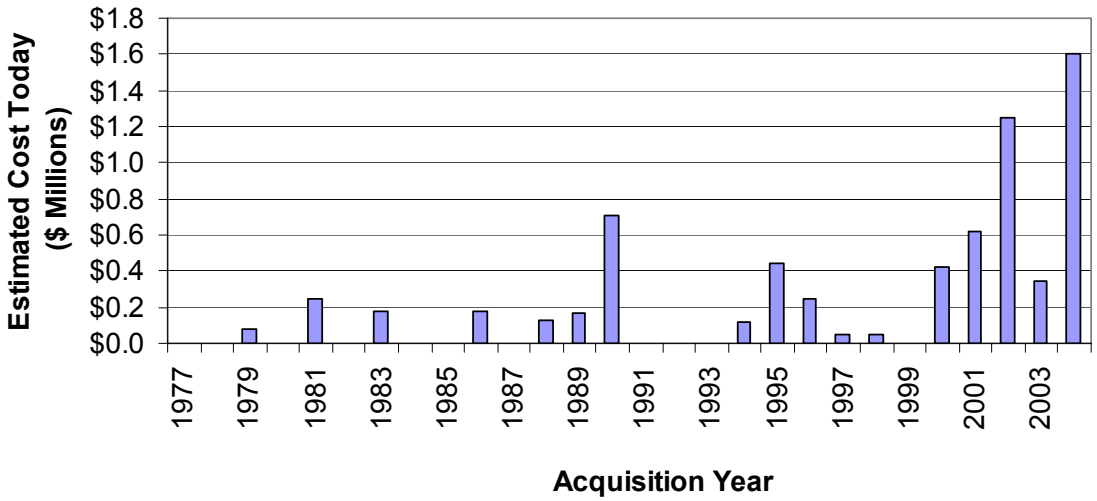
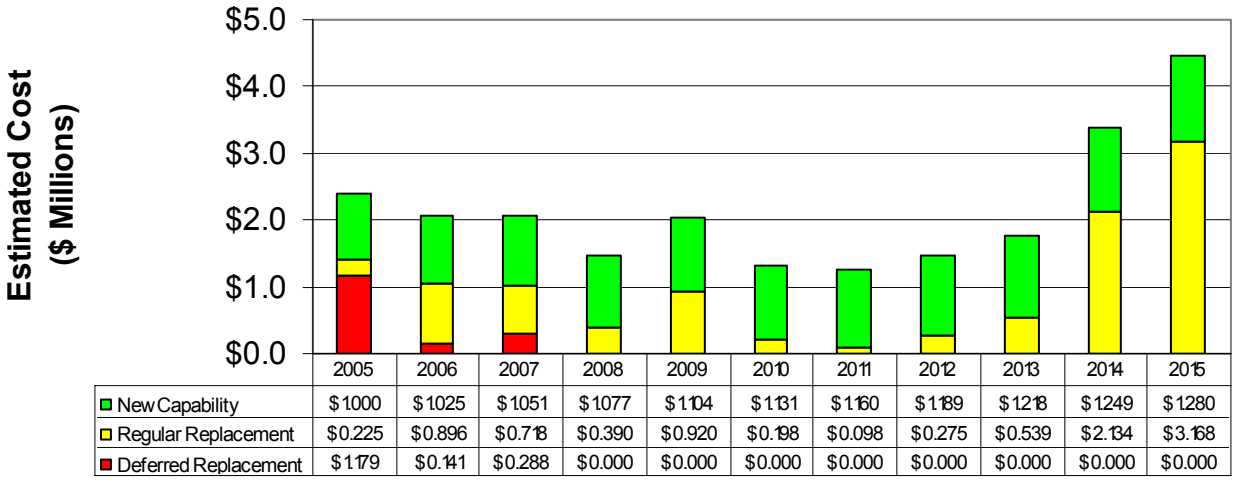


Figure 11.2.1. Age Distribution of Institutional Scientific Equipment at NREL

NREL faces two challenges. The first challenge is to maintain the existing institutional scientific instrumentation somewhere near the state-of-the-art in performance and technical capability. The distribution of the age of the equipment items is shown in Figure 11.2.1. The value of equipment in this category that is already beyond its strategic useful life (deferred replacement backlog) is $1.1 million, 16% of the value of all equipment in this category, which is a “Fair” equipment condition index rating.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	$1.000	$1.025	$1.051	$1.077	$1.104	$1.131	$1.160	$1.189	$1.218	$1.249	$1.280
Regular Replacement	$0.225	$0.896	$0.718	$0.390	$0.920	$0.198	$0.098	$0.275	$0.539	$2.134	$3.168
Deferred Replacement	$1.179	$0.141	$0.288	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000

Figure 11.2.2. Projections for Requirements for Institutional Scientific (General Purpose) Equipment (Excluding Facility-Specific Equipment, FY05-FY15)

The second challenge in managing institutional scientific instrumentation is to wisely invest in the new instruments, and major upgrades to existing instruments, that will most benefit NREL's programs today and for the next ten years. NREL researchers propose new instrumentation, or new accessories or major upgrades, before the start of each year, and a competitive process is used to determine those funded. The criteria include likelihood to broaden or deepen laboratory capabilities in cutting-edge research, improve effectiveness at reaching milestones across multiple programs, likelihood to encourage scientific breakthroughs, and general applicability across the laboratory.

Figure 11.2.2 shows the levels of investments necessary in the categories of deferred replacement, regular replacement, and estimated new capabilities for the next ten years.

11.3 Computational Science

Computational science (in contrast to general information technology which refers to administrative computer-related activities) is a rapidly growing multidisciplinary scientific field with connections to the physical and biological sciences, engineering, applied mathematics, numerical analysis, and computer science. Computational science focuses on the integration of knowledge and methodologies from all of these disciplines, and as such is a subject that is distinct from each of them. It focuses on developing and applying problem-solving methodologies and robust tools for the solution of scientific and engineering problems. Computational scientists are scientists in their own right. However, they often work with the discipline-specific scientists and engineers to apply computational science tools to real world problems.

Strategic Goals

Presidential Initiative

The Bush administration is striving for more research and development in supercomputing for fiscal 2006. Josh Bolten, director for the Office of Management and Budget, and John Marburger, director for the Science and Technology Policy Office, sent a memo to officials urging them to build 2006 budgets around high-end computing research and development. The August 12, 2004 memo states, "While the importance of each networking and IT research and development program areas continues, high-end computing and cyberinfrastructure R&D should be given higher relative priority due to the potential of each in furthering progress across a broad range of scientific and technological application areas." Furthermore, "Agency requests should reflect these two program priorities by reallocating funds from low priority efforts."

Mission: Perform world-class computational science research and provide high performance computing capabilities, leadership, and expertise enabling advances in the leading edge of renewable energy and energy efficiency technologies. Expected outcomes of this effort include:

- Bring simulation to a level of parity with experiment and theory at NREL in the scientific and engineering research enterprise.
- Improve the efficacy with which scientific research is conducted including expanding research options to more potential solutions, lowering cost of research, and reducing the time from concept to market.
- Produce breakthrough scientific results in materials research, molecular mechanical modeling, aeroacoustics research, biophysical modeling, and computational chemistry.
- Enable whole new areas of scientific discovery.

Current Activities at NREL

Current activities at NREL include prediction of material properties and material design at the nanoscale, molecular dynamics simulations and visualization of proteins and DNA, optimization of component designs for advanced hybrid vehicles, modeling of energy use in buildings, and modeling of wind turbine aerodynamics. Geographic information systems are used in analysis of energy resource availability; systems-driven analyses of energy options focusing on regional characteristics, and related applications.

NREL began a major investment in its institutional computational science capability in 2002, and at the end of FY2004 had six full-time staff devoted exclusively to provide computational

science expertise wherever needed in the Laboratory. The total number of scientists directly using computational science in their work at the Lab is approximately 75.

Planned R&D Activities

Based on the demand and success to date in several program areas for computational science, NREL intends to continue to support and grow this important area.

- Computational chemistry and biology, modeling of nanostructures, and application of theoretical modeling to hydrogen production and storage technologies are examples of increasing demand requiring expansion of NREL's computational science capabilities and expertise in these areas.
- Visualization is growing particularly rapidly at NREL. Visualization provides valuable insight into complex phenomena not possible by examining numerical output or even static images. NREL's goal is to develop a visualization group responsible for the resources and to work with NREL staff to visualize the large data sets produced by numerical modeling and simulation
- Geographic information systems have proven valuable and further expansion of those capabilities are required to ensure a systems approach to technical planning.

Facility Plan

While computational science activities occur in a variety of locations around the Laboratory, the heart of the computational science equipment is located in Denver West Building 17. This space should be adequate through FY2008. After 2008, several options are possible:

- Build a state-of-the-art Computational Sciences and Visualization Center within the Research Support Facility proposed for construction.
- Build a dedicated Computational Sciences Center in a new building on the STM site.
- Lease data center space as close as possible to research activities. This would require highly specialized facilities for high-speed data transfer between a remote leased site and the rest of the Laboratory, but the option should be studied.

Equipment Issues and Opportunities

NREL's initial high-performance computing resources in April 2002 consisted of a 64-processor IBM system with an absolute peak performance of 96 gigaflops. The system quickly became a popular resource, and demand has been so high at times that users have had to wait up to 36 hours from the time that they submitted their compute job into the queue until the job first started running. These long wait times mitigate the scientific progress of existing users and deter new users from getting started utilizing high performance computing in their research. The current plan is to retire the IBM in May 2005, as it is two full generations behind the current state-of-the-art systems available.

In August 2004, NREL invested GPE funds to substantially augment the Lab's high performance computing capabilities with two systems which combined have a peak floating point capability of 787 Gigaflops (0.8 Tflops). While this new acquisition increases NREL's compute capabilities eight-fold, it is expected that this new system will be fully saturated within a few months. NREL's modeling and simulation capabilities are growing but not fast enough to keep up with the rapid growth in demand for high performance computing.

Ten Teraflop Initiative

It is critical that NREL have sufficient resources to meet the growing demand for high performance computing. For instance, EERE's Wind & Hydropower Technologies Program needs to develop aero acoustic simulation codes to study the wind turbine tip noise problem. A typical simulation involves 37 million degrees of freedom running for 150K time steps on 128 processors, and takes about 30 days to complete. The scientists need to reduce the running time by a factor of ten. This would require a system about five times larger than NREL currently has just to support the needs of one group. Examples of large compute requirements abound at NREL with application to such areas as nanoscale material research, photovoltaics, biomass conversion, transportation, renewable hydrogen production, and hydrogen storage. Thus, the Laboratory anticipates that in FY2008 NREL would need a high performance computing system with a peak performance of 10 Tflops to appropriately support the EERE mission.

Providing this compute capability requires an investment of $0.4 million in FY2006 for a Visualization Lab, and $2.5 million for each of FY2007 and FY2008 to make the necessary improvements in teraflop capability to accomplish mission objectives. This investment would NREL to overcome hurdles the Laboratory now faces due to limited compute capability. For example, it would allow NREL to routinely run the aero acoustic simulations necessary to address wind turbine tip noise challenges mentioned above. It will also permit much more realistic fluid dynamics and heat transfer simulations necessary to optimize air-cooled heat exchanger designs used in the efficient generation of geothermal electricity. With this capability, the Laboratory will be able to go beyond modeling the energy usage of a building and actually optimize the building design for most efficient energy use. As the last example, this capability would enhance NREL's ability to run large-scale classical and quantum mechanical simulations needed to study electron transfer and protein dynamics in hydrogenase complexes that are part of photobiological hydrogen production.

Replacement Schedule and Other New Capabilities

The overall mission and goals of computational science requires a steady investment level to serve two purposes. The first purpose is to regularly replace computing nodes, storage devices, and interconnections, which have a strategic useful life of only about three years. This short useful life is due to the rapid obsolescence of computer equipment, especially in the field of high-performance computing. That need for periodic replacement is the reason for the cyclical nature of the project requirements as seen in Figure 11.3.1.

Also, experience has shown to maintain flexibility and responsiveness, modest funds will be needed annually beyond the one-time FY2007-FY2008 initiative for new capabilities. Examples of that include new visualization techniques under development that will be enable scientists to envision the inside of a protein, the movement of electrons and holes in optoelectronic materials, and other challenging areas of research. An investment level of about $0.5 million per year in new capabilities will be needed from FY2009 onward to support the growing and changing mission demand, as shown in Figure 11.3.1.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Initiative			$2.500	$2.500							
Ongoing New Capability	$0.000	$0.400	$0.000	$0.000	$0.500	$0.500	$0.500	$0.500	$0.500	$0.500	$0.500
Regular Replacement	$0.000	$0.000	$0.604	$0.000	$0.400	$3.104	$2.500	$0.900	$3.604	$3.000	$1400
Deferred Replacement	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000

Figure 11.3.1. Projections for Requirements for Computational Science (General Purpose) Equipment (Excluding Facility-Specific Equipment, FY05-FY15)

11.4 Institutional Information Equipment

Strategic Goals
Institutional information technology provides the backbone for scientific interchange, knowledge management, and all administrative computing needs for the Laboratory. Effective execution of NREL's mission requires information technology that supports all administrative functions including communications, and provides the architecture and networks necessary for analysis and communication of scientific information. Typical areas for capital investment include networks and storage, cyber security, telecommunications and hardware that supports core applications and services such as office productivity, email, and financial and human resources business systems.

Investment goals for information technology include:
- Safeguard information and IT assets
- Deliver cost-effective and reliable IT services
- Improve operational effectiveness
- Share NREL's research with the world
- Enable the creation of knowledge

Current Activities
NREL's institutional information technology supports opportunities that improve NREL's science and research; balances scientific flexibility with a stable and current information technology environment; empowers researchers and administrative staff with tools and training; and maintains consistent IT standards for the Laboratory.

Planned Activities
NREL's emphasis today is on improving operations, including safeguarding information and IT assets, and delivering cost-effective services. Over time, the emphasis of investments is expected to shift towards the longer-range goals of sharing research and enabling new knowledge.

Equipment Issues and Opportunities
In FY2000, the Laboratory committed capital funds for a wide-ranging series of IT improvements. This upgrade addressed several prior years of significantly diminished or deferred investment in the Laboratory's IT infrastructure. Since then, the Laboratory has worked hard to maintain and improve the Lab's IT with regular investments. However, the general purpose equipment funding has not been sufficient for all needs, and institutional IT currency and effectiveness is a continuing challenge.

NREL faces three challenges. The first is to maintain the existing institutional information systems somewhere near the state-of-the-art in performance and technical capability. The average age of NREL's institutional information equipment is 4.1 yrs (Table 11.4.1), compared to its average strategic useful life of 4.0 years. This is due to the rapid obsolescence of computer equipment, and the insufficient funding available to keep computer equipment up-to-date. The distribution of the age of the equipment items is shown in Figure 11.4.1. The value of equipment in this category that is already beyond its strategic useful life (deferred replacement backlog) as

of June 30, 2004, is $910,000, more than 34% of the value of all equipment in this category, which is a "Poor" equipment condition index rating.

Table 11.4.1. NREL Institutional Capital Equipment Condition

	Units	Institutional Information Equipment
Today's Value (all items)	million	$3.065
Today's Value (active, full-use only)	million	$2.667
Deferred Replacement Backlog	million	$0.919
Percent of Today's Value Deferred		34.4%
Average Strategic Useful Life	yrs	4.0
Average Age	yrs	4.1

The second challenge is to wisely invest in the new capabilities that will most benefit NREL's programs today and for the next ten years. Simply replacing existing information equipment will not satisfy the needs of a research organization in the rapidly changing world of 21st -century information management.

The third challenge is to meet the needs for increasing cyber security. These needs are rapidly changing. NREL estimates the need for cyber security equipment to be $1.5 million in the timeframe of FY2006 to FY2009, with such anticipated items as:

- Desktop Quarantine System ($200K)
- Firewall Upgrade ($100K)
- Automated Patch Distribution ($100K)
- Secure Remote Access – Citrix ($200K)
- Individual Security Plan Automation ($250K)
- Desktop Intrusion Detection & Prevention ($250K)
- Biometric Passwords ($400K)

This list, and this estimate of $1.5 million, do not include new equipment to respond to new Department of Homeland Security requirements. These requirements were not communicated to the Laboratory at the time this TYSP was prepared. They will be included in future revisions. These are some of the issues that must be considered both in replacing existing equipment and in investing in new capabilities:

- Exponential increases are required in bandwidth due to increased external collaboration, transfers of large scientific datasets, increasing use of web-delivered rich content will drive 10x-100x growth in the requirement for network and Internet bandwidth.
- Building and securing ubiquitous networks require an architecture that will allow access to the enterprise network from any place at any time. This will drive technologies such as wireless LAN's and virtual private networks.
- Enabling and expanding online collaboration is needed to provide the services that enable online collaboration – security, file storage, video conferencing, file sharing, etc.
- Meeting increased demand for data storage requires storing, archiving, indexing of digital content.

- Providing 24/7 access for key IT services requires building a high-availability infrastructure that is accessible at any time.
- Increasing cyber security in the face of growing threats requires securing NREL's IT environment from internal and external threats

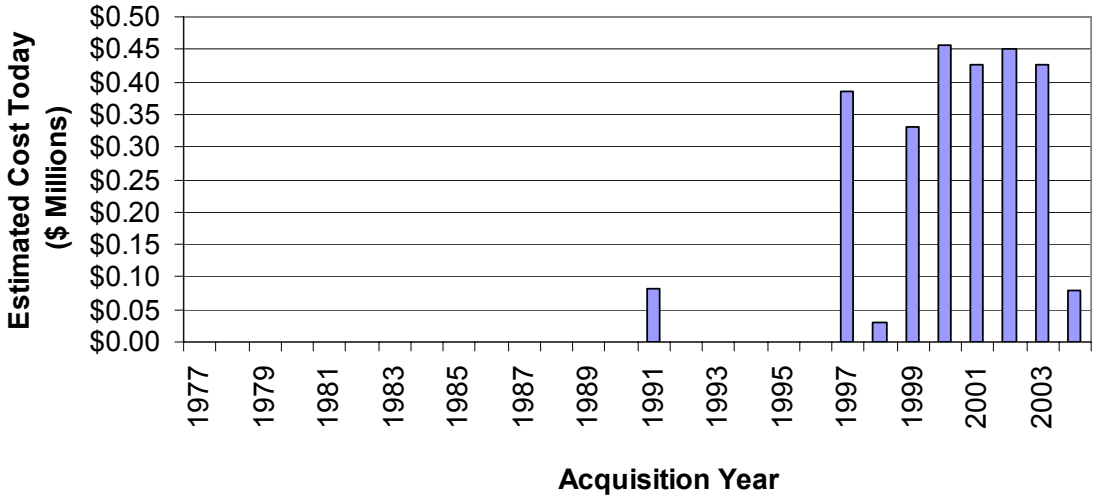
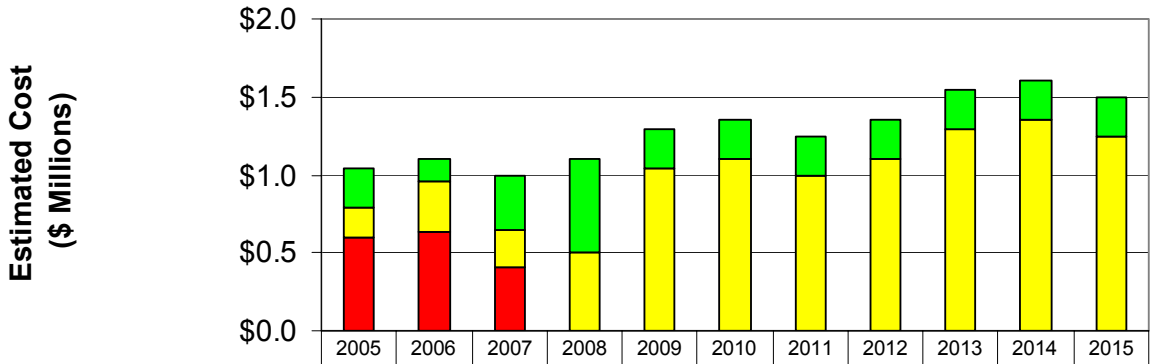


Figure 11.4.1. Age Distribution of Institutional Information Equipment at NREL



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
New Capability	$0.250	$0.142	$0.351	$0.600	$0.250	$0.250	$0.250	$0.250	$0.250	$0.250	$0.250
Regular Replacement	$0.188	$0.317	$0.238	$0.500	$1.040	$1.100	$1.000	$1.100	$1.290	$1.350	$1.250
Deferred Replacement	$0.602	$0.641	$0.411	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000

Figure 11.4.2. Projections for Requirements for Institutional Information (General Purpose) Equipment (Excluding Facility-Specific Equipment, FY05-FY15)

12 Budget Tables

Table 12.1. NREL Ten-Year Facilities, Infrastructure, and Equipment Plan -- FY 2005 - FY 2015 ($ Millions) (Notes 1,2)

Total Estimated Capital Cost (including facility-specific equipment)

	Project	Primary Beneficiaries	Fund	Prior	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	Total
	Small General Plant Projects	***All***	***Small GPP***		$2.0	$2.4	$4.7	$3.4	$4.8	$2.5	$2.9	$4.1	$9.3	$8.8	$3.9	$48.8
	General Purpose Equipment	***All***	***GPE***		$1.9	$3.4	$8.3	$5.0	$4.4	$6.3	$5.6	$3.8	$7.6	$8.5	$7.9	$62.7
	Program Capital Equipment Not Related to Specific Facilities	***All***	***PCE***		$5.5	$7.3	$9.9	$9.1	$9.5	$10.6	$5.2	$5.2	$5.7	$7.5	$5.4	$81.0
	Project Engineering & Design (PED) (Note 3)	***All***	***PED***	$1.6			$3.6									$5.2
	PED Project Allocation			A			B									
A	***Science & Technology Facility***	***Solar, HFCIT***	***CLI***	$5.5	$7.7	$13.3	$2.8									$29.2
B	***Engineering Test Laboratory***	***HFCIT/FCVT DER***	***CLI***				$3.6	$26.4	$6.0							$36.0
	FTLB HVAC Expansion	***All***	***Large GPP***				$1.1									$1.1
	STM Roads & Utility Extension Phases I and II	***All***	***Large GPP***				$2.7			$3.0						$5.7
	TOTAL			***$5.5***	***$17.1***	***$26.4***	***$33.0***	***$43.9***	***$24.6***	***$22.5***	***$13.6***	***$13.1***	***$22.5***	***$24.8***	***$17.2***	***$264.4***

Note 1 -- This table does not include the Research Support Facility, proposed for third-party financing. (See line below)

Note 2 - All numbers for FY2007 and beyond (excluding S&TF) represent uncertainties of +/- 20%.

Note 3 - Project Engineering & Design (for CLI) (PED) funds are required for CLI projects. The DOE process is normally to establish a PED pool for each program. NREL has chosen to identify PED funds project by project rather than showing a PED pool, but has summarized all the PED funds required here in one line, for information only.

Research Support Facility	***All***	***Third-Party***			$60.0											$60.0

Table 12.2 NREL Ten-Year Facilities, Infrastructure, and Equipment Project Detail -- FY2005 - FY2015 ($ Millions) (Notes 1,2)

	Fund	Prior	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	Revised FY2013	FY2014	FY2015	Total
Science & Technology Facility	***CLI***													
Conceptual Design	Operating	$0.380												$0.380
Project Engineering & Design (for CLI)	PED	$1.570												$1.570
Construction	CLI	$3.925	$6.680	$10.515										$21.120
Facility-specific Capital Equipment	PCE		$1.000	$2.750	$2.750									$6.500
Total Estimated Capital	*Capital*	*$5.495*	*$7.680*	*$13.265*	*$2.750*									*$29.190*
Engineering Test Laboratory	***CLI***													
Conceptual Design	Operating			$0.800										$0.800
Project Engineering & Design (for CLI)	PED				$3.600									$3.600
Construction	CLI					$26.400								$26.400
Facility-specific Capital Equipment	PCE						$6.000							$6.000
Total Estimated Capital	*Capital*				*$3.600*	*$26.400*	*$6.000*							*$36.000*
FTLB HVAC Expansion	***Large GPP***													
Conceptual Design	Operating													$0.000
Project Engineering & Design (for CLI)	N/A													$0.000
Detailed Design & Construction	Large GPP				$1.100									$1.100
Facility-specific Capital Equipment	PCE													$0.000
Total Estimated Capital	*Capital*				*$1.100*									*$1.100*
STM Roads & Utility Extension Phases I and II	***Large GPP***													
Conceptual Design	Operating			$0.093			$0.105							$0.198
Project Engineering & Design (for CLI)	N/A													$0.000
Detailed Design & Construction	Large GPP				$2.667			$3.003						$5.670
Facility-specific Capital Equipment	PCE													$0.000
Total Estimated Capital	*Capital*				*$2.667*			*$3.003*						*$5.670*

Note 1 -- This table does not include the Research Support Facility, proposed for third-party financing.
Note 2 - All numbers for FY2007 and beyond (excluding S&TF) represent uncertainties of +/- 20%.

Note 3 - Project Engineering & Design (for CLI) (PED) funds are required for CLI projects. The DOE process is normally to establish a PED pool for each program. NREL has to identify PED funds project by project rather than showing a PED pool, but has summarized all the PED funds required here in one line, for information only.

Appendices

A. Replacement Plant Value Detail and NREL Building Summary
B. South Table Mountain Site Detail
C. National Wind Technology Center Site Detail
D. Leased Facilities Detail
E. Deferred and Regular Maintenance Tables
F. General Purpose Equipment Request Detail, FY2006-FY2007
G. Recent GPP/GPE Investment Summaries
H. List of Tables and Figures
I. Acronyms
J. Definitions of Terms
K. References

Appendix A Replacement Plant Value Detail and NREL Building Summary

Table A.1. South Table Mountain Replacement Plant Value (RPV) Summary December 2004

Name-Building Number	Sq Ft*	FY05 RPV	R.S Means Model Description	R.S Means Base Model SF Cost	Denver Geo Factor	NREL Site Factor	Adj.Model SF Cost
	Col A	Col B	Col C	Col D	Col E	Col F	Col G
Alternative Fuels User Facility	32,751	15,306,701	Labs-Bio/Envir (80/20)	314	0.93	1.60	467
Bulk Storage Building	4,000	300,219	Warehouse/Storage	50	0.93	1.60	75
Facilities Building	3,786	705,492	Maintenance Shops	125	0.93	1.60	186
FETA Ammo Bunker	361	220,567	Bunkers/Magazines	411	0.93	1.60	611
Field Test Laboratory	118,288	55,283,780	Labs-Bio/Envir (80/20)	314	0.93	1.60	467
High Flux Solar Furnace-7117	261	19,589	Warehouse/Storage	50	0.93	1.60	75
High Flux Solar Furnace-7118	184	13,810	Warehouse/Storage	50	0.93	1.60	75
Concentrated Solar Flux Furnace	730	281,217	Lab-Physics/Comp. (80/20)	259	0.93	1.60	385
Historical Bunker-4317	386	235,841	Bunkers/Magazines	411	0.93	1.60	611
Outdoor Test Facility	11,247	5,256,465	Labs-Bio/Envir (80/20)	314	0.93	1.60	467
Shipping & Receiving Facility	14,206	3,815,293	Hardened Storage	179	0.93	1.60	266
Site Entrance Building	814	107,945	Security/Badging	89	0.93	1.60	133
Solar Energy Reseach Facility	115,891	54,163,504	Labs-Bio/Envir (80/20)	314	0.93	1.60	467
Solar Industrial Mesa Test Area-7421	1,220	227,338	Warehouse/Storage	125	0.93	1.60	186
Solar Industrial Mesa Test Area-7521	576	212,479	Lab-Physics/Comp. (50/50)	250	0.93	1.60	372
Thermal Test Facility	10,682	4,992,403	Labs-Bio/Envir (80/20)	314	0.93	1.60	467
Visitor's Center	6,459	1,042,322	Auditorium/Meeting	108	0.93	1.60	161
Waste Handling Facility	1,165	312,883	Hardened Storage	181	0.93	1.60	269
SRRL/Metrology-7225	2,684	1,034,153	Lab-Physics/Comp (80/20)	259	0.93	1.60	385
SRRL-7315	513	197,341	Lab-Physics/Comp (80/20)	259	0.93	1.60	385
Stone Face Bunker-FETA	327	199,996	Bunkers/Magazines	411	0.93	1.60	611
Subtotal	326,531	143,929,338					

NOTES: Column B = Column A x Column G

Column G = Column D x Column E x Column F

*Square footage differs from Table page A-5 because of rounding and other minor differences

Table A.2. NWTC Replacement Plant Value (RPV) Summary December 2004

Name-Building Number	Sq Ft*	FY05 RPV	R.S Means Model Description	R.S Means Base Model SF Cost	Denver Geo Factor	NREL Site Factor	Adj.Model SF Cost
	Col A	Col B	Col C	Col D	Col E	Col F	Col G
Admistrative Bldg-251	22,033	7,830,000	Labs-Hard Engn (80/20)	238	0.93	1.60	354
Blade Test Facility-252	2,563	910,922	Labs-Hard Engn (80/20)	238	0.93	1.60	354
Switchgear Bldg-253	803	149,633	Warehouse/Storage	125	0.93	1.60	186
IUF-254	11,735	4,170,764	Labs-Hard Engn (80/20)	238	0.93	1.60	354
Dynomometer-255	2,452	552,315	High Bay Facility	151	0.93	1.60	225
Modal/Elex Test-256	5,600	1,990,309	Labs-Hard Engn (80/20)	238	0.93	1.60	354
Hybrid Power Test H-1	1,790	689,692	Labs-Hard Engn (80/20)	238	0.93	1.60	354
Data Shed - 1.1	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 1.2	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 1.3	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 1.6	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 1.8	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 1.9	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 3.2	188	35,032	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 3.4	188	35,032	Warehouse/Storage	125	0.93	1.60	186
Data Shed - 4.2	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Building M1A	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Building M1B	50	9,317	Warehouse/Storage	125	0.93	1.60	186
Building M1C	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Research Tower M2	100	18,634	Warehouse/Storage	125	0.93	1.60	186
Research Tower M3	200	37,268	Warehouse/Storage	125	0.93	1.60	186
Pumphouse	452	84,227	Warehouse/Storage	125	0.93	1.60	186
Trailer-248	1,843	205,651	Office-Small	75	0.93	1.60	112
Trailer-249	1,843	205,651	Office-Small	75	0.93	1.60	112
Trailer-257	1,843	205,651	Office-Small	75	0.93	1.60	112
Subtotal	54,583	17,297,804					

NOTES: Column B = Column A x Column G

Column G = Column D x Column E x Column F

*Square footage differs from Table page A-5 because of rounding and other minor differences

Table A.3. NREL - Other Structures and Facilities

ID	Component	Usage Code	Quantity	Unit of Measure	Component Properties (RS Means)	RS Means Unit Costs	Geo Factor for Golden	NREL Site Factor	Adjusted Total Costs	Overall Condition
STM										
	Sidewalks	1129	4204	LF	3' wide 4inch thick concrete	$14.10	0.93	1.60	$88,203	Adequate
	Primary Roads	1729	6840	LF	22' wide asphalt, 10" thick	$86.00	0.93	1.60	$875,301	Good
	Secondary Roads	1738	4742	LF	22' wide asphalt, 10' thick	$86.00	0.93	1.60	$606,824	Adequate
	Paved Areas	1789	276850	SF	Asphalt, 4" base	$1.21	0.93	1.60	$498,463	Good
	Storm Water Drain Ditch	2009	300	LF	2" thick concrete liner	$13.25	0.93	1.60	$5,915	Good
	Storm Water Drain Pipe	8629	2801	LF	30" corrugated metal pipe	$54.50	0.93	1.60	$227,150	Good
	Gas Distribution Pipe	8329	200	LF	3" steel	$37.50	0.93	1.60	$11,160	Good
	Sewer Pipe	8119	3600	LF	8" steel	$49.00	0.93	1.60	$262,483	Good
	Domestic Water Pipe	8119	3600	LF	4" steel	$23.50	0.93	1.60	$125,885	Good
	Fire Water Pipe	8119	3600	LF	8" steel	$55.50	0.93	1.60	$297,302	Good
	Electrical Distribution	8909	12420	LF	500MCM cable, bus duct, manholes	$106.50	0.93	1.60	$1,968,222	Good
	Fencing	NA	15443	LF	Chainlink Fence, 8' barbwire	$36.00	0.93	1.60	$827,251	Good
	Fiber Optic Cable	7231	151	CLF	24 core	$3.40	0.93	1.60	$764	Good
	Street Lights	6919	52	EA	1000W Metal Halide, 20' Alum. Pole	$2,025.00	0.93	1.60	$156,686	Good
	Walkway Lights	6929	65	EA	250W Metal Halide, avg sq and rd	$710.00	0.93	1.60	$68,671	Good
	Wall-Mounted Lights	6929	80	EA	250 W Metal Halide	$91.00	0.93	1.60	$10,833	Good
	Awning Lights	6929	65	EA	250W Metal Halide, rd, recessed	$560.00	0.93	1.60	$54,163	Good
	Building Signs	NA	12	EA	4' x 6' alum. Sign, reflective, frame	$2,500.00	0.93	1.60	$44,640	Good
	Transformers	NA	1	LOT	13.2KV pri to 480V sec	$186,200	0.93	1.60	$277,066	Good
	Security Gate	NA	1	LOT	4ea motorized arm & 2 sliding	$55,000	0.93	1.60	$81,840	Good
	Alternative Fueling Stat.	NA	1	LOT	3ea- 3600 PSI fast fuel pumps	$131,000	0.93	1.60	$194,928	Good
	December 23, 2004							**TOTAL**	$6,683,750	

