Princeton Plasma Physics Laboratory

1. Mission and Overview

The Princeton Plasma Physics Laboratory is a collaborative national center for plasma and fusion energy sciences. It is the only Department of Energy (DOE) Laboratory devoted to these areas, and it is the lead U.S. institution investigating the science of magnetic fusion energy.

The Princeton Plasma Physics Laboratory (PPPL) has two coupled missions. First, PPPL develops the scientific knowledge to realize fusion energy as a clean, safe, and abundant energy source for all nations. Plasma is a hot, ionized gas that under appropriate conditions of temperature, density, and confinement produces fusion energy. PPPL has been a leader in developing the physics of high temperature plasmas needed for fusion. PPPL will continue to solve plasma physics problems crucial to fusion energy, as well as contribute to solutions of key engineering science challenges associated with the material structure that surrounds the hot plasma. The second mission is to develop plasma science over its broad range of physics challenges and applications. Modern plasma physics began with the advent of the world fusion program, and continues to lead to new discoveries in the nonlinear dynamics of this complex state of matter. The vast applications range from scientific (e.g., plasmas in the cosmos) to technological (e.g., plasma-aided manufacturing).

For over six decades PPPL has been a leader in magnetic confinement experiments and theory. PPPL is a partner in the U.S. Contributions to the ITER Project and leads multi-institutional collaborative work on the National Spherical Torus Experiment - Upgrade. The Laboratory hosts smaller experimental facilities used by multi-institutional research teams and collaborates strongly by sending scientists, engineers and specialized equipment to other fusion research facilities in the U.S. and abroad. To support these activities, the Laboratory maintains nationally leading programs in plasma theory and computation, plasma science and technology, and graduate education.

2. Lab-at-a-Glance

Location: Princeton, New Jersey
Type: Single-program Laboratory
Contractor: Princeton University
Responsible Site Office: Princeton Site Office
Website: www.pppl.gov

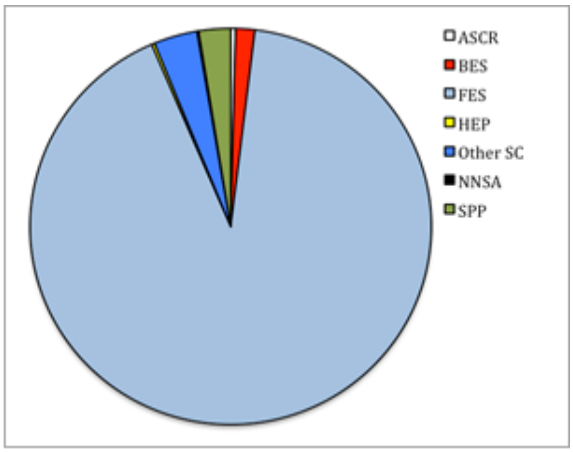
Physical Assets:

- 90.7 acres; 30 buildings
- 765K GSF in Active Operational Buildings
- Replacement Plant Value: $660M (total)
- Deferred Maintenance: $108M
- Asset Condition Index: 0.84
- Asset Utilization Index: >95%

Human Capital:

- 462 Full Time Equivalent Employees (FTEs)
- 5 Joint Faculty
- 12 Postdoctoral Researchers
- 40 Graduate students
- ~350 Visiting Scientists

FY 2015 Funding by Source (Costs in $M):



Total Lab Operating Costs (excluding Recovery Act): $90.0M
DOE/NNSA Costs: $87.7M
SPP (Non-DOE/Non-DHS) Costs: $2.3M
SPP as % Total Lab Operating Costs: 2.6%
DHS Costs: $0M

3. Core Capabilities

PPPL has significant scientific and engineering capabilities to support the DOE Office of Science's mission to develop the knowledge base for fusion energy and high temperature plasmas. These capabilities are vital for the Princeton University's Graduate Program in Plasma Physics, ranked one of the highest in the nation.

Plasma and Fusion Energy Sciences

PPPL has unique experimental and theoretical capabilities and facilities to explore the physical processes that take place within the high-temperature, high-pressure plasmas required for fusion energy. Areas of special strength include: the National Spherical Torus Experiment Upgrade (NSTX-U); the Lithium Tokamak Experiment (LTX); high-resolution techniques to measure plasma properties and processes at a wide range of space and time scales; extremely powerful capabilities for plasma heating and current drive; capabilities for analysis of data from high-temperature plasmas used by experimental teams around the world; expertise in understanding, numerically modeling, and operating a wide range of magnetic confinement configurations; world-leading basic plasma experimental facilities such as the Magnetic Reconnection Experiment (MRX); and premier analytic theory capabilities that are internationally recognized as a continuing source of seminal ideas and mathematical foundations for plasma physics and fusion energy science.

