A Partnership for 21st Century Energy Systems: Creating a Cost-Effective and Secure Energy Grid

Never before in American history have more stringent demands been placed on public utilities than those now being imposed on California's investor-owned utilities (IOUs). For instance, Senate Bill (SB) 17 requires a self-healing and resilient grid that will accommodate new energy resources, energy storage, and demand response, while SB 1368 places emissions standards on electricity generated outside the state and imported into California. Meeting a renewable portfolio standard of 33% by 2020 will further magnify the challenges posed by these regulations. Furthermore, IOUs will face greater investment recovery risk than they have ever faced before when rapidly deploying less-certain energy systems in a time of rapidly changing technology and climate. In response to these challenges, the Partnership for 21st Century Energy Systems (P21) proposes to help addresses these challenges by applying some of the nation's most advanced and proven problem-solving computational capabilities in a cooperative research, development, and deployment enterprise managed by California's IOUs, the California Public Utilities Commission (CPUC), and Lawrence Livermore National Laboratory (LLNL). The owners, operators, regulators, and a joint team of technical experts will combine data integration with the nation's most advanced modeling, simulation, and analytical tools to provide unprecedented insight and new information that can reduce risk and inform decisions that will tackle the challenges faced by 21st century energy systems.

Figure 1. Organizational structure of the Partnership for 21st Century Energy Systems.

California's three electricity-delivering IOUs—Pacific Gas and Electric, Southern California Edison, and San Diego Gas and Electric—along with the CPUC and LLNL are working together to form this partnership. The partnership will jointly run the program initiatives through a Governance Board with the assistance of a Technical Advisory Committee and a Workforce Development Committee, as shown in Figure 1 above. As benefits are demonstrated to ratepayers through this partnership, the Governance Board may consider inviting partners representing additional service areas.

The Governance Board will define the strategy and goals of the partnership, define and prioritize research program initiatives, and allocate funding to the program initiatives. The program initiatives will range from those uniquely serving an individual IOU to collaborative programs serving all IOUs and will be managed jointly by representatives of the utilities and LLNL. The Technical Advisory Committee will include membership from the utilities and LLNL and will advise the Governance Board on new and ongoing program initiatives and staffing and partnering requirements and serve on technical review and assessment committees. The Technical Advisory Committee will recommend to the Governance Board reprioritization or reallocation of funds depending on progress and new developments. The Workforce Development Committee will ensure that workforce preparedness initiatives are integrated into all program initiatives.

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The four proposed program initiative categories outlined below are representative of those that address the needs of the IOU's while best leveraging the strengths and capabilities of each partner. Once the partnership is established, the Governance Board will review the full range of possible research areas and decide which specific initiative would best serve the IOUs and ratepayers.

- Renewable & distributed energy resources
- Intermittency
- Demand response and customer participation
- Changes in load characteristics
- System efficiency and resiliency

Planning Tools. This proposed program initiative will work to enhance the capabilities of the IOUs' grid-planning efforts by improving existing planning tools and developing new ones. These new tools will exploit the latest advances in modeling and simulation capabilities and will, as necessary, take advantage of the broad services of the High-Performance Computing Innovation Center (HPC-IC) (discussed later in this report). The result will be significantly reduced run times and a higher level of detail, facilitating accurate, quick-turnaround options analysis and optimization. For example, these models can assist in examining the structure of future energy systems in multiple configurations, including different mixes of renewable, intermittent, and dispatchable generation and energy storage. By integrating models of price signaling and demand response, the impacts of new types of loads, such as plug-in electric vehicles, can be analyzed. This work can also estimate water needs for current and planned plants under once-through cooling constraints and changing climate. With the capabilities of advanced modeling tools developed in this program area, analyses that incorporate data from advanced metering and newly deployed grid data-collection equipment will be possible at time scales from minutes to decades.