Table A.4 NREL - Other Structures and Facilities

ID	Component	Usage Code	Quantity	Unit of Measure	Component Properties (RS Means)	RS Means Unit Costs	Geo Factor - Golden	NREL Site Factor	Adjusted Total Costs	Overall Condition
NWTC										
	Sidewalks	1129	330	LF	3' wide 4inch thick concrete	$14.10	0.93	1.60	$6,924	Fair
	Primary Roads	1729	4,650	LF	22' wide asphalt, 10" thick	$86.00	0.93	1.60	$595,051	Good
	Secondary Roads	1738	550	LF	22' wide asphalt, 10' thick	$86.00	0.93	1.60	$70,382	Good
	Unpaved Roads	1749	16,750	LF	22' wide roadway, no shoulders	$0.36	0.93	1.60	$8,973	Good
	Paved Areas	1789	70,089	SF	Asphalt, 4" base	$1.21	0.93	1.60	$126,194	Good
	Sewer Pipe	8119	950	LF	4" steel	$21.50	0.93	1.60	$30,392	Good
	Domestic Water Pipe	8119	6,230	LF	4" steel	$23.50	0.93	1.60	$217,851	Good
	Fire Water Pipe	8119	7,460	LF	8" steel	$55.50	0.93	1.60	$616,077	Good
	Electrical Distribution	8909	31,820	LF	500MCM cable, bus duct, manholes	$106.50	0.93	1.60	$5,042,579	Good
	Fencing	NA	15,953	LF	Three strand barbwire	$18.54	0.93	1.60	$440,104	Good
	Fiber Optic Cable	7231	300	CLF	24 core	$3.40	0.93	1.60	$1,518	Good
	Street Lights	6919	4	EA	1000W Metal Halide, 20' Alum. Pole	$2,025.00	0.93	1.60	$12,053	Good
	Walkway Lights	6929	5	EA	250W Metal Halide, avg sq and rd	$710.00	0.93	1.60	$5,282	Good
	Wall-Mounted Lights	6929	87	EA	250 W Metal Halide	$91.00	0.93	1.60	$11,780	Good
	Awning Lights	6929	3	EA	250W Metal Halide, rd, recessed	$560.00	0.93	1.60	$2,500	Good
	Building Signs	NA	6	EA	4' x 6' alum. Sign, reflective, frame	$2,500.00	0.93	1.60	$22,320	Good
	Transformers	NA	1	LOT	13.2KV pri to 480V sec	$573,937	0.93	1.60	$854,018	Good
	Security Gate	NA	1	LOT	Motorized sliding gate	$5,000	0.93	1.60	$7,440	Good
								TOTAL	$8,071,438	

December 23, 2004

Table A.5. NREL Building Detail (as of 12/31/04)

Site	Building Number	Building Name	Fiscal Year Acquired or Constructed*	Gross Sq. Ft.	Number of Occupants
LEASED					
Denver West Office Park	7	Denver West Bldg 7	2005	4,467	0
	15	Denver West Bldg 15	1979	33,567	78
	16	Denver West Bldg 16	1980	85,906	189
	17	Denver West Bldg 17	1980	87,774	248
	27	Denver West Bldg 27	1995	0	0
ReFUEL Facility		ReFUEL Facility	2002	4,576	6
Joyce Street Facility	6800	Joyce Street Facility	1989	56,000	0
Washington, D.C.	901	Washington D.C. Office	2000	8,090	15
		Total - Leased		280,380	536
OWNED					
	8606	Alternative Fuels User Facility	1985/1994	32,751	38
South Table Mountain	9304	Bulk Storage Building	1988	3,792	
	9306	Facility Maintenance Building	1988	3,787	
	5923	FETA Ammobunker	1990	361	
	7603	MISR Power Distribution	1980	0	
	5308	Field Test Laboratory	1984	125,927	127
	7117	High Flux Solar Furnace	1990	160	
	7118	High Flux Solar Furnace	1990	184	
	7119	High Flux Solar Furnace	1990	730	
	4317	Historical Bunker	1930	386	
	7704	Outdoor Test Facility	1995	11,247	14
	9400	Shipping and Receiving Facility	1997	14,207	13
	1802	Site Entrance Building	1994	814	16
	4515	Solar Energy Research Facility	1993	115,890	199
	7421	Solar Industrial Mesa Test Area	1992	544	
	7521	Solar Industrial Mesa Test Area	1992	576	
	8206	Thermal Test Facility	1996	10,682	9
	1904	Visitor's Center	1994	6,459	3
	4716	Waste Handling Facility	1991	1,065	
	7225	SRRL / Metrology	2000	2,688	7
		Total - STM		332,250	426
National Wind Technology Center	101	Guard Post	2003	160	
	251	NWTC Administration Building	1982	22,026	53
	252	NWTC Blade Test Facility	1979	2,469	
	253	NWTC Building 253	1981	803	
	254	NWTC Industrial Users Facility	1996	11,394	9
	248	NWTC Trailer	1998	1,843	11
	249	NWTC Trailer	1998	1,843	6
	257	NWTC Trailer	1998	1,843	6
	255	Dynomomenter Spin Test Facility	1999	5,570	1
	256	Modal Test Facility	1999	2,212	1
	152	Pump House		495	
	1.1	Data Shed 1.1	1994	108	
	1.2	Data Shed 1.2	1994	252	
	1.3	Data Shed 1.3	1994	144	
	1.4	Data Shed 1.4	1994	150	
	1.7	Data Shed 1.7	1996	54	
	1.8	Data Shed 1.8	1998	105	
	1.9	Data Shed 1.9	1998	105	
	1E.2	Data Shed	1997	441	
	3.1	Wind Turbine	1994	300	
	3.2	Data Shed 3.2	1994	80	
	3.4	Wind Turbine Test Site & Shed	2000	225	
	4.2	Data Shed 4.2	1996	625	3
	H-1	Hybrid Power Test Bed	1997/2001	1,790	1
	M-1-A	Building M-1-A	1994	525	
	M-1-B	Building M-1-B	1994	150	
	M-1-C	Building M-1-C	1994	180	
	M-2	Research Tower	1994	96	
	M-3	Research Tower	1994	96	
		Total - NWTC		56,084	91
		Total - Owned		388,334	517
		Totals		668,714	1,053

Appendix B South Table Mountain Site

B.1 Location, History, and Usage

The 327-acre STM site is located on the southeast side of South Table Mountain, north of I-70 and west of the I-70 and Denver West Boulevard interchange in unincorporated Jefferson County, near Golden, Colorado. A site map for the STM facility is presented in Figure B-1.

The STM site was formerly part of the Colorado National Guard facility, established between 1903 and 1924, at Camp George West (Figure B.2). The site was offered by the State of Colorado as part of its proposal to the Department to be the home for the proposed Solar Energy Research Institute. The excellent availability of sunshine in the high plains ecosystem of the Front Range of Colorado was one of the factors that contributed to the success of the state's proposal. DOE acquired the land in 1981, and ground was first broken in 1983 for the Field Test Laboratory Building.

In July 1999, the 25 acres south of Denver West Parkway were acquired from Jefferson County Open Space as part of a land exchange. As part of this agreement, DOE established a conservation easement of 177 acres and a trail easement of 10 acres that benefits Jefferson County Open Space. This action provided the DOE with additional acreage for site development and protected the slopes and most of the mesa top area within the STM site from any future development. NREL must initiate above ground site improvements within 20 years of acquiring the 25 acres or Jefferson County can exercise a 5-year option to designate the acreage as open space.

The South Table Mountain site is used for all areas of research and development excluding wind energy research. Most of the Laboratory's DOE-owned buildings are on the STM site, and its occupants (as of 12/31/04) total about 426. The site also houses NREL's shipping and receiving activity, and the NREL Visitors Center.

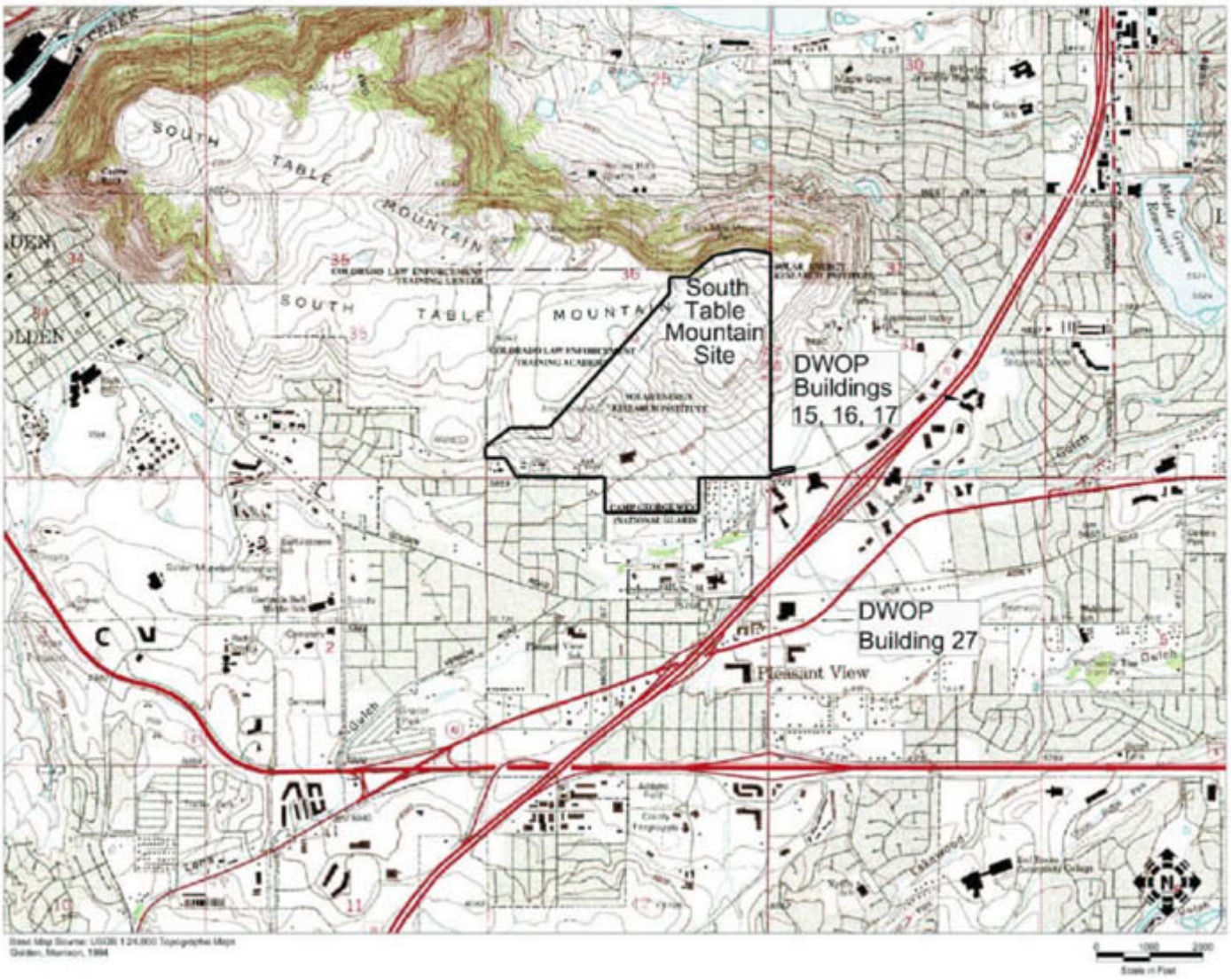


Figure B.1. South Table Mountain Vicinity Map

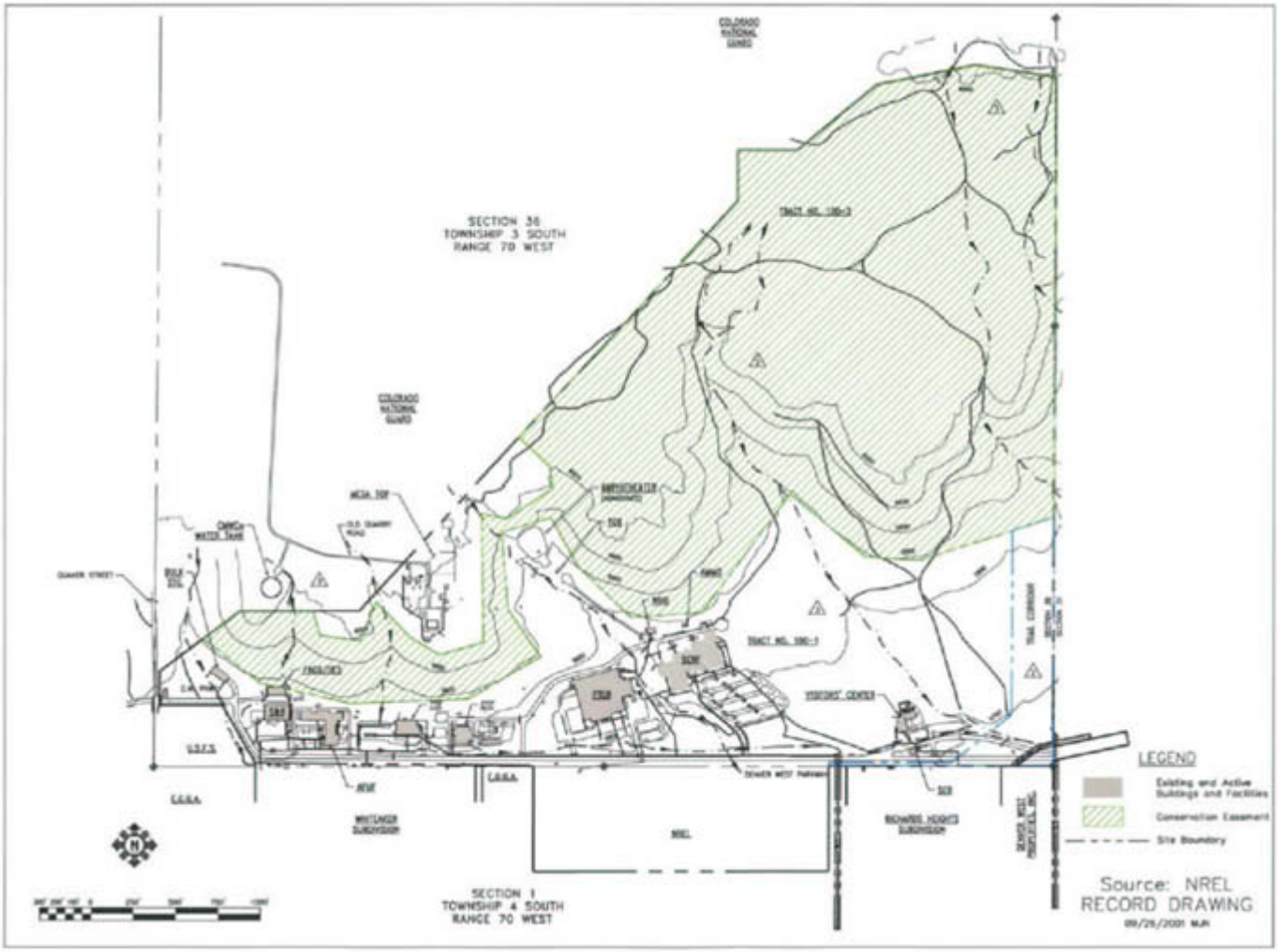


Figure B.2. South Table Mountain Site

B.2 Surrounding Community

The areas surrounding the STM site are within portions of unincorporated Jefferson County, as well as the Cities of Golden and Lakewood municipalities within Jefferson County. The Pleasant View Metropolitan District, within unincorporated Jefferson County, overlays portions of each of these jurisdictions (Figure B.3).

Specific uses adjacent to the STM site include the following:

- Denver West Office Park
- Camp George West (state- and county-owned facilities; see below)
- Colorado State Highway Patrol Driver Training Track and Jefferson County open space land to the northwest, on the mesa top
- Camden Denver West multi-family residential development and office buildings to the east

- The community of Pleasant View, with single-family residences, a community park, and an area planned for a regional park (supposed to begin development in 2005), borders the STM site on the south.
- Offices and a nursery associated with the Colorado Division of Forestry, and residential development and a neighborhood park within Pleasant View to the west
- A Marriott Hotel is located east of the STM site, north of Building 27 and southwest of Buildings 15, 16, and 17.

Camp George West currently comprises approximately 100 acres located south of the STM site (Figure B.2). Camp George West was established in 1903 as the Colorado National Guard's (CNG's) permanent rifle and range facility. Lands associated with the Camp totaled 750 acres during the mid-1920s to late-1930s, including the acreage comprising the current STM site (DOE had been a tenant of the State of Colorado prior to acquiring the STM property in 1981). Jefferson County also acquired a significant portion of former Camp George West lands. In addition to providing storage, maintenance, and classroom space for the CNG, the remaining lands known as Camp George West currently provide land for a variety of tenants including the Colorado Office of Emergency Management, Colorado Department of Transportation, Colorado State Patrol, and the Colorado Correctional Center at Golden. However, the CNG is in the process of relocating space at Camp George West. The State of Colorado has received several requests for reuse of the site. The Camp George West Historic District, which includes portions of the present Camp George West site and the STM site, was placed on the National Register in 1993 (Colorado Department of Corrections, 2002).

Major office, residential, and retail developments within a one-mile radius of NREL have occurred steadily since 1995. The latest addition, in November 2002, was a regional mall called Colorado Mills, which lies just south of I-70 about a mile from the STM site. Traffic in the area has increased markedly, but several local access roads were also widened as a part of this development, minimizing detrimental impacts on access to NREL's facilities.

The Jefferson County Planning Commission issued a draft Central Plains Community Plan in August 2003 in which it recommended developing a research and development light industrial park area between Old Golden Road and I-70, south of the STM site; this is a concept that NREL fully supports.

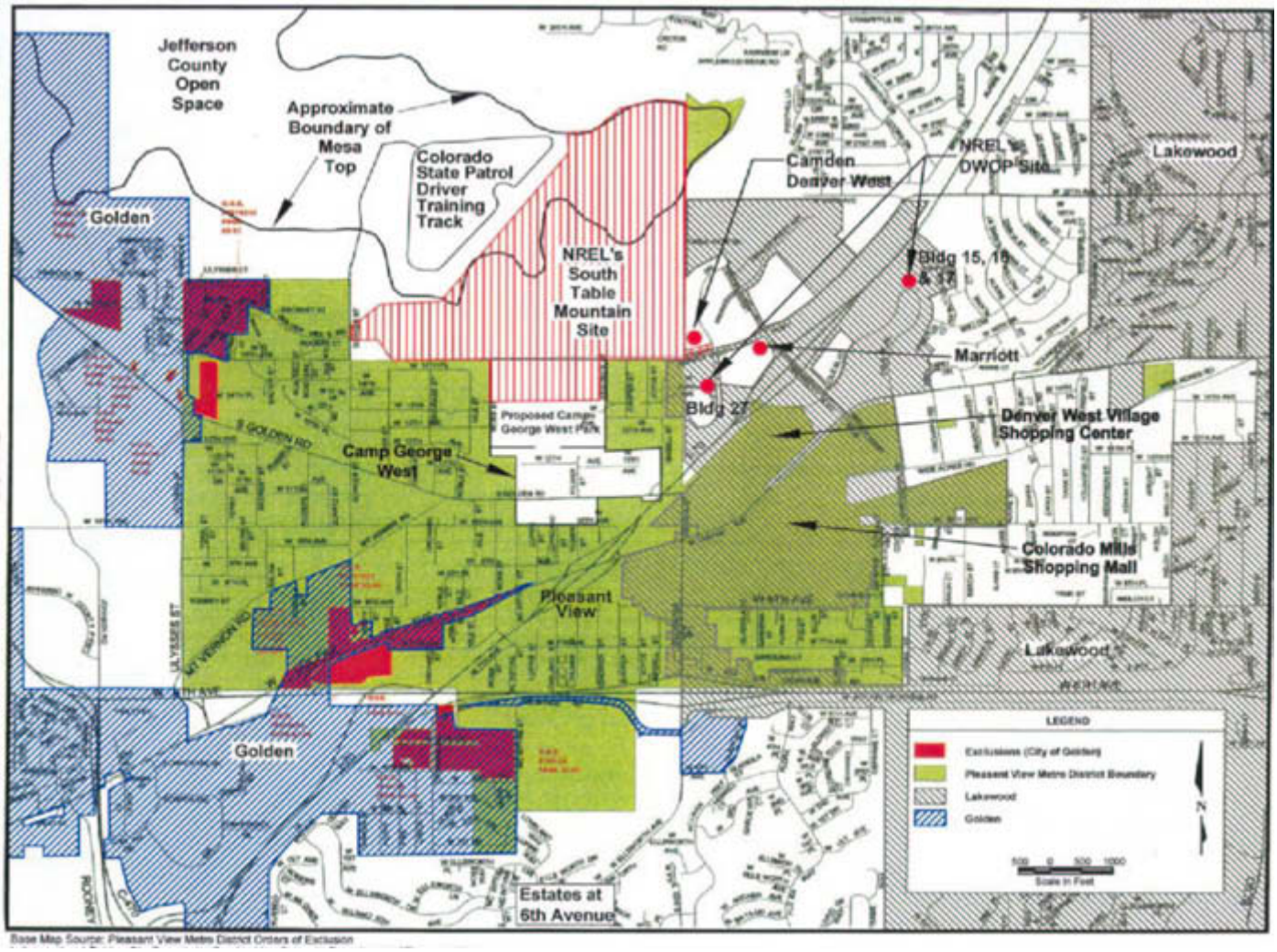


Figure B.3. Land Use and Local Jurisdictional Boundaries

B.3 Land Management

Topography

The site is located on the South Table Mountain top, slope, and toe, which limits site development. Although the mesa presents many unique design opportunities, a significant portion of the STM site has steep, erosive slopes; rock outcrops; deep drainage channels; and other physical constraints. The mesa slope has a grade greater than 20%, which prohibits construction, and the slope is unstable when disturbed. The rockfall zone, steep slopes, and major drainage ways is preserved as open space. Due to the topographical nature of the site it can only be partially developed.

- 136 acres are available for development. The central and east end of the mesa toe and the 25 acres south of Denver West Parkway (about 105 acres total) are the areas best suited for major research and administrative buildings. The two largest laboratory buildings and the Visitor Center are currently located in this area.
- 13 acres of the 136 developable acres are located on the mesa top. The mesa top has poor soil conditions and a shallow depth to bedrock resulting in difficult and expensive construction. Water, natural gas, and electrical service are accessible to the mesa top but it has no sewer

facilities. Access to the mesa top is via ~1 mile of unpaved road on an easement. Only low-impact activities are performed in low, unobtrusive buildings or as outdoor tests.
- 18 acres of the 136 developable acres comprise a narrow strip of land running along Denver West Parkway at the west end of the site. Numerous topographic factors make this more difficult to develop than the east end, and limit the size and placement of buildings. This area is used for small-scale buildings, field testing, pilot plants, maintenance activities, storage, and warehousing.
- 177 acres are protected by a conservation easement.
- 14 acres comprise a Jefferson County Open Space trail easement and utility easements for the STM site. The trail easement is located on the southeast corner of the STM site.

Climate and Ecology
The altitude of the site varies between 5750 ft. and 6050 ft. above sea level. The site is in the "foothills life zone," a transitional region between the grasslands of the plans life zone and the higher, tree-dominated montane life zone of the Rocky Mountains. With its location near the foothills, the weather conditions impact the facility designs and maintenance considerations due to the climate changes, snow loads, and high winds of the area.

STM site soils consist of mostly bedrock on the mesatop and mostly clay loam and cobbly clay loam in the areas where most of the development has occurred.

Vegetation on the STM site consists of a mixture of grasslands, shrublands, and a very small amount of wetlands. Some common wildlife found on the STM are coyote, fox, rabbit, muledeer, deer mice, numerous species of birds, bullsnakes, and rattlesnakes. Endangered species have been identified and handling of these endangered species, if found, is done in accordance with NREL and DOE Best Management Practices.

Visibility
The entire STM site is visible to the surrounding community for several miles. NREL is sensitive to the concerns of residential neighbors about minimizing the visual impact of research activities on the mesa top, and the appearance of all research facilities.

Storm Water Management
The STM resides in the Pleasant View Area watershed. There are three significant drainage basin – west, center, and east - that must be considered in site design, both overall and individually. These three basins are shown in Figure B.4. The storm water management plan that has been developed for this area recommends creating channels or improvements for the center and east drainage channels, including numerous drop structures. Also a 14-acre-foot pond is recommended for the east drainage basin.

As development occurs on the STM and to meet the intentions of the storm water management plan NREL plans to require provisions in the development plans to use landscape features as planted infiltration basins and trenches, porous pavement, and grassy swales to filter the runoff, along with localized detention ponds to slow down the runoff. This approach offers several advantages to NREL:

- It will not only slow down storm water runoff but also improve the quality of water leaving our site.
- The swales and planted basins will support added plant growth on the campus, and
- Land that would otherwise be needed for a regional detention pond can be used for another purpose.

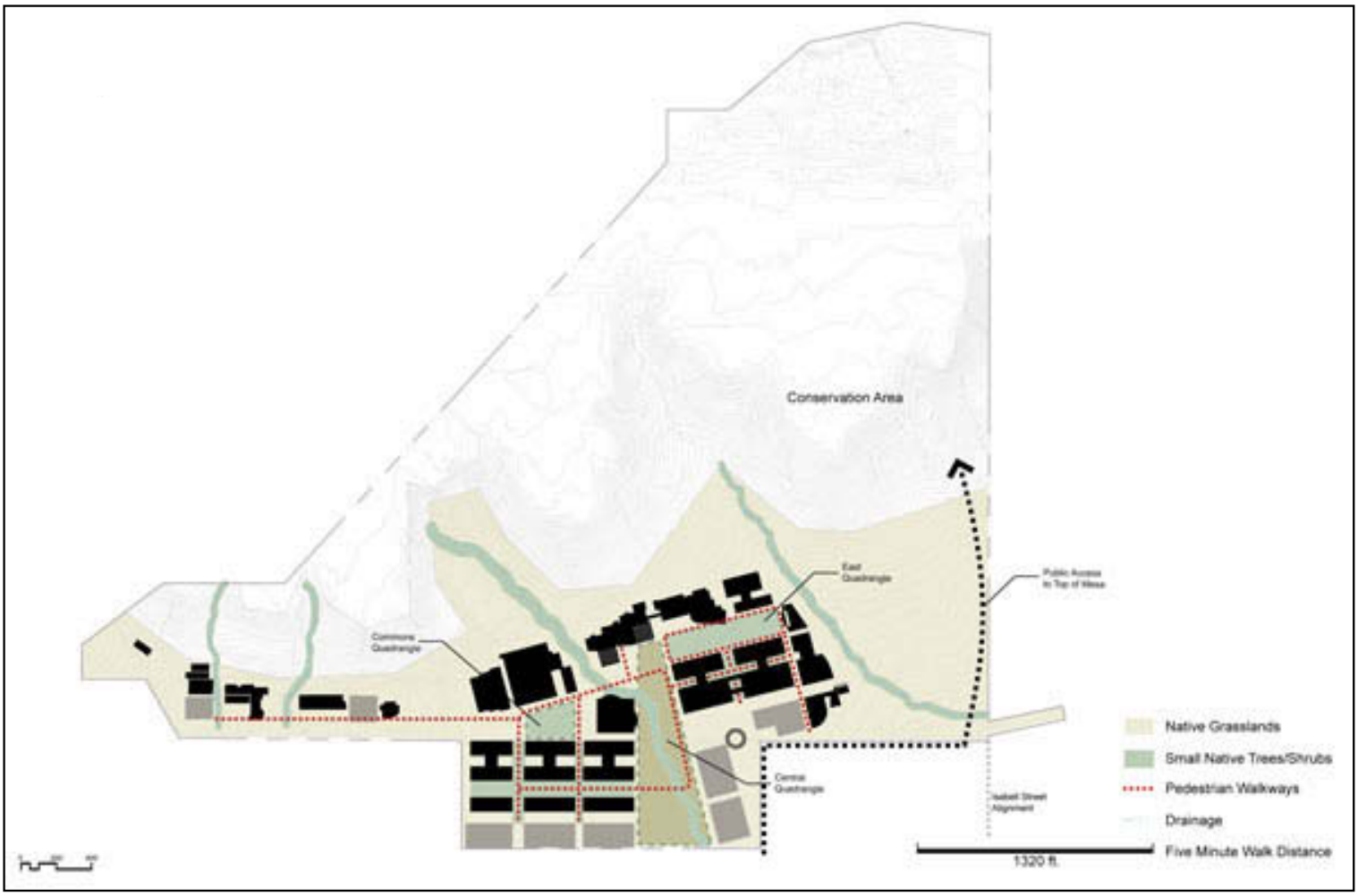


Figure B.4 Open Space Plan

B.4 Buildings

At the STM site, DOE owns approximately 330,000 gross square feet (gsf) of space, the total of all interior space. Table 6.3.4 describes the primary facilities on the STM site.

B.5 Utilities

The following discussions address electricity and gas, telecommunications, water, sewage service, emergency response and fire protection. Figure B.5 presents the locations of existing on-site utility lines.

Electricity and Gas
Electrical power for the STM site is delivered through an Xcel Energy overhead, 13.2-kilovolt (kV) electrical distribution line that enters the site via an easement from the west end of Denver West Parkway. The STM site features a 13.2-kV high voltage distribution system that features three loops to provide electricity to the buildings on site. This distribution system and the transformers associated with each of the on-site buildings are owned, maintained, and operated by NREL. It is anticipated that this electrical system is adequate to serve the STM site for the foreseeable future. In line with its mission, from 1999 through 2004 NREL committed to purchase "green power," in the form of wind power, from Xcel Energy. Beginning in 2005 NREL will purchase renewable energy credits from Community Energy. NREL is able to secure twice the greenhouse gas emission reduction credits from the same investment with Community Energy compared to Xcel Energy.

Xcel Energy also provides natural gas to the STM site via a main pipeline located along the main site access road (Figure B.5). In addition, a 20-inch regional distribution line (1,000 pounds per square inch (psi)) passes through the site. This pipeline runs north-to-south through the site between the FTLB and OTF and up to the mesa top. The gas line that serves the site is adequate to meet natural gas needs at the STM site for the foreseeable future.

NREL has a central boiler and chiller plant in the FTLB that serves that building and the buildings in the western part of the campus through an underground pipe that runs along the north side of the buildings. Another central plant is located in the SERF and is designed to serve the planned S&TF, as well. Future development would require additional utility corridors and central plants to serve new facilities.

Telecommunications
Qwest provides telephone and electronic communications services at the STM site. Although the existing telecommunications service at the site is considered adequate for current needs, NREL would increase the capacity of the system to meet increased needs in the future. The existing analog communications technology is being replaced with digital communications technology, and the Data System Infrastructure Project completed in 1997 with a budget of $2,925,000 installed fiber optic data and communications networks throughout the STM and DWOP sites to provide increased bandwidth of the data highway. It is anticipated that in the future, the capacity of these systems will need to be increased to allow access to high-performance computing capabilities at other laboratories. Two five-inch conduits are routed through Denver West Parkway to the west of the STM site for future use.

Water
The Consolidated Mutual Water Company (CMWC) provides domestic water to the STM site. The CMWC serves 85,000 people in Jefferson County within a 23 square-mile service area. The existing water system is considered adequate to meet current and future needs. Drought conditions in March of 2003 required substantial limitations on available water supplies.