PPPL also has unique computational capabilities to accelerate progress in understanding the physics of high temperature and burning plasmas (e.g., ITER). This includes codes for modeling small-scale plasma turbulence and associated plasma transport, nonlinear extended magnetohydrodynamics of larger scale plasma equilibria and motions, and wave-plasma interactions with plasma heating and the fusion-product induced instabilities possibly present in ITER. PPPL leads in advanced algorithmic development to enable efficient utilization of DOE-SC's leadership-class computing facilities for fusion research. This allows us to validate physics-based predictive models against existing experiments, to investigate innovations to successfully development fusion energy, and use the integrated models to guide ITER operations in the future.

Substantial expertise exists in the interaction of plasmas with materials. PPPL with Princeton University's Engineering Department has established two surface analysis laboratories to study fusion-relevant material issues. In addition PPPL has established a nano-laboratory to study the development of plasma produced carbon nanotubes. PPPL has theoretical and laboratory capabilities with regard to topics in plasma astrophysics.

Large Scale User Facilities/Advanced Instrumentation

PPPL has unique engineering capabilities in: plasma measurement, heating, and current drive system design and construction; safe and environmentally benign facility operation including the use of tritium fuel; and specialized fusion confinement facility design and construction. These strengths together with an enormously capable site for fusion research (shielded test cells, high-current power supplies, extensive cryogenic facilities, and high-speed broad-band network) support the operation of NSTXU, aid the development and testing of components for ITER, and enable collaborations on major national and international fusion research facilities. PPPL is a partner with ORNL and Savannah River in the U.S. ITER Program, and specifically manages the U.S. role in ITER diagnostics and the ITER steady state electric network. These capabilities provide a flexible, capable location for possible next-step U.S. fusion research facilities.

PPPL is internationally recognized as a pioneer in the development and implementation of fusion plasma diagnostics. It has provided diagnostics as well as the supporting expertise to many fusion programs around the world, often in collaboration with other U.S. institutions. PPPL's seminal contributions have been particularly strong in techniques to measure in detail the profile of the plasma parameters (density, temperature, current density, and rotation), fluctuation diagnostics to measure the underlying instabilities and turbulence responsible for plasma transport, and measurements of both the confined and lost alpha-particles produced by fusion reactions. PPPL has a long-standing, active collaboration program providing diagnostics to fusion programs around the world (JET, JT-60U, LHD, W7X, C-Mod, DIII-D, EAST, and KSTAR).

Mechanical Design and Engineering

The primary activity of PPPL is the development of fusion power based on magnetic confinement and high power heating of thermonuclear plasmas. The corresponding range of mechanical engineering technologies is multidisciplinary and overlaps plasma physics and electrical engineering activities at the Lab. PPPL's design engineers employ the latest in computer aided design tools. Design engineers benefit from the challenges of designing and fabricating state of the art components for experiments under construction such as ITER; and from experience maintaining large operating fusion experiments, historically TFTR and now, NSTX Upgrade. Collaborations within the U.S. augment the exposure of PPPL engineers to a wide range of technological advancements. Collaborations with laboratories and projects outside the U.S. expose PPPL engineers to the requirements of next generation nuclear experiments and power reactors.

PPPL's engineering analysis staff is expanding their simulation capabilities to include coupled multiphysics analysis of nuclear shielding, breeding, and activation; heat transfer; fluid dynamics of flow in magnetic fields and with free surface effects; transient non-linear magnetics; and structural mechanics including advanced materials models. Fully coupled simulations based on detailed CAD models are extremely demanding of computer resources. PPPL is exploring both fully consistent models and models dedicated to the physics being simulated with data mapping between models. At this time, PPPL engineering staff is making limited use of the advanced computing capabilities at PPPL. Currently nuclear and some electromagnetic simulations are run on the LINUX cluster, but this will change as more sophisticated coupled models are developed. Allied with the capabilities to perform materials tests and gain insight from performance of materials in NSTX-U, engineering mechanics and material science activities at PPPL will grow.

