



University of Pittsburgh

Mission Innovation Workshop on Grid Modernization

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Mission Innovation Workshop on Grid Modernization

— Workshop Report —

Hosted by the University of Pittsburgh Center for Energy

Friday, June 24, 2016

TABLE OF CONTENTS

I. WORKSHOP INTRODUCTION	4
II. WORKSHOP SUMMARY	4
III. WELCOME	6
IV. OPENING REMARKS	7
V. PANEL SESSION	8
Regional and National Grid Modernization Priorities	
VI. KEYNOTE ADDRESS	12
Discussion Following the Keynote Address	14
VII. MODERATED DISCUSSION SESSION #1	14
T&D Infrastructure, Distributed and Clean Energy Resource Integration	
VIII. MODERATED DISCUSSION SESSION #2	18
Integrated Energy Networks, Microgrids, Physical and Cyber Security	
IX. MODERATED DISCUSSION SESSION #3	20
Core Technologies: Energy Storage, Power Electronics, DC Power, and Others	
X. CONCLUDING REMARKS	23
XI. APPENDICES	24
Workshop Agenda	24
Speaker Bios	26
Workshop Participants	34

University of Pittsburgh GRID Institute Press Release	37
Speaker Presentation: Dr. Gregory Reed, University of Pittsburgh	39
Speaker Presentation: Mark McGranaghan, Electric Power Research Institute	63
Additional Presentation: District Energy in Pittsburgh	77

I. Workshop Introduction

The University of Pittsburgh's Center for Energy hosted the U.S. Department of Energy Mission Innovation Workshop on Grid Modernization on Friday, June 24, 2016, at the Energy Innovation Center in Pittsburgh's Hill District. The workshop focused on modernizing the nation's vast and complex electric power delivery system. The Pittsburgh region, similar to much of our nation, is confronting aging, legacy-based infrastructure and the need to integrate new technologies such as renewable and distributed resources, energy storage, electric vehicles, and the Internet of Things. Workshop topics included the interplay of grid technologies, system design, communication and control, integrated energy networks, system operations, regulation, and its influence on markets and policy. Participants discussed strategies, initiatives, and collaborations that will help to drive regional innovation, facilitate solutions, and advance progress toward a modern grid that will have national and international impact.

II. Workshop Summary

Dr. Gerald Holder, Dean of the Swanson School of Engineering at the University of Pittsburgh, and **Dr. Gregory Reed**, Professor and Director of the University of Pittsburgh's Center for Energy and the Electric Power Systems Laboratory welcomed the attendees, who included representatives from universities, foundations, nonprofits, utilities, vendors, industry groups, regulatory agencies, and local and federal government. They highlighted the University's emphasis on private–public research collaborations under Chancellor Patrick Gallagher, citing the newly-established Energy Grid Research and Infrastructure Development (GRID) Institute as a recent example. The GRID Institute will leverage public and private partnerships with new laboratory space at the Pittsburgh Energy Innovation Center to create a comprehensive solution center for industry, government, and community partners, while advancing research, development, demonstration, and deployment of evolving grid technologies and applications.

Grant Ervin, the City of Pittsburgh's Chief Resiliency Officer, spoke about the City's commitment to enabling 21st-century energy innovation and its focus on partnerships as a means to achieve this goal. Modernization of energy infrastructure is a primary focus for the City, as exemplified by its recent proposal for the national Smart Cities Challenge. Additionally, in 2015, the City and the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory (NETL) signed a memorandum of understanding to pursue advanced grid infrastructure, based on a district energy approach.

A panel discussion followed on Regional and National Grid Modernization Priorities, featuring representatives from the utility industry, the research community, and DOE. **Richard Riazzi**, President and CEO of Duquesne Light Company, discussed priorities and plans for grid modernization from the utility's perspective. **Mark McGranaghan**, Vice President of Power Delivery and Utilization at the Electric Power Research Institute (EPRI), cited the need for private–public partnerships in grid planning and design, and outlined the industry's top 10

research priorities. **Dr. Alexis Abramson**, Director of the Great Lakes Energy Institute (GLEI) at Case Western Reserve University, argued for innovative partnership models and highlighted the recently-formed Tri-State University Energy Alliance (TrUE). **Michael Pesin**, Deputy Secretary of DOE's Office of Electricity Delivery and Energy Reliability (OE), discussed the major drivers for grid modernization from DOE's perspective.

In the keynote address **Dr. Cynthia Powell**, NETL's Acting Deputy Director, Science & Technology, and **Dr. Franklin (Lynn) Orr**, Under Secretary for Science and Energy at DOE, outlined the agency's role in discovering, developing, and deploying clean energy technologies. Dr. Orr highlighted the strategic context of DOE's goals and the key priorities for the Mission Innovation initiative.

A series of moderated discussions followed, where participants shared perspectives on the following three topics:

- *Transmission and Distribution Infrastructure, Distributed and Clean Energy Resource Integration*

Summary: The first moderated discussion focused on integrating advanced grid technologies into existing infrastructure. To help frame the issues, the session used Pittsburgh as a case study. Benjamin Morris, Senior Manager, Strategic Planning & Operations Analytics at Duquesne Light Company, kicked off the conversation with an overview of the utility's current infrastructure. Grant Ervin followed with a description of the Mayor's vision for the City's energy future. The audience was invited to discuss paths to transition from the present to the future vision.

- *Integrated Energy Networks, Microgrids, Physical and Cyber Security*

Summary: This session focused on the role of downstream stakeholders, the risks and costs of grid modernization to consumers, and the question of what customers want. The spectrum of customers covers many types of end-users, from those who simply want to keep the lights on, to those with more evolved needs and preferences. Education about the risks and benefits of modern grid technologies and options is key to enabling end-users to make informed choices.

- *Core Technologies: Energy Storage, Power Electronics, DC Power, Other*

This discussion focused on core technologies to enable the transition to a modern grid. Storage was viewed as a breakthrough technology, because of its ability to buffer the intermittency of wind and solar and to help integrate renewables into the grid. Electric vehicles, for example, generate interest for their ability to provide both transportation and mobile backup power during outages. The costs, benefits, and applications of different battery choices were a central topic of debate. Many promising storage options exist but have yet to find widespread use. DC power and power electronics were mentioned as important technologies in the modern grid portfolio, warranting further research.

III. Welcome

Dr. Gerald Holder

U.S. Steel Dean

Swanson School of Engineering

University of Pittsburgh

Dr. Gerald Holder highlighted Chancellor Patrick Gallagher's focus on increasing public-private partnerships at the University of Pittsburgh. The University has a substantial investment in energy innovation through the Swanson School of Engineering and the Center for Energy, a University-wide endeavor to facilitate energy-related research programs and initiatives. The Center leverages more than 100 faculty members across departments and disciplines to collaborate with industry leaders and policy makers on challenges and opportunities in the generation, transmission, and use of energy. The history of the Pittsburgh region was shaped by energy innovation, including the first oil well, the first nuclear power plant, the first petroleum engineering program (at the University of Pittsburgh), the coal mining industry, and the unconventional natural gas industry. The region is ideally suited to address the challenges of modernizing the nation's electric power grid and energy infrastructure given its abundant natural resources, leadership in the development of clean energy technologies and energy infrastructure, the presence of leading global energy companies and energy research institutions, and engaged community and government stakeholders.

Dr. Gregory Reed

Professor and Director

Center for Energy and the Electric Power Systems Lab

University of Pittsburgh

Dr. Gregory Reed described the Energy Grid Research and Infrastructure Development (GRID) Institute, a newly-established entity at the University of Pittsburgh that will leverage public and private partnerships with new laboratory space to create a comprehensive solution center for industry, industry, government, and community partners working collaboratively on research, development, demonstration, and deployment of evolving grid technologies and applications.

The Institute's operations will be based at the Energy Innovation Center (EIC), a project developed by Pittsburgh Gateways Corporation as a case study in green adaptive reuse, which also served as the site of the Mission Innovation workshop.

The GRID Institute will focus on the challenges associated with integrating fast-growing distributed and renewable energy resources into existing, aging infrastructure. Its approach reflects Chancellor Gallagher's strong commitment to public-private partnerships. The EIC site combines state-of-the-art technology labs and incubator spaces with a diverse industry, university, nonprofit, and community presence. The initiative includes unique and innovative research capabilities, such as the new high-voltage/high-capacity AC/DC power laboratory, a

next-generation energy conversion and storage materials capabilities laboratory, advanced energy materials and corrosion testing facilities, and an incubator/commercialization space. The vision is not only to perform basic research, but also to act as a platform for demonstrating and deploying new technologies, markets, and approaches. As an off-campus facility, the EIC allows the University to collaborate more freely with industry and utility partners because of enhanced intellectual property protections. Initial partners include Duquesne Light, Eaton, the Electric Power Research Institute (EPRI), Dominion Virginia Power, FirstEnergy, Emerson, PITT-OHIO Express, Sargent Electric Company, Siemens, and Universal Electric Corp. Nonprofits including the Henry L. Hillman Foundation and the Richard King Mellon Foundation are also supporting the work of GRID. The Institute is coordinating closely with the City of Pittsburgh and with the National Energy Technology Laboratory on behalf of the U.S. Department of Energy on joint efforts to advance new energy technologies through an agreement aimed at designing a 21st century energy infrastructure for Pittsburgh. The Institute's leadership team is also exploring additional public-private partnerships in the Pittsburgh region and throughout the U.S.

The GRID Institute will also provide opportunities to partner with other universities through the recently formed TrUE- Alliance among the University of Pittsburgh, Carnegie Mellon University, Case Western Reserve University, and West Virginia University. The Institute will collaborate closely with the City of Pittsburgh and DOE through a memorandum of understanding aimed at implementing advanced energy. Dr. Reed cited the City as a true partner in innovation given the Mayor's genuine understanding of "where energy fits."

IV. Opening Remarks

Grant Ervin

**Chief Resiliency Officer
City of Pittsburgh**

Grant Ervin discussed the City's role in 21st-century innovation, referencing the City's recent application to the U.S. Department of Transportation's (DOT's) Smart City Challenge as a collaborative "deep think" on the topic. The resulting "Smart Pittsburgh" proposal laid out an ambitious plan to develop "electric avenues" pairing DC power infrastructure, solar generation, battery storage, and electric vehicle charging stations. These electric avenues would deploy some of the world's most advanced traffic signals and street lights to help streamline traffic, decrease emissions, and monitor air pollution. The effort involved in creating the proposal was an "urban barn raising" that brought together a broad coalition of local university, industry, nonprofit, and foundation expertise. It highlighted powerful opportunities to impact future infrastructure in three highly interconnected systems: information and communications technologies, transportation, and energy. The City and its partners are committed to realizing the Smart Pittsburgh goals regardless of the outcome of the challenge.

Understanding the interplay among communications, transportation, and energy systems, and how to optimize and develop them at a city-wide scale for the future, requires a high level of

technical understanding from policy makers. A century ago, Pittsburgh built the first drive-through gas station in the East Liberty neighborhood. For the 21st century, the challenge is to combine DC architecture with solar, storage, and rechargeable vehicles in a solution that can be replicated worldwide. The Smart Pittsburgh initiative is one of many energy-related projects in which the City has an active role. It is working with university, industry, business, foundation, and nonprofit partners as it builds toward its goal of a 50% reduction in energy and transportation emissions and water use by 2030. The City's Clean Tech initiative is looking to expand and strengthen sectors developing water, energy-efficient building, and renewable energy technologies. Under its memorandum of understanding with DOE, the City is working with university and utility partners to support the development of advanced energy infrastructure. This includes plans for a "grid of microgrids" at seven sites across the city that will provide a critical testbed for modern grid technologies and help accelerate the process of transitioning these technologies from research to commercialization.

Mr. Ervin summarized the five roles the City can play to advance innovation: (1) as convener, (2) as coordinator, (3) as legislator, (4) as administrator, and (5) as investor. Partnership and collaboration are central to its efforts, and the City's Roadmap for Inclusive Innovation puts the area's most challenged communities at the forefront of implementing new opportunities. Overall, the City's focus is on grid modernization.