Based on consultation with Consolidated Mutual on April 2003, the CMWC system is considered adequate in wet and normal years to meet existing and future water demands. During years of drought Consolidated Mutual would likely place substantial limitations on water use as was recently done in March 2003. While Consolidated Mutual has a tap moratorium in

place that applies to new users only, NREL's STM complex is an existing user not subject to the tap moratorium.

Sewer Service
The Pleasant View Water and Sanitation District provides sewer service to the lower portions of the STM site. A septic tank and leach field system serves the one toilet, one hand sink, and one janitor's sink located within the existing mesa top facilities.

Wastewater from the sewer system is discharged to Denver's Metro Wastewater Reclamation District. This system is considered adequate for existing and anticipated future sewage needs.

Emergency Response and Fire Protection
Fire fighting equipment for buildings and facilities located below the mesa slopes includes a water supply (fire hydrant, dry hydrant, or another type of water supply) for every building except the Bulk Storage Facility and the PDU Emergency Generator buildings. Facilities on the mesa top do not have a water supply for fire protection. All facilities at the STM site have external horns and strobes that are activated when the fire alarm is triggered. Fire detection systems at the STM site are monitored by the West Metro Fire Protection District (West Metro), which receives the signal directly from the NREL system. With the exception of the Bulk Storage and PDU Emergency Generator buildings (which do not have any form of fire protection), all buildings on the lower STM site have multiple fire protection systems. The Visitor Center, Site Entrance Building, FTLB, OTF, TTF, S&R, and Facilities Shed all feature fire detection (fire or smoke detector heads), fire alarm, and fire sprinkler systems. In addition to these systems, the SERF also features a standpipe and fire pump, while the AFUF has multiple fire sprinkler systems, a foam deluge system, and a fire pump. The SERF and AFUF have fire detection systems in the elevator lobbies and the heating, ventilation, and air conditioning systems.

To protect the site from wildfire, NREL applies its Fire Protection Program to the site, which includes wildfire protection requirements. In 2001, Fire Mark Limited conducted an Updated Fire and Life Safety Analysis of NREL's FTLB, a Wildfire Hazard Assessment of the STM site, and an Assessment of the NREL Fire Protection Program. This assessment concluded that Fire Protection Program at the STM site is excellent. The Fire Mark Limited Wildfire Hazard Assessment concluded that the wildfire hazard potential for both the lower STM site and the mesa is low.

In the event of a fire on the STM, West Metro is under contract to provide emergency service equipment and personnel. West Metro would also provide ambulance service. In the event of an on-site injury, illness, or other situation requiring an ambulance, West Metro personnel and equipment would be dispatched to the site. Emergency services for adjacent properties are provided by several jurisdictions including West Metro and Pleasant View. West Metro staff and equipment capabilities are being expanded to address the new demand created by the Colorado Mills Mall and other new development within their service boundaries.

In the event of a crime or other issues requiring law enforcement assistance at the STM site, on-site security personnel would respond. If off-site support were required, the Jefferson County Sheriff would be contacted.

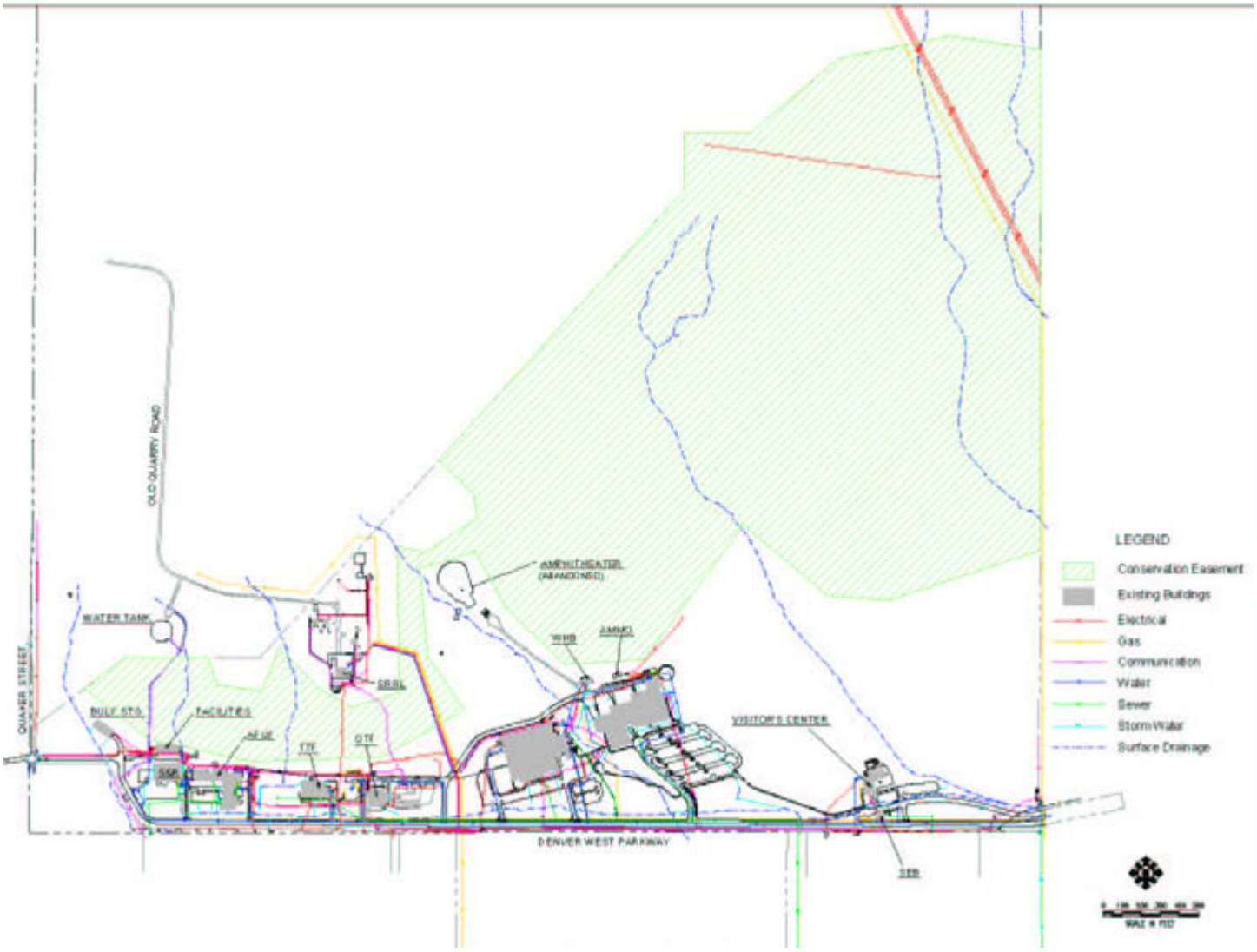


Figure B.5. South Table Mountain Utilities Map

B.6 Transportation

Interior Circulation

Within the STM site, the buildings are currently served by one two-lane, east-west primary road, with individual roads connecting to each facility. Parking is provided near each facility.

Pedestrian pathways are minimal on the site, connecting only the Visitor Center with the SERF, and the SERF with the FTLB. The inability to walk between other buildings is an ongoing issue currently being addressed by an NREL shuttle system that operates during normal business hours.

Access to the STM Site

The roadway network serving the STM is primarily composed of Denver West Parkway, Denver West Marriott Boulevard, West Colfax Avenue (U.S. 40), I-70, Cole Boulevard, and various local streets (Figure B.3).

The I-70/Denver West Marriott Boulevard interchange provides regional access to the STM. Denver West Marriott Boulevard is a 4-lane, divided roadway that extends between West Colfax Avenue and Denver West Parkway.

Denver West Marriott Boulevard intersects Denver West Parkway just north of the I-70/Denver West Marriott Boulevard interchange. Denver West Parkway is a four-lane, divided collector that parallels the north side of I-70 between the STM site and 20th Avenue. Denver West Parkway provides primary access to the STM site and Building 27 within the DWOP.

The main entry to the STM site is at the western terminus of Denver West Parkway about 2,000 feet west of the Denver West Parkway/Denver West Marriott Boulevard intersection. Gates control this entry point and a second entry point to the STM site off of Quaker Street. These entry points control interior access to roads within the lower portion of the STM site. Public access to parking areas near the Visitor's Center and security building is not controlled by the gate.

Quaker Street provides access to the STM facilities located on the mesa top. Quaker Street is paved to a point just north of the STM west gate. Beyond this point the road is unimproved. The unimproved portion of the road provides access to the mesatop for several users, including NREL, Consolidated Mutual, and the Colorado State Patrol. Maintenance of the road is provided as needed with cooperation between NREL and Consolidated Mutual. A gate is located at this location, but it is only closed and locked at night. The gate is open during the day because the road provides access to public open space. However, upon reaching the STM facilities on the mesa top, a security gate controls access to STM facilities. An access card is required to gain entry at the mesa top security gate and at the other two primary STM site gates.

Bus service to the project site is provided by the Denver Regional Transportation District's (RTD's) Route 20-125 bus line, which includes a stop at the STM Visitor's Center. The on-going commercialization of the Denver West area with the increased traffic due to the number of local residents, office personnel, and shoppers will substantively increase the traffic load on bridges and highway exchanges around the STM site. A Light Rail stop is planned in the Red Rocks Community College area along 6th Avenue, south of the STM site, in the future, and a shuttle to NREL has been discussed.

Pedestrian access to the STM site is provided via Denver West Parkway. Trail easements exist on-site along the eastern boundaries of the STM site and off-site trails just west of the site's western boundary. These trails provide access to open space areas located north of the STM site. An access easement located along the eastern edge of the 25-acre Camp George West parcel provides access between the security building and the future site of Camp George West Park (Figure B.3).

B.7 Disposition

NREL has no plans to dispose of any property or facilities in the foreseeable future.

Appendix C National Wind Technology Center

C.1 Location, History, and Usage

The 305-acre NWTC is located approximately 16 miles northwest of Denver and 20 miles north of NREL's South Table Mountain site. This is a relatively isolated area adjacent to DOE's RFETS in unimproved, unincorporated Jefferson County. The site is south of Highway 128 and northeast of aggregate mining and processing facilities on the east side of Highway 93 between Golden and Boulder, Colorado. The Boulder/Jefferson County line is the site's northern boundary line. A regional location map is presented in Figure C.1. A local setting map is presented in Figure C.2. A site map is presented in Figure C.3.

Since the mid-1970's, DOE has conducted wind research and development activities at the NWTC, formerly the Wind Energy Test Center, which is located within the legal boundaries of the buffer zone of the RFETS. Although the entire RFETS, including the buffer zone, is currently designated under CERCLA, the buffer zone was managed as a "no activity zone" during the production years of The Rocky Flats Nuclear Weapons Plant. No radiological operations were conducted on this site and there are no radiological contamination issues per groundwater sampling and air monitoring program data provided by RFETS. The site is hydrologically upslope and upwind of the RFETS. As part of the recent EA of the NWTC, the EPA sampled all areas of the NWTC and statistically found no radiological contamination above background levels. The EPA also formally redefined the CERCLA designated buffer zone of RFETS to exclude the 305-acre NWTC.

The mission of the NWTC is different than the mission at RFETS. Since 1993, DOE's Golden Field Office has managed the NWTC for wind, alternative, and renewable energy research, while the remainder of the RFETS continues to be managed by DOE's Rocky Flats Field Office as an environmental closure site. DOE/NREL will continue to manage the NWTC as an energy efficiency and renewable energy, research, development and testing site after RFETS is closed.

The Industrial User Facility (IUF) building was completed in 1994, providing 11,000 square feet of space that is used by the wind program and industry to assemble and test wind turbines and components. In 1994, NREL renovated Building 251 and installed a site-wide electrical grid. At that time, there were turbines on the site that continued to operate for specific research purposes. FY 1997 brought the installation of the Advanced Research Turbine (ART) and the Hybrid Power Test Bed (HPTB). Several NWTC facilities and infrastructure upgrades were made in 1997, including an emergency power generator, water system enhancements, access road safety improvements, and the site's main electrical switchgear. In FY 1999, the 2.5 MW dynamometer facilities and lab were completed. The Controls Advanced Wind Turbine (CART) was installed in FY00.

A contiguous piece of land about 25 acres, located in the adjacent to the NWTC, was recently designated for inclusion within the NWTC by the National Defense Authorization Act for Fiscal Year 2002 (Figure C.3). This property was previously a

legacy part of the NWTC in the mid 1970's. Two legacy test sites and unimproved roads are located on this land.

NWTC is primarily used for wind energy research, development and testing, and is the only facility of its type in the United States. The NWTC's unique facilities support wind turbine design, development, testing, and certification. Fundamental research is also conducted on turbine aerodynamic and mechanical behavior, as well as turbine interaction with atmospheric conditions.

In addition, the site supports NREL's research in the areas of hybrid power technologies and distributed energy resources. NWTC supports the development and validation of information, data, and testing standards associated with distributed generation equipment and its interconnections with the public utility grid. Hybrid and distributed energy systems that combine various traditional and renewable energy technologies also are tested, as are various distributed energy devices and systems.

Wind turbines and other energy generating facilities at the NWTC have and will continue to contribute power to the local electrical distribution system as a natural byproduct of the research and testing activities on-site. The amount of power produced varies depending upon research activity and hardware type. As larger machines in the multi-megawatt class are tested, these power contributions may be substantial. Currently, DOE has no power purchase agreement in place to receive credit for this energy production, but a power purchase agreement with the local utility company may be negotiated in the future.

The site, at the mouth of Eldorado Canyon, was selected because of intermittent, extreme high-wind characteristics that are favorable to research. These characteristics do not support the objective of full-time wind power generation because of the periods of calm winds between high wind events. The NWTC is not a wind farm or a dedicated renewable energy generation facility, and no short-term or long-term plans exist to convert the site to serve this purpose.

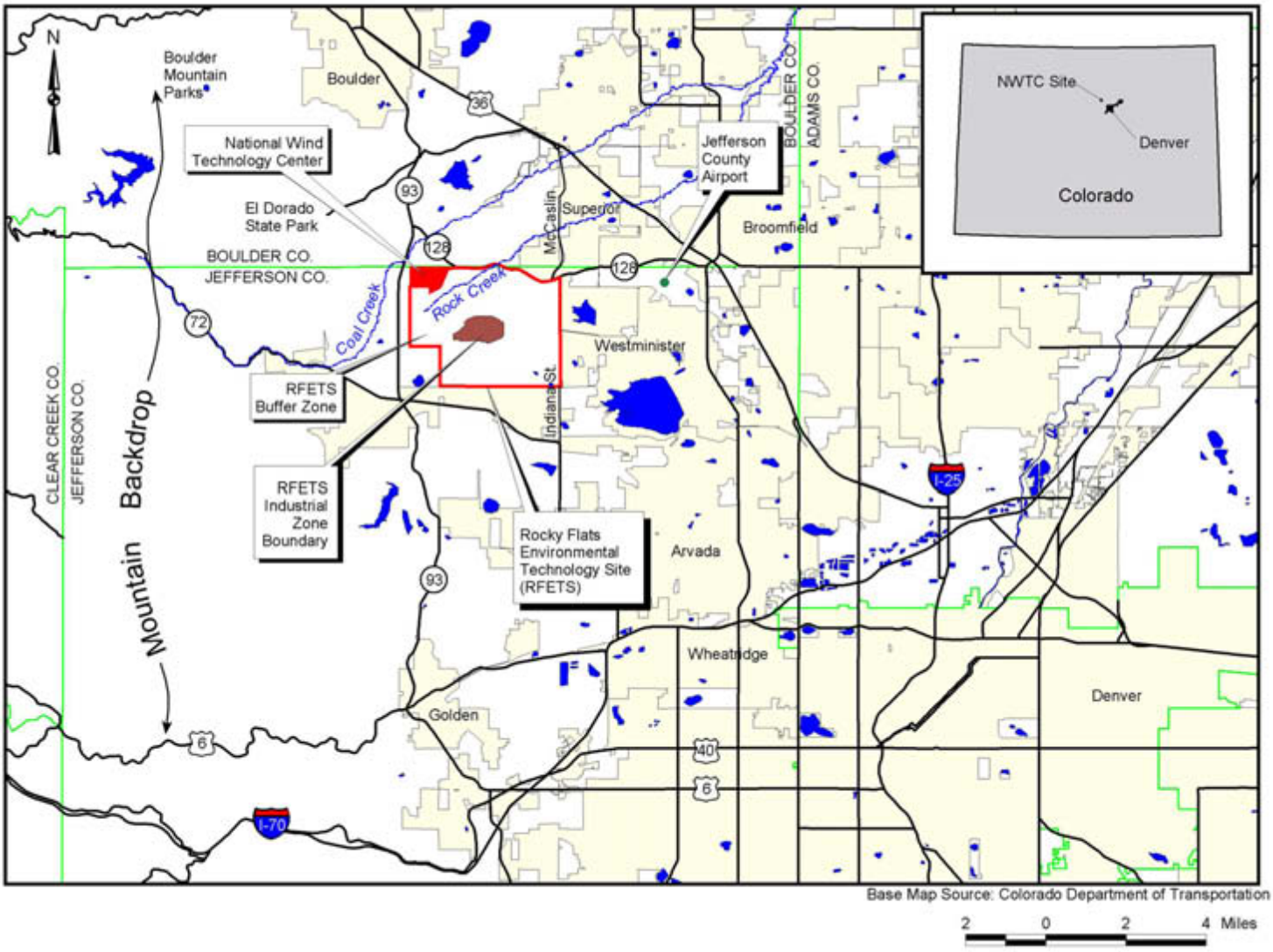


Figure C.1. Regional Location Map

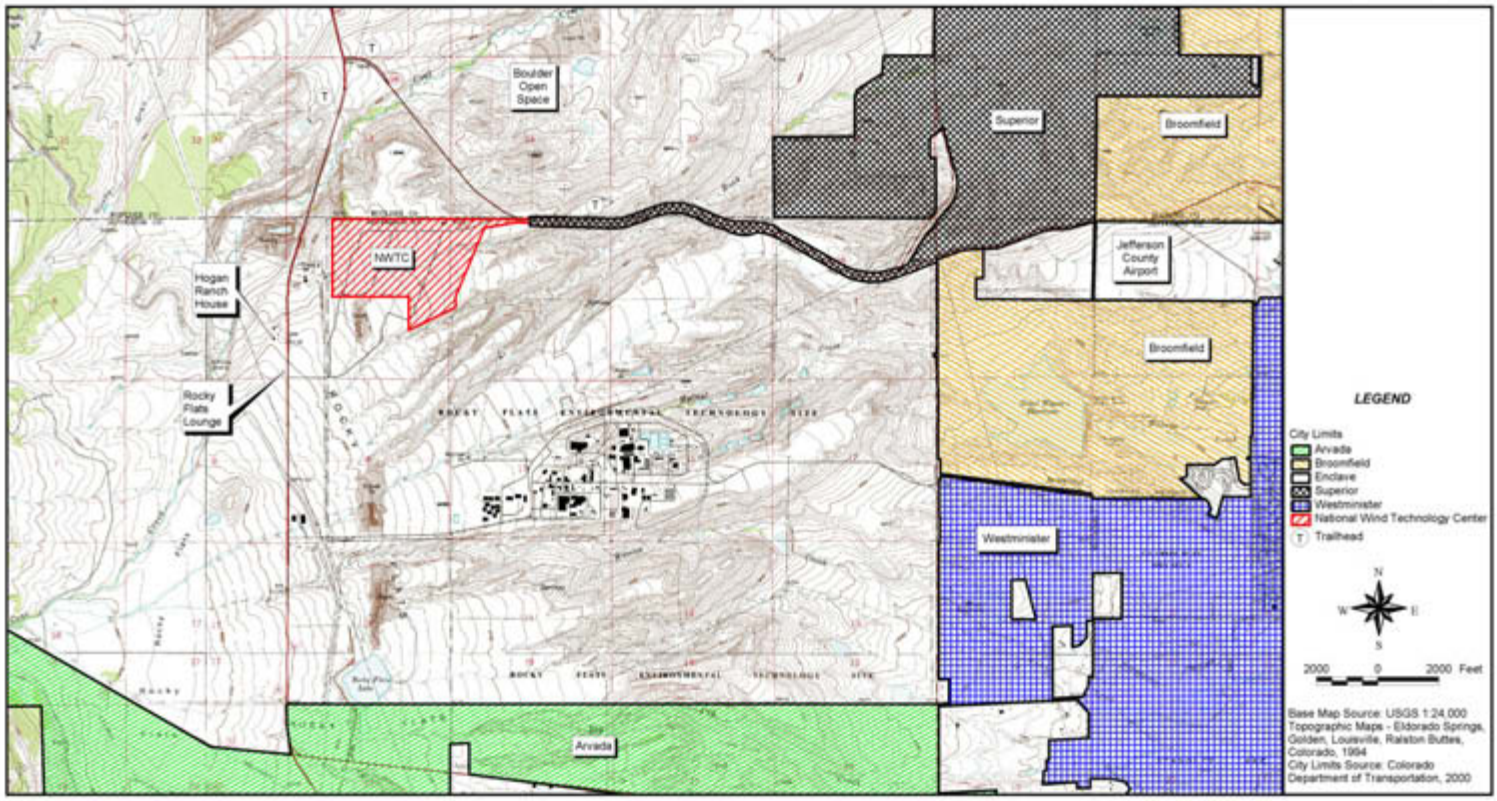


Figure C.2. Local Setting Map

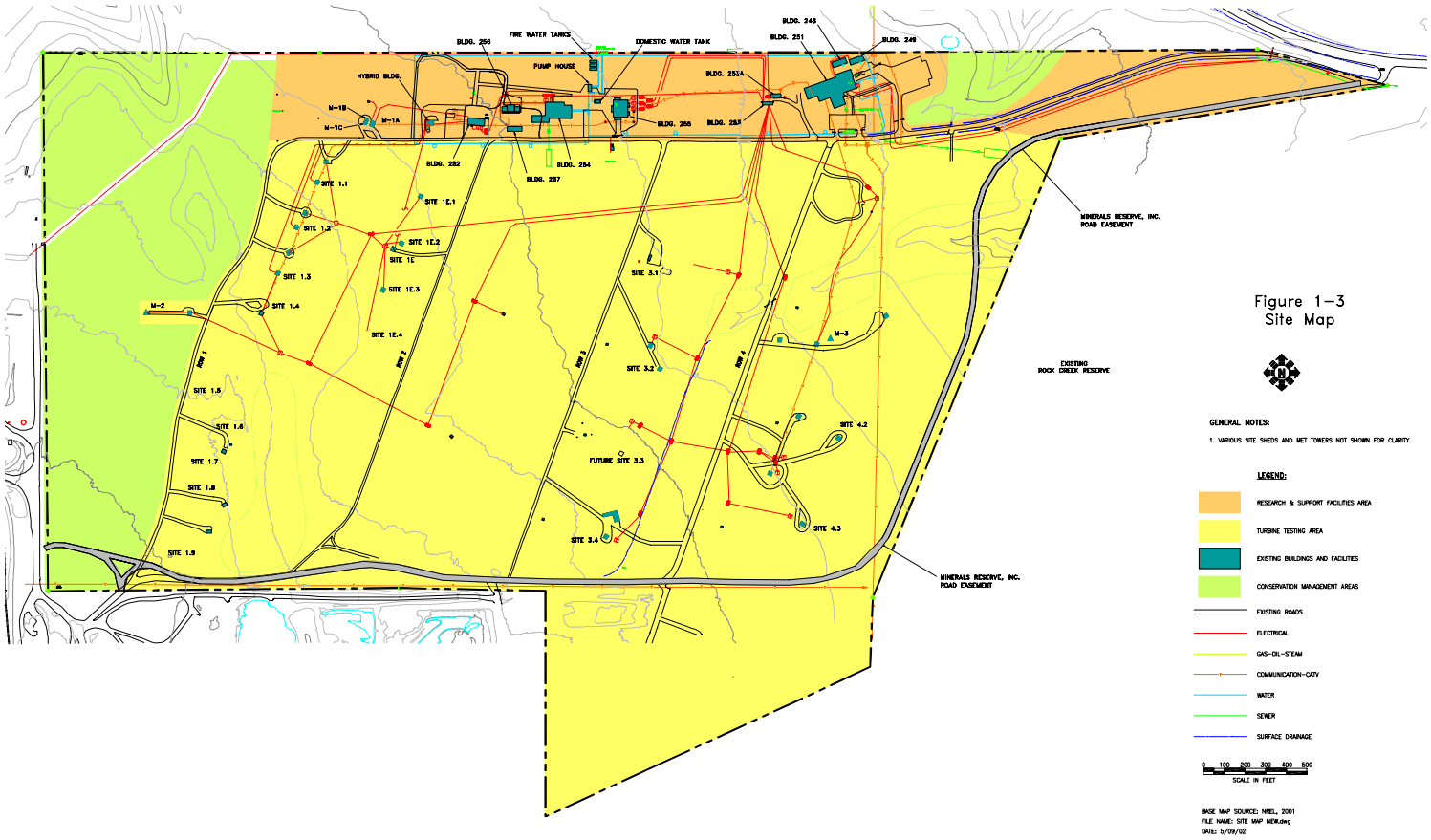


Figure C.3. National Wind Technology Center Site Map

C.2 Surrounding Community

Land uses on properties contiguous to the site include dedicated Boulder County and City of Boulder open space to the north and west of Highway 93, dedicated buffer lands of the RFETS and the recently designated National Wildlife Refuge to the east and south, and industrial uses on private land directly adjacent (AMS Drilling and Blasting) to the west as well as LaFarge aggregate mining and concrete batch-plant to the southwest.

The project vicinity beyond these contiguous areas is characterized by open space to the north and west, expanding residential and commercial development to the east involving the communities of Superior, Arvada, Broomfield, Westminster, and unincorporated areas of Jefferson County, and the industrial facilities on the RFETS to the south.

DOE owns the surface mineral rights of the site; however, the subsurface mineral rights are under private ownership. A local aggregate mining company, lessee of the subsurface mineral rights on the site, and DOE/GO have an agreement that no mining activities will be initiated within the boundaries of the NWTC through at least 2015.The aggregate mining facilities west and southwest of the site are comprised of surface excavations,

material conveyors, rail lines and processing facilities. Two companies, TXI and LaFarge operate on separate, but contiguous sites located between Highway 93 and the project site's western boundary. Mineral Reserve, Inc.'s aggregate mining operation is located south of the site.

Jefferson County Airport is located due east of the site near the U.S. Highway 36/Highway 287 interchange. Airport runways are aligned in a northeast/southwest configuration. Aircraft takeoff and landing patterns do not pass directly over the NWTC.

C.3 Land Management

Topography

The NWTC is basically flat and accessible. Most of the land has been reserved for wind turbine testing. Direct access to the wind from Eldorado Canyon is necessary for wind turbine testing; therefore, nothing can be situated on the NWTC that would interfere with the wind flow reaching the research turbines. Buildings have been developed primarily along the northern boundary to avoid interfering with the wind fetch, and to avoid building in areas that may be made unsafe by major failures in research turbine operation.

Although the land is basically flat and accessible, the absence of water and sewer service presents a challenge for large-scale development.

Climate and Ecology

The elevation of the site is between 5990 and 6100 feet above sea level. The site is in the "foothills life zone," a transitional region between the grasslands of the plans life zone and the higher, tree-dominated montane life zone of the Rocky Mountains. With its location near the foothills, the weather conditions impact the facility designs and maintenance considerations due to the climate changes and snow loads. The site has extreme winds at certain times of year, which can cause damage to vehicle windshields and make the site unsuitable for certain activities, especially outdoor tests other than wind turbines.

The soils at the NWTC site are mostly cobbly sandy loam. Soil samples at the NWTC were analyzed and detectable quantities of VOCs, petroleum hydrocarbons, PCBs, and radionuclides did not exceed the State of Colorado Regulatory limits.

NWTC vegetation consists of mostly grasslands with small amounts of shrublands, woodlands, and wetlands. Some of the common wildlife found at the NWTC includes deer mice, ground squirrels, jackrabbits, coyote, mule deer, black bear, mountain lion, rattlesnakes, lizards, bullsnakes, and frogs. Endangered species have been identified and handling of these endangered species, if found, is done in accordance with NREL and DOE Best Management Practices.

Future Development

Additional building development will be limited to the extreme northern portion of the site because of the safety area and wind fetch required for the turbines. See site plan (Figure C.4). To provide the largest area conducive to building construction, the east/west

road could relocate to the south. Additional space to the east makes an ideal location for a visitors center. Expansion of existing buildings also provide additional administrative and research space. Expansion into the 25 acres recently acquired would provide additional test pads for research.

Any proposed improvements at the NWTC would have minor on-site and off-site land use impacts. Each improvement is subject to review under applicable programs, policies and procedures implemented by NREL at the NWTC intended to avoid and/or minimize impacts at the site. Sensitive areas of the NWTC are protected by various policies and practices and in most cases, the requirements pertaining to Conservation Management Areas. Designated corridors would be used for utility installation and restoration is required for surface disturbances.

Construction of five megawatt-class turbines, more towers and/or higher towers requires coordination to address FAA requirements associated with Jefferson County Airport height restrictions for navigation and communication equipment. NREL complies with FAA requirements. Preliminary consultation with FAA indicates that approval of the anticipated towers would not be precluded, but certain lighting and other requirements would apply. Light fixture requirements are likely to be similar to existing fixtures, but it is possible they may be needed in multiple locations for the taller towers.

Storm Water Management
Potential impacts to surface water resulting from future construction would not be significant because NREL's existing programs, policies and practices would avoid or minimize impacts to storm water during construction and operations at the NWTC.

Storm water volume may increase due to future development because of a small increase in impervious surface areas. If the volume of storm water does increase, the additional amount should be small, and it is not expected to cause flooding, contribute significantly to erosion of storm water channels, or require substantial infrastructure modifications.

Groundwater Management
Site development would incrementally reduce on-site groundwater recharge by creating an additional amount of impervious surface on the site. This loss would represent a small percentage of the total NWTC site acreage and would not have meaningful consequences on recharge or groundwater availability.

Temporarily impacted lands, due to land clearing and disturbance from construction activities, have an increased susceptibility to noxious weed invasion. NREL actively manages weeds on-site through NREL's aggressive Weed Control Program.

C.4 Buildings and Test Sites

There are currently several research buildings and numerous smaller trailers, support and testing facilities located on the NWTC site located in the facility development area on the northern portion of the site between the site boundary and the primary access road (West 119th Avenue). These are briefly described in Table 6.3.5.

Figure C.4. Land Use Plan

C.5 Utilities

The following discussions address electricity, gas, telecommunications, water, sewage, police, fire and ambulance services and infrastructure. Figure 1-3 (EA label) presents the locations of on-site utility lines (electrical, gas-oil-steam, telecommunication-CATV, water, sewer and surface drainage).

Electricity and Gas

Electrical power for the NWTC is delivered through Xcel Energy power lines along Highway 93 and on-site. Overhead lines enter the NWTC property from the west along a 20-foot wide easement. The 13.2 kV power lines transition from overhead to underground at the NWTC west property line. From that point, all electric lines on the NWTC property are buried underground. The 13.2 kV power lines feed the Switchgear building (Bldg. 253), which feeds a split bus with two main circuit breakers. One bus feeds the site buildings, and the other feeds the turbine 13.2 kV distribution system to the test sites.

The turbine distribution is connected in a parallel configuration with Xcel Energy, thus allowing the NWTC to feed up to 10 MVA into Xcel Energy's grid with power generated

during wind turbine research activities. There is no agreement for the NWTC to sell power into the energy grid.

Power demand ranges from a low of approximately 521 kilowatts to 933 kilowatts. Monthly energy consumption ranges from approximately 141,000 to 413,000 kilowatt-hours. Annual consumption is approximately 3 million kilowatt-hours.

A new medium pressure 4" natural gas line was recently constructed at the NWTC. The gas line runs along the west and northern property boundaries. The gas provides service for Bldg. 251 and the DER research area. As funding becomes available, other facilities will be converted to gas heat.

Telecommunications
The NWTC is served with 15 phone lines coming directly from Qwest and two T1 high-speed lines coming from NREL's South Table Mountain Site. These connections are provided to the site via overhead power line structures that drop below ground at the site boundary.