Power Systems and Electrical Engineering

The primary activity of PPPL is the development of fusion power based on magnetic confinement and high power heating of thermonuclear plasmas. The corresponding range of electrical engineering technologies is extraordinary and overlaps those needed to address issues of transmission grid efficiency, reliability, and integration of variable generation. The utility-scale power systems at PPPL include a 138kV grid interface, large rotating machines used for energy storage, a local 13.8kV AC distribution system, and complex AC/DC converter systems using various power electronics devices and topologies. Peak power level is ~ 1000 MW with voltages up to 120kV and currents up to 150kA. Magnet systems designed by PPPL for use on its experimental devices include solenoidal and toroidal configurations operating at 10's of kV, up to 150kA, with 1000's of MJ of stored energy. Advanced digital control and protection systems on PPPL devices involve feedback loops operating above 1kHz on signals derived from advanced plasma diagnostic sensors as well as power system voltages and currents. PPPL's engineering staff has deep experience in the design, fabrication, and operation of the diagnostic, control, protection, electromagnetic, and power systems as cited above, including proficiency in related design and

simulation tools. These core competencies are directly related to the development of new power systems and electrical engineering technologies for transmission grid modernization and renewables integration. In addition, the PPPL infrastructure could be utilized as a test bed for various advanced technologies such as energy storage, advanced reactive power compensation and power flow control, etc. The PPPL competency and infrastructure as cited above exceed those at any other DOE laboratory and most if not all international laboratories. Moreover, PPPL electrical engineering has played a key role in the design of the ITER power systems which, when implemented, will be world-leading.

Systems Engineering and Integration

PPPL has the capability to produce whole-system design, fabrication and operation of fusion, plasma and large electro magnetic systems. Systems Engineering and Design Control and Integration is applied at three levels of fusion research. First, systems studies are applied at the reactor studies/concept stage. Second, systems studies are used to prepare for and conduct major construction projects. Third, systems simulations are used to control and protect large experiments during operation. PPPL personnel have the experience to provide the numerical modeling and optimization of systems with simultaneous physics and engineering simulations. On the physics side, PPPL has participated in the whole tokamak simulation project, which integrates many physics simulations and interfaces with the plasma facing components. Completing the reactor modeling, PPPL has provided the integrated engineering and physics system design studies of future U.S. & International facilities and programs including, the ARIES studies, the current Fusion Nuclear Science Facility (FNSF) Study, KDEMO (S. Korea), CFETR (China) and other Future U.S. tokamak and stellerator facilities.

During execution of major projects, systems studies are used to initially size and cost the project. The most recent example of this is the initial design study for NSTX-U. As the project progresses, PPPL employs a full complement of integrated CAD modeling as a part of design integration and configuration management. In parallel, engineering models are analyzed, and updated with the current configurations. This has included global models of the core and ancillary systems. The larger simulations provide design parameters and boundary conditions for sub models and subsystem models. These support component qualification, work progressing and value added reporting. The engineering department maintains a complete set of guidelines and procedures under the office of project management to provide guidance on project management, work planning, design verification, reporting, and ensures consistent technical excellence of the design and engineering process. Design verification includes multiple levels of peer reviews, often with outside participants, and requirements for preparation checking, and filing calculations.

The lab has provided management of and participation in multi-lab integrated design teams. PPPL maintains ongoing collaborations with other national labs to foster an understanding of operations at other collaborators institutions. PPPL has provided the systems engineering manager for the U.S.-ITER program, the ITER System design for auxiliary power systems, and the ITER system design for the diagnostic interface system including first-wall and shielding structures. PPPL has led the design of some of the ITER Internal Systems using integrated design capabilities. The ITER system designs included the equatorial and upper diagnostic port plugs and the internal magnetic coils.

The PPPL engineering staff has developed many parameter, multi-physics advanced real-time control systems, to optimize system performance while maintaining protection to the equipment. The newest of these systems is the NSTX-U Digital Coil Protection System (DCPS) which combines the electrical and power systems controls of NSTX-U with mechanical performance models to provide combined electro-mechanical protection. This system is

proving itself a reliable and valuable operational constraint during initial operations of NSTX-U. Structural instrumentation is beginning to support benchmarking of the mechanical modeling. Such a system has been suggested to ITER and is of increasing necessity for the higher value, higher consequence protection of next generation reactors.