Grid Operations. This proposed program initiative will provide a unique collaborative platform for utilities and system operators to adapt operational support systems to address the increasing complexity of the grid. As the grid becomes more complex, operational constraints such as transmission congestion, generator ramping limits, the variability of renewable resources, storage systems, and increased customer participation will impact daily operational decisions in ways that are difficult to predict. In addition, utilities can now leverage significantly more data from syncrophasers and advanced meters. Utilities and system operators will need increasingly sophisticated modeling tools to keep pace with this complexity. This program initiative will assist in developing these tools. For instance, we will support the IOUs' development of a grid operations computational test bed in which changes to grid operational parameters could be simulated before implementation. The test bed could incorporate high-fidelity modeling with significant operational detail of the grid and could be designed to evaluate both small areas of distribution and large, multiregion systems on a sub-hourly basis while observing real-word constraints. Livermore's high-performance computing capabilities will enable analysis of failure modes involving large number of possible combinations, including the complexity of coincident failures.

- Manage increased complexity
- Integrate increased data
- Use virtual test bed

Security. Securing the grid against both physical and cyber threats is becoming increasingly critical. Not only is the electric grid physically vulnerable to various hazards and threats, but also the increased reliance on computer-based operations and data collection increases the importance of protecting these cyber systems from intrusion and attack. The IOUs' current security efforts vary from organization to organization. For instance, an IOU that already has a robust security program may want less extensive security-related support from the partnership. Other IOUs may desire extensive support. The partnership may also offer the opportunity for the IOUs to share best practices. As needed, LLNL's high-performance computing platforms will allow the development and integration of computer systems, archives, tools, and sensors to rapidly detect and identify such combinations of rare events representing real threat. The security effort will leverage well-established decision support programs at LLNL that are already providing support to utilities nationwide in assessing and reducing vulnerabilities. This program initiative exemplifies the scientific value and insights offered by the computational community, cyber security analysts, and existing cyber defense programs at LLNL beyond our computational tools. To facilitate interactions, utility personnel will be provided with security clearances to allow enhanced relationships with Federal organizations supporting security threat information collection and analysis.

- Secure the physical grid
- Secure computerized operations
- Secure advanced metering and data

Workforce Preparedness. This proposed initiative seeks to ensure that advanced concepts and tools in the partnership's three core areas—planning, operations, and security—become an integral part of the skills, knowledge, and ability of both existing and future IOU staff. A multipronged approach will be employed: integrating IOU staff and students with the partnership's tool-development process, providing seminars, training, and hands-on

- Integrate utility staff in tool deployment
- Prepare the future workforce
- Partner with academic institutions
- Diversify curriculum

opportunities—including working shoulder-to-shoulder with LLNL scientists. Partnerships will be developed with academic institutions throughout northern and southern California, including universities and community colleges diverse in both geographic location and socioeconomic status, to promote the knowledge and skills necessary for a 21st century energy workforce. LLNL will partner with IOU staff to develop pilot programs integrated with LLNL's student and educational programs, which are attended by over 400 students onsite each summer. Another example of how the partnership can help prepare the future workforce is adapting undergraduate and graduate curricula in cyber security and computational science to the needs of the IOUs. The HPC-IC Educational Center will offer classrooms with visualization and telepresence technologies to allow broad and diverse engagement across the State of California.

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The HPC-IC is an enterprise consisting of advanced computing systems and network, storage, and application capabilities, along with experts to help partners utilize these resources. This shared center is made possible through shared investments by LLNL, IBM, industrial partners, and the P21 partnership (see Figure 2). This innovation center also builds on a decade of investments by DOE in advanced computing systems—infrastructure, people, facilities, and equipment—at LLNL.

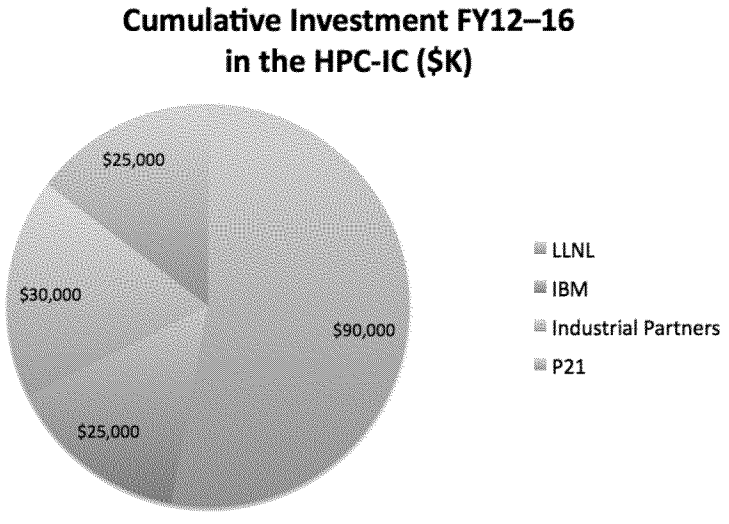

Figure 2. Cumulative investment in the High-Performance Computing Innovation Center.