V. Panel Session

Regional and National Grid Modernization Priorities

Dr. Gregory Reed introduced the panel, which included representatives from university, industry, and government sectors. He cited the new leadership at Duquesne Light Company, which is working to transform this local company into "one of the most forward-looking, progressive utilities in the country."

Richard Riazzi

President and CEO

Duquesne Light Company

Richard Riazzi, CEO of Duquesne Light Company since 2010, discussed priorities for grid modernization from the utility's perspective, and described his team's work and plans for the future. Electric vehicles, microgrids, solar energy, battery storage, renewables integration, and overall next generation of utilities comprise Duquesne Light's main points of focus. Citing the need to increase capital expenditures as existing infrastructure continues to age, the utility has invested approximately \$1 billion in upgrades in the past five years and expects to match that pace in the next five years. The investments strive to increase reliability and resiliency, to move toward an increased two-way flow of information, and integration of renewables.

Mr. Riazzi cited several trends that are converging to drive change and create new uncertainties for utilities and the grid:

- Changing business models and the evolving role of utilities in the energy market
- New technologies, such as microgrids and distributed energy resources
- Environmental objectives present cost and integration challenges
- Investment to address aging infrastructure and systems maintenance, as well as implementation of new technologies
- Declining demand for electricity due to efficiency and conservation
- The need to continue to provide reliable and affordable power to consumers, especially low-income customers.

He said that Duquesne Light has experienced flat throughput for five years as efficiency gains have offset growth in demand, and he expects throughput to decline by 1% per year over the next five years.

Regulatory uncertainty is another significant challenge. Mr. Riazzi highlighted the importance of helping policy and technologies evolve at a similar pace. He cited experience with large-scale wind generation in the Northwest and the recent net metering debates in Nevada and Hawaii as examples of the need to balance policy decisions with the business realities of capital investment.

To meet these numerous challenges, Duquesne Light continues to increase its operating efficiencies and to look to new revenue opportunities in batteries, renewables, microgrids, and electric vehicles. The utility is using data-driven decision making to deploy capital based on an “asset health model” that can predict the probability of infrastructure failures. Additionally, Duquesne Light is focused on grid modernization within its service area. The company is “investing in the future” through pilot projects such as the Woods Run microgrid and electric vehicle charging stations; developing the next generation of personnel, to address the issue of an aging workforce, which will drive 45% turnover in the next five years.

Grid modernization priorities focus on three areas: transmission, distribution, and sustainability. Transmission and distribution (T&D) projects include the first ring bus around Pittsburgh; a fully networked downtown distribution system; a water-tight underground infrastructure, including transformers; conversion of the distribution system to 23kV from 4kV (to better support distributed energy); and full deployment of advanced metering infrastructure within the next two to three years, including the supporting communications infrastructure. Sustainability goals include renewables integration and microgrid development, energy efficiency tools for residential customers, and battery storage. Maintaining high standards of reliability and security likewise remain priorities, with significant investments in cybersecurity and resilient design.

Mark McGranaghan

Vice President, Power Delivery & Utilization Electric Power Research Institute (EPRI)

Mark McGranaghan provided the perspective of the EPRI on grid modernization, citing a need for research and collaboration in planning and design as “we go green and modernize.” He briefly touched on 10 core priorities:

1. Planning methods and tools need to reflect the importance of thinking at a systems level and designing from the ground up with new resources and technologies in mind.
2. Distribution management systems (DMSs) need to be implemented and operational.
3. Smart inverters are necessary to integrate distributed energy resources and increase solar penetration.
4. Energy storage technology—including thermal storage—needs to be improved. While not currently economic in all areas, it will be very important in the future, especially at the customer level. In certain cases today, it can have unique value in meeting capacity needs and presenting a new value stream for customers.
5. Microgrids are a developing market that will integrate all the technologies referenced above. New York has performed 85 microgrid feasibility studies and energy provider Exelon Corp. has mapped the Chicago area in square-mile increments, ranked by microgrid potential.
6. Distributed Energy Resource Management Systems (DERMS) need to be developed and integrated. There is favorable potential for collaboration because of the need for good data analytics and the need to integrate DERMS with DMSs.
7. Customers are the “center of the universe” with regard to the industry’s future. Customers will increasingly drive investment through what they are buying, such as electric vehicles and energy services. An example of this is Eaton Corp.’s energy management circuit breaker, which integrates revenue-grade metering and cloud systems at the residential level, and which can also be used to charge electric vehicles, and is expected to sell for \$100 when commercialized in 2018. Adding cloud services to energy management helps to increase control and aligns utilities with emerging Internet of Things technologies.
8. Communications infrastructure will be crucial to making the modern grid work. Mr. McGranaghan cited Chattanooga, Tennessee, as a bellwether, where fiber optic lines are available in all homes, creating a system that is both efficient and also collects and communicates data. Demand response and distribution management depend on such systems and Mr. McGranaghan believes that cybersecurity risks are manageable.
9. Updating the existing grid infrastructure is critical to reliability. Technologies such as sensors and advanced metering infrastructure allow utilities to better respond to outages and to fix things in the right order, as with Duquesne Light’s asset health model.
10. Working collaborations on demonstration projects and pilots will help everyone come up the learning curve faster. Mr. McGranaghan challenged utilities to experiment with new technologies and to make their results public to collectively solve the complexities of grid interoperability and integration.

Dr. Alexis Abramson

Director

Great Lakes Energy Institute

Case Western Reserve University

Dr. Alexis Abramson provided perspective on the TrUE Alliance and the importance of university research and collaboration in grid modernization. The Alliance is a new collaboration which spans research initiatives across Western Pennsylvania, Ohio, and West Virginia, and is anchored by energy institutes at four universities: Carnegie Mellon University, University of Pittsburgh, Case Western Reserve University, and West Virginia University. Each of the four partner universities has unique technical and policy strengths, which together provide a strong foundation for addressing the challenges and opportunities facing our energy system. The alliance is currently working with government agencies, national energy laboratories, and industry to advance its research and development priorities, which so far encompass the electric power grid, energy storage, energy efficiency, energy policy, and shale gas development and utilization.

Dr. Abramson highlighted the importance of pilot and demonstration projects to large-scale implementation of grid modernization. The university partners are already involved in projects with utilities and private companies to show the value of new and emerging technologies. The TrUE Alliance is laying the logistical groundwork to make further collaboration as easy as possible—for instance, by creating a 501(c)(3) structure and a common set of contracts to enable industry partners to collaborate with the four universities.

The region has burgeoning opportunities in unconventional oil and gas resources that have profound impact on the U.S. and global economies. Dr. Abramson raised the open question of how these resources might fit into the region's advanced energy portfolio and how they might fuel grid modernization in the tri-state region. She focused on the value of “unusual alliances” to spur innovation moving forward, with collaborations and incentives that work across disciplines and sectors, rather than pursuing business as usual. University and industry partnerships that harness talent, optimize resources, and work to benefit all are central to realizing that potential.

Michael Pesin

Deputy Assistant Secretary

U.S. Department of Energy

Systems Engineering Research and Development Division

Office of Electricity Delivery and Energy Reliability

Michael Pesin discussed major drivers for change in the electric industry today from the perspective of DOE. He posed a series of questions to frame the challenges of transitioning to a modern grid:

- How do we integrate renewable energy?
- How do we contain disasters within the grid?

- How does the system respond to customer demand?

To address these questions, markets, technologies, and policies all need to work together to support grid modernization. In contrast to the past, where the grid was designed to operate as a centralized system focused almost solely on affordability, a group of essential characteristics define the future grid from a policy standpoint: reliability, resiliency, flexibility, sustainability, affordability, and security. In transitioning to a modern grid, Mr. Pesin identified five major drivers for change that markets, policy makers, and technologies must address: (1) the change in the electricity supply mix and shift toward renewables; (2) growing threats to resiliency and reliability; (3) new market opportunities for customers; (4) information and communication technology development; and (5) aging infrastructure.

As part of the Mission Innovation initiative, DOE plans to substantially increase its R&D spending in the next five years contingent on funding from Congress. Research areas of focus that support the Mission Innovation goals and address the challenges referenced above include energy storage systems, from both a technology and a policy standpoint; advanced distribution management systems (ADMSs) that provide a platform for applications in a competitive marketplace; synchrophasors that gather real-time data about the state of the energy network and enable faster response to crises or outages in the system; “transactive” energy programs that allow all end-user devices to participate in the energy market; transformers and advanced components that safeguard system resiliency; and smart meters, including initiatives to address data privacy risks of advanced metering technologies.

Mr. Pesin touched on how utilities might justify various grid modernization investments on factors other than cost. For instance, in some markets, energy storage might offer returns for frequency regulation even at today’s prices, and outage-management technologies can present a strong business case to certain customers and utilities. Chattanooga had great success with deploying fiber optic ADMSs, but fiber is expensive and one size does not fit all. DOE is looking for pathways that every utility can afford, and it is working to make sure these systems are interoperable and do not become obsolete.

VI. Keynote Address

The keynote discussion highlighted the larger vision of the Mission Innovation initiative in the context of DOE’s budget over the next five years. A discussion followed with audience members that focused on Pittsburgh’s innovation goals and capabilities and how these might support the Mission Innovation plan.

Dr. Cynthia Powell

**Acting Deputy Director, Science & Technology
National Energy Technology Laboratory (NETL)
U.S. Department of Energy**

Dr. Cynthia Powell briefly discussed NETL's mission as a DOE laboratory to discover, develop, and deploy clean energy solutions. She cited two regional initiatives that demonstrate NETL's role and underscore Mission Innovation's potential to spur regional partnerships that can add value on a local and a national level. A coalition consisting of Carnegie Mellon University, Eaton Corp., NASA, and North Carolina State University is investigating new materials, devices, and systems for power electronics that could help solve the dispatch ability of solar photovoltaics. The 2015 memorandum of understanding signed by Pittsburgh Mayor William Peduto and NETL Director Grace Bochenek seals NETL's commitment to assist the City in its drive to become the clean energy city of the future. Dr. Powell introduced Dr. Orr.

Dr. Franklin (Lynn) Orr

**Under Secretary of Science and Energy
U.S. Department of Energy**

Dr. Lynn Orr highlighted the strategic context of DOE's goals, asserting that economies that develop clean energy and deal with energy security will also provide the security that we all seek as a nation. The Mission Innovation agreement grew out of conversations surrounding COP21 and commits 20 countries, representing 75% of global carbon emissions from electricity, to double public investment in clean energy R&D over five years. The United States has the largest energy R&D budget in the world, representing about \$4.5 billion of the \$15 billion world total. DOE's increased funding request is currently in committee in both the House and Senate, with \$5.9 billion in the fiscal year 2017 budget aimed at increasing investments for clean energy research & development.

A key component of DOE's plan is to direct dollars toward regional groups that leverage these investments by harnessing stakeholders in their area to form collaborations with a regional focus. The agency envisions as many as 10 regional innovation hubs around the country to bring together existing knowledge clusters and capabilities to leverage regional economic assets at universities, federal laboratories, and private industries, as well as funding from local, state, and federal governments. The idea is to create regional nonprofit entities that do not do research themselves or involve bricks and mortar, but perform planning and funding tasks for the partners, such as creating a research agenda and administering R&D contracts and grants. This regional portfolio approach acknowledges that different settings have different advantages and constraints, and can thus generate different solutions.

Dr. Orr concluded by posing the following questions to the assembled workshop attendees:

1. What are the key energy innovation priorities for the Pittsburgh region?

2. How would regional stakeholders work together to advance innovation?
3. How can the region build on DOE programs and business models?

Discussion Following the Keynote Address

Q: Grant Ervin from the City of Pittsburgh: What are the key attributes of a highly functioning regional partnership?

A: Dr. Orr stressed that he did not want to be “too prescriptive” and challenged the group to think creatively about what the partnerships would look like. He commented that a successful partnership would include top-quality university research; state-level institutional support; a certainty of engaging with industry in the region, both large and small companies; and a mechanism to promote start-ups. The partnerships should develop creatively to address each region’s needs.