4. Science Strategy for the Future

PPPL has a dual mission to develop the scientific knowledge base needed for fusion energy for the world and to lead discoveries across the broad frontier of plasma science and technology. As evidenced by surging research in fusion abroad, there is a rapidly increasing imperative to develop clean, plentiful, and safe fusion energy. PPPL plans to provide solutions to the key physics and engineering challenges of fusion, seeking nothing less than development of a new energy source that will transform the way the world produces energy. The understanding of plasma has huge consequences to neighboring sciences (such as the visible cosmos, mostly composed of plasma) and to technological applications (from plasma-based nanotechnology to plasma centrifuges).

PPPL focuses on the approach fusion energy in which the hot fusion plasma is confined magnetically. PPPL is developing the compact, high pressure (relative to magnetic pressure) approach known as the spherical tokamak (ST), through its major collaborative user facility, the National Spherical Torus Experiment – Upgrade (NSTX-U). The ST provides unique physics information important for the international experiment ITER and fusion in general, develops novel solutions to the challenge of the plasma-material interface, and is a prime candidate for major next step facilities in fusion research. PPPL collaborates with conventional tokamak facilities in the U.S. and abroad, pursuing improved understanding of plasma confinement and enhanced performance scenarios in preparation for ITER. ITER is an international fusion experiment, based on the standard tokamak design, that will demonstrate net fusion power generation (of 500 MW) for the first time. ITER-focused research and development is spread throughout PPPL – including NSTX-U, collaboration on tokamaks in the U.S. and abroad, theory and simulation, and design/construction activities. A lab-wide program is exploring the use of a liquid wall as the material that faces a fusion plasma – a potential breakthrough solution if it is proven to be scientifically feasible. PPPL aims to enter the new era of integrated modeling using the most advanced computers to understand the full fusion plasma system. New 3D designs for fusion systems are under study – computational physicists can devise new, remarkable configurations that confine hot plasmas in steady state with reliability. Beyond fusion, PPPL performs research to understand how plasma processes determine the behavior of major astronomical objects. PPPL will enhance its contributions to plasma science and applications generally, in areas such as plasma-based mass filters for nuclear waste remediation, plasma-based nanotechnology for improved production of nanomaterials, plasma-based metamaterials and more. In addition to a broad program of national and international collaboration, new activities are being initiated between PPPL and other units of Princeton University, particularly with material scientists and astrophysicists. PPPL conducts an expansive education and outreach program, including operation of the Princeton University graduate program in plasma physics, research activeties for undergraduates, and science outreach activities for the general public.

5. Mission Readiness/Facilities and Infrastructure

Overview of Site Facilities and Infrastructure

Overview of Site Facilities and Infrastructure

The Laboratory is located on 90.7 acres within the Princeton University Forrestal Campus. The 1,750-acre Forrestal Campus is punctuated by dense woods, brooks and nearby streams; almost 500 acres remain in their natural state in order to protect and enhance the character of the campus. The PPPL Environmental Management System (ISO 14001 certified) provides a comprehensive approach for controlling PPPL activities to minimize negative impacts to the environment.

The Laboratory uses 766,181gross square feet (GSF) of space in 30 Government-owned buildings and 2 trailers located at PPPL ("C" and "D" Sites) including one offsite (pump house.) There are currently no leased buildings or facilities and no plans to enter into any external lease agreements. There were no real estate transactions during FY15 and none are currently planned. For the IOI Project, PPPL will rent temporary office trailers to house the staff displaced by the project.

As listed in the FIMS FY15 report, the total Replacement Value (RPV) of all PPPL facilities and infrastructure was ~$660M; Previously the Non-Programmatic RPV ~$478M was used for calculating indices. Recent Operational Improvement Committee guidance indicates that the total RPV ($660M) should be used for consistency. Every PPPL building asset utilization rating is greater than 95%, which is "Over Utilized" by the Laboratory Operations Board (LOB) criteria. The Laboratory has very little margin for growth. The Laboratory Operations Board directed condition assessments in FY14 that identified ~$81.6M of deferred maintenance. In 2015 PPPL learned that several laboratories use VFA Inc. to perform their condition assessments. In the interest of uniformity, PPPL also hired VFA Inc. to perform condition assessments of all C-Site buildings and D-Site mechanical equipment rooms. They did not assess OSFs or the D-Site buildings. By incorporating their data, our updated deferred maintenance is $108M with an overall ACI of .84. Most of the real property building assets have exceeded their expected life by more than ten years and therefore, have been placed on the deferred maintenance list. Much of the maintenance budget is spent keeping this aged equipment functional. Operation Improvement Committee working groups were recently formed to obtain uniform agreement amongst all laboratories for deferred maintenance, replacement plant value, and condition assessment calculations. PPPL will reassess assets based on this new guidance once received. The PPPL maintenance and repair budget for FY16 is approximately $7M.