Under P21, the IOUs will be partners in, and enjoy the full services of, the HPC-IC. The HPC-IC creates an innovation ecosystem leveraging high-performance computing and the innovative power of its partners to accelerate industry's research, development, prototyping, and deployment of advanced technologies. The HPC-IC brings three powerful advantages to industrial partners:

- Highly leveraged access to a spectrum of the most advanced high-performance computing systems, along with full operations and consulting services to assure ease of access
- Ready access to both industry and national laboratory expertise
- A physical location for collaborations

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Funding for this partnership will be collected through ratepayer fees at approximately the amounts shown in Figures 3 and 4, which will be split roughly by ratepayer base for each IOU. Of the total $123 million in funding, $98 million will be allocated to labor resources at LLNL and its contracted partners. The amount allocated to each program initiative will be decided by the Governing Board, will be reviewed each year, and cannot exceed—but can be less than—the amount shown. The continuation of this partnership and the appropriate funding levels will be planned for and approved by the Governance Board. The $25 million allocated to the HPC-IC in years 2 through 4 is fixed.

Investor Owned Utility	Year 1 ($M)	Year 2 ($M)	Year 3 ($M)	Year 4 ($M)	Year 5 ($M)	IOU Total
Pacific Gas and Electric	5.0	11.4	13.6	14.6	10.8	55.4
Southern California Edison	5.0	11.4	13.6	14.6	10.8	55.4
San Diego Gas and Electric	1.1	2.5	3.0	3.2	2.4	12.3
Total	11.0	25.3	30.3	32.3	24.0	
				5 Year Total	**123.0**	

Figure 3. Annual funding by partner.

Proposed Funding Allocations	Year 1 ($M)	Year 2 ($M)	Year 3 ($M)	Year 4 ($M)	Year 5 ($M)	Total
LLNL Staff	9.00	14.00	18.00	20.00	20.00	81.0
Contract Services (Labs, Universities, other partners)	2.00	3.00	4.00	4.00	4.00	17.0
High Performance Computing Innovation Center	0.00	8.33	8.33	8.34	0.00	25.0
Total	11.0	25.3	30.3	32.3	24.0	
				5 Year Total	**123.0**	

Figure 4. Proposed funding allocations.

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Each of the IOUs have laid out multiyear research plans and priorities consistent with and mindful of stakeholder benefits. P21 aims to create a research partnership that thoughtfully leverages LLNL capabilities with IOU expertise, research plans, and priorities. The engagement of research staff, well-established industrial and academic partners, and powerful computational tools at LLNL will help accelerate, enhance, or supplement many IOU program initiatives. The table below gives examples of the research areas in which the partnership can have tangible impact.

Table 1. Near-term, mid-term, and long-term benefits

Near Term	Mid Term	Long Term
Integration of advanced meters	Customer participation enahncement	Improved accommodation of local generation
Accommodation of energy storage	Integration of advanced storage technology	Improved planning for utility-scale storage
Accommodation of plug-in electric vehicles	Advanced integration of plug-in electric vehicles	Evaluation and development of vehicle-to-grid capability
Operation test bed enhancement	More automation of grid	Applied research and design to manage increased system complexity
Improved grid efficiency	Grid lifecycle management	California leadership in advanced grid management
Accommodation of demand response	Dynamic pricing	Deep penetration demand-side management
Improved cyber security	Unified cyber security	Integrated planning in western region
Improved physical security	Interactive customer communication	Defensible and efficient capital investments
Improved awareness of impacts of regulatory changes	Workforce knowledge management	Well-prepared future workforce
Assessment of regulatory impacts on customers and standard costs	Interpretation of increasing volumes of data	Accommodation of long-term climate change