Q: Mark McGranaghan of EPRI: Would DOE support sharing Mission Innovation work and findings among the 20 international partners?

A: Dr. Orr said there will not be a central planning group, but there will be some mechanism for bilateral sharing of information when that makes sense. He gave the example of Saudi Arabia, which has shown interest in low-carbon advanced cooling technologies, and of the bilateral agreement between the United States and China that already includes shared research funding. However, he also noted that the whole exercise is built on nations and regions maintaining control over their own initiatives.

VII. Moderated Discussion Session #1

T&D Infrastructure, Distributed and Clean Energy Resource Integration

Summary: The first moderated discussion focused on integrating advanced grid technologies with existing, legacy-based infrastructure. To help frame the issues, the session used Pittsburgh as a case study. Benjamin Morris kicked off the conversation with an overview of the current Duquesne Light infrastructure. Grant Ervin followed with a description of the Mayor’s vision for the City’s energy future. The audience was invited to discuss pathways to transition from the present to the future vision.

Moderator: Benjamin Morris

Senior Manager, Strategic Planning & Operations Analytics
Duquesne Light Company

Benjamin Morris explained that under deregulation, Duquesne Light has been a transmission-and-distribution only company, with no electricity generating capacity since 1997. Even so, the Pittsburgh business model still very much depends on centralized power plants located within Duquesne Light's service territory. These include the Beaver Valley nuclear power station, which supplies approximately 60% of customer demand within the service area; the coal-fired Cheswick power plant (second largest source); and a natural gas "peaker" plant owned by NRG Energy on Brunot Island near downtown Pittsburgh. Only 350 of the utility's customers—or 0.06%—employ net metering, a system in which solar panels or other renewable energy generators are connected to a public-utility power grid and surplus power is transferred onto the grid, allowing customers to offset the cost of power drawn from the utility. There are no utility-scale renewables in the system and participation comes primarily from households with residential solar.

Grant Ervin recapped the City's many energy-related initiatives and cited last year's "People, Place, Planet and Performance" (P4) Conference as a turning point in the local conversation about sustainable growth and development. The meeting focused on transitional neighborhoods, such as the Lower Hill District and the Almono site in Hazelwood (a 180-acre brownfield site), and helped catalyze opportunities to introduce modern grid concepts to legacy heating and cooling systems at the district energy level. The City's memorandum of understanding with DOE, along with other efforts, such as the 100 Resilient Cities initiative and the regional energy analysis provided by the Power of 32, furthered plans to introduce new distributed energy resources and microgrids locally. In parallel, the City is completing its third generation greenhouse gas inventory and developing its third climate action plan, with goals that include 50% reductions in energy and transportation emissions by 2030. These and other initiatives have enabled the City to think strategically about integrating future energy considerations into its development processes and policy goals.

About 130 megawatts of potential renewable energy generation are in the pipeline, provided by hydropower and the installation of solar panels on parking garages. From an economic development standpoint, research conducted by the Heinz Endowments and Carnegie Mellon University showed the clean tech sector to be one of the fastest growing industrial clusters in Pittsburgh, with a 22% annual growth rate over the past five years.

Comment: John Swanson noted that the city's electric supply is already very green, because 60-70% of it comes from nuclear. To achieve its emissions goals, the city needs to generate more electricity by, for example, electrifying transportation, heating, and cooling. Pittsburgh is an interesting case study for the future of nuclear energy, because if or when the Beaver Valley Nuclear Generating Station is shut down, it is considered unlikely that another nuclear facility would be built in the area to replace it.

Comment: Michael Pesin advised Pittsburgh to take the six characteristics of the future grid and determine the roadmap to reach each one of these goals, looking at the system not as a collection of individual projects, but as an ecosystem portfolio. For example, Duquesne Light has an excellent approach to resiliency and reliability, but if it decides to invest in utility-scale renewables, it will need to address the intermittency issue. Solutions might include energy

storage, demand response, or new solutions like market signals. There are applications such as conservation voltage reduction, a system that reduces customer end voltage and can achieve close to 1 to 1 savings. This is one application that can be deployed system-wide on the ADMS. Communication infrastructure is critical for the long term, but because the technologies are evolving so fast, utilities risk locking themselves into investments that then end up becoming obsolete.

Q: Joseph Belechak said that 20 or 25 years ago when energy efficiency began to be preached and then practiced, policy and technology were out of sync. Policy typically proceeded ahead of technology, pushing for energy efficiency when the technologies to achieve it were underdeveloped. As we now move forward with new technologies, how do we make sure that policy and technology run in parallel to ensure that we achieve traction?

A: Benjamin Morris said Duquesne Light's approach is to advance technology in baby steps, such as by using pilots. For example, in Pennsylvania, regulations are not sufficiently developed to allow microgrids to be implemented on a broad scale. Because of that, the company chose to implement a microgrid on its own property. This was an intentional decision to allow the company to learn about the technology and figure out the answers to regulatory or policy-related questions. Once it has the data, which is where The University of Pittsburgh is helping, it can go to the regulators and legislators with results that can be acted on from a policy perspective.

A: Richard Riazzi agreed that using pilot projects is important—as are meetings such as this Mission Innovation workshop that allow broad stakeholder input and healthy give and take. Using his past experience as a CEO of a hydroelectric utility in the Northwest, he identified some of the risks and suboptimal outcomes that can occur when policy moves ahead of data analysis and what is realistic from a cost standpoint for utilities. A key takeaway from past experience is the need to conduct pilot programs, to walk before you run, and to ensure an environment in which healthy debate can take place, with everyone at the table focusing on well-informed, data-driven solutions.

Q: Joseph Belechak noted past failures of start-ups equipped with strong technology capabilities that simply could not get to scale before they ran out of operating cash. He asked the panelists how this could be addressed in a prudent way, so that promising solutions can scale faster.

Benjamin Morris agreed that Mr. Belechak had identified a relevant challenge that must be addressed by multiple parties.

Darren Gill, Deputy Director of the Bureau of Technical Utility Services at the Pennsylvania Public Utility Commission, noted that there are two tracks for grid modernization: engineering and policy. Policy should move at a pace that is slightly ahead of the engineering, largely so that engineers know what to design for. The existing system is built to function at full capacity rather than taking advantage of distributed generation, thus demonstrating the need for policy to outpace engineering, if only by a small margin, lest we engineer for the wrong outcome.

Q: Dr. Deborah Stein, Associate Director for Policy Outreach for the Scott Institute for Energy Innovation at Carnegie Mellon University, offered that efficiency seemed to be missing from the conversation. She pointed out that, in this region, many small and medium-sized manufacturers could benefit from efficiency, but may lack the capital investment. The result is that even if they know how to implement efficiency measures, they often experience constraints that prevent them from doing so. She suggested that if Duquesne Light were to offer assistance, the utility would suffer from reduced demand and asked whether Duquesne Light does in fact work with these companies.

A: Benjamin Morris responded that while Duquesne Light does not currently have a solution to offer, he agreed that it merited further thought.

Aurora Sharrard, Executive Director and Vice President of Innovation for the Green Building Alliance, added that the subject of financing was also missing from the discussion. She raised the possibility of a regional or a state “green bank” that could make infrastructure investments happen at scale. She pointed out that similar institutions exist in other states, sometimes called infrastructure banks, and that their focus is not limited to energy efficiency.

Q: Another audience member noted Duquesne Light’s small number of net metering customers and asked whether the utility was looking to increase those numbers as a way to scale its investments in hardware, upgrades, and maintenance.

A: Richard Riazzi said that Duquesne Light’s system was built to serve the steel industry, which means that today there is a significant extra capacity available. Its utilization rate is currently approximately 50%. Peak demand occurs in the summer, so the utility needs to build load in the winter, which could be addressed with more electric heating. However, rooftop solar actually makes the problem worse, which is an issue Duquesne Light still has to work through. Utility-scale solar, by contrast, would flow through the system and not impact the company’s throughput.

Q: An audience member asked at what level of distributed generation Duquesne Light needs to be concerned about and inquired about the intended business model. As a solar installer, he wondered whether he should be ready to have a net zero export inverter as part of the solar systems he provides today or whether existing systems would be grandfathered into the Duquesne Light system as part of net metering.

Q: Another audience member asked whether Duquesne Light is considering leasing production capability on rooftops. Given that current regulations prevent Duquesne Light from being a generator, regardless of whether it would be beneficial to have local distributed generation, the utility cannot provide it. This prompted the audience member to ask whether, if Duquesne Light financed customer solar installation, this would be an extension of Duquesne Light’s production capability?

A: Richard Riazzi responded by noting that some of the pilot programs are designed to address these and other related questions, citing the microgrid at the Woods Run facility, which allows Duquesne Light to avoid regulatory issues. Thinking about it from a business

perspective, it seems that large, ground-based solar facilities that can track the sun would be more efficient than stationary rooftop solar systems and would allow Duquesne Light to transmit that power through the system. This would still be distributed across Duquesne Light's system.

Mark McGranahan said that there is no question that energy efficiency is the low hanging fruit for affordability and sustainability, while electrification is the simplest solution when addressing carbon emissions. He suggested that creating policies to convert the transportation and thermal sectors could make sense here, especially given Pittsburgh's 70% reliance on zero-emitting nuclear.

VIII. Moderated Discussion Session #2

Integrated Energy Networks, Microgrids, Physical and Cyber Security

Summary: The following session focused on the role of downstream stakeholders, the risks and costs of grid modernization to consumers, and the question of what customers want. The spectrum of customers covers many types of end-users. While most people may just want to keep the lights on, other consumers have distinct needs and preferences. Education about the risks and benefits of modern grid technologies and options is key to enabling end-users to make informed choices.

Moderator: Dr. Aimee Curtright

**Senior Physical Scientist
RAND Corporation**

Dr. Aimee Curtright framed the session in terms of the impact of grid modernization on customers, and vice versa. She asked the audience to reflect on the role of downstream stakeholders (people who are not making the technologies, but are driving the demand for them) in innovation and technology adoption. Among examples, she cited electricity consumers and "prosumers"—those who want solar panels and storage of their own, but still want to stay connected with the existing grid (although perhaps not pay for it). External actors who figure in this scenario range from hackers and squirrels to Mother Nature and other potential disruptors of the grid's physical and cyber security. Do the power industry and its policy makers have a very good understanding of what consumers want in this new model, especially prosumers? Absent an understanding of what consumers want, these players risk developing technology that consumers either cannot or do not want to adopt—or that they adopt and then do not like. They risk falling into the trap of thinking that the usefulness and desirability of new technologies are self-evident, when most consumers probably just want to flip the light switch on and have it work.

Cutting-edge technologies for the grid also come with new risks, which need to be addressed. A recent article by a data science professor from Princeton said that the term “smart” has become essentially synonymous with “probably horribly insecure.” Dr. Curtright asked the room:

- How should these concerns be addressed?
- How can the process of grid modernization incorporate the human element—the downstream stakeholders who are acting on their own, unlike a centralized utility?
- What are the tradeoffs of the technologies that are being developed?
- What is the balance between what consumers want and the security that they demand and need?

A: An audience member commented that when the Internet was created, most people did not even call it the Internet. People did not know that there was going to be Facebook, Google, etc., but they welcomed these innovations as improvements in their lives. The focus of grid modernization should be on power as easy to use, as abundant in supply, and as clean and affordable and reliable as possible. He disputed the notion that smart equals insecure, citing Y2K. As a centralized system, the existing grid is more vulnerable to cyberattack than a distributed modern grid would likely be. If “smartness” is combined with distribution resources and storage, the system will be more secure, because consumers can island themselves. From an engineering and efficiency standpoint, DC power makes much more sense than the existing AC system, largely because all of our electronics are better suited to it. At some point, the issue of DC power for consumers will need to be addressed, which would be a positive outcome.