SC Infrastructure Data Summary

Total Building Assets	30
Total Building Assets Assessed	30
Total Area Assessed*	764,837GSF
Total OSF	26
Total OSF Assessed*	24
Total Deferred Maintenance ($)	$108,157,324

* NSTX and TFTR experimental OSF assets and two trailers are not summarized as part of the infrastructure

Core Capabilities: Plasma/Fusion and User Facilities/Advanced Instrumentation				
Condition		Adequate	Substandard	Inadequate
	Buildings	3	5	22
Utilization	Under Utilized (GSF)	Not Utilized (GSF)	Excess (GSF)	Repurpose / Reuse (GSF)
	10,828	0	0	122,642
Other Structures (OSFs)				
Condition		Adequate	Substandard	Inadequate
	OSFs	23	2	1

Campus Plan

The Laboratory has a 10-year Campus Plan to cost-effectively improve the capacity, maintenance, and operations of the Laboratory in order to provide facilities that enable world-leading science and support the priorities discussed in the Science Strategy section above. Specifically, the objectives are to fully support the NSTX-U operations, to enable more international collaborations, to modernize the research and development space, and to update the office and collaborative spaces. The Plan addresses how real property assets will be used to support the objectives of the DOE Strategic Plan and guidance provided by the Office of Fusion Energy Science. Planning is developed in accordance with the Real Property Asset Management Order, DOE 0430.1B and the DOE-SC objective of integrating land use, facilities and infrastructure acquisition, maintenance, recapitalization, safety and security, and disposition plans into a comprehensive site-wide management plan. PPPL plans on updating the campus plan to determine if a more aggressive approach can be deployed to address the deferred maintenance issue. In addition, the plan will address a facility that will address the National Fire Protection Association Code for use of lithium research.

While the size of the PPPL site is adequate for current and anticipated future needs, the Condition Assessment identified many substandard and inadequate facilities and utility systems (as summarized in the previous table and shown in the figure below). The number of PPPL employees and activity mix is expected to remain unchanged in the near-term, while the number of onsite collaborators is expected to grow modestly with funding for the new initiatives and ITER work.

Items submitted for funding in previous SC Infrastructure Cross-cut Data Requests were not approved, but the need for investment still exists. Improving crosscut items would provide robustness to key site utilities that are required for NSTX-U operations and other facilities at PPPL. As a result, a request was made to increase GPP funds to support the utility improvements. This was favorably received and increases in GPP funding have been made. Nevertheless, deferred maintenance projections indicate a very slow reduction. The Laboratory must often use GPP funding to cover site-wide improvements and upkeep routinely required (e.g., road paving or roof replacement). The Laboratory's 2016 maintenance budget is $7M; ~1% of the overall RPV. Recent guidance indicates that laboratories with less than adequate overall ACI should receive 1-2% above the recommended 2-4% for future years to bring the Laboratory to a fully "adequate" condition. Also, recent guidance from SC is to use an escalation rate of 3% for the deferred maintenance. The RPV also rose 3%. Applying the 1% maintenance budget to routine maintenance and repair items while adding 1-2% of the total RPV direct funded investments through GPP and SLI funding streams for Deferred Maintenance would realize a significant reduction in deferred maintenance and achieve an ACI greater than .95, fully "adequate" condition, by the year 2027. It is also vital that the maintenance budget keep up with continual total property RPV escalation rate increases (difficult to do with pressure on indirect funding and other significant items that need to be replaced – e.g. new business system). SLI funded Infrastructure Operations Improvement project began in FY15 and provides a large initial investment toward implementing the Campus Plan. This investment will address $6.3M of deferred maintenance through the demolition of Mod VI ($899K), Renovation of the LSB Annex ($553K), and the repurposing of the CMG into a centrally located machine shop ($4,850K).

To prioritize the allocation of limited infrastructure funding, PPPL uses the Mission Readiness Process. In the Planned Investments table, the infrastructure funding is shown as individual items. The Laboratory uses the Capitol Asset Management Process (CAMP) to rank both capital and operationally funded improvements based on their risk and the benefit they provide to the Laboratory Mission. The Laboratory is considering newer, less subjective tools available such as VFA. Facilites, which is based on Pairwise comparison.