Water
The domestic water system consists of an underground 15,000-gallon tank, a transfer pump, a 2,000-gallon day tank, chlorine injection system, pressurizing pumps and an underground pipeline system to Buildings 251 and 254. The system has two pressurizing pumps. One is designed to be a backup if the primary pump cannot keep the system pressurized. Currently, approximately one 3,600-gallon truck delivery is made every week to replenish domestic water supplies. No off-site domestic water lines serve the site or adjacent properties. The absence of a domestic water supply is a challenge for further extensive development of the site.

Low water use fixtures have been installed throughout the NWTC as part of a comprehensive effort to reduce NWTC water consumption. Solar hot water heating may be included in future improvements.

Sewage
The sewage system at the NWTC consists of two separate septic tanks and leach fields at Buildings 251 and 254. The septic tanks are pumped once a year. Future buildings requiring domestic water would also require additional septic tank and leach fields. The size of each septic tank and leach field is based on maximum staffing and soil conditions at each facility.

Emergency Response and Fire Protection
The on-site fire protection system consists of three 25,000-gallon insulated tanks, a 1000-gallon per minute pump, a small pressurizing jockey pump, an emergency diesel generator, underground distribution pipeline, and fire hydrants. The underground pipeline extends around all buildings in a loop and fire hydrants are spaced along the main NWTC road. Currently, only Buildings 251 and 254 have fire sprinkler protection. Buildings 251, 252, 253, 254, 255, 256, 257, and the Hybrid Building have fire detection. The current

design is to provide a two-hour supply of fire protection water for a building fire. It is not likely that multiple building fires would occur simultaneously. Therefore, the existing fire protection system is considered adequate. However, extensive development of the site in the future would require additional fire protection water.

To protect the site from wildfire, NREL applies its Fire Protection Program to the site. NREL and the Colorado State Forest Service conduct periodic wildfire assessments to assess the hazards from wildfires and to determine if appropriate controls have been established to control these hazards. The Colorado State Forest Service completed a wildfire hazard assessment of the NWTC in September of 2001 and that NREL's Wildfire Hazard Assessment is technically sound and up to date.

In the event of a fire on the project site or adjacent lands, the Cherryvale Fire Protection District is under contract to provide emergency service equipment and personnel.

Ambulance service is provided by the Cherryvale Fire Protection District. In the event of an on-site injury, illness, or other situation requiring an ambulance, District personnel and equipment would be dispatched to the site.

In the event of a crime or other requirement for assistance on the project site, on-site security personnel would respond. If off-site support were required, the Jefferson County Sheriff would be contacted.

C.6 Transportation

Site Circulation and Access

The project site has one primary access and a perimeter circulation road that begins at an intersection with Highway 128 and forms a loop within the site (Figures C.2 and C.3). The site access road is paved from Highway 128 to the Hybrid Power Test Building. The remainder of the perimeter road and other site access routes shown in Figure 1-3 have gravel surfaces.

Highway 93 is located west of the site. Highway 93 and 128 intersect northwest of the site.

The NWTC granted a road easement across the site to aggregate operators to the south and west (Figure C.3). There is no short-term or long-term plan or schedule in place for construction of a road using this easement.

Future Road Improvements

CDOT, the Regional Transit District (RTD), and local governments are addressing substantial road and transit improvement needs in the vicinity of the NWTC. The major improvements are those associated with U.S. 36 and the Northwest Parkway projects. Improvements to U.S. 36 are expected to involve 4 lanes in each direction and improved bus and commuter rail service in the corridor between Denver and Boulder.

The Northwest Quadrant Feasibility Study proposes the following long-term improvements in the project vicinity:

- Widen Highway 128 to four lanes, two in each direction;
- Widen Highway 93 to four lanes, two in each direction; and
- Construct an interchange at the Highway 128/93 intersection.

However, due to limited funding it is not expected that this construction would occur in the next 10 to 15 years. No major interim improvements are identified for either highway or for the Highway 128/93 intersection. Some widening of shoulders and bridges along Highway 93 has been done and may be done in the future to improve safety, especially for bicycles.

Additional on-site improvements would include paving of some of the gravel roads and road extension onto the 25-acre addition to provide road access for new test sites.

C.7 Disposition

NREL has no plans to dispose of any property or facilities in the foreseeable future.

Appendix D Leased Facilities

D.1 Location, History, and Usage

NREL occupies several leased facilities on three separate sites – Denver West Office Park (DWOP), the Joyce Street Facility, and the ReFUEL Facility. In addition, NREL maintains a leased office space in Washington, D.C.

The DWOP site is located just east of the STM site in the vicinity of the I-70/Denver West Boulevard interchange near Golden, Colorado. DOE and NREL occupy four buildings located at the eastern end of the office complex (Buildings 7, 15, 16, and 17). With a total of about 212,000 square feet (sf) of leased space, these buildings house about 50 percent of NREL's workers, as well as DOE Golden Field Office (GO) staff. These facilities provide space for administration and research support activities. Building 16 provides some space for limited laboratory research. The general laboratory limitations in Building 16 include:

- Major work must be capable of being done on bench top.
- Chemical processes are excluded that require routine use of the local exhaust ventilation system (e.g., laboratory hood) for capturing airborne contaminants or for capturing a catastrophic release (e.g., canopy hood over process). Work requiring use of laboratory hoods shall be limited to intermittent ancillary support activities, such as sample preparation.
- Laboratory activities will be excluded from the first floor.
- Second and third floor interior laboratory space will be restricted to "dry" activities only. Activities requiring any ventilation beyond standard building ventilation are excluded.

The Joyce Street Facility is located to the north of NREL and is used as a warehouse.

The ReFUEL Facility is located near downtown Denver. The facility contains a small dynamometer and other equipment used for vehicle and fuel research.

Table D.1 lists the current leases.

Table D.1 Current Leased Facilities

Building	Location	Sq.Ft.	Lease Terms	Lease Dates	Annual Cost (Current)
Bldg. 7	Denver West	4,467	No right to cancel	04/01/01-11/08/08	$44,670.00
Bldg. 15	Denver West	29,100	No right to cancel	04/01/01-11/08/08	$401,370.00
Bldg. 16	Denver West	85,906	No right to cancel	07/01/94-11/08/08	$1,474,677.90
Bldg. 17	Denver West	87,744	No right to cancel	07/01/94-11/08/08	$1,436,415.52
Bldg. 27*	Jefferson County Schools	38,096	Right to cancel after 3 years	11/01/99-12/15/04	$719,995.50
Refuel Facility	Denver, CO	4,576	Right to cancel after 3 years	07/05/02-07/04/07	$30,888.00
JSF	Arvada, CO	56,000	Right to cancel after 3 yrs	09/01/97-01/31/08	$226,800.00
L'Enfant Plaza Access Agreement	Washington, D.C.	8,090	No right to cancel except by Gov. Order	10/01/03-09/30/07	$338,232.00
L'Enfant Plaza Services Agreement	Washington, D.C.	8,090 (based on sq. ft. from Access Agreement)	No right to cancel except by Gov. Order	10/01/04-09/30/05	$27,255.00
TOTALS		322,069			$4,700,303.92

*In December 2004 the Bldg. 27 lease was terminated; additional square footage was leased in Bldg. 15, Bldg. 17, and Bldg. 7 and is reflected in the above table.

D.2 Surrounding Community

The areas surrounding the DWOP sites are within portions of unincorporated Jefferson County, as well as the Cities of Golden and Lakewood municipalities within Jefferson County. The Pleasant View Metropolitan District, within unincorporated Jefferson County, overlays portions of each of these jurisdictions (Figure D.1).

General land uses surrounding the DWOP site include commercial uses to the north and west and commercial and residential uses to the east. The recently completed Colorado Mills Mall is located on the south side of West Colfax Avenue southwest of NREL's DWOP facilities. I-70 bisects the DWOP (Figure D.1).

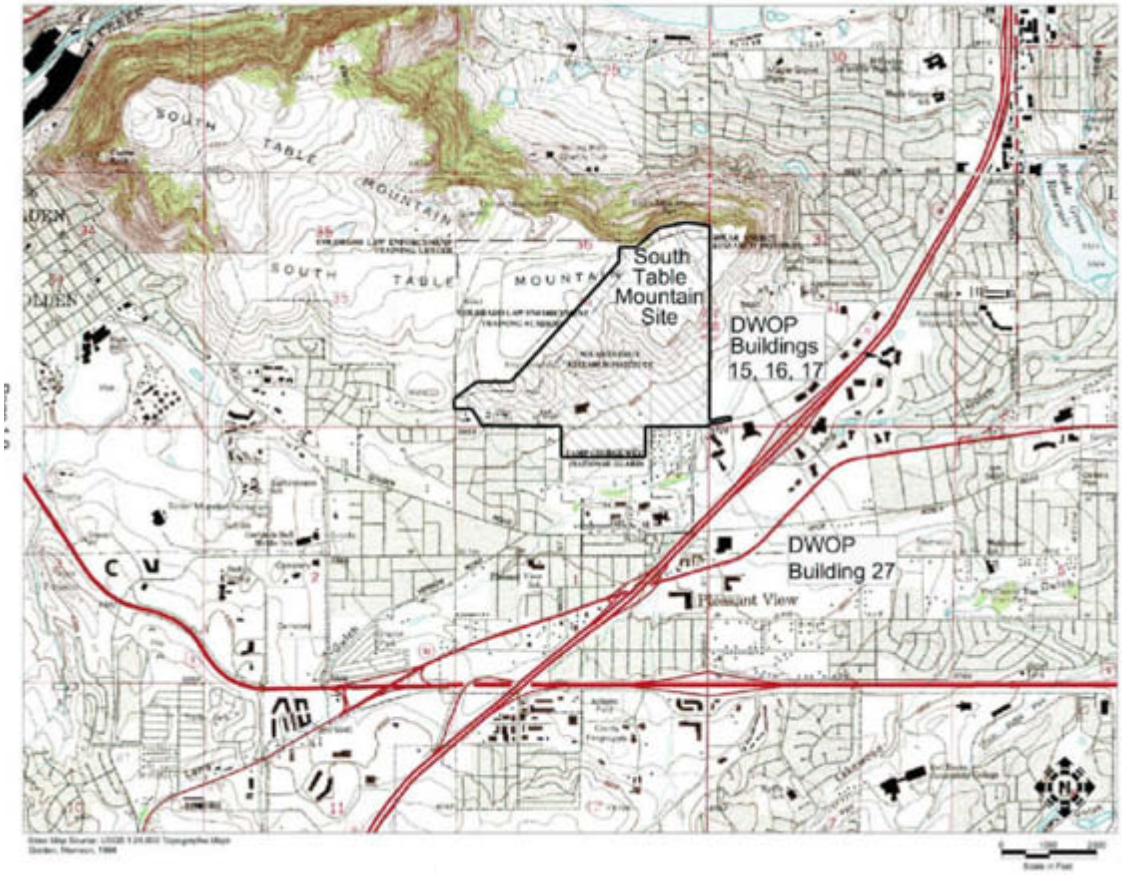


Figure D.1. Leased Facilities in Relation to South Table Mountain Site

D.3 Utilities and Protective Services

Electricity, gas, telephone, electronic communication services, water, and sewer are provided to DWOP as part of the ownership of the property. NREL use of these services is negotiated in the lease payments.

In the event of a crime or other issues requiring law enforcement assistance at the DWOP site, the City of Lakewood Police Department would be contacted.

In the event of a fire on the DWOP sites, West Metro Fire District is under contract to provide emergency service equipment and personnel. West Metro would also provide ambulance service. In the event of an on-site injury, illness, or other situation requiring an ambulance, West Metro personnel and equipment would be dispatched to the site. Emergency services for adjacent properties are provided by several jurisdictions including West Metro and Pleasant View. West Metro staff and equipment capabilities are being expanded to address the new demand created by the Colorado Mills Mall and other new development within their service boundaries.

D.4 Transportation

Roadway Network

The roadway network serving the DWOP sites is primarily composed of Denver West Parkway, Denver West Marriott Boulevard, West Colfax Avenue (U.S. 40), I-70, Cole Boulevard, and various local streets (Figure D.2).

The I-70/Denver West Marriott Boulevard interchange provides regional access to the DWOP sites. Denver West Marriott Boulevard is a 4-lane, divided roadway that extends between West Colfax Avenue and Denver West Parkway.

Buildings 15, 16, and 17 of the DWOP site are on Cole Boulevard just east of the STM site. The buildings can be accessed via West Colfax Avenue and Denver West Marriott Boulevard (Figure D.2).

Future Improvements

Improvements associated with the recently opened Colorado Mills Mall development have enhanced the transportation network in the project vicinity.

Some proposed improvements in the vicinity of DWOP are:

- Widening South Golden Road from two lanes to four lanes between Indiana Street and Ulysses Street; and
- Widening West Colfax Avenue from four lanes to six lanes from I-70 to U.S. Highway 6.

The following interchange/intersection improvements are also proposed:

- Conducting a study to determine the feasibility of eliminating the skewed, at-grade signalized intersection at U.S. Highway 6/West Colfax Avenue;
- Investigating alternatives for intersection of U.S. Highway 6/Indiana Street; and
- Adding turn lanes at major intersections along Indiana Street and West Colfax Avenue.

Transit/Bicycle/Pedestrian Circulation
Bus service to the DWOP is provided by the Denver Regional Transportation District (RTD) along West Colfax Avenue.

Several planned bike paths are located in the vicinity of the DWOP. Improvements for bicycle and pedestrian paths are proposed along South Golden Road and West Colfax Avenue.

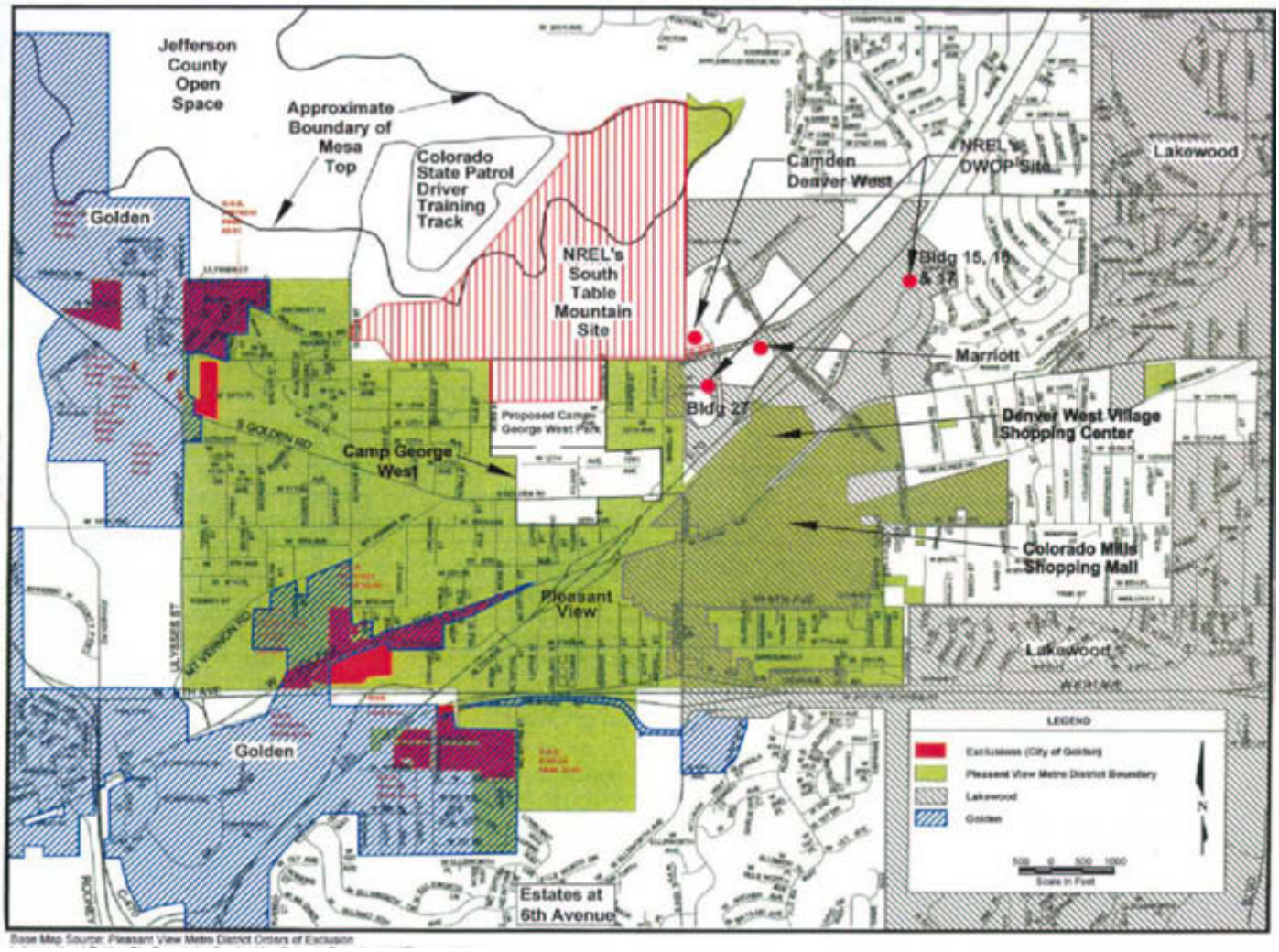


Figure D.2 Land Use and Local Jurisdictional Boundaries

D.5 Disposition

NREL will continue to lease space as required until permanent space is available at the STM or NWTC sites.

Appendix E Deferred and Regular Maintenance Tables

E.1 South Table Mountain Site Deferred Maintenance List – (STM) Site

The Deferred Maintenance List for the South Table Mountain Site is a compilation of all Condition Assessment Information System (CAIS) entries for which the Deferred Maintenance field is selected as YES. Deferred Maintenance, for this purpose, included repair of components for which the action is recommended within one year, due primarily to condition or to having reached or exceeded the useful design life.

Deferred Maintenance actions for FY 2005 – FY 2009 are listed by year and facility.
For each of the actions, the following information is provided:

- The Year in which the optimum period ended for the inspection unit.
- Facility ID and Name
- Component description
- CAIS Tracking number
- Equipment ID, where known
- Unit of Measure and quantity of component to be replaced
- Cost as calculated by the CAIS program including a locating factor for Golden, CO and an NREL site-specific factor

For those components having reached or exceeded the useful design life but with a condition of Adequate or better, the year for which the actions is recommended, the Optimum Year, is adjusted. In those cases, tasks associated with an Adequate condition are recommended for completion in 1-2 years; those for Good or Excellent conditions in 3-5 years.

- Total cost for each fiscal year with a condition of adequate or better is shown below
  - FY 2005 - $791,022
  - FY 2006 - $9,754
  - FY 2007 - $1,093,785
  - FY 2008 - $530,000
  - FY 2009 - $532,894
  - TOTAL - $957,455

The list should not be reviewed as static. It should be updated as actions are accomplished and further actions items are identified. The CAIS Deferred Maintenance Report provides a summary of deferred maintenance for each facility and provides the specifics of each maintenance action with the means to track the status of deferred maintenance at any given time.

DEFERRED MAINTENANCE LIST - STM

Year	Facility	CAIS Tracking No.	Equip	Component	QTY	UM	Cos
1999							
	8606-ALTERNATIVE FUELS USER			MECH;TERMINAL			
		1486	UNKNOWN		1	EACH	$1,402
				Yearly Total			**$1,402**
2003							
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1005	1EL1-7		1	EACH	$1,999
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1014	CPL2		1	EACH	$7,668
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1015	CPH2		1	EACH	$6,050
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1020	CPEL1		1	EACH	$7,668
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1021	CPEH1		1	EACH	$6,045
	5308-FIELD TEST LAB BUILDING			ELEC;TRANSFORMERS,OIL FILLED			
		1031	T5308A		1	EACH	$56,297
	5308-FIELD TEST LAB BUILDING			ELEC;SWITCHBOARD,DIST. SECTION			
		1036	CPMDP		3	EACH	$38,411
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1043	CPH3		1	EACH	$4,506
	5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL			
		1044	CPL3		1	EACH	$7,668
	5308-FIELD TEST LAB BUILDING			ELEC;MOTOR CONTROL CENTER;(ASSY)			
		1046	CP-MCC2		1	EACH	$54,307
	5308-FIELD TEST LAB BUILDING			MECH;TERMINAL UNITS;COOLING			
		1055	UH1, 2,3, 4		4	EACH	$6,657
	5308-FIELD TEST LAB BUILDING			MECH;COOLING TOWER;(ASSY)			
		1056	10346		2	EA.	$220,092

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP			
	1057	UNKNOWN	2	EACH	$19,249
5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP			
	1058	SHP-1, SHP-2	2	EACH	$12,547
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1059	20775	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1060	UNKNOWN	2	EACH	$3,328
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1062	FPPH-2	1	EACH	$6,050
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1063	FPPEH2	1	EACH	$3,670
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1064	FPPEH1	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1065	FPPH-1 SECT1, SECT2	2	EACH	$7,339
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1066	FEL	1	EACH	$3,204
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1068	FPPEH	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1069	FPPH SECT1, SECT2, SECT3	3	EACH	$18,025
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1070	FL	1	EACH	$4,209
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1071	FH	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1072	FPPEH-B	1	EACH	$5,049
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1074	IH7	1	EACH	$6,045

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
5308-FIELD TEST LAB BUILDING			MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)		
	1075	EC-5	1	EACH	$57,081
5308-FIELD TEST LAB BUILDING			MECH;PUMP;FLUID;GP		
	1076	P-15-1, P-15-2	2	EACH	$11,229
5308-FIELD TEST LAB BUILDING			MECH;PUMP;FLUID;GP		
	1077	P-17-A, P-17-	2	EACH	$11,229
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1078	144	1	EACH	$28,955
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1079	SF-8	1	EACH	$32,610
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1080	EF-1	1	EACH	$32,610
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1081	EF-1	1	EACH	$32,610
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1083	UNKNOWN	2	EACH	$74,281
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1085	UNKNOWN	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1086	UH-3	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1087	UNKNOWN	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1088	UNKNOWN	4	EACH	$4,408
5308-FIELD TEST LAB BUILDING			MECH;WATER HEATER		
	1089	UNKNOWN	2	EACH	$20,920
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1090	EF-35,	2	EACH	$7,431

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1091	EF-66,	1	EACH	$3,715
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL		
	1093	10457, 10456	2	EACH	$2,204
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1094	UNKNOWN	1	EACH	$32,610
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1096	UNKNOWN	1	EACH	$68,268
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1097	VENT 107	1	EACH	$2,388
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL		
	1098	10453, 10454, 10456	3	EACH	$3,306
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1099	UNKNOWN	1	EACH	$31,335
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1100	UNKNOWN	1	EACH	$31,335
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1101	UNKNOWN	2	EACH	$62,669
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1103	UNKNOWN	2	EACH	$8,606
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL		
	1104	10487, 10488	2	EACH	$2,204
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING		
	1114	20777	1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING		
	1115	FCU53	1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;AIR COMPRESSORS		
	1116	UNKNOWN	1	EACH	$23,046
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1117	10609	1	EACH	$4,641

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP		
	1118	EF-55, EF-56	2	EACH	$74,281
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1119	UNKNOWN	2	EACH	$10,278
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1123	P-16, P-16A	2	EACH	$9,282
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL		
	1124	10451, 10452	2	EACH	$2,204
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING		
	1125	UNKNOWN	4	EACH	$72,584
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1128	10752, 10753	2	EACH	$8,885
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1129	P-12, P-12A	2	EACH	$8,606
	5308-FIELD TEST LAB BUILDING		MECH;PUMP;FLUID;GP		
	1130	10349, 10350	2	EACH	$8,606
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1131	PB151A	1	EACH	$2,540
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1132	PB-142	1	EACH	$2,917
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1133	PB-141	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1134	PB-140	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1135	PB-139	1	EACH	$5,177
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1136	IEL3	1	EACH	$3,204
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1137	IEH3	1	EACH	$5,253

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1138	IH3 SECT1, SECT2	2	EACH	$12,099
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1140	PB147	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1141	PB148	1	EACH	$6,045
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1143	PB153	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1144	PB150	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1145	PB151	1	EACH	$6,045
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1146	PB149	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1147	IPPL-150C	1	EACH	$3,204
	5308-FIELD TEST LAB BUILDING		ELEC;DISCONNECT		
	1149	UNKNOWN	1	EACH	$1,487
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1150	IPPL-156A, 156B	2	EACH	$6,409
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1151	PB156B	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1152	P1H5	1	EACH	$8,601
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1153	IPPL-156D	1	EACH	$3,704
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1154	1EL1	1	EACH	$3,204
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1155	1L1	1	EACH	$3,704

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1165	IH4	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1166	IL4	1	EACH	$2,540
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1173	IEH5	1	EACH	$5,253
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1174	IEL5	1	EACH	$3,204
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1175	IL5	1	EACH	$3,704
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1176	IH5	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1181	IEH2	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1182	IH2	1	EACH	$3,670
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1183	FCU64, FCU65	2	EACH	$3,328
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1184	FCU8	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1185	FCU66	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1186	FCU38, FCU39	2	EACH	$3,328
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1187	FCU21	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1188	FCU45, FCU46, FCU47	3	EACH	$4,992
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1189	FCU23	1	EACH	$1,664

DEFERRED MAINTENANCE LIST - STM

Year	Facility CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2003						
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1190	UNKNOWN		2	EACH	$3,328
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1191	FCU98		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1192	UNKNOWN		3	EACH	$3,306
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1193	UNKNOWN		2	EACH	$2,204
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1201	RH-1		1	EACH	$2,645
	5308-FIELD TEST LAB BUILDING		MECH;FANS+BLOWERS;GP			
	1202	EF-S4		1	EACH	$3,715
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1203	UNKNOWN		4	EACH	$6,657
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1204	FCU 29		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1205	FCU 36		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1206	FCU 41		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1207	FCU 49		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1208	FCU 50		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1209	FCU 51		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1210	FCU 52		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1211	FCU 105		1	EACH	$1,664

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1212	FCU 113	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1213	UNKNOWN	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1214	UNKNOWN	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1215	10471	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1216	UNKNOWN	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1217	UNKNOWN	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING		MECH;TERMINAL			
	1218	UNKNOWN	4	EACH	$4,408
5308-FIELD TEST LAB BUILDING		MECH;AIR COMPRESSORS			
	1219	UNKNOWN	1	EACH	$23,046
5308-FIELD TEST LAB BUILDING		MECH;FILTERS+DRYERS;AIR			
	1220	UNKNOWN	2	EACH	$5,202
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1223	PB-131A	1	EACH	$6,045
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1224	PB-131	1	EACH	$6,045
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1226	UNKNOWN	1	EACH	$6,045
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1229	2EL4	1	EACH	$3,704
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1230	PB290 LABORATORY	1	EACH	$3,204
5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1231	PB 287 LABORATORY	1	EACH	$3,204

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2003					
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1232	2EL3	1	EACH	$3,204
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1234	2H3 SECT 1, SECT 2	2	EACH	$17,201
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1236	PB-205	1	EACH	$5,177
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1237	PB-204	1	EACH	$5,177
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1238	IPPL-131	1	EACH	$7,668
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1241	2L3	1	EACH	$2,917
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1243	PB285 LABORATORY	1	EACH	$5,800
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1245	2EH3	1	EACH	$4,506
5308-FIELD TEST LAB BUILDING			ELEC;PANELBOARD,COMMERCIAL		
	1266	PB215	1	EACH	$5,177
5308-FIELD TEST LAB BUILDING			MECH;FANS+BLOWERS;GP		
	1269	EF-2	3	EACH	$4,806
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL UNITS;COOLING		
	1270	FCU32, FCU33, FCU31	3	EACH	$4,992
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL UNITS;COOLING		
	1271	UNKNOWN	1	EACH	$1,664
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1272	UNKNOWN	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1273	213	1	EACH	$1,102
5308-FIELD TEST LAB BUILDING			MECH;TERMINAL		
	1274	UNKNOWN	1	EACH	$1,102

DEFERRED MAINTENANCE LIST - STM

Year	Facility CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2003						
	5308-FIELD TEST LAB BUILDING		MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST			
	1275	UNKNOWN		1	EACH	$2,457
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1277	2L1		1	EACH	$5,177
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1278	PB282		1	EACH	$5,177
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1279	PB216		1	EACH	$5,177
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1281	PB222		1	EACH	$6,045
	5308-FIELD TEST LAB BUILDING		MECH;TERMINAL UNITS;COOLING			
	1291	FCU 112		1	EACH	$1,664
	5308-FIELD TEST LAB BUILDING		ROOF;BU MEMBRANE			
	1301			100,089	SQFT	$420,537
	9306-FACILITIES BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	1716	PANEL 2		1	EACH	$8,601
					Yearly Total	**$2,094,492**
2004						
	0001-DENVER WEST PKY_(PAVED RD)		PAVING;ROADWAYS			
	1913			1,760	L.F.	$239,135
	0004-STM- PAVED/PARKING AREAS		PAVING;PARKING AREAS			
	1923			38,759	S.F.	$103,015
	4515-SOLAR ENERGY RESEARCH		INT;PAINT			
	1785			8,000	SQFT	$3,818
	4515-SOLAR ENERGY RESEARCH		INT;PAINT			
	1786			8,000	SQFT	$2,689

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2004					
	5308-FIELD TEST LAB BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	1239	PP130H	1	EACH	$7,668
	7119-CONCENTRATED SOLAR FLUX		MECH;TERMINAL		
	1749	UNKNOWN	2	EACH	$2,805
	8206-THERMAL TEST FACILITY		MECH;COMPRESSOR;RECIPROCATING		
	1702	UNKNOWN	1	EACH	$6,405
	8606-ALTERNATIVE FUELS USER		ELEC;PANELBOARD,COMMERCIAL		
	1475	CPP-1	1	EACH	$6,045
	8606-ALTERNATIVE FUELS USER		ELEC;PANELBOARD,COMMERCIAL		
	1476	LK	1	EACH	$6,045
	8606-ALTERNATIVE FUELS USER		ELEC;PANELBOARD,COMMERCIAL		
	1479	PDP-2, PDP-2A	2	EACH	$9,012
	8606-ALTERNATIVE FUELS USER		ELEC;PANELBOARD,COMMERCIAL		
	1480	PDP-1	1	EACH	$3,670
	8606-ALTERNATIVE FUELS USER		ELEC;SWITCHBOARD,DIST. SECTION		
	1492	SWG1	1	EACH	$10,924
	8606-ALTERNATIVE FUELS USER		MECH;TERMINAL		
	1517	UNKNOWN	3	EACH	$3,306
	8606-ALTERNATIVE FUELS USER		MECH;TERMINAL		
	1518	UNKNOWN	2	EACH	$2,204
	8606-ALTERNATIVE FUELS USER		MECH;PUMP;FLUID;GP		
	1519	UNKNOWN	2	EACH	$17,299
	8606-ALTERNATIVE FUELS USER		MECH;PUMPS;FIRE		
	1520	UNKNOWN	1	EACH	$42,759
	8606-ALTERNATIVE FUELS USER		MECH;PUMP;FLUID;GP		
	1521	P-9	1	EACH	$4,303

DEFERRED MAINTENANCE LIST - STM

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2004					
8606-ALTERNATIVE FUELS USER			MECH;TANKS FLUID STORAGE;EXPANSION		
	1522	UNKNOWN	1	EACH	$11,122
8606-ALTERNATIVE FUELS USER			MECH;TERMINAL UNITS;COOLING		
	1524	UNKNOWN	1	EACH	$2,573
8606-ALTERNATIVE FUELS USER			MECH;FANS+BLOWERS;GP		
	1525	UNKNOWN	3	EACH	$9,203
8606-ALTERNATIVE FUELS USER			MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)		
	1526	AHU-1	1	EACH	$16,437
8606-ALTERNATIVE FUELS USER			ELEC;PANELBOARD,COMMERCIAL		
	1527	LB	1	EACH	$6,045
8606-ALTERNATIVE FUELS USER			MECH;TERMINAL UNITS;COOLING		
	1530	UNKNOWN	1	EACH	$1,664
8606-ALTERNATIVE FUELS USER			MECH;TERMINAL		
	1531	UNKNOWN	2	EACH	$2,204
8606-ALTERNATIVE FUELS USER			MECH;CONDENSER PKGD;(ASSY)		
	1532	UNKNOWN	1	EACH	$1,487
8606-ALTERNATIVE FUELS USER			MECH;TERMINAL		
	1533	HX-201	1	EACH	$37,213
8606-ALTERNATIVE FUELS USER			MECH;FANS+BLOWERS;GP		
	1535	UNKNOWN	1	EACH	$2,425
8606-ALTERNATIVE FUELS USER			MECH;FANS+BLOWERS;GP		
	1537	UNKNOWN	3	EACH	$11,146
8606-ALTERNATIVE FUELS USER			MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)		
	1538	MAU-1	1	EACH	$28,733
8606-ALTERNATIVE FUELS USER			MECH;PUMP;FLUID;GP		
	1539	P-1, P-2, P-3, P-4	4	EACH	$17,769
8606-ALTERNATIVE FUELS USER			MECH;PUMP;FLUID;GP		
	1540	P-8	1	EACH	$4,641

DEFERRED MAINTENANCE LIST - STM

Year	Facility CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2004						
	8606-ALTERNATIVE FUELS USER 1541	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1542	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1543	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1544	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1545	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1546	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1547	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1548	UNKNOWN	MECH;TERMINAL	2	EACH	$2,204
	8606-ALTERNATIVE FUELS USER 1549	UNKNOWN	MECH;FANS+BLOWERS;GP	11	EACH	$40,868
	8606-ALTERNATIVE FUELS USER 1550	UNKNOWN	MECH;FANS+BLOWERS;GP	2	EACH	$7,431
	8606-ALTERNATIVE FUELS USER 1560	UNKNOWN	MECH;TERMINAL UNITS;COOLING	1	EACH	$1,664
	8606-ALTERNATIVE FUELS USER 1561	UNKNOWN	MECH;TERMINAL UNITS;COOLING	1	EACH	$1,664
	8606-ALTERNATIVE FUELS USER 1562	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
	8606-ALTERNATIVE FUELS USER 1564	AIR COMP 3	MECH;AIR COMPRESSORS	1	EACH	$23,034
	8606-ALTERNATIVE FUELS USER 1565	UNKNOWN	MECH;FILTERS+DRYERS;AIR	1	EACH	$16,613

DEFERRED MAINTENANCE LIST - STM

Year	Facility CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2004						
	8606-ALTERNATIVE FUELS USER		MECH;COMPRESSOR;RECIPROCATING			
	1567	UNKNOWN		1	EACH	$10,116
	8606-ALTERNATIVE FUELS USER		MECH;PUMP;FLUID;GP			
	1571	P-6, P-7		2	EACH	$8,606
	8606-ALTERNATIVE FUELS USER		MECH;FANS+BLOWERS;GP			
	1573	EF-6, EF-7		2	EACH	$38,479
	8606-ALTERNATIVE FUELS USER		MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST			
	1575	UNKNOWN		1	EACH	$2,457
	8606-ALTERNATIVE FUELS USER		EXT;PAINT			
	1632			10,000	SQFT	$4,339
	8606-ALTERNATIVE FUELS USER		INT;FLOOR;CARPET			
	1633			200	SQYD	$7,690
			Yearly Total			**$797,745**
2005						
	4515-SOLAR ENERGY RESEARCH		MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST			
	1845			3	EACH	$60,000
	5923-FETA AMMO BUNKER		ELEC;TRANSFORMERS,DRY TYPE			
	1766	UNKNOWN		1	EACH	$3,816
			Yearly Total			**$63,816**
			Total			**$2,957,455**

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E.2 National Wind Technology Center Deferred Maintenance List – (NWTC) Site

The Deferred Maintenance List for the National Wind Technology Center is a compilation of all Condition Assessment Information System (CAIS) entries for which the Deferred Maintenance field is selected as YES. Deferred Maintenance, for this purpose, includes repair of components for which the action is recommended within one year, due primarily to condition or to having reached or exceeded the useful design life.