A: Another Audience member observed that that no one will make shiny gadgets if there is not an abundant electricity supply. As with computing, there needs to be abundant memory, data, microprocessors, and so on, before much can be done. The current centralized production model is not equipped to handle demand growth. That is not to say that utilities do not have a future—they have a huge role, just as the “cloud” purveyors in the data systems do. Utilities will be the cloud operators that help facilitate the future uses of electricity.

A: Michael Pesin observed that there is no such thing as a typical consumer. Everyone wants different things. Many consumers do, indeed, just want the lights to come on when they flip the switch or focus on the size of their electric bill. For them, the best technology is the technology that they do not know is there—and studies show the less intrusive the technology, the more successful it is. However, other consumers like to play with technology and focus on ways to do right by the environment. There are technologies available that enable these different customer choices. There is a way to actually show customers where their energy comes from, which can be done by segregating the physical transaction from the financial transaction.

Aimee Curtright argued that those who create the new technologies might be considered to be “energy nerds” and that they might constitute a minority among consumers, many of whom only require reliability and affordability.

Q: Michael Pesin asked how we ensure that people who want the technology get it without increasing prices for the rest of the customers.

A: Michele Somerday from First Energy Corp. commented that most customers just want reliable power and that the existing grid is 99.999% reliable. But we also have to consider the continuum of requirements that range across a broad spectrum of customers and the ways in which a utility will look to accommodate everyone. That is where education comes in. People need to better understand the potential tradeoffs of grid modernization and the associated costs, because it is not free. We need to surface costs and benefits. It is the job of utilities, policy makers, and those developing the technology to educate consumers, so when they are deciding what they want, they are making informed decisions.

Another audience member said that reliability statistics are not especially comforting. Low probability events like cyber terrorism, electromagnetic pulses, and natural disasters are 100% real when they happen. This is important as we rely more on electronic devices over time.

Q: Aimee Curtright raised the question of how much consumers will be willing to pay for their everyday electricity in order to mitigate relatively invisible and abstract risks, such as big outages, which are still pretty rare.

A: James Fields from Pitt Ohio, a local freight company, said the company is an early adopter of advance technologies such as microgrids, and worked closely with the University of Pittsburgh's Center for Energy to develop integrated, sustainable energy from wind and solar power. While it gets reliable electric supply from utilities at its 21 facilities throughout the Mid-Atlantic states, the company handles a lot of emergency products that people would need if the power went out. Electricity is interwoven in everything it does, and when the power goes out, it inevitably seems to be at the most inopportune times—the busiest and costliest times of the day. It is worth it to hedge the business interruption risk by being an early adopter of distributed energy resources and microgrids. Pitt Ohio sees long-term opportunities for these technologies that outpace even the current benefits.

Michael Pesin said that the utilities' role in technology innovation depends on their business models. If they are not equipped to serve these new devices when something goes wrong, it is something to consider before jumping in. Sometimes these investments do not pay for themselves.

IX. Moderated Discussion Session #3

Core Technologies: Energy Storage, Power Electronics, DC Power, and Others

Summary: The third discussion focused on core technologies to enable the transition to a modern grid. Storage was viewed as a breakthrough technology, because of its ability to buffer the intermittency of wind and solar and help integrate renewables into the grid. Electric vehicles generated interest for their ability to provide both transportation and mobile backup power during outages. The costs, benefits, and applications of different battery choices were a central topic of debate. Many promising storage options exist, but have yet to find widespread use. DC

power and power electronics were mentioned as important, if often underappreciated, technologies in the modern grid portfolio, and both were seen as warranting further research.

Moderator: Thomas Feeley

**Local and Regional Partnership Manager
National Energy Technology Laboratory**

Thomas Feeley framed the discussion from a Pittsburgh perspective. The City is looking to build advanced, modern grid infrastructure to encompass distributed energy—a “grid of microgrids.” Some of the questions that arise include if the City wants to promote renewables, how quickly can it make that transition? What is the role of natural gas, and how can that resource potentially help the city transition to a system based on renewables? What renewable technologies are ready to be implemented in the city? How do these technologies uphold the six characteristics of a modern grid: reliability, resiliency, security, flexibility, affordability, and sustainability?

Q: Adam Rossi of Adam Solar Resources commented he thinks the electric vehicle market is taking off and that energy storage should be focused there. Instead of having a stationary battery bank, there could be a mobile battery bank that could be dispatched where it is needed. Even for a home-based system, the price per kilowatt hour for a lithium battery pack is about \$200-\$300 per kilowatt hour and only going down. No one wants a car with a 100-mile range anymore and electric vehicles should be considered for microgrid and storage applications.

Q: Greg Reed asked how \$200-\$300 compares to the price of batteries a couple of years ago—or where solar prices currently sit? He quoted **John Swanson** as saying the Holy Grail for batteries will be \$100 per kilowatt hour, which compares to recent pricing of \$500-\$1,000 per kilowatt hour. There is a storage technology in Japan that can plug into a fast-charging port that provides enough energy to run a house or a small business. Unlike stationary batteries that might sit stagnant until there is a problem with the grid, electric vehicle batteries let people drive their cars around throughout the day and still have a battery backup for a grid-down scenario. When the power is out, the car, which is easily mobile, can be moved to a generation source to recharge, and then moved back again to where the outage is.

A: Michael Pesin said storage is a complex question from a government perspective. Transportation batteries are different from grid batteries, requiring more power density. Citing prices for energy storage can be misleading, because when talking about grid batteries there are more components than just the battery (think inverters, for example). It is better to compare the levelized cost of electricity, which takes into account more than just the battery. People who want green energy need to have a buffer to deal with the intermittency of renewables, and they can do that with storage.

Q: An audience member asked about other types of storage technology, such as inertial energy storage, compressed air, or other options.

A: Michael Pesin said that electrochemical storage is only one way to store energy. It has gained great momentum because of advances in its use for transportation. There have been attempts to use flywheels and supercapacitors, but they did not work well. Lithium ion batteries seem to work best right now and also enjoy economies of scale, which are driving prices down, though he acknowledged that they are still expensive. Pump hydro is a great technology but it, too, is expensive. DOE has had great success with flow batteries, which unlike other batteries have the advantage of separating the energy from the power. DOE is also looking into compressed air storage, liquid air storage, and hydrogen. Some automotive companies actually think hydrogen is more promising than electric vehicles with battery storage. The advantage is that hydrogen can be used both as energy storage and fuel. Toyota and Honda have developed some hydrogen vehicles. Flywheel technology shows promise, despite the recent bankruptcy of one company involved in this. On the chemical storage side, the traditional lead acid battery is cheap but does not last long. Each one has costs and benefits that must be compared.

Q: Greg Reed talked about the ways in which the technology shift to batteries and DC power will enable progress toward cleaner energy future with more renewables and then questioned the role of natural gas. He observed that natural gas is an important baseload fuel and presumed that most people in the room would agree it has a role in the region's energy future, whether or not it is as a transition fuel. But outside of Duquesne Light's 70% nuclear service area, the picture is very different. The Power of 32's analysis of the energy flows in 32 counties in Ohio, West Virginia, Maryland, and Pennsylvania showed coal and gas still dominate the region. When thinking about enabling technologies, including storage, think about the integration of all of those resources. This also highlights the role of power electronics. A few years ago, DOE estimated that 30% of all electricity passes through an inverter, but by 2030 that number is projected to be 80%. Not many programs focus on power electronics development though they should.

John Swanson pointed out that if utilities make large solar fields, these can provide great stabilization for the grid. Solar fields can be turned on and off as fast as batteries can be turned on and off. Utilities might invest in solar fields as another way to control the grid, especially during the day time. If solar fields are distributed, clouds are not a big issue.

Michael Pesin agreed that solar fields can be controlled very precisely, but to fully utilize them, they need to have support, which is where batteries come in handy. Mr. Pesin commented that he completely agrees with Dr. Reed's assessment of the importance to have larger investments in this area and said that this is reflected in the budget request to Congress. The agency has a number of successful research programs in this area, and it is extremely important. The agency also wants to focus on power electronics and DC. There is a concept called MAGIC box, which in the future could give every home DC/AC supply, which is an optimal scenario.

An audience member commented that some data centers now have a concept for solar-powered data centers called "clouds for clouds." They can move their workload to the place where the real clouds are not, to avoid intermittency issues.

X. Concluding Remarks

Dr. Reed concluded by thanking all presenters for their contributions, and the audience members for participating in the discussions.

This Grid Modernization Workshop demonstrated that the Mid-Atlantic Region is well-suited as a hub for clean energy research and development in the area of grid modernization. Relevant work is already underway in the greater Pittsburgh area, as exemplified by the TrUE Alliance, the memorandum of understanding between DOE and the City, the establishment of the new Pitt Energy GRID Institute, and the development of the EIC as a center for collaboration between industry, government, academia, and the public sector.

Over the past four decades, our region, once known as the Rust Belt, successfully transitioned from a highly industrial economy to a highly diverse economy based on technology, energy, education, health care, and medical research. The transition of the Mid-Atlantic economy has and continues to evolve against the backdrop of a legacy grid infrastructure. Continued efficiency, innovation, and growth require equivalent modernization of our legacy grid.

The region presents an opportunity to showcase modern grid technologies, leveraging local and existing assets. Within the Mid-Atlantic alone, clusters of research universities have come together to work on energy specific topics, major utility companies are testing innovative approaches to grid development, and industry partners are investing in the region.

The stewards of our current grid infrastructure, which was designed and built to support a machine-age economy, now have the opportunity and obligation to become part of an integrated technological future. The organizations, assets, facilities, ideas, and talent represented in the room today have the potential to come together as a DOE Mission Innovation Hub and advance the grid's future evolution.

XI. Appendices

Workshop Agenda

U.S. Department of Energy – Mission Innovation Workshop on Grid Modernization

Host: The University of Pittsburgh, Center for Energy Date: Friday June 24, 2016

The Energy Innovation Center* – Pittsburgh, PA

10:00 AM	Registration and Networking
11:00 AM	<u>Welcome:</u> University of Pittsburgh Dr. Gerald Holder – U.S. Steel Dean, Swanson School of Engineering Dr. Gregory Reed – Professor and Director, Center for Energy and Electric Power Lab
11:15 AM	<u>Opening Remarks:</u> Grant Ervin – Chief Resiliency Officer City of Pittsburgh, Office of the Mayor
11:40 AM	<u>Panel Session:</u> “Regional and National Grid Modernization Priorities” Richard Riazzi – President and CEO Duquesne Light Co. Mark McGranaghan – Vice President, Power Delivery and Utilization Electric Power Research Institute (EPRI) Alexis Abramson – Director, Great Lakes Energy Institute Case Western Reserve University Michael Pesin – Deputy Assistant Secretary Office of Electricity Delivery & Energy Reliability., U.S. Dept. of Energy
1:00 PM	Lunch
1:30 PM	<u>Luncheon Keynote Address:</u> Dr. Cynthia Powell – Acting Deputy Director, Science & Technology National Energy Technology Laboratory, U.S. Department of Energy

Dr. Franklin (Lynn) Orr – Under Secretary for Science and Energy
U.S. Department of Energy

2:00 PM

Moderated Discussion – Subtopic 1

“T&D Infrastructure, Distributed and Clean Energy Resource Integration”

Moderator:

Benjamin Morris – Senior Manager, Strategic Planning & Operational Analytics
Duquesne Light Company

2:35 PM

Moderated Discussion – Subtopic 2

“Integrated Energy Networks, Microgrids, Physical and Cyber Security”

Moderator:

Aimee Curtright – Senior Physical Scientist
RAND Corporation

3:10 PM

Moderated Discussion – Subtopic 3

“Core Technologies: Energy Storage, Power Electronics, DC, other”

Moderator:

Thomas Feeley – Local and Regional Partnerships Manager
National Energy Technology Laboratory

Discussion Session Rapporteurs:

Barbara Granito – Strategic Director, Science & Engineering Ambassadors Program
National Academy of Sciences and National Academy of Engineering

Ann Merchant – Deputy Executive Director, Office of Communications
National Academies of Science, Engineering, and Medicine

3:45 PM

Wrap-Up, Next Steps, and Closing Remarks

4:00 PM

Dessert and Coffee Reception

**Optional: Tours of EIC facility and current construction
of the Pitt Center for Energy / Energy GRID Institute space**

Speaker Bios

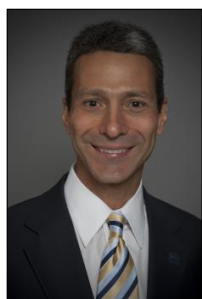
Welcome: University of Pittsburgh



Dr. Gerald D. Holder is U.S. Steel Dean of Engineering and Professor of Chemical Engineering at the Swanson School of Engineering at the University of Pittsburgh. He received his BA from Kalamazoo College and his BSE, MSE and PhD in Chemical Engineering from the University of Michigan. He has served on the faculties of Columbia University and subsequently the University of Pittsburgh. He has been Dean of the Swanson School since 1996 and has led a period of substantial growth in enrollment, student quality, and faculty research. Dr. Holder was employed at corporations including Exxon, Gulf Oil and General Motors.