Condition Assessment (as of May 31, 2016)

Infrastructure Funding Needs

The Laboratory Cross-cut proposal for 2016 includes the following key areas: The 138kV yard main duct bank has exceeded its expected life and could threaten laboratory wide power including experimental operations; a number of HVAC units that have greatly exceeded their useful life and pose serious risk and direct impact to operational systems; renovation of the RF and COB building to accommodate small and medium size experiments in accordance with the campus plan. As part of that the laboratory is looking at other buildings or new construction to accommodate the liquid metals program described in section 4.0 of this document. Lithium in quantity requires specific controls to comply with the NFPA code and this will be an activity developed and deployed in FY17. The CMG and RF buildings have transite external walls that have an insulation value of R1.5, allowing significant energy waste. The neighboring CS building was previously covered with insulation panels that will extend the life of the transite walls indefinitely, while providing an additional benefit of raising the insulation rating of R19. The insulation of the CMG wall will be addressed in the SLI project; the remaining RF building wall will need to be covered with GPP funding.

Infrastructure Funding Needs

Objectives	Fully Support NSTX-U Operations
	Enable Improved International Cooperation
	Modernized, Flexible, Safe Laboratory Space for Small and Medium Experiment
	"People Space" that Facilitates the Exchange of Ideas
	General Purpose Infrastructure that is updated to support R&D efforts

Planned Capital Investments (Dollars in Thousands)

Project	Total	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Activity Type	Funding Program
Install 2400SF, Plasma Based Nano Lab in 1st floor at RF BLDG C40	1,770	700	1,070												GPP	FES
Install 2700SF, FLARE Experiment in 1st floor at CS BLDG C41	1,700	949	751												GPP	FES
Years 2019-2027	0														GPP	FES
Improve 3 floors, 7500SF of LSB Annex at BLDG C01 1	3,460			3,460											LI	SLI
Demolish 8216SF, Module 6 in C-Site at BLDG C55 2	231				231										LI	SLI
Consolidate 4600SF, HAZMAT C93 into 6360SF RAD WASTE BLDG D45 3	444			444											GPP	FES
Improve 12000SF, 1st floor in C-Site at BLDG ENG Wing C20	1,541		1,541												GPP	FES
Improve 2622SF second Floor in C-Site at BLDG Facilities C61	174				174										GPP	FES
Years 2019-2027 (SLI Funding)	50,000							25,000	25,000						LI	SLI
Improve 32400SF, in C-Site at CMG C51 4	8,269				8,269										LI	SLI
Improve 20000SF, in C-Site at RESA C90	2,120				2,120										LI	SLI
Replace S2A1 to S2 Cables	1,022		200	822											GPP	FES
Improve DI Water and Electrical Service in C-Site at BLDG CS C41	905			905											GPP	FES
Replace RF Chilled Water Header	119			119											GPP	FES
Replace 1500FT, Chilled water transite pipe	2,142	2,142													GPP	FES
Replace 4824SF, Roof D-Site LEC Tank D34	94	94													GPP	FES
Replace 4750SF, Roof in D-Site at Pump House D70	94	94													GPP	FES
Replace 8 HVAC Control systems in D-Site at BLDG D42* 5	624				624										GPP	FES
Replace 1 138kV Underground duct bank in C-Site at power yard* 6	1,284			1,284											GPP	FES
Replace 1 Heat Pump in C-Site at Material Services C64* 7	117			117											GPP	FES
Replace 1 UPS Emergency Lighting system in C-Site at BLDG LSB C01 8	578			578											GPP	FES
Replace 1 fire alarm Panel in C-Site at BLDG ESAT C50 9	75			75											GPP	FES
Replace 1 fire alarm Panel in C-Site at BLDG PLT Power C52 10	75			75											GPP	FES
Replace 1 fire alarm Panel in C-Site at BLDG CMG C51 11	75			75											GPP	FES
Improve 19600SF exterior transite wall in C-Site at RF BLDG C40*	1,848				1,848										GPP	FES
Replace 2 HVAC Units in C-Site at BLDG COB C42* 12	768				768										GPP	FES
Replace 2 HVAC Units in C-Site at BLDG Shop C32* 13	768				768										GPP	FES
Replace 1 HVAC Unit inD-Site at BLDG DMG D72* 14	138				138										GPP	FES
Repair 60000SF roadway 15	308				308										GPP	FES
Improve cell phone communications	115				115										GPP	FES
Years 2019-2027 (GPP Funding)	92,858	3,979	3,562	7,954	15,363	10,000	10,000	10,000	9,000	7,000	4,000	4,000	4,000	4,000	GPP	FES

Overall funding needs for infrastructure during the next ten years is shown below.