Deferred Maintenance actions for FY2005-2009 are listed by Year and Facility.
For each of the actions, the following information is provided:

- The Year in which the optimum period ended for the inspection unit.
- Facility ID and Name
- Component description
- CAIS Tracking number
- Equipment ID, where known
- Unit of Measure and quantity of component to be replaced
- Cost as calculated by the CAIS program including a locating factor for Golden, CO and an NREL site-specific factor

For those components having reached or exceeded the useful design life, but with a condition of Adequate or better, the year for which the actions is recommended, the Optimum Year, is adjusted. In those cases, tasks associated with an Adequate condition are recommended for completion in 1-2 years; those for Good or Excellent conditions in 3-5 years.

- Total cost for each fiscal year with a condition of adequate or better is shown below
  - FY2005 - $37,293
  - FY2006 - $2,773
  - FY2007 - $170,000
  - FY2008 - $170,000
  - FY2009 - $169,840
  - TOTAL - $549,906

The list should not be reviewed as static. It should be updated as actions are accomplished and further actions items are identified. The CAIS Deferred Maintenance Report provides a summary of deferred maintenance for each facility and provides the specifics of each maintenance action with the means to track the status of deferred maintenance at any given time.

DEFERRED MAINTENANCE LIST - NWTC

Year	Facility / CAIS Tracking No.	Equip	Component	QTY	UM	Cos
1994						
	252-NWTC-BLADE TEST FACILITY		MECH;TERMINAL			
	161	UNKNOWN		5	EACH	$7,011
					Yearly	**$7,011**
1997						
	1000-NWTC SIDEWALKS		PAVING;WALKWAYS			
	1904			330	SQFT	$6,924
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	35	CUH-2		1	EACH	$1,402
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	36	CUH-3		1	EACH	$1,402
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	37	CUH-4		1	EACH	$1,402
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	38	CUH-5		1	EACH	$1,402
					Yearly	**$12,532**
1999						
	252-NWTC-BLADE TEST FACILITY		MECH;FANS+BLOWERS;GP			
	118	UNKNOWN		1	EACH	$12,975
	252-NWTC-BLADE TEST FACILITY		MECH;HVAC UNIT PKGD;(ASSY)			
	119	UNKNOWN		1	EACH	$3,372
	252-NWTC-BLADE TEST FACILITY		ELEC;PANELBOARD,COMMERCIAL			
	145	PNL A, PNL B		2	EACH	$3,587
	252-NWTC-BLADE TEST FACILITY		MECH;COMPRESSOR;RECIPROCATING			
	160	UNKNOWN		1	EACH	$6,405
					Yearly	**$26,339**
2001						

DEFERRED MAINTENANCE LIST - NWTC

Year	Facility		Component		
	CAIS Tracking No.	Equip	QTY	UM	Cos
2001					
	1.1-NWTC DATA SHEDS		MECH;HVAC UNIT PKGD;(ASSY)		
	195	UNKNOWN	1	EACH	$6,704
	1.2-NWTC DATA SHEDS		ELEC;TRANSFORMERS		
	197	TR1.2	1	EACH	$3,498
	1.2-NWTC DATA SHEDS		MECH;HVAC UNIT PKGD;(ASSY)		
	199	UNKNOWN	1	EACH	$6,704
	1.3-NWTC DATA SHEDS		ELEC;TRANSFORMERS,DRY TYPE		
	201	TR1.3	1	EACH	$4,556
	1.3-NWTC DATA SHEDS		ELEC;PANELBOARD,COMMERCIAL		
	202	LP1.3	1	EACH	$5,049
	1.3-NWTC DATA SHEDS		MECH;HVAC UNIT PKGD;(ASSY)		
	205	UNKNOWN	1	EACH	$6,704
	1.8-NWTC DATA SHEDS		ELEC;GENERATORS;STANDBY,EMERGENCY;(ASSY)		
	206	126686	1	EACH	$37,829
	253-NWTC BUILDING 253		ELEC;PANELBOARD,COMMERCIAL		
	164	253A-LP7	1	EACH	$3,204
	253-NWTC BUILDING 253		MECH;TERMINAL		
	168	UNKNOWN	1	EACH	$1,402
				Yearly	**$75,650**
2002					
	1004-NWTC-EXTERIOR LIGHTING		ELEC; EXTERIOR		
	1962		5	EACH	$4,450
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL		
	15	L1E	1	EACH	$3,204

DEFERRED MAINTENANCE LIST - NWTC

Year	Facility CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2002						
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	16	LDP		1	EACH	$3,204
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	20	L1M		1	EACH	$2,379
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	21	H7B		1	EACH	$7,094
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	23	H2M		1	EACH	$10,348
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	24	H1A		1	EACH	$5,049
	251-NWTC-ADMINISTRATION BUILDING		ELEC;PANELBOARD,COMMERCIAL			
	25	H1E		1	EACH	$2,502
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	34	CUH-1		1	EACH	$1,102
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	39	UNKNOWN		1	EACH	$1,102
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	40	UNKNOWN		4	EACH	$4,925
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	41	UH-4		1	EACH	$1,102
	251-NWTC-ADMINISTRATION BUILDING		MECH;FANS+BLOWERS;GP			
	42	UNKNOWN		4	EACH	$14,861
	251-NWTC-ADMINISTRATION BUILDING		MECH;FANS+BLOWERS;GP			
	43	UNKNOWN		1	EACH	$3,342
	251-NWTC-ADMINISTRATION BUILDING		MECH;FANS+BLOWERS;GP			
	44	UNKNOWN		1	EACH	$14,615
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	52	UH-1		1	EACH	$1,102
	251-NWTC-ADMINISTRATION BUILDING		MECH;TERMINAL			
	53	UH-10		1	EACH	$1,102

DEFERRED MAINTENANCE LIST - NWTC

Year / Facility CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2002					
251-NWTC-ADMINISTRATION BUILDING 54	UNKNOWN	MECH;TERMINAL	1	EACH	$1,102
251-NWTC-ADMINISTRATION BUILDING 55	UH-3	MECH;TERMINAL	1	EACH	$1,102
251-NWTC-ADMINISTRATION BUILDING 57	L1G	ELEC;PANELBOARD,COMMERCIAL	1	EACH	$7,668
251-NWTC-ADMINISTRATION BUILDING 58	L1P	ELEC;PANELBOARD,COMMERCIAL	1	EACH	$7,668
251-NWTC-ADMINISTRATION BUILDING 59	L1J	ELEC;PANELBOARD,COMMERCIAL	1	EACH	$3,704
251-NWTC-ADMINISTRATION BUILDING 60	L1C	ELEC;PANELBOARD,COMMERCIAL	1	EACH	$3,704
251-NWTC-ADMINISTRATION BUILDING 61	L1A	ELEC;PANELBOARD,COMMERCIAL	1	EACH	$3,204
251-NWTC-ADMINISTRATION BUILDING 65	AC2	MECH;COMPRESSOR;RECIPROCATING	1	EACH	$6,405
251-NWTC-ADMINISTRATION BUILDING 70	RTU-2	MECH;HVAC UNIT PKGD;(ASSY)	1	EACH	$18,080
251-NWTC-ADMINISTRATION BUILDING 131		ROOF;BU MEMBRANE	3,000	SQFT	$12,605
NWTC-1004-UNPAVED ROADS 1970		SITE;EARTHWORK;GRADING	40,944	S.Y.	$34,088
NWTC-1005-PAVED/PARKING AREAS 1969		PAVING;PARKING AREAS	70,089	S.F.	$186,285
				Yearly	**$367,098**

2003

DEFERRED MAINTENANCE LIST - NWTC

Year / Facility / CAIS Tracking No.	Equip	Component	QTY	UM	Cos
2003					
253-NWTC BUILDING 253		MECH;TERMINAL			
165	UNKNOWN		2	EACH	$2,805
			Yearly		**$2,805**
2004					
251-NWTC-ADMINISTRATION BUILDING		EXT;GLAZED CURTAIN WALL			
132			4,000	SQFT	$58,471
			Yearly		**$58,471**
			Total		**$549,906**

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E.3 Ten-Year Maintenance Plan - South Table Mountain (STM) Site

The Ten-year Maintenance Plan for the South Table Mountain Site for FY2005-2014 consists of all replacement actions regardless of deferred maintenance status. Consequently, in addition to actions currently classified as deferred maintenance, it includes those for components not yet at the end of useful design life but projected to reach the end during the period of the plan.

Maintenance is "…work that is required to sustain property in a condition for it to be used for its designated purpose(s)……" while repair is "the restoration of failed or malfunctioning equipment, system, or facility to its intended function or design condition." Finally, sustainment is defined as "maintenance and repair activities to keep the inventory in good working order." For the purpose of the planning process, replacement of components or systems constitutes a sustainment action.

The year in which the action is recommended is the Optimum Period. It is defined in the draft of DOE O 430.1B as "that time in the life cycle of an asset when maintenance actions should be accomplished to preserve and maximize the useful life of the asset. The determination is based on engineering/maintenance analysis and is independent of funding availability." It corresponds to the Optimum Year field in the CAIS2000 database.

The plan format provides the details of the actions for each year. It is arranged such that the highest priority is given to the actions associated with the facility with the worst Facility Condition Index (FCI) rating. Within each facility, the actions are arranged from worst condition to best. The FCI is calculated as the ratio of deferred maintenance cost to Replacement Plant Value (RPV) of the facility, Work Breakdown Structure (WBS) category, or component. The FCI used throughout is that existing at the conclusion of the condition assessment and the priorities for each year are based upon this FCI. These priorities will be impacted as actions are completed and additional deficiencies are identified and entered into the Condition Assessment Information System (CAIS) database.

The following information is contained for each recommended action:

- Facility ID and Name
- Component description
- Component condition – The component condition consists of a subjective description that, in turn, is associated with the percentage of the component Replacement Plant Value (RPV) required for the repair or replacement. The condition categories, with the associated replacement cost percentages, are listed below.
    - Excellent <2% (0 to 1.9)
    - Good <5% (2.0 to 4.9)
    - Adequate <10% (5.0 to 9.9)
    - Fair <25% (10.0 to 24.9)
    - Poor <60% (25.0 to 59.9)
    - Fail <100% (60.0 to 99.9; however, the percentage may exceed 100 when the calculated cost of replacement exceeds the approved replacement cost)
- Facility Condition Index (FCI)
- Priority – Assigned for each year such that 1A is the highest priority for the first year (FY 2005), 2A is the highest for the second year (FY2006) and so on.
- Unit of Measure and quantity of component to be replaced

- Cost as calculated by the CAIS program including a location factor for Golden, CO and an NREL site specific factor.
- Equipment ID, where known
- Comments relevant to the recommended action.

In addition, total costs for each Facility and Year are noted, as is the overall total for the ten years. The yearly and overall totals are summarized below:
FY 2005 - $82,926
FY 2006 - $133,016
FY 2007 - $54,413
FY 2008 - $312,101
FY 2009 - $1,222,319
FY 2010 - $60,612
FY 2011 - $58,655
FY 2012 - $227,723
FY 2013 - $3,682,647
FY 2014 - $3,680,297
FY 2015 - $384,251
TOTAL - $9,898,960
Yearly revisions to the costs can be made based upon current component and system condition and funds availability at the time of reevaluation. No adjustments were made at the onset because the yearly cost allocations reflect the current status of the plant.

TEN-YEAR MAINTENANCE PLAN - STM

YEAR				
Facility	**FCI**			
Condition		**UM**	**QTY**	**Cost**
Component		**Equip ID**		
Comments				
2005				
5923 - FETA AMMO BUNKER	**1.70%**			
GOOD <5%		EACH	1	$3,816
ELEC;TRANSFORMERS,DRY TYPE		UNKNOWN		
Facility Total			**$3,816**	
4515 - Solar Energy Research Facility	**0.30%**			
FAIR <25%		EACH	3	$60,000
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST				
MODEL SYSTEM 16, SN-1433, SN-516-0442, SN-516-0266				
			Facility Total	**$60,000**
8606 - Alternative Fuels User Facility	**0.10%**			
FAIR <25%		SQFT	20,000	$19,110
ROOF,WALL; INSULATION				
INSULATION IS NOT EASILY ACCESSABLE DUE TO HEIGHT OF CEILING, BUILDING STRUCTURE, PIPES, EQUIPMENT, ETC. AN ALTERNATIVE TO REMOVAL AND REPLACEMENT IS PATCHING OF EXISTING				
			Facility Total	**$19,110**
			Yearly Total:	**$82,926**
2006				
5308 - Field Test Lab Building	**4.20%**			
GOOD <5%		EACH	1	$131,766
CVY;ELEV CABS;HYDRAULIC				
ELEVATOR CURRENTLY INSTALLLED IS A 4 STOP, 3000 LB PASSENGER ELEVATOR				
			Facility Total	**$131,766**
4716 - Waste Handling Facility	**0.00%**			
GOOD <5%		EACH	1	$1,250
MECH;HEATERS;IN-LINE;AIR		UNKNOWN		
			Facility Total	**$1,250**
			Yearly Total:	**$133,016**

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2007				
5308 - Field Test Lab Building	**4.20%**			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		IEL-4		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		PB234		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		PB237		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		PB236		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		PB-235		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		PB-233		
GOOD <5%		EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL		IH6		
GOOD <5%		EACH	1	$2,379
ELEC;PANELBOARD,COMMERCIAL		2EL4		
		Facility Total		**$44,909**
9306 - Facilities Building	**1.20%**			
GOOD <5%		EACH	1	$5,800
ELEC;PANELBOARD,COMMERCIAL		MDP		
		Facility Total		**$5,800**
9304 - Bulk Storage Facility	**0.70%**			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		LP		

YEAR

Facility **FCI**

Condition **UM** **QTY** **Cost**

Component **Equip ID**

Comments

2007

Facility Total **$3,704**

Yearly Total: **$54,413**

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2008				
5308 - Field Test Lab Building	**4.20%**			
GOOD <5%		EACH	1	$64,031
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID		HX-2		
GOOD <5%		EACH	1	$112,813
ELEC;GENERATORS;STANDBY,EMERGENCY;(ASSY)		UNKNOWN		
GOOD <5%		EACH	1	$67,371
ELEC;GENERATORS;STANDBY,EMERGENCY;(ASSY)		UNKNOWN		
		Facility Total		**$244,215**
9306 - Facilities Building	**1.20%**			
ADQT <10%		EACH	4	$5,232
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID		UNKNOWN		
ADQT <10%		EACH	1	$6,405
MECH;COMPRESSOR;RECIPROCATING		UNKNOWN		
ADQT <10%		EACH	1	$1,730
MECH;TERMINAL UNITS;COOLING		UNKNOWN		
ADQT <10%		EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST		UNKNOWN		
GOOD <5%		EACH	1	$3,204
ELEC;PANELBOARD,COMMERCIAL		PANEL 1		
		Facility Total		**$19,028**
9304 - Bulk Storage Facility	**0.70%**			
GOOD <5%		EACH	2	$2,616
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID		UNKNOWN		
GOOD <5%		EACH	2	$2,616
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID		UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2008				
		Facility Total		**$5,232**
4515 - Solar Energy Research Facility	**0.30%**			
GOOD <5%		EACH	1	$1,102
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID		UNKNOWN		
		Facility Total		**$1,102**
8606 - Alternative Fuels User Facility	**0.10%**			
GOOD <5%		EACH	1	$42,524
MECH;AIR COMPRESSORS		AIR COMP 2		
		Facility Total		**$42,524**
		Yearly Total:		**$312,101**

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2009				
5308 - Field Test Lab Building	**4.20%**			
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB174			
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB120			
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB178			
GOOD <5%		EACH	1	$5,253
ELEC;PANELBOARD,COMMERCIAL	1EL6-C			
GOOD <5%		EACH	2	$12,090
ELEC;PANELBOARD,COMMERCIAL	1EL6-A, 1EL6-B			
		Facility Total		**$35,478**
1904 - Visitor's Center	**0.40%**			
GOOD <5%		EACH	1	$31,256
ELEC;TRANSFER SWITCHES	C2			
		Facility Total		**$31,256**
4515 - Solar Energy Research Facility	**0.30%**			
ADQT <10%		EACH	1	$1,402
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
ADQT <10%		EACH	3	$4,207
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
ADQT <10%		EACH	2	$2,805
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
ADQT <10%		EA.	2	$220,092
MECH;COOLING TOWER;(ASSY)	CT-1, CT-2			

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2009				
ADQT <10%		EACH	1	$1,402
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UH-3W4			
ADQT <10%		EACH	4	$5,609
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
GOOD <5%		EACH	3	$4,207
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
GOOD <5%		EACH	1	$1,402
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
		Facility Total		**$241,126**
8606 - Alternative Fuels User Facility	**0.10%**			
GOOD <5%		EACH	1	$6,196
MECH;WATER HEATER	UNKNOWN			
		Facility Total		**$6,196**
7119 - Concentrated Solar Flux Facility	**0.00%**			
GOOD <5%		EACH	1	$3,204
ELEC;PANELBOARD,COMMERCIAL	L2S			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	L1C			
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	L7S			
GOOD <5%		EACH	1	$1,487
MECH;CONDENSER PKGD;(ASSY)	UNKNOWN			
GOOD <5%		EACH	1	$3,671
MECH;COMPRESSOR;RECIPROCATING	UNKNOWN			

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2009				
GOOD <5%		EACH	1	$1,402
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
GOOD <5%		EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN			
GOOD <5%		EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN			
GOOD <5%		EACH	1	$1,702
MECH;CONDENSER PKGD;(ASSY)	UNKNOWN			
		Facility Total		**$24,543**
STM-1005 - S. Table Mountain Fence	**No FCI Value for OSF's**			
GOOD <5%		LNFT	15,443	$883,720
FENCES;CHAINLINK				
		Facility Total		**$883,720**
		Yearly Total:		**$1,222,319**

TEN-YEAR MAINTENANCE PLAN - STM

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2010				
5308 - Field Test Lab Building	**4.20%**			
GOOD <5%		EACH	1	$6,888
ELEC;PANELBOARD,COMMERCIAL		IPPL2-131		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		IPPL6-1		
GOOD <5%		EACH	1	$1,634
ELEC;PANELBOARD,COMMERCIAL		PB202		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		PB149		
		Facility Total		**$20,612**
4515 - Solar Energy Research Facility	**0.30%**			
GOOD <5%		EACH	4	$40,000
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST				
MODEL # CM4 SN-851-5043, SN-851-7004, SN-851-1909, SN-851-5044				
		Facility Total		**$40,000**
		Yearly Total:		**$60,612**

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2011				
5923 - FETA AMMO BUNKER	**1.70%**			
GOOD <5%		EACH	4	$10,785
MECH;FANS+BLOWERS;GP		UNKNOWN		
		Facility Total		**$10,785**
8606 - Alternative Fuels User Facility	**0.10%**			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		PB208		
		Facility Total		**$3,704**
4317 - HISTORICAL BUNKER	**0.00%**			
GOOD <5%		EACH	1	$2,696
MECH;FANS+BLOWERS;GP		UNKNOWN		
		Facility Total		**$2,696**
4716 - Waste Handling Facility	**0.00%**			
GOOD <5%		EACH	1	$5,800
ELEC;PANELBOARD,COMMERCIAL		HI		
GOOD <5%		EACH	1	$7,361
MECH;FANS+BLOWERS;GP		UNKNOWN		
GOOD <5%		EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL		L1		
1 PANEL BLANK IS MISSING				
GOOD <5%		EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST		UNKNOWN		
GOOD <5%		EACH	3	$11,146
MECH;FANS+BLOWERS;GP		UNKNOWN		
GOOD <5%		EACH	1	$1,252
ELEC;DISCONNECT		DH7		

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2011				
GOOD <5%		EACH	2	$7,409
ELEC;PANELBOARD,COMMERCIAL		SERVICE		
		Facility Total		**$41,470**
		Yearly Total:		**$58,655**

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2012				
5308 - Field Test Lab Building	**4.20%**			
GOOD <5%		EACH	1	$23,034
MECH;AIR COMPRESSORS		10500		
GOOD <5%		EACH	1	$9,749
MECH;FILTERS+DRYERS;AIR		AD-4, 10261		
GOOD <5%		EACH	1	$23,950
MECH;AIR COMPRESSORS		10845		
		Facility Total		**$56,733**
7421 - Solar Industrial Mesa Test Area	**1.50%**			
GOOD <5%		EACH	1	$4,556
ELEC;TRANSFORMERS,DRY TYPE		TR-1		
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		LV-1B		
GOOD <5%		EACH	1	$2,230
MECH;CONDENSER PKGD;(ASSY)		UNKNOWN		
GOOD <5%		EACH	1	$2,258
MECH;COMPRESSOR;RECIPROCATING		UNKNOWN		
		Facility Total		**$12,748**
4515 - Solar Energy Research Facility	**0.30%**			
GOOD <5%		EACH	4	$70,285
ELEC;SWITCHBOARD,DIST. SECTION		UNKNOWN		
		Facility Total		**$70,285**
8606 - Alternative Fuels User Facility	**0.10%**			
GOOD <5%		EACH	1	$5,800
ELEC;PANELBOARD,COMMERCIAL		HA2		

YEAR / Facility / Condition / Component / Comments	FCI	UM / Equip ID	QTY	Cost
2012				
GOOD <5%		EACH	1	$3,204
ELEC;PANELBOARD,COMMERCIAL		UNKNOWN		
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		LB		
GOOD <5%		EACH	1	$1,634
ELEC;PANELBOARD,COMMERCIAL		LC1		
GOOD <5%		EACH	1	$46,680
MECH;CHILLER PKGD;RECIPROCATING;(ASSY)		UNKNOWN		
GOOD <5%		EACH	1	$9,481
MECH;BOILERS;GAS(ASSY)		UNKNOWN		
GOOD <5%		EACH	1	$2,291
ELEC;PANELBOARD,COMMERCIAL		L2		
		Facility Total		**$72,794**
7119 - Concentrated Solar Flux Facility	**0.00%**			
GOOD <5%		EACH	1	$3,068
MECH;FANS+BLOWERS;GP		UNKNOWN		
		Facility Total		**$3,068**
7521 - SOLAR INDUSTRIAL MESSA TEST	**0.00%**			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		LV-1A		
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL		LV1C		
GOOD <5%		EACH	1	$2,230
MECH;CONDENSER PKGD;(ASSY)		UNKNOWN		

TEN-YEAR MAINTENANCE PLAN - STM

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2012			
GOOD <5% MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST SERVES BUILDING 7521 AND 7421.	EACH UNKNOWN	1	$2,457
		Facility Total	**$12,095**
		Yearly Total:	**$227,723**

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2013			
5308 - Field Test Lab Building	**4.20%**		
ADQT <10%	EACH	1	$841
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		
GOOD <5%	EACH	2	$58,091
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$3,207
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$3,816
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$3,816
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$4,556
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$4,556
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$9,149
ELEC;TRANSFORMERS,DRY TYPE	T-2		
GOOD <5%	EACH	1	$29,045
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	2	$15,202
ELEC;SWITCHBOARD,DIST. SECTION	IPPL-4		
GOOD <5%	EACH	1	$7,268
ELEC;TRANSFORMERS,DRY TYPE	T-01		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2013			
GOOD <5%	EACH	1	$5,348
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	4	$34,900
ELEC;SWITCHBOARD,DIST. SECTION	MAIN, MDP-2,		
GOOD <5%	EACH	1	$7,268
ELEC;TRANSFORMERS,DRY TYPE	T3		
GOOD <5%	EACH	2	$15,202
ELEC;SWITCHBOARD,DIST. SECTION	IPPH-5		
GOOD <5%	EACH	1	$3,816
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	2	$11,190
ELEC;SWITCHBOARD,DIST. SECTION	IPPH-3 SECT1,		
GOOD <5%	EACH	2	$5,595
ELEC;SWITCHBOARD,DIST. SECTION	1 PPH-4		
GOOD <5%	EACH	1	$4,624
ELEC;SWITCHBOARD,DIST. SECTION	IPPH5-2		
GOOD <5%	EACH	1	$4,624
ELEC;SWITCHBOARD,DIST. SECTION	IPPEH-5		
GOOD <5%	EACH	1	$42,015
ELEC;TRANSFER SWITCHES	CPE-ATS		
GOOD <5%	EACH	1	$31,256
ELEC;TRANSFER SWITCHES	UNKNOWN		
GOOD <5%	EACH	1	$841
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2013			
GOOD <5%	EACH	2	$17,450
ELEC;SWITCHBOARD,DIST. SECTION	IPPL-2		
GOOD <5%	EACH	2	$9,407
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$841
MECH;TANKS FLUID STORAGE;GP	ET-1		
GOOD <5%	EACH	1	$10,460
MECH;WATER HEATER	UNKNOWN		
GOOD <5%	EACH	1	$4,400
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		
GOOD <5%	EACH	3	$29,647
ELEC;SWITCHBOARD,DIST. SECTION	IPPL-3		
GOOD <5%	EACH	1	$7,268
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$2,945
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		
GOOD <5%	SQYD	1,000	$38,448
INT;FLOOR;CARPET			
GOOD <5%	EACH	2	$15,968
EXT;DOORS;METAL	UNKNOWN		
GOOD <5%	EACH	1	$841
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		
GOOD <5%	EACH	1	$7,984
EXT;DOORS;METAL	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2013			
GOOD <5%	EACH	1	$2,277
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	2	$5,852
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$4,231
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$1,252
ELEC;DISCONNECT	CPH3, 20, 22, 24		
GOOD <5%	EACH	1	$7,268
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$54,307
ELEC;MOTOR CONTROL CENTER;(ASSY)	CPE-MCC7		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	IPPL2		
MISSING A PANEL BLANK ON CIRCUIT #34			
GOOD <5%	EACH	2	$15,968
EXT;DOORS;METAL	UNKNOWN		
GOOD <5%	EACH	1	$1,252
ELEC;DISCONNECT	CPH1, 2, 3, 5		
GOOD <5%	EACH	1	$2,926
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$1,252
ELEC;DISCONNECT	UNKNOWN		
GOOD <5%	EACH	1	$1,252
ELEC;DISCONNECT	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2013				
GOOD <5%		EACH	1	$1,252
ELEC;DISCONNECT	UNKNOWN			
GOOD <5%		EACH	1	$1,838
ELEC;DISCONNECT	UNKNOWN			
		Facility Total		**$558,857**
4515 - Solar Energy Research Facility	**0.30%**			
GOOD <5%		L.F.	8	$721
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
GOOD <5%		EACH	1	$5,049
ELEC;PANELBOARD,COMMERCIAL	UNKNOWN			
GOOD <5%		EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2HP-B16			
GOOD <5%		EACH	1	$15,808
ELEC;UPS	11250601			
GOOD <5%		EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	1HP-G16A			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	2ELP-S3			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	C2C			
GOOD <5%		EACH	2	$11,600
ELEC;PANELBOARD,COMMERCIAL	1HP--6, 1HP-P6A			
GOOD <5%		L.F.	7	$631
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2013			
GOOD <5%	EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	C2W		
GOOD <5%	L.F.	6	$541
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	8	$48,361
ELEC;PANELBOARD,COMMERCIAL			
PANELS C215-L1, C211-L1, C212-L1, L2, C217-L1, C219-L1, C221-L1, C213-L1			
GOOD <5%	EACH	9	$54,407
ELEC;PANELBOARD,COMMERCIAL			
PANELS W212-L1,L2,L3,L4, W216-L1, W214-L1, W213-L1,L2, W209-L1			
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	2LP-B18		
GOOD <5%	EACH	2	$12,090
ELEC;PANELBOARD,COMMERCIAL	1LP-E21, E22		
GOOD <5%	EACH	2	$17,031
MECH;FANS+BLOWERS;GP	RAF1, 2		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	1LP-U12		
GOOD <5%	EACH	1	$10,432
ELEC;PANELBOARD,COMMERCIAL	2HDP-T3		
GOOD <5%	EACH	2	$20,864
ELEC;PANELBOARD,COMMERCIAL	2EHDP-T3 SECT 1,		
GOOD <5%	EACH	2	$44,497
ELEC;UPS	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2013			
GOOD <5%	EACH	3	$24,389
MECH;PUMP;FLUID;GP	CWP-1, CWP-2,		
GOOD <5%	EACH	1	$11,984
ELEC;UPS	123568		
GOOD <5%	EACH	1	$7,601
ELEC;SWITCHBOARD,DIST. SECTION	PLDP-R8		
GOOD <5%	EACH	2	$44,497
ELEC;UPS	UNKNOWN		
GOOD <5%	EACH	2	$66,387
ELEC;UPS	123656, 123657		
GOOD <5%	EACH	2	$20,864
ELEC;PANELBOARD,COMMERCIAL	2HDP-P6, SECT1,		
GOOD <5%	EACH	1	$193,570
CVY;ELEV CABS;HYDRAULIC			
CURRENT ELEVATOR IS A 4 STOP, 5000LB MODEL # EP-17040			
GOOD <5%	EACH	1	$193,570
CVY;ELEV CABS;HYDRAULIC			
CURRENT ELEVATOR IS 3 STOP, 4500 LBS, MODEL # EP-15040			
GOOD <5%	EACH	1	$79,258
CVY;ELEV CABS;HYDRAULIC			
GOOD <5%	EACH	1	$193,570
CVY;ELEV CABS;HYDRAULIC			
CURRENT ELEVATOR IS A 3 STOP, 4500 LB MODEL # EP-15040			
GOOD <5%	EACH	1	$5,348
ELEC;TRANSFORMERS,DRY TYPE	TPB-16		