Dr. Holder is a member of the American Society for Engineering Education (ASEE), the American Institute of Chemical Engineers (AIChE), the Society of Petroleum Engineering (SPE), the American Association for the Advancement of Science (AAAS), and the American Chemical Society (ACS), and also a Fellow of AAAS and AIChE. He is a 2008 William Metcalf Awardee for lifetime contributions to the engineering profession and received the Board of Visitors Faculty Award and Meritorious Achievement in Research Award from the University of Pittsburgh.

He currently serves on the ASEE EDC Executive Board, and the ASEE EDC Public Policy Committee. He has served as a board member on the Catalyst Connection, Oak Ridge Associated Universities (ORAU), Three Rivers Connect, the Pittsburgh Applied Research Corporation, Council for Chemical Research, and currently serves on the Advisory Board of the Pittsburgh Coal Conference. He has served on the National Academy of Science Review Panel on NSF Fellowships in Engineering, and as Chairman of the Organizing Committee for the 3rd International Conference on Gas Hydrates in Salt Lake City, Utah. He is the author of more than 100 journal articles and has raised over \$10 million in support of his research in the areas of high-pressure thermodynamics and phase behavior, and in various aspects of energy research including synthetic fuels and natural gas hydrates.



Dr. Gregory Reed is the Director of the University of Pittsburgh's Center for Energy, Director of the Electric Power Systems Laboratory in the Swanson School of Engineering at Pitt, and Professor of Electric Power Engineering in the Swanson School's Electrical & Computer Engineering Department. He is also the Director of the Grid Technologies Collaborative for the U.S. Department of Energy; and an inaugural member of the National Academies of Science and Engineering's Energy Ambassador Program. In addition to these roles, he is the owner and principal consultant of Power Grid Technology Consulting, LLC, and currently serves as Chief Science Advisor on the Board of Directors for the E-Merge DC Alliance.

His research interests, teaching activities, and related pursuits include advanced electric power grid and energy generation, transmission, and distribution system technologies; power

electronics and control technologies (FACTS, HVDC, and MVDC systems); micro-grids and DC infrastructure development, renewable energy systems and integration; smart grid technologies and applications; and energy storage.

Reed has 30 years of combined industry and academic experience in the electric power and energy sector, including positions in engineering, research & development, and executive management throughout his career with the Consolidated Edison Co. of New York, ABB Inc., Mitsubishi Electric Corp., and DNV-KEMA.

He has authored or co-authored more than 80 published papers and technical articles in the areas of electric power system analysis, the applications of advanced power systems and power electronics technologies, and power engineering education. Reed has well over 100 media citations, credits and appearances – including regional and national print, radio, and television – on various topics related to energy and the power grid. He is also the recipient of several industry, academia, community, and professional society awards.

He is an active member of the Institute of Electrical & Electronic Engineers (IEEE), including the IEEE Power & Energy Society (PES), Power Electronics Society (PELS), and Industrial Applications Society (IAS); and is a member of the American Society of Engineering Education (ASEE). Past IEEE positions include governing board member of the Power & Energy Society, as well as the president of the IEEE PES Pittsburgh chapter. He is also the founder and chair of the annual Pitt Electric Power Industry Conference (EPIC), established in 2006; and co-founder/co-chair of the DOE Grid Technologies Collaborative National Conference, established in 2013.

Reed earned his Ph.D. in electric power engineering from the University of Pittsburgh (1997); his M.Eng. in electric power from Rensselaer Polytechnic Institute (1986), and his B.S.E.E. with electric power concentration from Gannon University (1985).

Opening Remarks:



Grant Ervin serves as the Chief Resiliency Officer for the City of Pittsburgh. Before joining the City of Pittsburgh, Grant served as the Regional Director for 10,000 Friends of Pennsylvania, a statewide smart growth and sustainable development advocacy organization; and as Public Policy Manager for Pittsburgh Community Reinvestment Group (PCRG).

Grant brings fifteen years of experience, intersecting the worlds of environmental, community & economic development and infrastructure policy to create innovative and sustainable solutions for local governments, community development organizations and state agencies. Grant has helped lead the development of a variety of innovative programs including the Pittsburgh and Neighborhood Community Information System and the Pennsylvania Community Transportation Initiative.

Panel Session: “Regional and National Grid Modernization Priorities”



Richard Riazzi serves as Chief Executive Officer and President of Duquesne Light Company. Before joining Duquesne Light, Mr. Riazzi was the General Manager and CEO of Public Utility District No. 1 of Chelan County, Washington. He has also served as President and CEO of Idacorp Energy LP and its subsidiary Idaho Power Company. Mr. Riazzi also served as an Independent Director of US Ecology, Inc. (Formerly American Ecology Corp.) from 2004-2007. Early in his career, he was a pipe fitter for Peoples Gas, and he worked for Equitable Gas Company in gas and energy marketing positions. Previously, Mr. Riazzi served as Vice President of Corporate Marketing at Equitable Resources Inc. He has been Director of Duquesne Light Company since August 2010. He has bachelors and master's degrees from the University of Pittsburgh.



Mark McGranaghan is Vice President of Power Delivery and Utilization for the Electric Power Research Institute (EPRI). He leads the teams responsible for EPRI's research involving technologies, systems, and practices for power delivery systems from the generator to the plug and for the devices and technologies that use the electricity.

From 2003 to 2010, McGranaghan was Director of Research in the Distribution and Smart Grid areas for EPRI. Priorities during this period were restructuring of the distribution research program, coordinating EPRI research in the smart grid area with government and industry efforts, creating the smart grid demonstration initiative, and increasing the technical strength of the EPRI research team.

Prior to joining EPRI, McGranaghan was Vice President at Electrotek Concepts (1998-2003), where he helped develop a new business area around power quality and power system studies into a world leader. From 1978 to 1988 McGranaghan was a Manager at McGraw-Edison/Cooper Power in Canonsburg, Pennsylvania. He managed studies for the utility industry and internal studies for application of McGraw-Edison products (power transformers, circuit breakers, arresters, distribution switchgear, capacitors) and directed a wide range of power system studies.

McGranaghan has Bachelor of Science, Electrical Engineering and Master of Science, Electrical Engineering degrees from the University of Toledo, and MBA from the University of Pittsburgh. He has taught seminars and workshops around the world and is very active in standards development and industry activities (IEEE, CIGRE, IEC). He is a member of the NIST Smart Grid Interoperability Panel Governing Board and he is the Vice-Chairman of the CIRED U.S. National Committee.



Alexis Abramson is Director of the Great Lakes Energy Institute at Case Western Reserve University. In her academic role, Dr. Abramson has published numerous peer-reviewed publications and has given over fifty presentations on cutting-edge scientific topics that span subject matter from novel techniques for thermal characterization of nanostructures (resulting in a patent) to the design and synthesis of unique nanomaterials for use in alternative energy applications. Additionally, she has published various reports and articles on subjects relating to nanotechnology and its development throughout the world.

Alexis is also a productive teacher in the university classroom and has led and participated in various programs focused on science education and outreach, including a middle/high school teaching module on nanotechnology. Complementary to her academic activities, Alexis has also explored an interest in technology based economic development through interaction with NorTech. A champion of nanotechnology's development in the NE Ohio region, she has given over fifty presentations on nanotechnology to area companies and institutions and initiated programs to stimulate collaboration and commercialization of nanotechnology. Additionally, Dr. Abramson was the chief organizer of the NanoApp Summit (2007) and the Nanomedicine Summit (2008), both national conferences with great visibility. More recently, Alexis has been working to develop strategies to help accelerate technology commercialization at the region's universities and research institutions.



Michael Pesin is Deputy Assistant Secretary for the Power Systems Engineering Research and Development Division in the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability. Mr. Pesin has 30 years of experience in the electric utility industry, much of it directing development and execution of advanced technology programs.

His most recent assignment was with Seattle City Light where he developed the technology strategy, managed research and development projects and directed strategic programs to management demonstration projects. His subordinate strategic programs included substation automation, distribution automation, advanced metering infrastructure (AMI), enterprise OT communication networks, cyber security, energy storage, distributed generation, microgrids, electric vehicles, transactive energy, energy management (EMS) and distribution management systems (DMS).

Mr. Pesin has numerous professional affiliations, publications and patents. He holds a Master of Science in Electrical Engineering from St. Petersburg State Polytechnic University, St. Petersburg, Russia, is a Licensed Professional Electrical Engineer (PE), and has a number of other management and technical certifications.

Luncheon Keynote Address:



Dr. Cynthia Powell is the Deputy Director (Acting) for Science & Technology Strategic Plans & Programs at the National Energy Technology Laboratory (NETL). In this role, she is responsible for implementing a research and development portfolio that positions the Laboratory as an international resource for fossil energy technology discovery, development, and deployment. As part of this role, she promotes safe and efficient research operations at NETL and ensures the Laboratory's research personnel are equipped with the technical competencies and knowledge needed to effectively support its research mission. Previously, Dr. Powell served as NETL's Materials Science Focus Area Lead. She has more than 15 years of experience in high-temperature phase and microstructural development of structural materials and the effects of these phase changes on the bulk properties of such materials. She received her Ph.D. in materials science from Case Western Reserve University; this was preceded by an M.S. and B.S. in ceramic engineering from Clemson University. Dr. Powell's research also addressed microstructure/processing relationships in a wide range of intermetallic, metallic, ceramic, and composite materials, and the influence of microstructure on the tribological performance of ceramics and ceramics-based composites.



Dr. Franklin (Lynn) M. Orr was sworn in as the Under Secretary for Science and Energy on December 17, 2014. As the Under Secretary, Dr. Orr is the principal advisor to the Secretary and Deputy Secretary on clean energy technologies and science and energy research initiatives. Dr. Orr is the inaugural Under Secretary for the office, which was created by Secretary of Energy Ernest Moniz to closely integrate DOE's basic science, applied research, technology development, and deployment efforts. As Under Secretary, he oversees DOE's offices of Electricity Delivery and Energy Reliability, Energy Efficiency and Renewable Energy, Fossil Energy, Indian Energy Policy and Programs, Nuclear Energy, and Science. In total, these programs steward the majority of DOE's National Laboratories (13 of 17).

Prior to joining the Department of Energy, Dr. Orr was the Keleen and Carlton Beal Professor Emeritus in the Department of Energy Resources Engineering at Stanford University. He joined Stanford in 1985. He served as the founding director of the Precourt Institute for Energy at Stanford University from 2009 to 2013. He was the founding director of the Stanford Global Climate and Energy Project from 2002 to 2008, and he served as Dean of the School of Earth Sciences at Stanford from 1994 to 2002. He was head of the miscible flooding section at the New Mexico Petroleum Recovery Research Center, New Mexico Institute of Mining and Technology from 1978 to 1985, a research engineer at the Shell Development Company Bellaire Research Center from 1976 to 1978, and assistant to the director, Office of Federal Activities, U.S. Environmental Protection Agency from 1970 to 1972. He holds a Ph.D. from the University of Minnesota and a B.S. from Stanford University, both in Chemical Engineering.