Investment Summary ($M)

(Dollars in Thousands)

FES Funding Investments	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Direct Funded (GPP)	2,500	5,000	4,321	5,000	10,000	10,000	10,000	9,000	7,000	4,000	4,000	4,000	4,000
Direct Funded (SLI)	25,000						25,000	25,000					
Maintenance and Repair (For Federally Owned Facilities)	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Predictive, Preventive and Corrective M&R (incl. DM Reduction)													
Direct Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Funded	6,800	7,000	8,000	8,200	8,500	8,700	9,000	9,200	7,200	7,400	7,700	7,900	8,100
Total Predictive, Preventive and Corrective	**6,800**	**7,000**	**8,000**	**8,200**	**8,500**	**8,700**	**9,000**	**9,200**	**7,200**	**7,400**	**7,700**	**7,900**	**8,100**
Operation, Surveillance & Maintenance (OS&M) of Excess and Unutilized Facilities													
Direct Funded													
Indirect Funded													
Total OS&M of Excess and Unutilized Facilities	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Maintenance and Repair	**6,800**	**7,000**	**8,000**	**8,200**	**8,500**	**8,700**	**9,000**	**9,200**	**7,200**	**7,400**	**7,700**	**7,900**	**8,100**
Deferred Maintenance Projection*	140,515	108,157	107,081	105,293	98,452	91,405	70,698	50,039	44,540	41,876	39,132	36,306	33,395

Other	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Replacement Plant Value Projection ($000)	654,099	659,582	679,369	699,751	720,743	742,365	764,636	787,575	811,203	835,539	860,605	886,423	913,016
Building Area (Thousands GSF)	766	766	766	758	758	758	758	758	758	758	758	758	758
Excess and Unutilized Facilities (Thousands GSF)	0	0	0	0	0	0	0	0	0	0	0	0	0

*DM adjusted based on OIC DM working group guidance (3% 2016 and continuing 3% thereafter) reduced primarily through GPP and SLI investments

Excess Facilities

PPPL does not have any excess facilities at this time. When the Infrastructure Operations Improvement Project is implemented, the Mod VI facility will be vacated and removed as part of that project. In accordance with the latest FIMs guidance, PPPL will record excess facilities when identified into the system.

PPPL Computing Decision Making Process

At PPPL computing is organized under the Chief Information Officer and Head of Information Technology Department. The department is currently comprised of five divisions: cyber security, systems and networking, business computing, operations and user support, and controls and data acquisitions. The systems and networking division is responsible for scientific computing (R&D computing) along with networking and telecommunications (commodity IT). Cyber security and controls and data acquisition divisions are direct funded, while systems and networking, business computing, and operations and user support are indirect funded.

Our computing decision making process is based around a series of councils and committees that provide recommendations to the Laboratory leadership regarding proposed priorities and suggested strategic investments. These groups include: the Laboratory Council (comprised of senior leadership of the lab and set general direction), the Business and Human Resources Committee (comprised of senior leadership and evaluate both staffing and resources), and the Scientific Computing Resources Committee (comprised of the users of our high performance computing clusters).

Every year the Scientific Computing Resources Committee meets to review the status of the high performance computing clusters through a presentation delivered by the head of systems and networking. The committee then discusses the millions of simulations needed, the event size, the anticipated data rates and storage, etc. From those discussions, a universal view of the evolving demands on scientific computing is developed. Based on this input the ITD management team then sets priorities and provides multiple suggestions on how to upgrade and/or expand hardware infrastructure, partition hits M&S resources into disk, tape, and CPU to best meet the changing demands over the next fiscal year. The yearly allocation of hardware purchased is via General Purpose Equipment (GPE) direct fund that is approved by the Director's Office.