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2013				
GOOD <5%		EACH	1	$79,258
CVY;ELEV CABS;HYDRAULIC				
		Facility Total		**$1,202,732**
8606 - Alternative Fuels User Facility	**0.10%**			
GOOD <5%		EACH	1	$79,258
CVY;ELEV CABS;HYDRAULIC				
GOOD <5%		EACH	3	$26,016
ELEC;CONTROL UNIT;ELEC;(ASSY)	UNKNOWN			
GOOD <5%		EACH	1	$79,258
CVY;ELEV CABS;HYDRAULIC				
GOOD <5%		EACH	1	$42,524
MECH;AIR COMPRESSORS	AIR COMP 4			
GOOD <5%		EACH	1	$4,303
MECH;PUMP;FLUID;GP	P-5			
		Facility Total		**$231,359**
7119 - Concentrated Solar Flux Facility	**0.00%**			
GOOD <5%		EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN			
		Facility Total		**$1,664**
0002 - STM - Secondary Roads	**No FCI Value for OSF's**			
GOOD <5%		L.F.	2,371	$397,454
PAVING;ROADWAYS				
		Facility Total		**$397,454**
0004 - STM- Paved/Parking Areas	**No FCI Value for OSF's**			
GOOD <5%		S.F.	110,740	$294,329
PAVING;PARKING AREAS				

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2013				
		Facility Total		**$294,329**
102 - STM - Exterior Lighting	**No FCI Value for OSF's**			
GOOD <5%		EACH	65	$57,851
ELEC; EXTERIOR				
GOOD <5%		EACH	52	$126,072
ELEC; EXTERIOR				
GOOD <5%		EACH	52	$64,610
ELEC; EXTERIOR				
GOOD <5%		EACH	65	$73,147
ELEC; EXTERIOR				
GOOD <5%		EACH	808	$110,185
ELEC; EXTERIOR				
		Facility Total		**$431,865**
2501 - Storm Water Drain System	**No FCI Value for OSF's**			
GOOD <5%		LNFT	2,801	$256,430
MECH,PIPING;DRAINAGE & SEWAGE				
		Facility Total		**$256,430**
2505 - STM - Fire Water Pipe	**No FCI Value for OSF's**			
GOOD <5%		LNFT	3,600	$306,029
MECH;PIPING;CAST IRON				
		Facility Total		**$306,029**
8000 - STM- Natural Gas Distribution	**No FCI Value for OSF's**			
GOOD <5%		LNFT	200	$1,928
MECH;PIPING(WO/FITTINGS)				
		Facility Total		**$1,928**
		Yearly Total:		**$3,682,647**

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
1904 - Visitor's Center	**0.40%**		
GOOD <5%	EACH	1	$7,615
MECH;CONDENSER PKGD;(ASSY)	UNKNOWN		
GOOD <5%	EACH	1	$16,952
ELEC;TRANSFORMERS,OIL FILLED	UNKNOWN		
GOOD <5%	EACH	1	$7,668
ELEC;PANELBOARD,COMMERCIAL	SES		
GOOD <5%	EACH	1	$5,500
MECH;CONDENSER PKGD;(ASSY)	UNKNOWN		
GOOD <5%	EACH	1	$3,636
MECH;CONDENSER PKGD;(ASSY)	UNKNOWN		
GOOD <5%	EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST	UNKNOWN		
GOOD <5%	EACH	1	$11,473
MECH;WATER HEATER	UNKNOWN		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	VC1		
GOOD <5%	EACH	1	$19,172
MECH;BOILERS;GAS(ASSY)	UNKNOWN		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	VC2		
GOOD <5%	EACH	2	$4,303
MECH;FANS+BLOWERS;GP	EF-1, EF-2		

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2014				
GOOD <5%		EACH	3	$26,615
MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)	AHU-1, AHU-2,			
		Facility Total		**$117,481**
4515 - Solar Energy Research Facility	**0.30%**			
ADQT <10%		EACH	7	$42,316
ELEC;PANELBOARD,COMMERCIAL				
PANELS EB102L1, EB114L1, EB108L1, EB109L1, EB103L1, EB106L1 SECT1, SECT2				
ADQT <10%		EACH	1	$6,050
ELEC;PANELBOARD,COMMERCIAL	2HP-P6A			
ADQT <10%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	C2E			
ADQT <10%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	C1E			
ADQT <10%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	C1C			
ADQT <10%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	C1W			
ADQT <10%		EACH	2	$8,418
ELEC;PANELBOARD,COMMERCIAL	1LP-N12, 1LP-M12			
ADQT <10%		EACH	1	$6,050
ELEC;PANELBOARD,COMMERCIAL	2HP-G16A			
ADQT <10%		EACH	1	$4,209
ELEC;PANELBOARD,COMMERCIAL	2LP-P6			
ADQT <10%		EACH	1	$4,209
ELEC;PANELBOARD,COMMERCIAL	1LP-U13			

TEN-YEAR MAINTENANCE PLAN - STM

YEAR Facility Condition Component Comments	FCI UM Equip ID	QTY	Cost
2014			
ADQT <10% ELEC;PANELBOARD,COMMERCIAL	EACH EB100L1	1	$10,432
ADQT <10% INT,EXT;DOORS;OVHD ROLL-UP	EACH UNKNOWN	1	$4,704
ADQT <10% MECH;CHILLER;CENTRIFUGAL;(ASSY)	EACH CH-1, CH-2	2	$320,301
ADQT <10% MECH;PUMP;FLUID;GP	EACH HXP-1	1	$5,615
ADQT <10% ELEC;PANELBOARD,COMMERCIAL	EACH 1HP-N12	1	$5,253
ADQT <10% MECH;PUMP;FLUID;GP	EACH PRCWP-1,	2	$17,299
ADQT <10% MECH;PUMP;FLUID;GP	EACH SCWP-1, SCWP-2	2	$17,299
ADQT <10% MECH;TERMINAL UNITS;COOLING UNIT HAS SMALL WATER LEAK	EACH UNKNOWN	1	$2,573
ADQT <10% MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	L.F. UNKNOWN	10	$901
ADQT <10% MECH;PUMP;FLUID;GP	EACH P-1, P-2	2	$16,259
ADQT <10% MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	L.F. UNKNOWN	54	$4,866
ADQT <10% MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	L.F. UNKNOWN	12	$1,081

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
ADQT <10%	L.F.	12	$1,081
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	L.F.	40	$3,604
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	L.F.	12	$1,081
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	EACH	2	$94,470
MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)	AH1, AH2		
ADQT <10%	L.F.	36	$3,244
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	EACH	1	$5,253
ELEC;PANELBOARD,COMMERCIAL	1H-G16		
ADQT <10%	L.F.	12	$1,081
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	L.F.	8	$721
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	EACH	2	$7,431
MECH;FANS+BLOWERS;GP	GEF-1, GEF-2		
ADQT <10%	L.F.	12	$1,081
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	EACH	1	$27,904
MECH;PUMPS;FIRE	UNKNOWN		
ADQT <10%	L.F.	40	$3,604
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
ADQT <10%	EACH	1	$3,715
MECH;FANS+BLOWERS;GP	GEF-3		
ADQT <10%	EACH	4	$156,379
MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)	MAU-1, MAU-2,		
ADQT <10%	EACH	3	$18,821
MECH;PUMP;FLUID;GP	SHWP-1, PHWP-2,		
ADQT <10%	EACH	1	$9,624
MECH;PUMP;FLUID;GP	UNKNOWN		
ADQT <10%	EACH	2	$33,180
MECH;PUMP;FLUID;GP	HRP-1, HRP-2		
ADQT <10%	L.F.	72	$6,488
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
ADQT <10%	L.F.	36	$3,244
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	1HP-N12A		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2HDP-N12		
GOOD <5%	EACH	1	$122,197
ELEC;TRANSFORMERS,OIL FILLED	T4515A		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	BLP-P6		
GOOD <5%	EACH	1	$5,253
ELEC;PANELBOARD,COMMERCIAL	1EHP-N12		

TEN-YEAR MAINTENANCE PLAN - STM

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
GOOD <5%	EACH	1	$121,109
MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)	HX-1		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2ELP-G11		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2LP-G11		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	EB-100H1		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2HP-N12A		
GOOD <5%	EACH	1	$5,773
MECH;FILTERS+DRYERS;AIR	UNKNOWN		
GOOD <5%	EACH	2	$89,373
MECH;FANS+BLOWERS;GP	EAF-5, EAF-6		
GOOD <5%	EACH	2	$20,920
MECH;WATER HEATER	UNKNOWN		
GOOD <5%	EACH	9	$77,406
ELEC;PANELBOARD,COMMERCIAL			
PANELS E216L2, E216L1, E222L1, E222L2, E217L2, E217L1, E220L1, E219L1, E218L1			
GOOD <5%	EACH	1	$23,034
MECH;AIR COMPRESSORS	UNKNOWN		
GOOD <5%	EACH	2	$46,069
MECH;AIR COMPRESSORS	UNKNOWN		
GOOD <5%	EACH	2	$149,845
MECH;FILTERS+DRYERS;AIR	AD1, AD2		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
GOOD <5%	EACH	2	$2,204
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	2	$2,204
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	2	$326,164
MECH;BOILERS;GAS(ASSY)	B-1, B-2		
GOOD <5%	EACH	1	$81,647
MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)	HX-2		
GOOD <5%	EACH	4	$111,209
MECH;FANS+BLOWERS;GP	EAF1, EAF2, EAF3,		
GOOD <5%	EACH	2	$21,840
MECH;FANS+BLOWERS;GP	EAF7, EAF8		
GOOD <5%	EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST	UNKNOWN		
GOOD <5%	EACH	1	$6,704
MECH;TERMINAL UNITS;COOLING	HPU1		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	IELP-N12		
GOOD <5%	EACH	1	$6,704
MECH;TERMINAL UNITS;COOLING	HPU4		
GOOD <5%	EACH	9	$77,406
ELEC;PANELBOARD,COMMERCIAL			
PANELS E133L1, E129L1, E134L1, E135L1, E130L1, E130L2, E136L1, E131L1, E140L1			

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
GOOD <5%	EACH	9	$77,406
ELEC;PANELBOARD,COMMERCIAL			
PANELS E142L1, C125L1, C124L1, E137L1, C122L1, W135L1, C121L1, C120L1, W133L1			
GOOD <5%	EACH	7	$60,205
ELEC;PANELBOARD,COMMERCIAL			
PANELS W125L1, W132L1, W132L14, W127L2, W127L1, W129L1, W129L2			
GOOD <5%	EACH	7	$60,205
ELEC;PANELBOARD,COMMERCIAL	UNKNOWN		
GOOD <5%	EACH	2	$8,418
ELEC;PANELBOARD,COMMERCIAL	2LP-N12, 2LP-M12		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN		
GOOD <5%	EACH	1	$6,704
MECH;TERMINAL UNITS;COOLING	HPU6		
GOOD <5%	EACH	1	$3,378
ELEC;PANELBOARD,COMMERCIAL	2ELP-N12		
GOOD <5%	EACH	1	$6,704
MECH;TERMINAL UNITS;COOLING	HPU3		
GOOD <5%	EACH	1	$6,704
MECH;TERMINAL UNITS;COOLING	HPU-5		
GOOD <5%	EACH	1	$6,704
MECH;TERMINAL UNITS;COOLING	HPU2		
GOOD <5%	EACH	35	$58,245
MECH;TERMINAL UNITS;COOLING			
FCU 20103, 20115, 20210, 20670, 20671, 20672, 20669, 20151, 20147, 20145, 20186, 20261, 20137, 20135, 20140, 20128, 20130, 20132, 20677, 20250, 20252, 20490, 20246, 20235, 20238, 20240, 20244, 20215, 20259, 1002, 20201, 20202, 20200, 20199, 20190			

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
	Facility Total		**$2,536,764**
8606 - Alternative Fuels User Facility	**0.10%**		
GOOD <5%	EACH	1	$5,348
ELEC;TRANSFORMERS,DRY TYPE	PDP-2 CKT-1		
GOOD <5%	EACH	6	$51,604
ELEC;PANELBOARD,COMMERCIAL	LE-1, LE-2, 2C6R,		
GOOD <5%	EACH	1	$6,722
ELEC;TRANSFER SWITCHES	ATS		
APPEARS ABANDONDED IN PLACE			
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2C6H		
GOOD <5%	EACH	2	$17,201
ELEC;PANELBOARD,COMMERCIAL	1B5HE, 1B5H		
GOOD <5%	EACH	1	$3,670
ELEC;PANELBOARD,COMMERCIAL	2B5H		
GOOD <5%	EACH	1	$55,545
ELEC;MOTOR CONTROL CENTER;(ASSY)	MCC3		
GOOD <5%	EACH	1	$7,268
ELEC;TRANSFORMERS,DRY TYPE	T-LK		
GOOD <5%	EACH	1	$2,945
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		
FIRE SUPPRESSION SYSTEM CONTAINS ANSULITE ALCOHOL RESISTANT CONCENTRATE			
GOOD <5%	EACH	1	$4,624
ELEC;SWITCHBOARD,DIST. SECTION	SWG7		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
GOOD <5%	EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	1B5L		
GOOD <5%	EACH	1	$54,307
ELEC;MOTOR CONTROL CENTER;(ASSY)	UNKNOWN		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	2C6L		
GOOD <5%	EACH	1	$55,545
ELEC;MOTOR CONTROL CENTER;(ASSY)	MCC2A		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	2	$7,409
ELEC;PANELBOARD,COMMERCIAL	LA-LEFT, LA-RIGHT		
GOOD <5%	EACH	2	$8,418
ELEC;PANELBOARD,COMMERCIAL	LA, LD		
GOOD <5%	EACH	1	$138,276
MECH;BOILERS;GAS(ASSY)	UNKNOWN		
GOOD <5%	EACH	2	$2,037
ELEC;DISCONNECT	HA37,39		
GOOD <5%	EACH	1	$6,508
MECH;FILTERS+DRYERS;AIR	UNKNOWN		
GOOD <5%	EACH	1	$39,708
ELEC;MOTOR CONTROL CENTER;(ASSY)	MCC-2		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	HA		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
GOOD <5%	EACH	1	$4,000
ELEC;GENERATORS;STANDBY,EMERGENCY;(ASSY)	AFUP		
THIS UNIT IS NO LONGER IN SERVICE AND NEEDS TO BE REMOVED FROM THE PROPERTY.			
GOOD <5%	EACH	1	$2,277
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	6	$22,226
ELEC;PANELBOARD,COMMERCIAL	2B5L		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
	Facility Total		**$536,701**
1802 - Site Entrance Building	**0.00%**		
ADQT <10%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	ELSB		
ADQT <10%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	EL		
ADQT <10%	EACH	1	$1,853
MECH;FURNACES;HOT AIR;(ASSY)	UNKNOWN		
ADQT <10%	EACH	1	$1,702
MECH;CONDENSER PKGD;(ASSY)	UNKNOWN		
	Facility Total		**$15,645**
7704 - Outdoor Test Facility	**0.00%**		
GOOD <5%	EACH	1	$16,155
MECH;COMPRESSOR;RECIPROCATING	UNKNOWN		

TEN-YEAR MAINTENANCE PLAN - STM

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2014			
GOOD <5%	EACH	1	$16,437
MECH;AIR HANDLERS;HEAT/VENT UNITS;(ASSY)	AHU-1		
GOOD <5%	EACH	1	$3,068
MECH;FANS+BLOWERS;GP	UNKNOWN		
GOOD <5%	EACH	1	$3,068
MECH;FANS+BLOWERS;GP	UNKNOWN		
	Facility Total		**$38,728**
0004 - STM- Paved/Parking Areas	**No FCI Value for OSF's**		
GOOD <5%	S.F.	13,843	$36,792
PAVING;PARKING AREAS			
	Facility Total		**$36,792**
2502 - STM- Sewer Pipe	**No FCI Value for OSF's**		
GOOD <5%	L.F.	3,600	$267,803
MECH;PIPE FITTINGS			
	Facility Total		**$267,803**
2503 - STM - Domestic Water Pipe	**No FCI Value for OSF's**		
GOOD <5%	L.F.	3,600	$130,383
MECH;PIPE FITTINGS			
	Facility Total		**$130,383**
	Yearly Total:		**$3,680,297**
	Grand Total:		**$9,514,709**

ONE-YEAR MAINTENANCE PLAN 2015 -

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2015			
5308 - Field Test Lab Building	**4.20%**		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB280		
GOOD <5%	EACH	1	$7,668
ELEC;PANELBOARD,COMMERCIAL	CHPA4		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	CPL4A		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB272		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	2EL5 LABORATORY		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB299		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB300		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB276		
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB271B		
GOOD <5%	EACH	1	$5,177
ELEC;PANELBOARD,COMMERCIAL	PB272CP		
GOOD <5%	EACH	1	$2,540
ELEC;PANELBOARD,COMMERCIAL	PB285CP		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2015			
GOOD <5%	EACH	1	$6,045
ELEC;PANELBOARD,COMMERCIAL	PB270		
GOOD <5%	EACH	1	$1,999
ELEC;PANELBOARD,COMMERCIAL	IPPL-6		
GOOD <5%	EACH	2	$12,090
ELEC;PANELBOARD,COMMERCIAL	2L13B, 2L13A		
GOOD <5%	EACH	1	$2,917
ELEC;PANELBOARD,COMMERCIAL	PB278		
MISSING THREE (3) PANEL BLANKS			
GOOD <5%	EACH	1	$3,378
ELEC;PANELBOARD,COMMERCIAL	PB290CP		
GOOD <5%	EACH	1	$4,209
ELEC;PANELBOARD,COMMERCIAL	PB271A		
GOOD <5%	EACH	1	$5,177
ELEC;PANELBOARD,COMMERCIAL	2EL6		
GOOD <5%	EACH	1	$8,601
ELEC;PANELBOARD,COMMERCIAL	2H12 BUILDING CIR		
	Facility Total		**$108,161**
8606 - Alternative Fuels User Facility	**0.10%**		
GOOD <5%	EA.	1	$68,461
MECH;COOLING TOWER;(ASSY)	TOWER 1		
	Facility Total		**$68,461**
7704 - Outdoor Test Facility	**0.00%**		
GOOD <5%	EACH	1	$6,274
MECH;PUMP;FLUID;GP	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2015			
GOOD <5%	EACH	4	$6,657
MECH;TERMINAL UNITS;COOLING	FCU-4A, FCU-4B,		
GOOD <5%	EACH	3	$26,175
ELEC;SWITCHBOARD,DIST. SECTION	SWGR		
GOOD <5%	EACH	1	$5,049
ELEC;PANELBOARD,COMMERCIAL	HVL		
GOOD <5%	EACH	1	$6,888
ELEC;PANELBOARD,COMMERCIAL	HV1		
GOOD <5%	EACH	1	$3,204
ELEC;PANELBOARD,COMMERCIAL	UNKNOWN		
GOOD <5%	EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	LV1		
GOOD <5%	L.F.	20	$1,802
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	1	$2,789
MECH;FILTERS+DRYERS;AIR	UNKNOWN		
GOOD <5%	EACH	1	$1,102
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	1	$1,102
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	2	$2,204
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	2	$2,204
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2015			
GOOD <5%	EACH	2	$2,204
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	2	$2,204
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	L.F.	9	$811
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	L.F.	12	$1,081
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	L.F.	5	$451
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	L.F.	5	$451
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	2	$17,299
MECH;PUMP;FLUID;GP	UNKNOWN		
GOOD <5%	L.F.	21	$1,892
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	EACH	1	$16,155
MECH;COMPRESSOR;RECIPROCATING	UNKNOWN		
GOOD <5%	L.F.	4	$360
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	L.F.	4	$360
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
GOOD <5%	L.F.	14	$1,262
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2015			
GOOD <5%	EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST	UNKNOWN		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	FCU-3		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	FCU-7A, FCU-7B		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	FCU-8A, FCU-8B		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	FCU-5A		
GOOD <5%	EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN		
GOOD <5%	L.F.	19	$1,712
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
	Facility Total		**$127,837**
0004 - STM- Paved/Parking Areas	**No FCI Value for OSF's**		
GOOD <5%	S.F.	13,843	$36,792
PAVING;PARKING AREAS			
	Facility Total		**$36,792**
STM-1003 - Alternative Fuel Vehicle Fueling Station	**No FCI Value for OSF's**		
GOOD <5%	EACH	2	$43,000
MECH;TANKS FLUID STORAGE;GP			
CNG REFUELING STATION, 2 DISPENSERS (3000 PSI)			

ONE-YEAR MAINTENANCE PLAN 2015 -

YEAR

Facility **FCI**

Condition **UM** **QTY** **Cost**

Component **Equip ID**

Comments

2015

Facility Total **$43,000**

Yearly Total: **$384,251**

Grand Total: **$384,251**

E.4 Ten –Year Maintenance Plan - National Wind Technology Center (NWTC) Site

The Ten-year Maintenance Plan for the National Wind Technology Center for FY2005-2014 consists of all replacement actions regardless of deferred maintenance status. Consequently, in addition to actions currently classified as deferred maintenance, it includes those for components not yet at the end of useful design life but projected to reach the end during the period of the plan.

Maintenance is "…work that is required to sustain property in a condition for it to be used for its designated purpose(s)……" while repair is "the restoration of failed or malfunctioning equipment, system, or facility to its intended function or design condition." Finally, sustainment is defined as "maintenance and repair activities to keep the inventory in good working order." For the purpose of the planning process, replacement of components or systems constitutes a sustainment action.

The year in which the action is recommended is the Optimum Period. It is defined in the draft of DOE O 430.1B as "that time in the life cycle of an asset when maintenance actions should be accomplished to preserve and maximize the useful life of the asset. The determination is based on engineering/maintenance analysis and is independent of funding availability." It corresponds to the Optimum Year field in the CAIS2000 database.

The plan format provides the details of the actions for each year. It is arranged such that the highest priority is given to the actions associated with the facility with the worst Facility Condition Index (FCI) rating. Within each facility, the actions are arranged from worst condition to best. The FCI is calculated as the ratio of deferred maintenance cost to Replacement Plant Value (RPV) of the facility, Work Breakdown Structure (WBS) category, or component. The FCI used throughout is that existing at the conclusion of the condition assessment and the priorities for each year are based upon this FCI. These priorities will be impacted as actions are completed and additional deficiencies are identified and entered into the Condition Assessment Information System (CAIS) database.

The following information is contained for each recommended action:

- Facility ID and Name
- Component description
- Component condition – The component condition consists of a subjective description that, in turn, is associated with the percentage of the component Replacement Plant Value (RPV) required for the repair or replacement. The condition categories, with the associated replacement cost percentages, are listed below.
    - Excellent <2% (0 to 1.9)
    - Good <5% (2.0 to 4.9)
    - Adequate <10% (5.0 to 9.9)
    - Fair <25% (10.0 to 24.9)
    - Poor <60% (25.0 to 59.9)
    - Fail <100% (60.0 to 99.9; however, the percentage may exceed 100 when the calculated cost of replacement exceeds the approved replacement cost)
- Facility Condition Index (FCI)
- Priority – Assigned for each year such that 1A is the highest priority for the first year (FY 2005), 2A is the highest for the second year (FY2006) and so on.
- Unit of Measure and quantity of component to be replaced

- Cost as calculated by the CAIS program including a location factor for Golden, CO and an NREL site specific factor.
- Equipment ID, where known
- Comments relevant to the recommended action.

In addition, total costs for each Facility and Year are noted, as is the overall total for the ten years. The yearly and overall totals are summarized below:
FY 2005 - $0
FY 2006 - $78,209
FY 2007 - $498,654
FY 2008 - $49,178
FY 2009 - $83,112
FY 2010 - $7,268
FY 2011 - $169,810
FY 2012 - $802,297
FY 2013 - $689,651
FY 2014 - $58,763
FY 2015 - $109,291
TOTAL - $2,546,233
Yearly revisions to the costs can be made based upon current component and system condition and funds availability at the time of reevaluation. No adjustments were made at the onset because the yearly cost allocations reflect the current status of the plant.

TEN-YEAR MAINTENANCE PLAN - NWTC

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2006			
254 - Industrial User's Facility	**4.40%**		
GOOD <5%	EACH	1	$78,209
ELEC;GENERATORS;STANDBY,EMERGENCY;(ASSY)			
	Facility Total		**$78,209**
	Yearly Total:		**$78,209**
2007			
251 - NWTC-Administration Building	**1.90%**		
GOOD <5%	EACH	1	$1,402
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
	Facility Total		**$1,402**
NWTC-1006 - Fencing	**No FCI Value for OSF's**		
GOOD <5%	LNFT	15,953	$497,252
FENCES;CHAINLINK			
	Facility Total		**$497,252**
	Yearly Total:		**$498,654**
2008			
253 - NWTC BUILDING 253	**5.00%**		
GOOD <5%	EACH	1	$4,251
ELEC;PANELBOARD,COMMERCIAL	UNKNOWN		
	Facility Total		**$4,251**
251 - NWTC-Administration Building	**1.90%**		
ADQT <10%	EACH	2	$44,927
MECH;WATER HEATER	UNKNOWN		
	Facility Total		**$44,927**
	Yearly Total:		**$49,178**

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2009				
252 - NWTC-Blade Test Facility	**4.00%**			
ADQT <10%		EACH	5	$4,128
ELEC;DISCONNECT	D1, D2, D4, D5, D6			
ADQT <10%		EACH	3	$21,804
ELEC;TRANSFORMERS,DRY TYPE	T1, T2, T3			
ADQT <10%		EACH	2	$2,973
ELEC;DISCONNECT	D3, SPARE			
ADQT <10%		EACH	1	$3,095
ELEC;DISCONNECT	UNKNOWN			
ADQT <10%		SQ.	26	$7,364
ROOF;1-PLY MEMBRANE				
GOOD <5%		EACH	1	$2,926
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN			
		Facility Total		**$42,290**
1003 - NWTC - Power Distribution	**No FCI Value for OSF's**			
GOOD <5%		EACH	1	$40,822
ELEC;TRANSFORMERS,OIL FILLED				
		Facility Total		**$40,822**
		Yearly Total:		**$83,112**
2010				
M1A - NWTC BUILDING M1A	**0.00%**			
GOOD <5%		EACH	1	$7,268
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN			
		Facility Total		**$7,268**
		Yearly Total:		**$7,268**

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2011			
1.3 - NWTC DATA SHEDS	**87.50%**		
ADQT <10%	EACH	1	$9,195
ELEC;TRANSFER SWITCHES	MTS1.3		
	Facility Total		**$9,195**
1.1 - NWTC Data Sheds	**36.00%**		
GOOD <5%	EACH	1	$1,487
ELEC;DISCONNECT	MTS 1.1		
	Facility Total		**$1,487**
M1A - NWTC BUILDING M1A	**0.00%**		
GOOD <5%	EACH	2	$2,805
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN		
	Facility Total		**$2,805**
1003 - NWTC - Power Distribution	**No FCI Value for OSF's**		
GOOD <5%	EACH	1	$48,074
ELEC;TRANSFORMERS,OIL FILLED			
GOOD <5%	EACH	1	$14,437
ELEC;TRANSFORMERS,OIL FILLED			
GOOD <5%	EACH	1	$27,570
ELEC;TRANSFORMERS,OIL FILLED			
GOOD <5%	EACH	1	$33,121
ELEC;TRANSFORMERS,OIL FILLED			
GOOD <5%	EACH	1	$33,121
ELEC;TRANSFORMERS,OIL FILLED			
	Facility Total		**$156,323**
	Yearly Total:		**$169,810**

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2012			
254 - Industrial User's Facility	**4.40%**		
GOOD <5%	EACH	2	$19,458
INT;DOORS;METAL	UNKNOWN		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	2	$23,989
ELEC;TRANSFER SWITCHES	UNKNOWN		
GOOD <5%	EACH	2	$77,340
ELEC;TRANSFORMERS,OIL FILLED	T9, T10		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
GOOD <5%	EACH	1	$4,704
INT,EXT;DOORS;OVHD ROLL-UP	UNKNOWN		
	Facility Total		**$139,603**
251 - NWTC-Administration Building	**1.90%**		
FAIR <25%	EACH	1	$976
ELEC;DISCONNECT	MTS7		
FAIR <25%	EACH	1	$976
ELEC;DISCONNECT	UNKNOWN		
ADQT <10%	EACH	2	$5,598
ELEC;DISCONNECT	FS11, FS12		
ADQT <10%	EACH	2	$2,973
ELEC;DISCONNECT	FS18, FS19		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2012			
ADQT <10%	EACH	1	$1,054
ELEC;TRANSFORMERS	T14		
ADQT <10%	EACH	1	$2,799
ELEC;DISCONNECT	UNKNOWN		
ADQT <10%	EACH	1	$4,103
INT;DOORS;METAL	UNKNOWN		
ADQT <10%	EACH	1	$7,984
INT;DOORS;METAL	UNKNOWN		
ADQT <10%	EACH	1	$9,149
ELEC;TRANSFORMERS,DRY TYPE	TR1		
ADQT <10%	EACH	3	$29,647
ELEC;SWITCHBOARD,DIST. SECTION	SWGR		
ADQT <10%	EACH	1	$11,221
ELEC;TRANSFORMERS,DRY TYPE	TR3		
GOOD <5%	EACH	1	$3,204
ELEC;PANELBOARD,COMMERCIAL	L1K		
GOOD <5%	EACH	1	$1,794
ELEC;PANELBOARD,COMMERCIAL	L1MC		
GOOD <5%	EACH	1	$3,204
ELEC;PANELBOARD,COMMERCIAL	L1D-A		
GOOD <5%	EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	L1D		
GOOD <5%	EACH	1	$388
ELEC;DISCONNECT	FS14		

YEAR / Facility / Condition / Component / Comments	FCI / UM / Equip ID	QTY	Cost
2012			
GOOD <5%	EACH	1	$4,556
ELEC;TRANSFORMERS,DRY TYPE	TR7		
GOOD <5%	EACH	1	$4,556
ELEC;TRANSFORMERS,DRY TYPE	TR2		
GOOD <5%	EACH	1	$83,116
ELEC;UPS	121906		
GOOD <5%	EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST	L1E CIR6		
GOOD <5%	EACH	1	$9,149
ELEC;TRANSFORMERS,DRY TYPE	TR5		
GOOD <5%	EACH	1	$9,149
ELEC;TRANSFORMERS,DRY TYPE	TR4		
GOOD <5%	EACH	1	$4,556
ELEC;TRANSFORMERS,DRY TYPE	UNKNOWN		
GOOD <5%	EACH	1	$841
MECH;TANKS FLUID STORAGE;GP	UNKNOWN		
GOOD <5%	EACH	1	$112,813
ELEC;GENERATORS;STANDBY,EMERGENCY;(ASSY)	UNKNOWN		
GOOD <5%	EACH	2	$5,790
MECH;PUMP;FLUID;GP	PUMP #1, #2		
GOOD <5%	EACH	1	$15,287
MECH;BOILERS;ELECTRIC(ASSY)	UNKNOWN		
EXCL <2%	EACH	1	$1,469
ELEC;DISCONNECT	DC POWER		

YEAR / Facility / Condition / Component / Comments	FCI	UM	QTY	Cost
2012				
EXCL <2%		EACH	1	$1,469
ELEC;DISCONNECT	FS10			
EXCL <2%		EACH	1	$1,469
ELEC;DISCONNECT	FS7			
		Facility Total		**$345,451**
1001 - NWTC - Sewer Pipe	**No FCI Value for OSF's**			
GOOD <5%		L.F.	950	$30,646
MECH;PIPE FITTINGS				
		Facility Total		**$30,646**
1003 - NWTC - Power Distribution	**No FCI Value for OSF's**			
GOOD <5%		EACH	1	$40,822
ELEC;TRANSFORMERS,OIL FILLED				
		Facility Total		**$40,822**
NWTC-1002 - Water Sys. Upgrade-Design and Construct	**No FCI Value for OSF's**			
GOOD <5%		L.F.	6,230	$245,775
MECH;PIPE FITTINGS				
		Facility Total		**$245,775**
		Yearly Total:		**$802,297**