Dr. Orr is also a member of the National Academy of Engineering. He served as a member of the Board of Directors of the Monterey Bay Aquarium Research Institute from 1987 to 2014, and

was a member of the Board of Trustees of the David and Lucile Packard Foundation from 1999 to 2008, for which he has also chaired the Science Advisory Panel for the Packard Fellowships in Science and Engineering from 1988 to 2014. He served as a member of the 2008/09 National Research Council Committee on America's Energy Future.

Moderated Discussion: “T&D Infrastructure, Distributed and Clean Energy Resource Integration”



Benjamin Morris is Senior Manager, Strategic Planning & Operational Analytics at Duquesne Light Company, a regulated electric transmission and distribution utility serving 590,000 customers in and around Pittsburgh, Pennsylvania. In this capacity, Morris is responsible for optimizing asset utilization and performance, developing and monitoring asset health, and assisting with strategic planning. Morris also aids Duquesne Light Company in its initiatives related to grid modernization and the integration of distributed energy resources.

Prior to joining Duquesne Light Company, Morris was a Vice President in the Regulated Utilities group of Macquarie Infrastructure and Real Assets, Inc., where he helped to identify new private equity investment opportunities and to manage existing private equity investments in the regulated utility industry. Specific private equity investments in the regulated utility industry that Morris helped to manage included Duquesne Light Company; Aquarion Company, a water utility serving 223,000 customers in Connecticut, Massachusetts, and New Hampshire; and Hawai'i Gas, a gas utility serving 68,000 customers in Hawaii.

Previously, Morris was an Associate in the Oil & Gas investment banking group of Macquarie Capital (USA) Inc., where he worked with clients in the upstream, midstream, downstream, and equipment/services sectors of the oil and gas industry. Specifically, Morris helped to provide strategic advice related to mergers and acquisitions, restructurings, and recapitalizations and to raise capital in the private and public equity and debt capital markets. Morris holds Bachelor of Arts degrees from Middlebury College and Columbia University. Additionally, Morris holds a Master of Arts degree from Middlebury College, a Master of Finance degree from INSEAD, and a Master of Business Administration degree from Columbia University.

Moderated Discussion: “Integrated Energy Networks, Microgrids, Physical and Cyber Security”



Aimee Curtright is Senior Physical Scientist at RAND Corporation. She works primarily in the areas of energy policy and technology assessment. Her recent and ongoing projects include a life-cycle assessment of the greenhouse gas emissions of biomass energy feedstocks, a study on the technical and logistical barriers to co-firing biomass in existing coal-fired power plants, and an analysis of the costs and benefits of imposing a 25 percent renewable energy mandate.

Curtright's past experience includes postdoctoral research at Carnegie Mellon University in the department of engineering and public policy, a fellowship at the National Academies with the Board on Energy and Environmental Systems, and research in microbattery fabrication at the U.S. Naval Research Lab. Curtright received her Ph.D. in physical chemistry from the University of California, Berkeley.

Moderated Discussion: “Core Technologies: Energy Storage, Power Electronics, DC, other”

Thomas Feeley has been a Local and Regional Partnerships Manager for the past six months. Prior to that, he was the Director of the Public Affairs and Strategic Outreach Division where he was responsible for the day-to-day management of the Laboratory's public affairs, communications, congressional affairs, K-12 STEM education, strategic outreach, and business development activities. Duties include supervisory responsibility for fifteen public affairs and outreach specialists carrying out a broad array of tasks including media relations, website development, multi-media, technical writing, education outreach, international collaboration, technology transfer and licensing, and collaborations and agreements.

From 2009-2011, Mr. Feeley participated in a Brookings Institute Congressional Fellows program with U.S. Senator Robert P. Casey, Jr. in Washington, DC, where he provided technical and policy support to the Senator on issues ranging from climate change to shale gas development.

Mr. Feeley has been with the National Energy Technology Laboratory since 1981 and has served in a variety of senior management positions including Director for the Office of Coal and Power R&D where he was responsible for strategic planning and management of over \$360 million in coal and power research and development programs focusing on carbon capture and sequestration, advanced turbines, fuel cells, advanced research, fuels, and gasification. He has also served as a Division Director and as the Technology Manager of the Innovations for Existing Plants Program where he managed the development of technologies to control carbon dioxide, sulfur oxides, nitrogen oxides, air toxics (mercury), and fine particulate matter emissions, to manage coal combustion byproducts, and to manage power plant water use. Before joining NETL, Mr. Feeley worked for Roy F. Weston, an environmental consulting firm.

Mr. Feeley has a Bachelor of Science degree in Environmental Sciences from California University of Pennsylvania. He also has a Masters degree in Energy Resources from the University of Pittsburgh and a Masters in Public Policy and Management from the Heinz School at Carnegie Mellon University. Mr. Feeley is a Qualified Environmental Professional and a Fellow in the Council for Excellence in Government.

Discussion Session Rapporteurs:



Barbara Granito is the Strategic Director of the Science & Engineering Ambassadors Program, a Pittsburgh-based activity of the National Academy of Sciences and the National Academy of Engineering. She was an award-winning journalist at The Wall Street Journal, where she served as a News Editor and Staff Reporter in New York, and prior to that at Dow Jones & Co. as the AP-Dow Jones Bureau Chief in Rome, Italy, and at Institutional Investor magazine as a Contributing Editor in Paris, France, and New York City. After retiring in 1995, she has served on boards and committees of numerous charitable organizations. Since moving to Pittsburgh in 2005, she has served as a Trustee of Phipps Conservatory and Botanical Gardens and The Ellis School, and as a board member for the ARCS Foundation – Pittsburgh Chapter, the Carnegie Museum of Art’s Women’s Committee, and the Pittsburgh Symphony Association. B.A., Dartmouth College, summa cum laude, Senior Fellow.



Ann Merchant is the Deputy Executive Director for Communications at the National Academies in Washington, D.C. Merchant has worked in marketing and communications for more than 20 years and her work at the Academies primarily revolves around planning a variety of science communications events and managing innovative outreach programs that, together, contribute to increased public understanding of science. With a special interest in promoting science, engineering, and medicine through non-traditional entertainment channels such as television, film, and video games, she was instrumental in launching the Science & Entertainment Exchange, a program of the National Academy of Sciences that seeks to connect entertainment industry professionals with top scientists and engineers.

Merchant also served for many years as marketing director for the Academies’ publishing division where she and her staff promoted and marketed more than 175 new titles every year. During that time, she served as adjunct professor of marketing at George Washington University in the College of Professional Studies. She continues to work with the Academies’ publishing group, helping to bring visibility to the core work of the institution. In particular, she maintains relationships with publishers around the world in order to facilitate foreign language translations of Academies reports.

Workshop Participants

First Name	Last Name	Organization	Title
Brian	Anderson	West Virginia University	Director, WVU Energy Institute
Dianne	Anderson	Anderson Energy	
Tim	Avampato	Eaton	
Rebecca	Bagley	University of Pittsburgh	Vice Chancellor for Economic Partnerships
Joe	Barron	MEPPI	
Michael	Bauer	AMSC	Managing Director Global Sales
Lindsay	Baxter	Pennsylvania Environmental Council	Program Manager, Energy and Climate
Joe	Belechak	DiGioiaGray	President
Matt	Blackburn	Pat Toomey Delegate	
Jason	Blake	ReliabilityFirst Corporation	General Counsel
Chuck	Brandt	Innovation Works	VP Technology Programs
Gladys	Brown	PA Public Utility Commission	Chairman
Alex	Brunory	Keith Rothfus Delegate	
Eileen	Buzzelli	FirstEnergy	
Alvaro	Cardoza	University of Pittsburgh	Graduate Student Researcher
Robert	Casey	U.S. Senate	U.S. Senator
Liang	Cheng	Lehigh University	Prof.
Dave	Conti	Trib	
Tom	Crawford	Pitt	Associate Vice Chancellor
Aimee	Curtright	RAND	Sr Physical Scientist
Del	Dausman	NRG Energy Center Pittsburgh	General Manager & Vice President
Austin	Davis	Allegheny County	Executive Assistant to Executive
Richard	DiClaudio	The Energy Innovation Center	Executive Director, trustee, and officer
Tony	DiGioia		
Alexander	Ebbert	HICO America	Director
Grant	Ervin	City of Pittsburgh	Chief Resilience Officer
Thomas	Esselman	LPI, Inc.	Principal
Thomas	Feeley	DOE/NETL	Strategic Partnerships
David	Feldmann	HICO America	Marketing Coordinator
James	Fields	PITT OHIO	COO
Liz	Fishback	Bob Casey Delegate	
Richard	Fox	Greg Vitali Delegate	
pradeep	fulay	WVU	Associate Dean for Research
Christina	Gabriel		
Darren	Gill	PA Public Utility Commission	Deputy Director, Technical
Court	Gould	Sustainable Pittsburgh	Sustainable Pittsburgh
Tyler	Gourley	Hillman Family Foundations	Program Officer
Brandon	Grainger	University of Pittsburgh	
barbara	granito	National Academy of Sciences	Senior Program Officer
David	Hall	Curtiss Wright APS	Principal Engineer
Bryan	Hannegan	NREL	Associate Laboratory Director
Brian	Hill	RKMF	Sr. Program Officer
Gerald	Holder	Swanson School of Engineering	Dean

Wayne	Honath	University of Pittsburgh	Project Manager, Center for Energy
Danielle	Ilchuk	Center for Energy	Administrative Coordinator
Kate	Jackson	KeySource	Director, Energy & Technology Consulting
Sameer	Kher	ANSYS	Senior Manager, R&D
Fred	King	West Virginia University	Vice President of Research
Neil	Kirby	GE Grid Solutions	Business Development Manager
Michael	Latsko	Westinghouse	VP Strategy
Ariel	Lattanzi	City of Pittsburgh	Resilience Analyst
Patrick	Lewis	University of Pittsburgh	Graduate Student Researcher
Mark	McGranaghan	EPRI	
Anna	Merchant	National Academy of Sciences	
Bill	Miller	Pittsburgh Gateways/EIC	COO & VP
Daniel	Moore	Post-Gazette	
Benjamin	Morris	Duquesne Light Company	Senior Manager, Strategic Planning & Operational Analytics
Douglas	Nofi	Allegheny County, Facilities Management	Director
Mark	Nootbaar	WESA/NRP	
Lynn	Orr	DOE	
Brian	Patterson	EMerge Alliance	President
Ben	Patton	Sargent Electric	Preconstruction Manager
Michael	Pesin	US DOE	
Cynthia	Pezze	Westinghouse/Engineering	Vice President and Chief Technology Officer
Cynthia	Powell	NETL	Deputy Director, Science & Technology
Maya	Prica	Case Western	Assistant Professor
Sharmila	Ravula	Bosch	
Gregory	Reed	Center for Energy	Director
George	Reynolds	Sargent Electric Company	Vice President
Richard	Riazzi	Duquesne Light Company	President & CEO
Mike	Ringler	University of Pittsburgh	Sr. Director of Federal Relations
Devlin	Robinson	Tim Murphy Delegate	
Michael	Rooney	Hillman Foundation	
Steve	Ross	Universal Electric Corporation	COO
Adam	Rossi	Adam Solar Resources	
Mark	Rupnik	BPL Global	CEO
Aurora	Sharrard	Green Building Alliance	Executive Director & VP of Innovation
Charles	Shelton	Robert Bosch LLC	Dr.
Anna J.	Siefken	Green Building Alliance	VP of Strategic Engagement and Pittsburgh 2030 District Director
Michele	Somerday	FirstEnergy	Manager, Energy Policy
Deborah	Stine	Carnegie Mellon University Scott Institute for Energy Innovation	Associate Director
Paul	Supowitz	University of Pittsburgh	Vice Chancellor for Community and Governmental Relations
John	Swanson	Swanson School of Engineering	
Mutmainna	Tania	Dominion Virginia Power	

Alan	Traugott	CJL Engineering	Managing Principal
David	Vorp	University of Pittsburgh	Associate Dean for Research, Swanson School of Engineering
Jay	Whitacre	Carnegie Mellon University	Professor
James	Wilson	National Energy Technology Laboratory (DOE)	Chief Financial Officer
Corey	Young	Washington and Jefferson College Center for Energy Policy and Management	Director

University of Pittsburgh GRID Institute Press Release



News Release

CONTACT: Paul Kovach, Director of Marketing and Communications
Swanson School of Engineering, University of Pittsburgh
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University of Pittsburgh launches Energy GRID Institute

“Solution center” draws together utility, industry, government and foundation partners to modernize energy infrastructure

PITTSBURGH (June 23, 2016) ... The U.S. power and energy infrastructure is at a crossroads. Aging, legacy-based systems face demands to integrate the growth of distributed and renewable energy resources, with sources ranging from the average consumer with a solar rooftop to commercial industry developing on-site microgrids.