Enclosure 6: PPPL Investments

Objectives:

- Fully Support NSTX-U Operations
- Modernized, Flexible, Safe Laboratory Space for Small and Medium Experiment
- "People Space" that Facilitates the Exchange of Ideas
- General Purpose Infrastructure that is updated to support R&D efforts

Planned Capital Investments (Dollars in Thousands)

Project	Total	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Activity Type	Funding Program	Core Capability
															Select from Drop Down Menu		
Install 2400SF, Plasma Based Nano Lab in 1st floor at RF BLDG C40	**1,770**	700	1,070												GPP	FES	Plasma and Fusion Energy Sciences
Install 2700SF, FLARE Experiment in 1st floor at CS BLDG C41	**1,700**	949	751												GPP	FES	Plasma and Fusion Energy Sciences
Years 2019-2027	**0**														GPP	FES	Plasma and Fusion Energy Sciences
Improve 3 floors, 7500SF of LSB Annex at BLDG C01 1	**3,460**			3,460											LI	SLI	Plasma and Fusion Energy Sciences
Demolish 8216SF, Module 6 in C-Site at BLDG C55 2	**231**				231										LI	SLI	Plasma and Fusion Energy Sciences
Consolidate 4600SF, HAZMAT C93 into 6360SF RAD WASTE BLDG D45 3	**444**			444											GPP	FES	Plasma and Fusion Energy Sciences
Improve 12000SF, 1st floor in C-Site at BLDG ENG Wing C20	**1,541**		1,541												GPP	FES	Plasma and Fusion Energy Sciences
Improve 2622SF second Floor in C-Site at BLDG Facilities C61	**174**				174										GPP	FES	Plasma and Fusion Energy Sciences
Years 2019-2027 (SLI Funding)	**50,000**							25,000	25,000						LI	SLI	Plasma and Fusion Energy Sciences
Improve 32400SF, in C-Site at CMG C51 4	**8,269**				8,269										LI	SLI	Plasma and Fusion Energy Sciences
Improve 20000SF, in C-Site at RESA C90	**2,120**				2,120										LI	SLI	Plasma and Fusion Energy Sciences
Replace S2A1 to S2 Cables	**1,022**		200	822											GPP	FES	Plasma and Fusion Energy Sciences
Improve DI Water and Electrical Service in C-Site at BLDG CS C41	**905**			905											GPP	FES	Plasma and Fusion Energy Sciences
Replace RF Chilled Water Header	**119**			119											GPP	FES	Plasma and Fusion Energy Sciences
Replace 1500FT, Chilled water transite pipe	**2,142**	2,142													GPP	FES	Plasma and Fusion Energy Sciences
Replace 4824SF, Roof D-Site LEC Tank D34	**94**	94													GPP	FES	Plasma and Fusion Energy Sciences
Replace 4750SF, Roof in D-Site at Pump House D70	**94**	94													GPP	FES	Plasma and Fusion Energy Sciences
Replace 8 HVAC Control systems in D-Site at BLDG D42* 5	**624**				624										GPP	FES	Plasma and Fusion Energy Sciences
Replace 1 138kV Underground duct bank in C-Site at power yard* 6	**1,284**			1,284											GPP	FES	Plasma and Fusion Energy Sciences
Replace 1 Heat Pump in C-Site at Material Services C64* 7	**117**			117											GPP	FES	Plasma and Fusion Energy Sciences
Replace 1 UPS Emergency Lighting system in C-Site at BLDG LSB C01 8	**578**			578											GPP	FES	Plasma and Fusion Energy Sciences
Replace 1 fire alarm Panel in C-Site at BLDG ESAT C50 9	**75**			75											GPP	FES	Plasma and Fusion Energy Sciences
Replace 1 fire alarm Panel in C-Site at BLDG PLT Power C52 10	**75**			75											GPP	FES	Plasma and Fusion Energy Sciences

Replace 1 fire alarm Panel in C-Site at BLDG CMG C51 11	**75**			75											GPP	FES	Plasma and Fusion Energy Sciences
Improve 19600SF exterior transite wall in C-Site at RF BLDG C40*	**1,848**				1,848										GPP	FES	Plasma and Fusion Energy Sciences
Replace 2 HVAC Units in C-Site at BLDG COB C42* 12	**768**				768										GPP	FES	Plasma and Fusion Energy Sciences
Replace 2 HVAC Units in C-Site at BLDG Shop C32* 13	**768**				768										GPP	FES	Plasma and Fusion Energy Sciences
Replace 1 HVAC Unit in D-Site at BLDG DMG D72* 14	**138**				138										GPP	FES	Plasma and Fusion Energy Sciences
Repair 60000SF roadway 15	**308**				308										GPP	FES	Plasma and Fusion Energy Sciences
Improve cell phone communications	**115**				115										GPP	FES	Plasma and Fusion Energy Sciences
Years 2019-2027 (GPP Funding)	**92,858**	3,979	3,562	7,954	15,363	10,000	10,000	10,000	9,000	7,000	4,000	4,000	4,000	4,000	GPP	FES	Plasma and Fusion Energy Sciences