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2013				
252 - NWTC-Blade Test Facility	**4.00%**			
GOOD <5%		EACH	1	$1,664
MECH;TERMINAL UNITS;COOLING	UNKNOWN			
GOOD <5%		EACH	1	$2,457
MECH;DETECTORS,ALARMS,CONTROLS;FIRE SYST	UNKNOWN			
		Facility Total		**$4,121**
255 - NWTC DYNOMOMENTER SPIN TEST FACILITY	**0.00%**			
GOOD <5%		EACH	4	$44,279
MECH;EQUIPMENT CONTROLS+PANELS				
		Facility Total		**$44,279**
1002 - NWTC - Fire Water Pipe	**No FCI Value for OSF's**			
GOOD <5%		LNFT	7,460	$634,160
MECH;PIPING;CAST IRON				
		Facility Total		**$634,160**
1004 - NWTC-Exterior Lighting	**No FCI Value for OSF's**			
GOOD <5%		EACH	52	$7,091
ELEC; EXTERIOR				
		Facility Total		**$7,091**
		Yearly Total:		**$689,651**

TEN-YEAR MAINTENANCE PLAN - NWTC

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2014				
251 - NWTC-Administration Building	**1.90%**			
ADQT <10%		EACH	1	$17,856
MECH;CONDENSER PKGD;(ASSY)	RTU-1			
GOOD <5%		EACH	1	$3,704
ELEC;PANELBOARD,COMMERCIAL	L5			
GOOD <5%		EACH	1	$5,551
MECH;COMPRESSOR;RECIPROCATING	AC1			
GOOD <5%		EACH	1	$13,699
ELEC;PANELBOARD,COMMERCIAL	H7C			
GOOD <5%		EACH	1	$2,930
MECH;FILTERS+DRYERS;AIR	UNKNOWN			
	Facility Total			**$43,740**
255 - NWTC DYNOMOMENTER SPIN TEST FACILITY	**0.00%**			
ADQT <10%		EACH	8	$13,354
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
ADQT <10%		EACH	1	$1,669
MECH;TERMINAL UNITS;HTRS,RDTRS,HUMID	UNKNOWN			
	Facility Total			**$15,023**
	Yearly Total:			**$58,763**
	Grand Total:			**$2,436,942**

ONE YEAR MAINTENANCE PLAN 2015 -

YEAR / Facility / Condition / Component / Comments	FCI / Equip ID	UM	QTY	Cost
2015				

254 - Industrial User's Facility		**4.40%**		
ADQT <10%		EACH	1	$8,725
ELEC;SWITCHBOARD,DIST. SECTION		SWGR		
ADQT <10%		EACH	2	$17,450
ELEC;SWITCHBOARD,DIST. SECTION		SWGR 991-1, SWGR 991-2		
GOOD <5%		EACH	1	$83,116
ELEC;UPS		UPS		
		Facility Total		**$109,291**
		Yearly Total:		**$109,291**
		Grand Total:		**$109,291**

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Appendix F General Purpose Equipment Request Detail, FY 2006-FY 2007

Representative Candidates for FY2006 and FY2007 General Purpose Equipment Funding*

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
2006	2005	Deferred Replacement	Institutional Info Tech	Web Statistics Server Replacement	31	$60,000	1999	126050
2006	1999	Deferred Replacement	Institutional Info Tech	Sun SparcServer 1000	31	$78,000	1995	122624
2006	2002	Deferred Replacement	Institutional Info Tech	SGI Origin 2000	31	$138,000	1998	125785
2006	2003	Deferred Replacement	Institutional Info Tech	Sun Server UE 450 webdev	31	$79,000	1999	126059
2006	2004	Deferred Replacement	Institutional Info Tech	Sun Server UE 450 athena	31	$37,000	2000	126214
2006	2004	Deferred Replacement	Institutional Info Tech	Workstations (6 @ $42K)	31	$252,000	2000	126221-6
2006	2005	Deferred Replacement	Institutional Info Tech	Sun Server UE 450 afdcweb	31	$79,000	1999	126038
2006	2005	Deferred Replacement	Other Equipment	Machining Mill	35	$30,000	1994	121775
2006	2005	Deferred Replacement	Other Equipment	Programmable Lathe	35	$35,000	1989	117200
2006	2005	Deferred Replacement	Scientific Instrumentation	Hewlett Packard Gas chromatograph	59	$50,000	1980s	
2006	2005	Deferred Replacement	Scientific Instrumentation	Hewlett Packard Gas chromatograph	59	$50,000	1980s	
2006	2005	Deferred Replacement	Scientific Instrumentation	Cary spectrophotometer	59	$70,000	1994	
2006	2000	Deferred Replacement	Scientific Instrumentation	Coy Anaerobic glove box, big size	59	$25,000	1980s	

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
2006	2005	Deferred Replacement	Scientific Instrumentation	Spectroradiometer UV Vis NIR	56	$110,000	1990	117767
2006	2005	Deferred Replacement	Scientific Instrumentation	Sky Scanner	56	$47,400	1997	124549
2006	2005	Deferred Replacement	Scientific Instrumentation	Hewlett Packard High Pressure Liquid Chromatograph	59	$80,000	1995	
2006	n/a	New Capability	Computational Science	CS Visualization Lab Equipment	53	$400,000		
2006	n/a	New Capability	Institutional Info Tech	Data Center Disk Backup System	31	$40,000		GPE-31-4
2006	n/a	New Capability	Institutional Info Tech	Enterprise SQL Server	31	$38,000		GPE-31-5
2006	n/a	New Capability	Institutional Info Tech	Wireless interconnects	31	$90,000		
2006	n/a	New Capability	Other Equipment	Automatic External Defibrillators (AEDs)	19	$35,000		GPE-19-1
2006	n/a	New Capability	Scientific Instrumentation	Hydrogen Testbed Storage	56	$100,000		GPE-56-1
2006	n/a	New Capability	Scientific Instrumentation	High-Precision Atomic Force Microscope Accessory	52	$90,000		GPE-52-4
2006	n/a	New Capability	Scientific Instrumentation	High Performance Liquid Chromatography (HPLC) System	59	$66,000		GPE-59-1
2006	n/a	New Capability	Scientific Instrumentation	Particle size analyzer	51	$120,000		
2006	n/a	New Capability	Scientific Instrumentation	Carbon/Nitrogen Analyzer for gram samples	51	$75,000		
2006	n/a	New Capability	Scientific Instrumentation	Automated Surface Area Analyzer	51	$80,000		
2006	n/a	New Capability	Scientific Instrumentation	3D Printer	54	$198,000		GPE-54-2

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
2006	n/a	New Capability	Scientific Instrumentation	LC/MS Triple Quadrupole	51	$250,000		
2006	n/a	New Capability	Scientific Instrumentation	IC-Mass Spectrometer	51	$180,000		
2006	n/a	New Capability	Scientific Instrumentation	Particle Size Analyzer	54	$100,000		
2006	2006	Regular Replacement	Institutional Info Tech	Network Filer Head Orastor 1033053	31	$129,000	2002	126704
2007	2003	Deferred Replacement	Institutional Info Tech	Sun Server UE 3500 zephyr	31	$43,000	1999	126030
2007	2006	Deferred Replacement	Institutional Info Tech	Sun Server V880 Aries	31	$48,000	2002	126528
2007	2004	Deferred Replacement	Institutional Info Tech	Sun Workstation U80 (3 @$45K)	31	$135,000	2001	126361-3
2007	2005	Deferred Replacement	Institutional Info Tech	Balance of Telephone Systems	31	$124,000	1994-1997	122008etc
2007	2005	Deferred Replacement	Institutional Info Tech	Network Storage netapp01	31	$190,000	2001	126330
2007	2006	Deferred Replacement	Institutional Info Tech	Network storage netapp03	31	$201,000	2002	126496
2007	2006	Deferred Replacement	Institutional Info Tech	Network Storage netap04	31	$168,000	2002	126497
2007	2003	Deferred Replacement	Institutional Info Tech	Sun Server UE450 rock	31	$79,000	1999	126107
2007	2004	Deferred Replacement	Institutional Info Tech	Sun UE450 stortek	31	$79,000	2000	126151
2007	2004	Deferred Replacement	Institutional Info Tech	Sun UE450 syssrv18	31	$79,000	2004	126186
2007	2005	Deferred Replacement	Other Equipment	Personnel Boom Lift for Maintenance	35	$30,000	1980	111045
2007	2005	Deferred	Scientific	Simulator Solar Array	56	$166,362	1981	114979

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
		Replacement	Instrumentation					
2007	2006	Deferred Replacement	Scientific Instrumentation	CIMEL Sunphotometer System	56	$50,000		
2007	2006	Deferred Replacement	Scientific Instrumentation	Baseline Measurement System Solar Trackers	56	$60,000		
2007	2005	Deferred Replacement	Scientific Instrumentation	Coy Anaerobic glove box, big size	59	$25,000	1980s	
2007	2007	Deferred Replacement	Scientific Instrumentation	Air-Cooled Heat Exchanger	55	$66,000	1992	119453
2007	2005	Deferred Replacement	Scientific Instrumentation	Computer Workstation	55	$27,000	1997	125386
2007	2005	Deferred Replacement	Scientific Instrumentation	Digitizer Programmable Waveform	52	$58,000	1981	112330
2007	2005	Deferred Replacement	Scientific Instrumentation	Chamber System	52	$62,000	1989	117254
2007	2005	Deferred Replacement	Scientific Instrumentation	Laser Argon Ion	52	$102,000	1989	117556
2007	2005	Deferred Replacement	Scientific Instrumentation	IV Outdoor System Rack	52	$57,000	1992	118818
2007	2005	Deferred Replacement	Scientific Instrumentation	Vacuum Chamber	52	$51,000	1992	119495
2007	2006	Deferred Replacement	Scientific Instrumentation	Hydrogen Injection System	52	$58,000	1994	122336
2007	2006	Deferred Replacement	Scientific Instrumentation	Microscope	52	$446,000	1995	123025
2007	2006	Deferred Replacement	Scientific Instrumentation	Multitracer	52	$39,000	1996	124279
2007	2007	Deferred Replacement	Scientific Instrumentation	Spectrophotometer	52	$164,000	1997	125525
2007	2006	Deferred Replacement	Scientific Instrumentation	Workstation	52	$45,000	2001	126362

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
2007	2005	Deferred Replacement	Scientific Instrumentation	Pump Wide Range Turbomolecular	52	$43,000	1993	117254
2007	2005	Deferred Replacement	Scientific Instrumentation	Instrument Controller	52	$57,000	1995	123129
2007	2007	Deferred Replacement	Scientific Instrumentation	Laser System UV Dye	51	$180,000	1983	114432
2007	2005	Deferred Replacement	Scientific Instrumentation	FTIR Optical Bench Gas Analyzer	51	$82,000	1990	117728
2007	2007	Deferred Replacement	Scientific Instrumentation	Quadropole Mass Spec	51	$74,000	1992	118883
2007	2005	Deferred Replacement	Scientific Instrumentation	Controller Multitask	51	$72,000	1993	119582
2007	2006	Deferred Replacement	Scientific Instrumentation	Mass Spectrometer	51	$57,000	1994	119981
2007	2005	Deferred Replacement	Scientific Instrumentation	Spectrophotometer	51	$38,000	1993	121169
2007	2006	Deferred Replacement	Scientific Instrumentation	Workstation	51	$45,000	2001	126363
2007	2007	Deferred Replacement	Scientific Instrumentation	Sterilizer Electrically heat	51	$43,000	1994	122204
2007	2007	Deferred Replacement	Scientific Instrumentation	Sterilizer Electrically heat	51	$43,000	1994	122205
2007	2005	Deferred Replacement	Scientific Instrumentation	Workstation	50	$42,000	2000	126222
2007	n/a	New Capability	Computational Science	CS Processors	53	$2,000,000		
2007	n/a	New Capability	Computational Science	CS Storage	53	$250,000		
2007	n/a	New Capability	Computational Science	CS Interconnection Hardware	53	$250,000		
2007	n/a	New Capability	Institutional Info	color printer E size	35	$80,000		

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
			Tech					
2007	n/a	New Capability	Institutional Info Tech	Wireless base stations	31	$320,000		
2007	n/a	New Capability	Other Equipment	AFUF Transpired Solar Collector	35	$40,000		GPE-35-2
2007	n/a	New Capability	Scientific Instrumentation	Hydrogen Fuel Dispenser	56	$150,000		
2007	n/a	New Capability	Scientific Instrumentation	Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FT-ICR-MS)	51	$800,000		
2007	n/a	New Capability	Scientific Instrumentation	Time-of-Flight Mass Spectrometer for novel nanoclusters	51	$500,000		
2007	n/a	New Capability	Scientific Instrumentation	Variable Temperature/Pressure Probe for NMR	59	$50,000		
2007	n/a	New Capability	Scientific Instrumentation	Single Crystal Xray Diffractometer	59	$300,000		
2007	n/a	New Capability	Scientific Instrumentation	Spectroradiometer Calibration Transfer System	56	$150,000		
2007	n/a	New Capability	Scientific Instrumentation	Micropulse Lidar	56	$200,000		
2007	n/a	New Capability	Scientific Instrumentation	All-Weather Digital Video Camera System	56	$28,000		
2007	2007	Regular Replacement	Computational Science	CS Processors 2004	53	$604,000	2004	
2007	2007	Regular Replacement	Institutional Info Tech	Radio Repeater System	31	$38,000	2002	121960
2007	2007	Regular Replacement	Institutional Info Tech	Sun Server V880 titan	31	$108,000	2003	126775
2007	2007	Regular Replacement	Institutional Info Tech	HP Mail Server	31	$189,000	2003	126725
2007	2005	Regular	Other Equipment	TTF HVAC Upgrade	35	$30,000		GPE-35-5

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Proposed Funding Year	Optimal Replacement Year	Category	Type of Equipment	Item	NREL Center	Estimated Cost	In Service Year	NREL Identifier
		Replacement						
2007	2007	Regular Replacement	Scientific Instrumentation	Conviron Growth chamber	59	$50,000	1979	
2007	2005	Regular Replacement	Scientific Instrumentation	Computer Workstation	54	$42,000	2000	126226
2007	2005	Regular Replacement	Scientific Instrumentation	Computer Workstation	55	$42,000	2000	126223
2007	2006	Regular Replacement	Scientific Instrumentation	Autoprobe LS	52	$34,000	1995	123071
2007	2007	Regular Replacement	Scientific Instrumentation	Cathodoluminescence System	52	$203,000	2000	126167

* Actual GPE projects are selected at the beginning of each fiscal year. These are representative projects only.

Appendix G Recent GPP/GPE Investment Summaries

FY 2003 GPE Investments

Liquid Chromatograph – Mass Spectrometer

FY 2003 General Purpose Equipment

$270,000 / New Capability

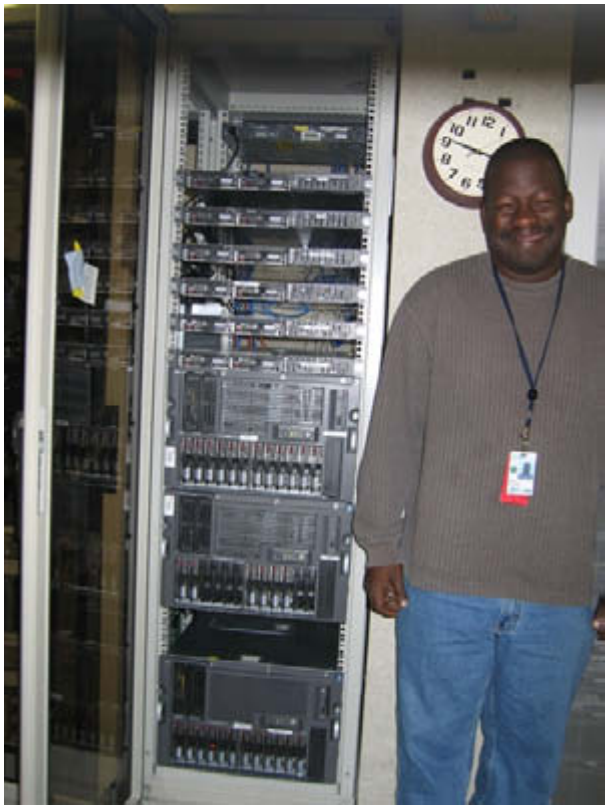
- An analytical tool used to identify peptides, proteins, metabolites and other non-volatile organic compounds in complex mixtures.
- Has benefited EERE Biomass, Industrial Technologies, and DDRD Programs plus several industrial customers in CRADAs and WFOs.
- Created a new capability for the Laboratory, especially in exact mass measurement of biological molecules in the 90–20,000 AMU range.
- Coupled with soft-ionization techniques, matrix-assisted laser desorption and elecrospray, to characterize carbohydrates and proteins in glycoproteins.

Storage for Electronic Processing

FY 2003 General Purpose Equipment

$130,000 / New Capability

- Provided the storage necessary for the first two phases of the Electronic Processing Initiative (EP).
- Benefits all of NREL by moving from paper-based systems to data-based systems.
- This project gave NREL the capability to store the hundreds of thousands of transactions necessary for the early phases of EP to be successful. It allows for the auditing processes required of us by DOE and MRI. Additional storage may be required as the average transaction size grows for the various phases.



E-mail Server Replacement

FY 2003 General Purpose Equipment

$194,000 / Deferred Replacement

- The servers are used around the clock to provide mail to users at the Laboratory sites and remotely through the Web.
- Benefits NREL e-mail users
- Upgrades existing Exchange servers with new hardware and provided a hardware platform that supported migration to Exchange 2000
- Provided more reliability, faster processing, greater storage, and increased functionality. If not available, would have increased the likelihood of hardware failures, lessened support from Microsoft, made it difficult to find replacement parts, and increased management costs related to the lack of disk space.

High-Res Variable Temperature Scanning Probe Microscope (STM)

FY 2003 General Purpose Equipment

$413,000 / Deferred Replacement

- Perform high-resolution STM/AFM from 25-1500 degrees Kelvin.
- Benefits EERE Biomass and Solar Energy Technologies Programs, and Office of Science
- Current STM does not have cryogenic capability and is unstable to obtain reliable atomic images of nanoscale materials. The item replaced is in storage.
- Research on materials has the potential to significantly impact energy efficiency, storage, and production. If not available, would miss opportunity to address important scientific and technical issues related to nanoscience.

Rotating Shadowband Spectroradiometer

FY 2003 General Purpose Equipment

$108,000 / New Capability

- Provide continuous Web-accessible irradiance measurements from 360 – 1100 nm and atmospheric optical depth data.
- Benefits Solar Energy Technologies and Building Technologies Programs
- Measurements and information from this instrument are important for designing spectrally selective PV devices, solar resource model development, material properties research, and environmental analyses. If not available, NREL would not have technology lead for continuous measurement of solar spectral irradiance and associated benefits.

Core Routing and Switch – Phase II

FY 2003 General Purpose Equipment

$274,000 / Deferred Replacement

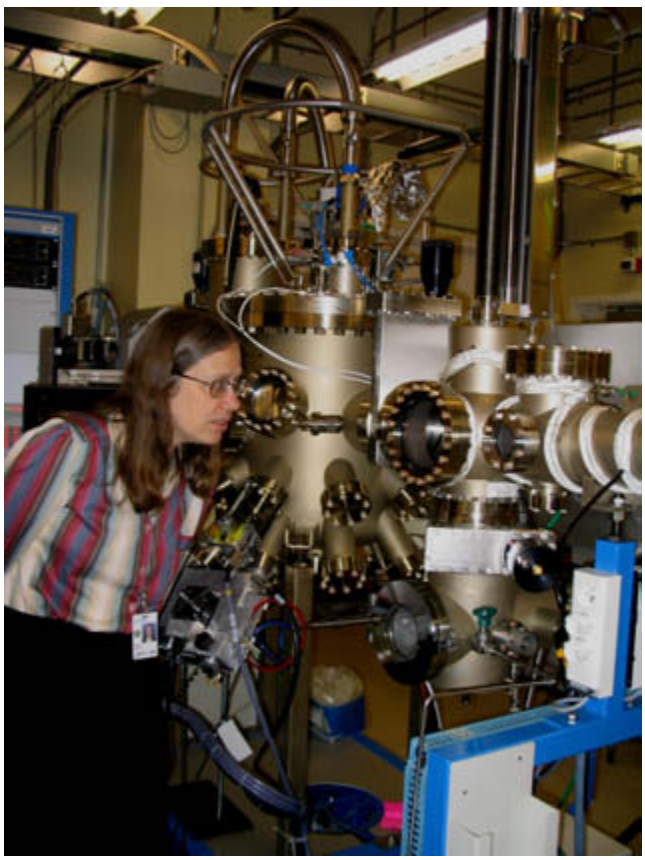
- Upgraded core routers and switches at the NWTC and Building 27 to match the FY02 upgrades at Denver West and the SERF.
- Benefited NWTC and Building 27 network users
- Upgraded core routers and switches to keep up with the growing performance and technology requirements of NREL. If not available, performance within the core networks would have been mismatched. Bottlenecks would have resulted and made it impossible to deploy other advanced networking technologies.

Server for Electronic Processing

FY 2003 General Purpose Equipment

$112,000 / New Capability

- Provided the server hardware necessary for the Electronic Processing Initiative (EP).
- Benefits all of NREL by moving from paper-based systems to data-based systems.
- This project gave NREL the capability to handle the thousands of transactions necessary for EP to be successful. The hardware purchased allows for future growth.



Molecular Beam Epitaxy Facility – Phase I

FY 2003 General Purpose Equipment

$593,000 / New Capability

- The system allows for ultimate control and study of epitaxial growth processes on a sub-monolayer scale.
- Benefits EERE Solar Energy Technologies Program and Office of Science
- Advances studies of advanced materials growth and in-situ characterization techniques. If not available, would impede ability to remain in the forefront of semiconductor materials science research. New ideas for advanced solar cells and light emitting devices–as well as many areas of nanoscience research could not be pursued without this new system.

Uninterruptible Power System for Computer Center

FY 2003 General Purpose Equipment

$65,000 / New Capability

- Added another 50 KVA of protected power to the 17/1 Data Center.
- Benefits Information Services and Computational Sciences Center; allows for expansion of capabilities.
- This project doubled the amount of UPS protected power to the 17/1 Data Center, allowing for the additional of a number of new processing capabilities at NREL, including the IBM Supercomputer and the hardware to support Electronic Processing. It also allowed for the two UPS units to be co-located in an electrical room, making room for additional hardware in the Data Center.

FY 2003 GPP Investments

SERF Chiller Upgrade

FY 2003 General Purpose Projects

$774,000 / Regular Maintenance

- The new 400 ton chiller serves as the primary chiller for the SERF.
- Benefits all programs and offices located in the SERF. Houses future equipment for S&TF
- The 400-ton chiller will provide primary cooling for the SERF and the current 215-ton chillers will serve as the backup chillers for the SERF and S&TF.
- Will increase chiller capacity at the SERF and provide system back up. The current system is reaching maximum chiller capacity using both 215-ton chillers and leaving no back-up capacity. Failure would curtail research activities for extended periods.

SERF Heat Exchanger to Process Cooling

FY 2003 General Purpose Projects

$38,000 / Regular Maintenance

- Adding a heat exchanger between the process cooling load and the heat recovery system.
- Benefits all programs and offices at the SERF.
- Adding the heat exchanger will minimize use of the chilled water from the chiller and reduce energy consumption by 20,000 therms/year. Estimated savings are ~$8K/year and simple payback will be 3.8 years, exceeding EO13123 goals.

SERF VFDs to Center and West Exhaust Fans

FY 2003 General Purpose Projects

$85,000 / Regular Maintenance

- A constant volume exhaust air system that extracts the exhaust air from the laboratories at a constant rate. This is an addition of variable frequency drives (VFDs) on the three main exhaust fan motors.
- Benefits all programs and offices at the SERF.
- Addition of the VFDs will reduce electric energy consumption by 500,000 kWhr/year and will result in energy cost savings of $25,000/year with a simple payback period of 3.4 years, meeting EO13123 goals.

National Bioenergy Center Consolidation

FY 2003 General Purpose Projects

$61,000 / New Capability

- Provides consolidation of personnel in the Bioenergy programs.
- Benefits all programs and offices at the FTLB.
- Constructs office space in the FTLB.
- Provides better synergies for the Bioenergy programs.

NREL DDC Upgrade – Phases 0 & 1

FY 2003 General Purpose Projects

$350,000 / Deferred Maintenance

- The Direct Digital Control (DDC) system controls nearly all of the heating, ventilating, and air conditioning equipment on the STM and NWTC sites. It also controls toxic gas monitoring stations, after hours on-call alarming, critical equipment back up, some outdoor and indoor lighting, and other miscellaneous equipment.
- Benefits NREL by improving the building controls on the STM site and NWTC.
- Provides more advanced energy management capabilities through additional memory and calculating potential, and also replaced equipment before it became obsolete. Reduces Deferred Maintenance backlog.

FTLB Lab 207 Exhaust System

FY 2003 General Purpose Projects

$57,000 / Regular Maintenance

- Two laboratory hoods used for radioactive material work are exhausted by an on-roof fan separate from the central fan loft.
- Benefits DOE Office of Science and EERE's Biomass Program
- The in-line system replaces a single belt drive motor with no redundant motor/fan capacity for the radiation hood. The system is located on the roof of the FTLB.
- A fully redundant motor/fan capacity will be consistent with the rest of the FTLB laboratories. Will result in increased operability for the exhaust system for the radioactive material laboratory hoods.

FTLB Fuel Synthesis Test Cell

FY 2003 General Purpose Projects

$83,000 / New Capability

- Upgrade FTLB rooms 127 & 128 to flammable test cell standards.
- Benefits programs needing space testing of flammable chemicals.
- Construct room to meet flammable requirements. Installation of utilities to support equipment with vapor components.
- Provides space for flammable chemical testing.

SERF HVAC Improvements

FY 2003 General Purpose Projects

$46,000 / Regular Maintenance

- Improve HVAC in the SERF.
- Benefits programs and offices in the SERF.
- Miscellaneous upgrades to lab areas, medical office areas, the MDA monitor room, and SERF west wing exhaust system.
- Improved ventilation to lab C-111 and the MDA room will prevent overheating of monitoring and lab equipment. Provides energy savings by reducing electrical and HVAC loads.

SERF Lab Fire Detection Upgrade

FY 2003 General Purpose Projects

$229,000 / Regular Maintenance

- Upgrade existing fire alarm detection system to detect smoke in labs.
- Benefits SERF programs and staff.
- Replace existing fire alarm detection system that was at the end of its life cycle.
- Detection of smoke or heat will be automatically performed by the system.

NWTC Industrial User Facility Office/Kitchen Upgrade

FY 2003 General Purpose Projects

$42,000 / Regular Maintenance

- Modifies IUF Building entrance hallway to accommodate kitchen facilities.
- Benefits DOE Wind Energy and Distributive Energy Program.
- Eliminates unsanitary usage of janitor sink and office area for kitchen activities.

NWTC Industrial User Facility Compressor Upgrade

FY 2003 General Purpose Projects

$37,000 / Regular Maintenance

- Replaces current, minimally sized air compressor that was installed during construction to save money.
- Benefits NWTC programs.
- Adds a compressed air dryer to increase air quality and prolong compressed air tool life.

STM Road Rehabilitation - Phase 3

FY 2003 General Purpose Projects

$281,000 / Deferred Maintenance

- Replace roadway. Road deterioration includes cracking, potholes, checking, and subsurface erosion.
- Benefits NREL staff and visitors.
- Existing asphalt and damaged curb & gutter replaced.
- Provides a safe roadway for traffic. Reduces Deferred Maintenance backlog.

Roof Life Extension Project

FY 2003 General Purpose Projects

$46,000 / Deferred Maintenance

- Skylight replacement, patch and seal roof leaks, caulking repairs, roof fastener repairs, gutter repairs, and other associated fixes.
- Benefits all programs and offices in the NREL facilities.
- Repairs made to minimize further damage to the roof and building interiors. Reduces Deferred Maintenance backlog.

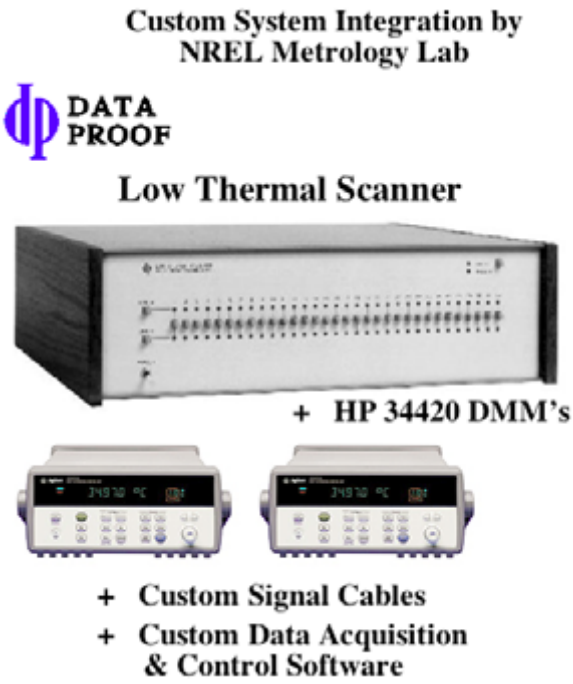
Biomass Surface Characterization Lab

FY 2003 General Purpose Projects

$865,000 / New Capability

- User facility for National Bioenergy Center, Basic Sciences, and other centers doing biomass and biological research.
- Benefits biomass, hydrogen, Office of Science, and solar research.
- State of the art laboratory suite housing 4 electron microscopes under strictly controlled environmental conditions. Part of world class biomass research facilities including Nuclear Magnetic Resonance lab, and forthcoming Genomics Lab.
- Basic research to lower the cost of ethanol.

FY 2004 GPE Investments



Radiometer Calibration Data Acquisition System

FY 2004 General Purpose Equipment

$33,000 / Deferred Replacement

- Upgraded system used for broadband outdoor radiometer calibrations.
- Benefits DOE Solar Energy Technologies Program, other Metrology Lab customers, and existing/potential WFOs.
- Replaces the existing obsolete data acquisition system.
- The systems supports our core capability to provide outdoor radiometer calibrations using existing custom software developed in house and replaces data logger, which is not longer supported by the manufacturer. If not installed, increases risk of failure to provide basic calibration services.

Rapid Catalyst Evaluation Micro-activity Test System

FY 2004 General Purpose Equipment

$108,000 / New Capability

- Provides capability for rapid, reproducible, small-scale catalyst testing to facilitate optimization of reforming and tar cracking catalyst compositions.
- Benefits DOE Hydrogen, Fuels Cells, and Infrastructure Technologies Program and the Biomass Program.
- The system will significantly enhance the catalyst optimization process by pre-screening numerous catalyst compositions with a 3-reactor MAT unit, which can handle several catalysts at one time and screen up to 1–12 catalyst compositions per day. This reduces the time of two staff members and numerous days to assess one composition.

Expanded NREL High Performance Computing Capability

FY 2004 General Purpose Equipment

$608,000 / New Capability

- Additional computational capability with state-of-the-art processors and commensurate data storage.
- Benefits all DOE programs.
- This computer is eight times more capable than the current IBM system, whose lease expires in April 2005.
- This new system meets the growing demand for high performance computing at NREL. NREL scientists and engineers can now reduce the turn around time for their simulations or run much more detailed simulations thus improving the rate of scientific progress.

Multiplex Quantitative PCR System

FY 2004 General Purpose Equipment

$65,000 / New Capability

- Procedure allows for quick, accurate and precise measurement of specific genes that are turned on or off under different environmental conditions.
- Benefits DOE Office of Science, Biomass and Hydrogen, Fuel Cells, and Infrastructure Technologies Programs
- Quantitative PCR gives much greater accuracy over a larger dynamic range, and is routinely used to follow and confirm leads observed in transcription profiling. The savings in research time and in the cost of disposal of hazardous radioactive material will significantly impact NREL's budget. A decrease in the use of radioactive material constitutes a potential increase in safety.

DC Power Processing System

FY 2004 General Purpose Equipment

$405,000 / New Capability

- Testing and developing electrical and electro-mechanical systems including hybrid electric vehicle components, motors, inverters, and fuel cells.
- Benefits DOE's Hydrogen, Fuels Cells, and Infrastructure Technologies, FreedomCAR, Vehicle Technologies, Wind, DER and Solar Energy Technologies Programs.
- Provides expanded capability in renewable power electronics area over a wide range of voltages and currents in conducting research in both fuel cell and advanced power electronics. If not installed, we will be unable to conduct research at power levels needed by industry and unavailable at other DOE laboratories.

Enterprise Voicemail System Replacement

FY 2004 General Purpose Equipment

$142,000 / Deferred Replacement

- Provides enhanced voicemail capabilities.
- Benefits all programs and offices.
- Replaces outdated equipment that is 12 years old. The vendor is discontinuing support of the existing system.
- Improved voicemail capabilities by adding 2000 hours of message time and 7x improvement in site-wide notification times (global voicemails). Old system experienced voicemail system failure resulting in inability for callers to leave voice messages, and inability for staff to retrieve new messages or access archived/saved voicemails.

Rotating Solar Platform

FY 2004 General Purpose Equipment

$126,000 / New Capability

- Test platform capable of providing long-term on-sun tracking for a variety of solar R&D activities.
- Benefits the DOE Solar Energy Technologies Program.
- The system will replace the current SAIC dish system. It will be lower and less visible than the current system. CSP activities are becoming more focused on trough-based R&D and NREL is leading the management of this activity. If not installed, NREL will need to use antiquated systems and will not be able to meet industry's support needs.

Cyber Security – Web Server Migration

FY 2004 General Purpose Equipment

$101,000 / Deferred Replacement

- Prevents public access to NREL's internal networks.
- Benefits all programs and offices.
- Moving the external websites that are on NREL's internal networks to this server, which is in a protected area of NREL's network, gives hackers a smaller target at NREL. Servers are centrally managed and updated, putting the job of securing NREL's network into the hands of the experts. Servers run standardized versions of the operating system, improving vendor support and reducing complexity.

Laser Break Down Spectroscopy Instrument

FY 2004 General Purpose Equipment

$121,000 / New Capability

- The instruments measure elemental composition of organic and inorganic materials and has been applied to analysis of trace inorganics in organic materials.
- Benefits the DOE Biomass Program, and the DOE Office of Science.
- The instrument increases the range of capabilities in spectroscopic analyses of biomass components and biomass processing systems. It appears to have application for looking at issues in processing of PV materials.

Electrochemical Impedance Spectroscopy (EIS) Instrument

FY 2004 General Purpose Equipment

$70,000 / New Capability

- Characterize electrochemical interfaces and is used extensively in the fuel cell and battery industries and in photoelectrochemical research.
- Benefits DOE Office of Science and the Hydrogen, Fuel Cells, and Infrastructure Technologies Program.
- This is a very important measurement tool for anything involving electrochemical systems. The current systems are oversubscribed and the current instrumentation does not have the power handling capability to be able to test our samples.

FY 2004 GPP Investments

Building 251 HVAC Replacement

FY 2004 General Purpose Projects

$88,000 / Deferred Maintenance

- Replaced heaters that had exceeded their life expectancy.
- Benefits DOE Wind and Hydropower Technologies Program.
- Converted electrical heaters to hot water heaters.

NWTC Fire Alarm System Upgrade

FY 2004 General Purpose Projects

$33,000 / Deferred Maintenance

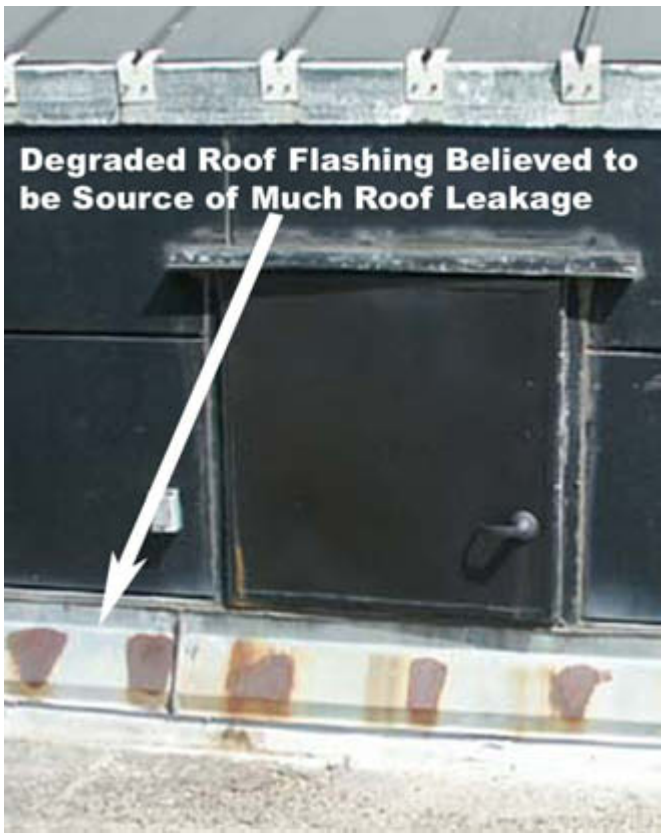
- Adds an addressable fire panel and detectors in the Hybrid Building.
- Benefits the DOE Distributed Energy and Hydrogen Technology Programs.
- Enhances the Fire Departments ability to quickly locate fires in the Hybrid Area.

FTLB HVAC Equipment Replacement

FY 2004 General Purpose Projects

$230,000 / Deferred Maintenance

- Replaces three main fan lofts and four evaporative coolers located on the roof above the greenhouse at the FTLB.
- Benefits DOE Biomass Program, Hydrogen, Solar, and Basic Sciences
- Supply fans and the evaporative coolers were identified as mechanical equipment that have surpassed equipment life. Reduces Deferred Maintenance backlog.



FTLB Roof Rehabilitation

FY 2004 General Purpose Projects

$280,000/ Deferred Maintenance

- Renovate roof for service lift extension.
- Benefits FTLB programs and staff.
- Remove and replace rock ballast and upper layer of roofing material. Encapsulate asbestos reducing future exposure to substance.
- Extends roof service life. Reduces Deferred Maintenance backlog.

White Lines Illustrate Typical Application Areas
for Silicone Sealant
(Width Exaggerated for Illustration)

SERF Roof Life Extension

FY 2004 General Purpose Projects

$94,000 / Deferred Maintenance

- Repair all roof single-ply seams.
- Benefits SERF programs and staff.
- Seal all the single-ply seams on the SERF roof. This will significantly extend the service life of the roof.
- Reduces Deferred Maintenance backlog.

Access Badge Reader Upgrade

FY 2004 General Purpose Projects

$109,000 / Deferred Maintenance

- Badge readers are used to gain access into the STM, NWTC, and leased facilities.
- Benefits all NREL staff.
- Replaces 50 badge readers currently in use with proximity readers.
- Improve functionality. Replaces current badge readers that have become obsolete.

NREL DDC Upgrade - Phase II

FY 2004 General Purpose Projects

$276,000 / Deferred Maintenance

- Phase II of a three phase project to upgrade the existing Direct Digital Control (DDC) system. (Phase I completed in FY03)
- Benefits NREL by improving the building controls on the STM site and NWTC.
- Upgrade of the controls for chillers, cooling towers, boilers, pumps, supply and exhaust fans, and other mechanical and lighting equipment.
- Provides more advanced energy management capabilities through additional memory and calculating potential, and also replaced equipment before it became obsolete. Reduces Deferred Maintenance backlog.

FTLB 118 Firewall/Hood Relocation

FY 2004 General Purpose Projects

$120,000 / Deferred Maintenance

- Provide fire rated walls for lab in accordance with code and design standards.
- Benefits FTLB programs and staff.
- Corridor walls extended to the ceiling and all penetrations into the room sealed to allow for a slight negative room pressure. Install hood.
- Provides more usable and fully functional lab area.

Walking Path – STM East Boundary to VC

FY 2004 General Purpose Projects

$39,000 / New Capability

- Provides walking path for employees and visitors to access the STM site.
- Benefits NREL staff and visitors.
- The path provides a better and safer access for employees and visitors who walk and bike to the STM.

VC Mechanical, Electrical, Sustainability Upgrade

FY 2004 General Purpose Projects

$254,000 / Deferred Maintenance

- Provides updated HVAC, lighting, and other systems.
- Benefits all programs and offices who use the Visitors Center.
- Replaces inefficient and ineffective HVAC, lighting, and other systems.
- Improves the overall comfort and sustainability of the facility.

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Appendix I Acronyms

ACI	Asset Condition Index
AFUF	Alternative Fuels User Facility
AUI	Asset Utilization Index
BCCL	Biomass Chemical Characterization Laboratory
BTF	Blade Test Facility
BPCL	Biobased Polymer and Composites Laboratory
CAIS	Condition Assessment Information System
CAS	Condition Assessment Survey
CFR	Code of Federal Regulations
CRADA	Cooperative Research and Development Agreement
CRD	Contractor Requirements Document
CRS	Certified Realty Specialist
CSO	Cognizant Secretarial Office
DAB	Design Advisory Board
DOE	Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EPA	Environmental Protection Agency
FAC	FIMS Advisory Committee
FCI	Facility Condition Index
FIMS	Facilities Information Management System
FTLB	Field Test Laboratory Building
GDV	General Development Vision
GPE	General Plant Equipment
GPP	General Plant Project
GSF	Gross Square Feet
IGPP	Institutional General Plant Project
IFI	Integrated Facilities and Infrastructure
LEED	Leadership in Energy and Environmental Design
LPSO	Lead Program Secretarial Office
LTS	Long-term Stewardship
LWTTF	Large Wind Turbine Test Facility
NEPA	National Environmental Policy Act
NIR	Near Infra Red
NREL	National Renewable Energy Laboratory
OECM	Office of Engineering and Construction Management
OMB	Office of Management and Budget
PDU	Process Development Unit
PPBES	Planning, Programming, Budgeting, and Evaluation System
PSO	Program Secretarial Office
PY	Prior Year
RPV	Replacement Plant Value
SERF	Solar Energy Research Facility
S&TF	Science and Technology Facility
SRRL	Solar Radiation Research Laboratory

TCPDU	Thermo-Chemical Process Development Unit
TYSP	Ten-Year Site Plan
VE	Value Engineering
VFD	Variable Frequency Drive
WFO	Work For Others Agreement

Appendix J Definitions of Terms

Alterations. Adjustments to interior arrangements or other physical characteristics of an existing facility so that it may be more effectively adapted to or used for its designated purpose. Alterations do not result in betterment to a facility. Examples of alterations are as follows.

a. Removal or installation of interior walls for purposes of rearranging the layout of an office building, and incidental heating and ventilation ducting system.
b. Modifications that do not significantly extend the capacity of the system.
c. Construction of a door or passage through an interior structural wall.
d. Installation of new lighting fixtures that do not significantly increase the lumens emitted but may result in energy or maintenance savings. (RPAM)

Annual Utilization Surveys. Annual utilization surveys are directed by Federal Property Management Regulations § 101-47.802 to determine how well the real property assets are being put to use. The survey content must address the standard specified in Federal Property Management Regulations § 101-47.801, Standards. (RPAM)

Authorization Basis. Safety documentation supporting the decision to allow a process or facility to operate. Included are corporate operational and environmental requirements as found in regulations and specific permits and, for specific activities, work packages or job safety analysis [per DOE G 450.4-1B, Integrated Safety Management System Guide, dated 3-1-01]. (RPAM)

Betterments. Capitalized improvements to facilities that result in better quality work, increased capacity, and/or extended useful life as required to accommodate regulatory and other changes to requirements. Determining when and to what extent expenditure should be treated as betterment requires judgment. The proper basis for determining whether betterment is effected is when the effect of the replacement is related to each unit when a minor item is replaced in each of a number of similar units, rather than to the cumulative costs. Listed below are the various terms that are commonly used to describe various categories of betterments.

a. Construction is the erection, installation, or assembly of a new plant facility; the addition, expansion, improvement, or replacement of an existing facility; or the relocation of a facility. Construction includes equipment installed in and made part of the facility and related site preparation; excavation, filling and landscaping, or other land improvements; and design of the facility. Examples of improvements to an existing facility include the following types of work.
    i. Replacing standard walls with fireproof walls.
    ii. Installing a fire sprinkler system in a space that was previously not protected with a sprinkler system.
    iii. Replacing utility system components with a significantly larger capacity components (e.g., replacing a 200-ton chiller with a 300-ton chiller) and converting the functional purpose of a room (e.g., converting an office into a computer room).

b. Conversion is a major structural revision of a facility that changes the functional purpose for which the facility was originally designed or used.
c. Major Renovation and Replacement is a complete reconstruction of a facility that has deteriorated or has been damaged beyond the point where its individual parts can be economically repaired. If the item replaced is a retirement unit, its original costs (including installation cost) are removed from the plant and capital equipment accounts, and the cost of the newly installed item (including installation cost) is added to the plant and capital equipment accounts. (RPAM)

Capital Equipment. All types of equipment (structure-integrated, standalone, facility-specific, not-related-to-construction) for which DOE will retain title, costs $25,000 or more including the costs for installing the equipment, has an expected service life of at least two years, and will not be used up or destroyed or reduced to scrap during an experiment. (EERE, NREL)

Capital Equipment Not Related To Construction. Capital Equipment Not Related to Construction is Capital Equipment for which DOE will retain title, costs $25,000 or more including the costs for installing the equipment, has an expected service life of at least two years, and is not required to complete a general plant project or construction line item. Items of Capital Equipment Not Related to Construction required for experimental projects shall be budgeted from operating expenses if expectations are that the equipment will be destroyed during the experiment, or will have no further value other than scrap upon completion of the experiment.

- *Differentiating Between Capital Equipment and Construction Projects*. In most cases, Capital Equipment can be installed with little or no significant installation costs or construction activities required. However, in some cases the equipment requires significant construction activities to function, such as the provision of foundations, utilities, and structural modifications and additions to a building. As a rule, construction funds should be used when these construction activities constitute more than 20 percent of the equipment cost.
- *Differentiating Between Capital Equipment Related to Construction and Capital Equipment Not Related to Construction*. All projects, facilities, and Capital Equipment necessary to complete and operate a project are Project Specific General Plant Project and Capital Equipment; therefore, they are Capital Equipment Related to Construction. Other Capital Equipment acquisitions meeting the criteria in paragraph 2.5 are Capital Equipment Not Related to Construction. (EERE)

Computational Science. Computational science (in contrast to general information technology which refers to administrative computer-related activities)is a rapidly growing multidisciplinary scientific field with connections to the physical and biological sciences, engineering, applied mathematics, numerical analysis, and computer science. Computational science focuses on the integration of knowledge and methodologies from all of these disciplines, and as such is a subject that is distinct from each of them. It focuses on developing and applying problem-solving methodologies and robust tools for

the solution of scientific and engineering problems. Computational scientists are scientists in their own right. However, they often work with the discipline-specific scientists and engineers to apply computational science tools to real world problems.

Construction. Construction is the erection, installation, or assembly of a new plant facility; the addition, expansion, improvement, or replacement of an existing facility (e.g., demolish existing facility and construct new one), or the relocation of a facility. Construction includes equipment installed in and made part of the facility and related site preparation; excavation, filling and landscaping, or other land improvements; and the design of the facility. Examples of improvements of an existing facility include replacing standard walls with fireproof walls or installing a fire sprinkler system, or replacing utility system components with components of significantly larger capacity (such as replacing a 200-ton chiller with a 300-ton chiller). (EERE)

Construction Line Item. Separate project activities that programs submit for funding in amounts greater than or equal to $5 million, and that the Congress specifically reviews and approves. (EERE)

Corporate Review Budget. Internal DOE budget prepared for the DOE Controller's Office. (NREL)

Corrective Maintenance. The repair or restoration of failed or malfunctioning equipment, systems, or facilities to their intended functions or design conditions. It does not result in a significant extension of the expected useful life. (RPAM)

Critical Decision Points. CD-0 through CD-4 are decision points in the process of developing and approving a construction line item project as delineated in DOE Order 413.3. See Table Z (section 5) and Figure X (section 5). While the development of a general plant project is qualitatively the same as a construction line item project, the critical decision points are not formally used with general plant projects. (NREL)

Current Real Property Assets. The site's total area in square feet for all operating and excess facilities less (a) those excess that have been funded for disposal, including demolition, sale, and out-lease, in the enacted budget and (b) those facilities that have been deactivated and decontaminated but not fully decommissioned and are being placed into long-term stewardship. For land it is the acreage of the DOE site. (RPAM)

Deferred Maintenance. Maintenance that was not performed when it should have been or was scheduled to be and which, therefore, is put off or delayed for a future period. (RPAM)

Deferred Replacement. Purchase of a new, sometimes upgraded or expanded capital equipment item to replace an existing asset after the end of the strategic useful life of the asset. (See "Regular Replacement" and "New Capability"). (NREL)

Deferred Replacement Backlog. As of any given date, the total value of the active capital equipment that is older than its strategic useful life. (NREL)

Deferred Replacement Projections. The total value of the active capital equipment that is projected to be replaced in any given year that will be more than one year older than its strategic useful life when replaced. (NREL)

Disposal. Permanent or temporary transfer of DOE control and custody of real property assets to a third party who thereby acquires rights to control, use, or relinquish the property. (RPAM)

Equipment Condition Index. The ratio of the value of equipment that is beyond its strategic useful life (also referred to as the Deferred Replacement Backlog) to the value of the rest of the equipment in the same category. The qualitative descriptors of good, excellent, etc are the same as the Facility Condition Index. (NREL)

Estimated Value Today. The acquisition cost escalated using Denver Consumer Price Index to 2004 (also referred to as Escalated Acquisition Cost). For equipment, this is the best equivalent available to the Replacement Plant Value used for facilities and infrastructure. (NREL)

Excess Real Property. Land, improvements to land, or both, including interest therein, which is not required for the Department's needs or the discharge of its responsibilities. For the purposes of reporting deferred maintenance, excess real property is an asset that is on the path for disposition. (RPAM)

Facility. Land, buildings, and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein, including site development features outside the plant, such as landscaping, roads, walks, parking areas, outside lighting and communication systems, central utility plants, utilities supply and distribution systems, and other physical plant features. These include any of the DOE-owned, -leased, or -controlled facilities, and they may or may not be furnished to a contractor under a contract with DOE. (RPAM)

Facility Condition Index (FCI). The FCI is the ratio of the cost of deferred maintenance to the facility's replacement plant value. The cost of deferred maintenance deficiencies is determined by condition assessment inspections. Facilities Information Management System data is used to calculate FCI.DOE adopted the FCI in 1998 as its tool for measuring the condition of its facilities. [See GAO Report, NSIAD-99-100 Military Infrastructure: Real Property Management Needs Improvement, dated September 1999 (reference u) and National Association of College and University Business Officers Managing the Facilities Portfolio—A Practical Approach to Institutional Facility Renewal and Deferred Maintenance, 1991.] (RPAM)

Facility-Specific Capital Equipment. Standalone capital equipment that will be needed when a new facility is initially occupied in order to accomplish the mission of the facility. These items are typically research and/or information equipment. (EERE)

General Plant Projects. Any work performed that modifies, improves, or even just attaches to, an NREL facility or an NREL site. The work must benefit the entire lab or multiple programs/centers, cost greater than $25,000, and have a useful life of at least two years. The project must be an installation or assembly of a new facility, an installation that will be made a permanent part of an existing facility, or be related to utilities (water and sewage; heating, cooling, and power; communications or fire prevention systems). Each general plant project has a limit of $5 million, and each project mush result in a discrete, stand-alone entity, resulting in the delivery of a complete and usable facility, including the initial complement of equipment required for the facility to meet its intended purpose. Incremental general plant projects cannot be used to construct larger facilities. See the DOE Accounting Handbook, Chapter 10, "Plant and Capital Equipment." General plant projects can be used to adapt facilities for changes in research projects, to effect economics of operations, and to reduce or eliminate health, fire, and security problems. These projects provide for design and/or construction, additions, and improvements to land, buildings, and utility systems; and they may include the construction of small new buildings, replacements, or additions to roads, and general area improvements. (NREL, EERE, RPAM)

General Purpose Equipment. (Same as institutional equipment.) Equipment items that benefit the entire lab or multiple programs/centers, cost greater than $25,000, and have a useful life of at least two years. If this is a "systems" purchase where each component purchased is less than $25,000, the total system cost must be greater than $25,000 (e.g., a computer system). If this is a software purchase, it must be an operating system, defined as only the software necessary for the computer to operate as intended. Items such as paint, carpeting or similar items used in repair or maintenance would not be included as general purpose equipment. The equipment must not be intended for an experiment in which the equipment is expected to be used up, broken, or otherwise have no further use beyond the experiment (e.g., an experimental wind turbine blade). (NREL)

Information Technology Equipment. In general, all capital equipment at NREL can be broken into two main groups: information technology equipment, which typically has a strategic useful life of 3-5 years, and R&D equipment, which typically has a strategic useful life of 7-25 years. Information technology equipment includes computers, servers, electronic storage media, workstations, and other computer-related equipment. IT is discussed in three categories at NREL: 1) institutional information equipment or institutional IT (see below); 2) computational science equipment, which is used to perform scientific calculations in support of research; and 3) information technology equipment that researchers use other than computational science equipment, such as the computers researchers have on their desks. Computer-related equipment that is part of a large scientific instrument, as is now common, is considered R&D equipment. (NREL)

Integrated Facilities and Infrastructure (IFI) Crosscut Budget. A crosscut budget exhibit that has been developed to ensure sustained improvement in real property management. It constitutes, with the exception of new mission line-item projects, the resources required to implement a Ten-Year Site Plan. This crosscut budget identifies renovation, recapitalization, maintenance, and demolition projects for buildings and facilities by program and site. The IFI budget also includes reports on direct maintenance and an estimate of indirect maintenance and repair funding requirements. The IFI is developed in conjunction with the Department's budgeting process and submitted annually with the Presidential Budget to Congress. (RPAM)

Infrastructure. All real property, installed equipment, and related real property that is not solely supporting a single program mission at a multiprogram site or that is not programmatic real property at a single program site. (RPAM)

Institutional Equipment. (Same as general purpose equipment.) Capital equipment items that are used to support the general infrastructure of the institution. These typically include institutional information equipment, institutional scientific equipment, and institutional other equipment. (NREL)

Institutional Information Equipment. Computers, workstations, servers, electronic storage media, and similar capital equipment, that is necessary to manage administrative information such as that related to financial accounting, human resources, facilities management, email and telecommunications, etc. This does not include the computers, workstations, etc specifically used for computational science or high-performance computing in support of scientific investigation. (NREL)

Institutional Scientific Equipment. Spectrometers, microscopes, chromatographs, and other items of capital equipment that are used for conducting research that benefits multiple programmatic areas. This does not include the same types of instruments that are purchased and dedicated specifically to one program. (NREL)

Institutional Other Equipment. Miscellaneous items of capital equipment that support the activities of the institution that do not fit the information or scientific equipment categories. These typically include equipment items related to security, safety, facilities management, shops, etc. (NREL)

Land-Use Planning. A formal, integrated planning process that is used to identify an appropriate mix of land uses at each site and guidelines for development. [See DOE P 430.1, Land and Facility Use Planning, dated 7-9-96.] (RPAM)

Large General Plant Project. A general plant project that is estimated to cost between $1 million and $5 million.

Lead Program Secretarial Office (LPSO). A Program Secretarial Office (PSO) that is responsible for implementation of policy promulgated by Headquarters staff and support organizations for a field office. The LPSO owns the site, manages its own program

projects, and acts as a host for tenant Cognizant Secretarial Offices/PSOs by providing facility and/or infrastructure support. The LPSO for NREL is the Office of Energy Efficiency and Renewable Energy. (RPAM)

Life Cycle. The life of an asset from planning through acquisition, maintenance, operation, remediation, disposition, long-term stewardship, and disposal. (RPAM)

Life-Cycle Cost. The sum total of the direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of real property over its anticipated useful life span. (RPAM)

Long-Term Stewardship. The physical controls, institutions, information, and other mechanisms needed to ensure protection of people and the environment at sites where DOE has completed or plans to complete cleanup (e.g., landfill closures, remedial actions, removal actions, and facility stabilization). This concept includes land-use controls, monitoring, maintenance, and information management. (RPAM)

Maintenance. Day to day work that is required to sustain property in a condition suitable for it to be used for its designated purposes, including preventive, predictive, and corrective maintenance. Maintenance costs and work do not include the following.

a. Regularly scheduled janitorial work such as cleaning, and preserving facilities and equipment.
b. Work performed in relocating or installing partitions, office furniture, and other associated activities.
c. Work usually associated with the removal, moving, and placement of equipment.
d. Work aimed at expanding the capacity of an asset or otherwise upgrading it to serve needs different from or significantly greater than those originally intended.
e. Improvement work performed directly by in-house workers or in support of construction contractors accomplishing an improvement.
f. Work performed on special projects not directly in support of maintenance or construction.
g. Non-maintenance roads and grounds work such as grass cutting and street sweeping. (RPAM)

Mission Essential Real Property Assets. Those facilities and infrastructure assets that directly contribute to accomplishment of the program assigned missions or mitigation of environmental, safety, or health issues, which if not available, would adversely impact the mission. (RPAM)

Operating Facilities. Facilities that have a Facilities Information Management System status code of operating, operating standby, operating pending excess, operating under out-grant, or operating pending decontamination and demolition/disposition. (RPAM)

Optimum Period. That time in the life cycle of a real asset when maintenance actions should be accomplished to preserve and maximize the useful life of the asset. The determination is based on engineering/maintenance analysis and is independent of funding availability or other resource implications. (RPAM)

Performance Measures. A quantitative or qualitative characterization of performance toward an objective. [See DOE G 430.1-4.] (RPAM)

Performance Objective. A statement of the desired output/outcome for an organization or activity. [See DOE G 430.1-4.] (RPAM)

Plant, Property & Equipment. Tangible assets that meet the capitalization criteria, that are not intended for sale in the ordinary course of operations, and have been acquired or constructed with the intention of being used, or being available for use by the entity. Plant, property, and equipment includes site infrastructure. (RPAM)

Predictive Maintenance. Those activities involving continuous or periodic monitoring and diagnosis to forecast component degradation so that "as needed" maintenance can be scheduled for facilities and infrastructure. (RPAM)

Preventive Maintenance. Those periodic and planned actions taken to maintain a piece of equipment within design operating conditions and extend its life and performed before equipment failure or to prevent equipment failure for facilities and infrastructure. (RPAM)

Prior Year (PY). The fiscal year immediately preceding the current year and two fiscal years preceding the budget year. For the field, Congressional Review, and the Office of Management and Budget, PY is the fiscal year in which the budget is being executed. For the Congressional cycle, the PY is the most recently completed fiscal year. (RPAM)

Programmatic Real Property. Refers to reactors, accelerators, and similar devices used by programmatic personnel, acquired with line item funding, and listed in the Facilities Information Management System as "Other Structures and Facilities" under the 3200 series usage codes, such as 3209, 3221, 3251, and 3261. (RPAM)

Programmatic Capital Equipment (PCE). Equipment items not essential to the operation of a building that are purchased with program funds, cost more than $25,000, have a useful life of more than two years, and are not used up in an experiment. Programmatic capital equipment can include both capital equipment related to construction and capital equipment not related to construction. (NREL)

Program Secretarial Office (PSO). A senior outlay program office which has work performed at a site, but not as the host Lead Program Secretarial Office or Cognizant Secretarial Office at that site, and provides annual program direction and guidance to the site/field manager for the work to be performed at the site, and for budgeting to support

program work and an appropriate share of their tenant costs to the landlord. The Office of Science is a PSO at NREL. (RPAM)

R&D Equipment. Capital equipment items that are purchased for research purposes. Also called scientific instrumentation. As examples, this includes large lab instruments such as spectrometers or microscopes, which typically have a strategic useful life of 7-10 years; centrifuges or vacuum pumps, which may have a strategic useful life of 10-15 years; and fermentors and cranes to move wind turbine blades, which may have a strategic useful life of 15-25 years. R&D equipment is considered in two categories according to the funding source and therefore the beneficiary: 1) institutional scientific instruments or equipment, which benefits the entire lab or multiple programs, and 2) program capital equipment, which benefits one or perhaps two programs. (NREL)

Real Property Assets. Any interest in land, together with the improvements, facilities, structures, and fixtures located thereon, including prefabricated movable structures and appurtenances thereto, under the control of DOE. All real property owned by or leased to the Government or acquired by the Government under the terms of the contract. It includes both government-furnished property and contractor-acquired property as defined in Federal Acquisition Regulation 45.101. DOE-owned, -used, and -controlled land, land improvements, structures, utilities, installed equipment, and components are included. Real property and real estate means land and rights in land, ground improvements, utility distribution systems, and buildings and other structures. Real Property Assets are defined by the Federal Property Management Regulations § 101-47.103-12, Real Property. (RPAM)

Recapitalization. Major renovations or reconstruction activities, including facility replacements, needed to keep existing facilities modern and relevant in an environment of changing standards and missions. This includes the restoration and modernization of existing facilities but not the acquisition of new facilities or the demolition of old ones, unless the demolition is carried out as part of a renovation project or in conjunction with construction of replacement footprint elsewhere. (RPAM)

Regular Replacement. Purchase of a new, sometimes upgraded or expanded capital equipment item to replace an existing asset on or before the end of the strategic useful life of the asset. (See "Deferred Replacement" and "New Capability"). (NREL)

Repair. The restoration of failed or malfunctioning equipment, system, or facility to its intended function or design condition. Repair does not result in a significant extension of the expected useful life. (RPAM)

Replacement Plant Value (RPV). As applied to a structure, the cost to replace the existing structure with a new structure of comparable size using current technology, codes, standards, and materials. As applied to programmatic capital equipment or general purpose equipment, the cost to replace the existing equipment with equipment of comparable or upgraded functionality. Because of the lack of other cost estimating procedures, RPV for equipment is often estimated as the original acquisition cost

escalated to the current date using an appropriate consumer price index. (RPAM and NREL)

Site. A geographic area owned or leased by or for the account of the Federal Government for the performance of DOE program activities. The term includes any extant buildings, infrastructure, and other improvements. (RPAM)

Small General Plant Project. A general plant project that is estimated to cost about $1 million or less. (NREL)

Standalone Capital Equipment. Capital equipment items that are not part of the functioning of a building. Standalone capital equipment includes scientific instrumentation, process development equipment, computer equipment, etc. (See structure-integrated capital equipment.) (NREL)

Structure-Integrated Capital Equipment. Capital equipment items that are part of the functioning of a building, such as chillers, fans, toxic gas monitors, etc. (NREL)

Surveillance and Maintenance. Activities conducted throughout the facility life-cycle, including providing, in a cost effective manner, periodic inspections and maintenance of structures, systems and equipment necessary for the satisfactory containment of contamination, and for the protection of workers, the public, and the environment. RPAM)

Sustainment. Maintenance and repair activities necessary to keep the inventory of facilities in good working order. This includes regularly scheduled maintenance as well as anticipated major repairs or replacement of components that occur periodically over the expected service life of the facilities. (RPAM)

Sustainability. The simultaneous and balanced pursuit of economic viability, environmental health, and public responsibility over the long term through appropriate investment decisions and operating practices. (NREL)

Ten-Year Site Plan (TYSP). A planning document that identifies the site's annual and strategic program requirements and priorities, and links these to real property asset requirements. Real property asset requirements must be consistent with program missions, budgets, and planning estimates. Planning employs costing efficiencies, eliminates excess buildings, consolidates operations where practicable, and addresses mission-critical requirements through an appropriate mix of recapitalization, new construction, and disposal of excess facilities. (RPAM)

Total Estimated Costs (TEC). The Total Estimated Cost of a project is the specific cost of the project including cost of land and land rights; engineering, design, and inspection costs; direct and indirect construction costs; and the cost of initial equipment necessary to place the plant or installation in operation. (RPAM)

Total Project Costs (TPC). The Total Project cost is the Total Estimated Cost plus the following: All research and development, operating, plant and capital equipment costs, specifically associated with project construction up to the point of routine operations, which will include but not limited to: pre-title I activities, R&D necessary for fabrication, testing, and rework of prototype equipment; R&D required prior to start of construction; one-time costs related to testing, startup, operator training, and commissioning; initial inventories and spare parts; site suitability testing and evaluation; quality assurance related to site suitability and testing; regulation compliance; grant to state and local governments; payments equal to taxes; systems studies and selected systems engineering services; institutional activities related to facility siting and external interactions; decontamination and decommissioning costs; economic escalation; contingency (applicable to TPC). (RPAM)

Strategic Useful Life. The estimated length of time that an item of equipment, not essential to the functioning of a building, is expected to be used. This is estimated by the individuals using the items of equipment, and is more specific than the useful life as designated for asset categories according to the DOE accounting handbook. (NREL)

Value Engineering. An organized effort directed at analyzing the functions of systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety. For purposes of this Order, value analysis, value management, and value control are considered synonymous with value engineering. (RPAM)

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