This rapidly evolving environment affects grid technologies, systems, designs, operations and regulation, and influences markets and policy.

To address these challenges, the University of Pittsburgh is launching the **Energy Grid Research and Infrastructure Development (GRID) Institute**. This new entity, grounded in research from Pitt’s Center for Energy, will leverage the University’s public and private partnerships with new laboratory space at the Energy Innovation Center in downtown Pittsburgh to create a comprehensive international solution center for industry.

The Institute’s inaugural partners include Duquesne Light, Eaton, the Electric Power Research Institute (EPRI), Dominion Virginia Power, FirstEnergy, Emerson, PITT-OHIO Express, Sargent Electric Company, Siemens, and Universal Electric Corp. Nonprofits including the Henry L. Hillman Foundation and the Richard King Mellon Foundation are also supporting the work of GRID. The Institute is coordinating closely with the City of Pittsburgh and with the National Energy Technology Laboratory on behalf of the U.S. Department of Energy on joint efforts to advance new energy technologies through an agreement aimed at designing a 21st century energy infrastructure for Pittsburgh. The Institute’s leadership team is also exploring additional public-private partnerships in the Pittsburgh region and throughout the U.S.

“Considering the expansive and somewhat daunting goal—to modernize the nation’s electric power grid and energy infrastructure—it’s vital that research institutions such as Pitt partner with the utility industry and the community to find solutions addressing security, resiliency, and reliability,” Pitt Chancellor Patrick D. Gallagher said. “The Energy GRID Institute will serve as

the nexus for collaborative research that encourages economic growth and job creation, and enhances our incubator, start-up, and commercialization potential.”

Groundwork for the Institute was developed under the leadership of Gregory Reed, Professor of Electrical and Computer Engineering in Pitt’s Swanson School of Engineering and Director of the Center for Energy, and Rebecca Bagley, Vice Chancellor for Economic Partnerships.

GRID’s operations will be based in new research and incubator space currently under construction by Pitt at the Energy Innovation Center (EIC), a project developed by Pittsburgh Gateways Corporation in the former Connelly Trade School. The 18,600-square-foot laboratory will include the **Electric Power Technologies Laboratory**, led by Reed; the **Next Generation Energy Conversion and Storage Technologies Laboratory**, headed by Prashant Kumta, professor of bioengineering, mechanical engineering and materials science, and chemical and petroleum engineering; the **High-Temperature Corrosion Testing Laboratory**, led by Brian Gleeson, professor and chair of mechanical engineering and materials science; and the **Pitt Energy Incubator Laboratories**, developed by Mark S. Redfern, vice provost for research.

In collaboration with these researchers, the GRID Institute will address the utility sector’s critical issues, including:

- Micro grids and resilient energy systems
- Renewable technology integration (solar, wind, micro-hydroelectric, etc.)
- Energy storage and power electronics technologies
- Electric vehicle-to-grid concepts
- Direct current (DC) infrastructure, technologies, and standards
- Hybrid AC/DC systems
- Integrated Energy Networks

“The University’s leading research in energy and sustainability and state-of-the-art laboratory space at the Energy Innovation Center enables GRID to evaluate, assess, and develop solutions collaboratively with our partners on major issues and technologies that impact not only our nation’s power grid, but also energy transmission and distribution infrastructure around the globe,” said Reed.

Collaborative partnerships are a key element of the enterprise, Bagley said. “We’re developing a world-class enterprise for energy and power grid research, development, demonstration, and deployment in collaboration with energy-based industry and utilities” she said. “We appreciate the contributions of our existing partner entities and are actively seeking to add to the group in order to enrich the exchange of ideas and reach universally beneficial outcomes more quickly.”

###

Speaker Presentation: Dr. Gregory Reed, University of Pittsburgh



University of Pittsburgh

The Pitt Center for Energy

EIC Facilities Up-date and the Energy GRID Institute

DOE Mission Innovation – June, 2016

Dr. Gregory Reed

Director, University of Pittsburgh Center for Energy
Director, Electric Power Initiative and Power Systems Lab
Professor, Electrical & Computer Engineering Department
Swanson School of Engineering – University of Pittsburgh





Center for Energy

Off-Campus Research Facilities

Plans for the
Energy Innovation Center (EIC)

“Pitt @ the EIC”



Pittsburgh Energy Innovation Center

- **Old Connolly Trade School (Bedford Avenue)**
 - aka, the **Energy Innovation Center**
 - located adjacent to downtown Pittsburgh,
across the street from the former Mellon Arena
- **Built in 1930 and closed as a school in 2004.**
- **Consists of a 5-story tower, with a single-story,
high bay – former technical shop extension.**
- **Building currently under renovation by the
Pittsburgh Gateways**
 - non-profit entity, support from private and public funding
- **Pitt Center for Energy Labs/Facilities:**
 - over 20,000 sq. ft. of total space
 - construction underway as of Dec. 2015

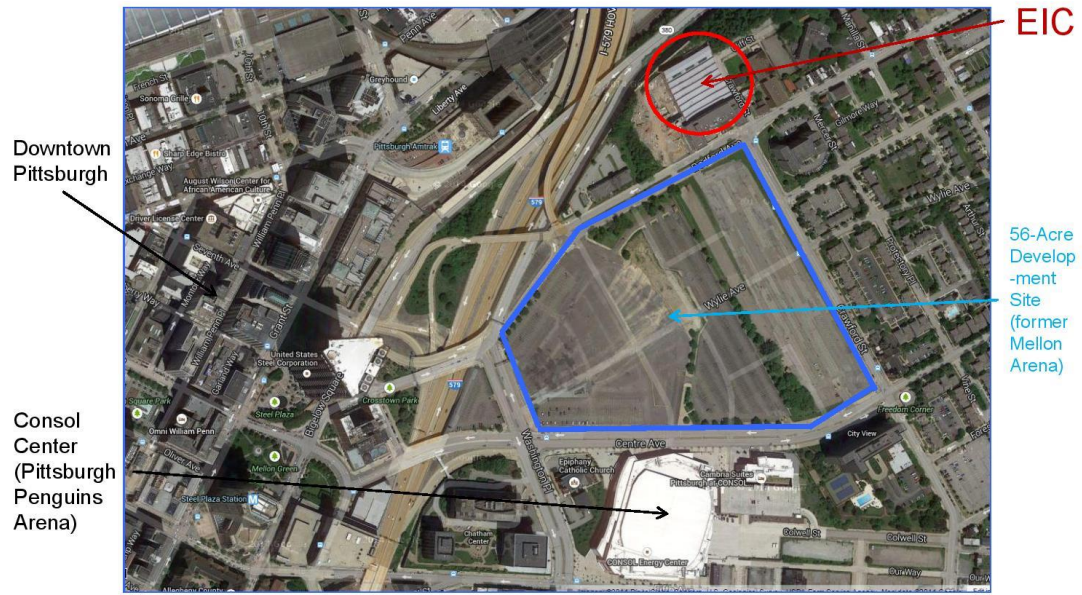


Energy Innovation Center





Energy Innovation Center - Location

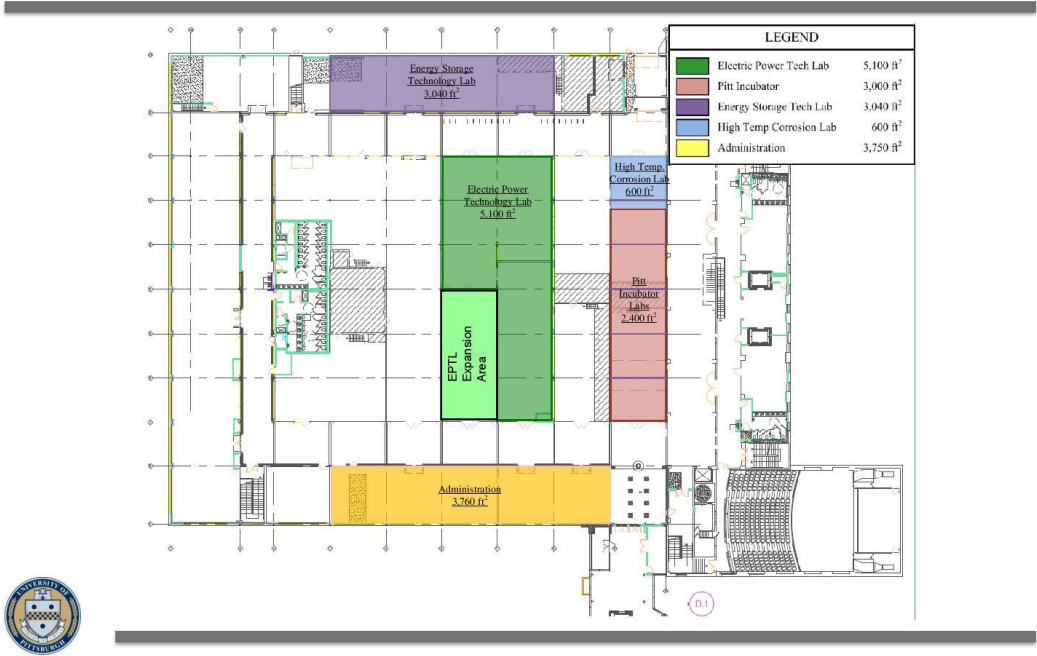




Center for Energy Laboratories to be Developed for “Pitt @ the EIC”

- **Electric Power Technologies Lab**
 - Dr. Gregory Reed
 - High Voltage/Capacity AC and DC Grid Facility
- **Energy Storage Technologies Lab**
 - Dr. Prashant Kumta
- **High-Temperature Corrosion Testing Lab**
 - Dr. Brian Gleeson
 - Current facility at Iowa State University
- **Energy-Related University Incubator Space**
 - Dr. Mark Redfern







Pitt at the EIC

Value Proposition for Partners and Users:

- **Collaborative R&D programs**
- **Utility investigations and testing**
- **Technology development, prototyping, and demonstration**
- **Commercialization opportunities**
- **Joint utility-vendor-government collaborations**
- **Various levels and constructs of partnerships**
- **Fee-for-service and contract R&D options**
- **Independent testing/certification and third-party operations**
- **Student development and access**
- **Education and training**



Electric Power Technologies Laboratory (EPTL)

- 2016/2017 Operation

- **University research & development and independent industry activities**
- **Focus will be on the ELECTRIC UTILITY INDUSTRY**
- **Concept and vision is for a high-voltage/high-capacity capability and multiple use facility:**
 - Plan is for **15 kV-ac, 5 MVA** and **1.5 kV-dc, 1 MVA** capacity
 - **Ring-Bus** configuration and **dedicated DC area**
 - **AC and DC Micro-Grid/Micro-Energy** Environments at the **Utility Distribution Level**
 - Resource, **Distributed Energy Generation**, and **Load Integration**



Pitt EPTL

Opportunities:

- **Industry collaborative research & development**
- **Electric Utility Industry – R&D / Solutions Center**
- **EPRI collaborations and programs**
- **DOE (OE, EERE), ONR, DoD, and other energy-related programs**
e.g., **Regional grid hub, Microgrid/energy center, DER,**
Renewables, DC technologies, Power electronics, etc.
- **NETL-RUA Grid Technologies Collaborative growth**
- **NSF (I/UCRC or ERC in electric power technologies)**
- **NIST (standards and testing activities)**
- **Technology prototyping, development, and commercialization**
- **Standards development, testing, and certification**
- **Witness testing services and third party verification**
- **Training and courses / distance learning / certificate programs**
- **Other Services – consulting, business development, etc.**



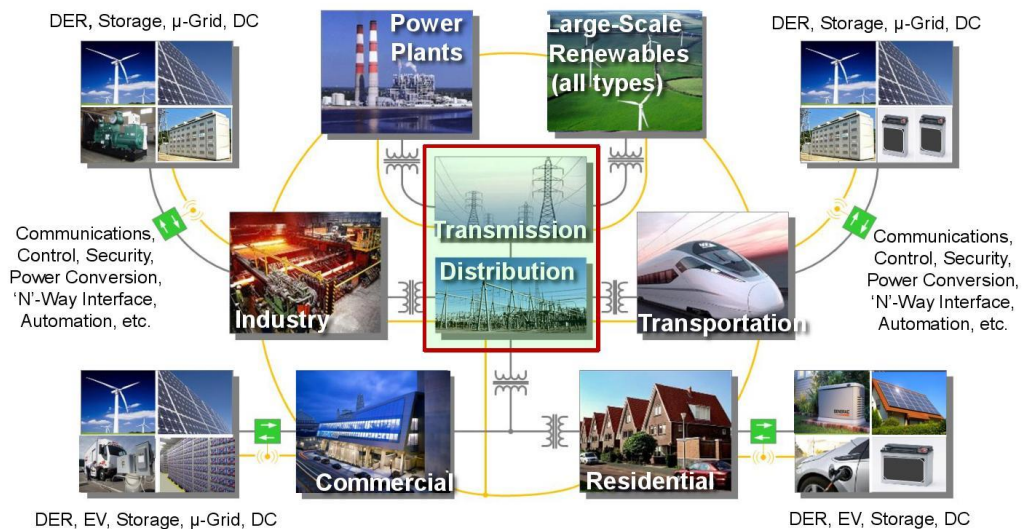
Pitt EPTL

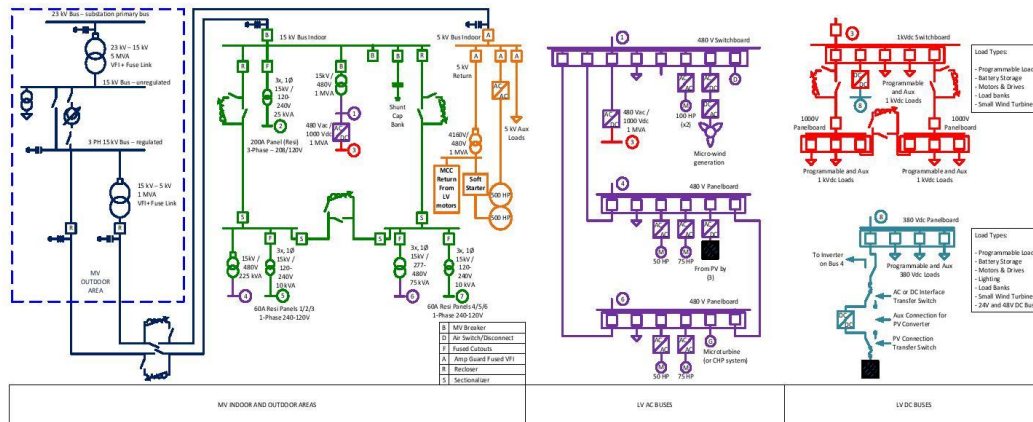
Industry Engagement – initial discussions and significant interest in participation/support:

- **Eaton, Electrical Sector***
- **Universal Electric***
- **Dominion VP***
- **ANSYS***
- **EPRI**
- **DOE NETL**
- **ABB**
- **Aquion Energy**
- **Concurrent Technologies**
- **General Electric**
- **RTDS**
- **Schweitzer Engineering Labs (SEL)**
- **Others (U.S. DOE OE/EERE, NIST, NSF, EEL, etc.)**
- **Duquesne Light Co.***
- **Emerson Process Management***
- **Mitsubishi Electric**
- **FirstEnergy Corp.**
- **Siemens Energy and Industry**
- **Alstom Grid**
- **S&C Electric**
- **Enernex**
- **Tollgrade Communications**
- **OSISoft**
- **Typhoon Hill**
- **Princeton Power Systems**



The 21st Century Grid – RD&D is Imperative





Electric Power Technologies Lab: One-Line Diagram of Grid Infrastructure Plan

(AC network: 23-kV/15-kV/4.16-kV/480-V > system)

(DC network – 1.5-kV/380-V > system)



Proposed EPTL Layout

Power Distribution Areas

- **MV Grid Lab:** Reconfigurable lab for traditional or microgrid projects. Designed using utility-grade distribution equipment.
- **Test Lab:** Isolated testing facility for safe testing of industry technologies, and EPTML research projects.
- **AC and DC:** Flexible power architecture capabilities – AC, DC, and hybrid systems

Specialty Areas

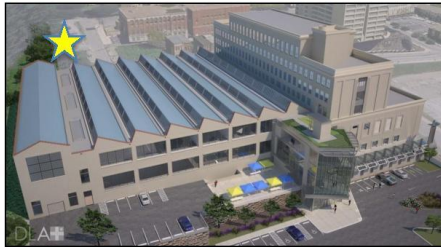
- **Rapid Prototyping:** Advanced machine shop for development of professional grade components and projects.
- **SCADA Center:** Automation, metering, and control for distribution network.
- **Relaying and Controls:** Protective relaying technologies, Phasor-measurement, and advanced control
- **RTDS Center:** Real-Time Digital Simulator and hardware in the loop capabilities – research and testing on industry leading equipment.

**EPTL
Expansion
Area**

Laboratory Ratings and Features

- 15 kV-ac, 5 MVA and 1 kV-dc, 1 MVA capacity
- Micro-Grid/Micro-Energy Environment at Electric Utility Distribution Level
- Distributed Energy Resource and Load Integration
- Renewable Technologies (Solar PV, Wind, etc.)
- Energy Storage, Electric Vehicle-2-Grid
- Distribution Feeder Infrastructure
- Real Time Digital Simulator (RTDS)
- SCADA and Systems Operations
- Protective Relaying and Substation Automation
- Advanced Control and Communications, PMU
- Modeling, Simulation, and Analysis
- FACTS and HVDC Control Systems
- Power Electronics Converters (and other power technologies development, prototyping, and testing -- e.g., IEEE 1547 certification)
- DC standards development (IEC SG 4)
- Integration of feeder analytics
- Technology testing and certification

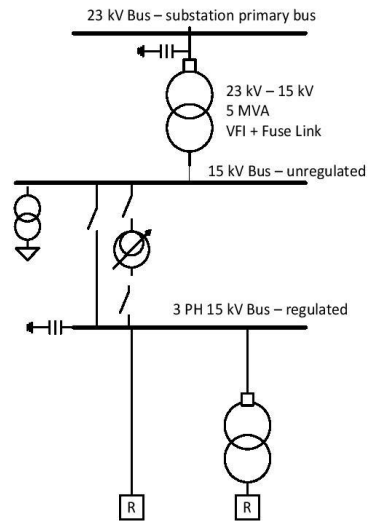




Outdoor Location of HV Interconnection – MITS



Modular Integrated Transportable Substation
(MITS)



Electrical One-Line of MITS

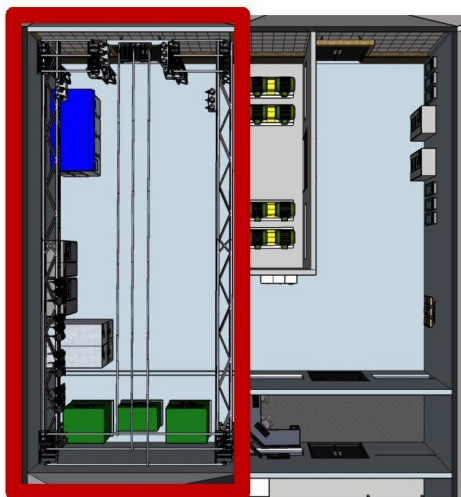


View from Administration Hallway



View from Loading Dock Hallway





Medium Voltage Area

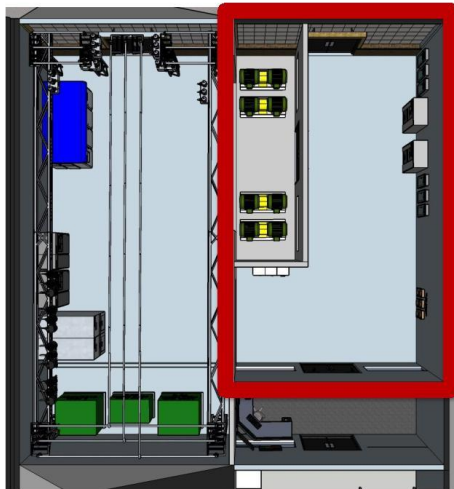


View from Lab Entrance

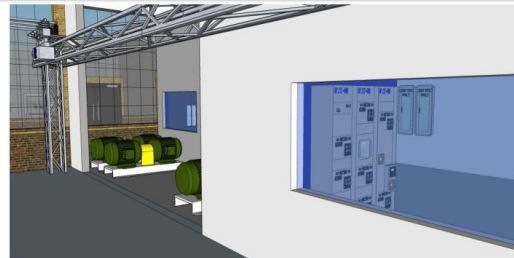


View from Mezzanine

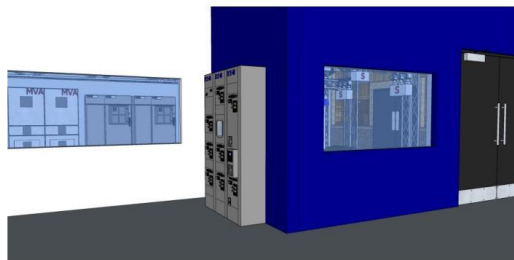




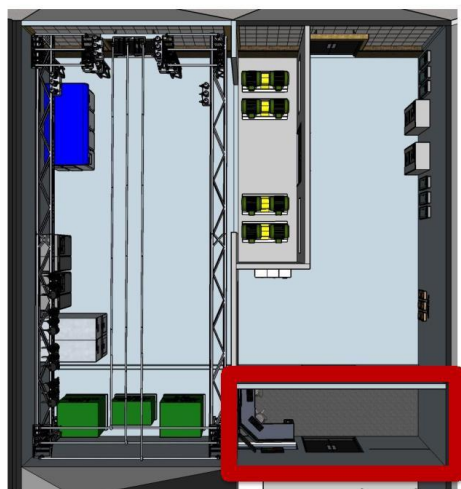
Testing and Motor Areas



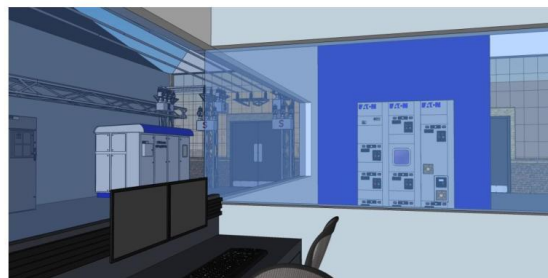
View from Medium Voltage Area into Testing Area



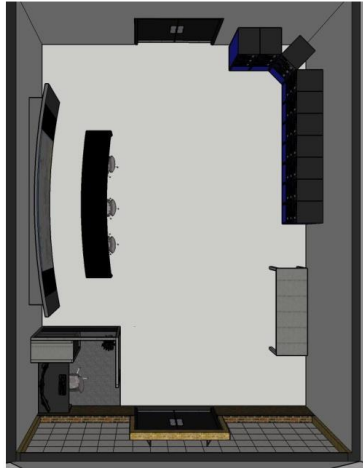
View from Testing Area into Medium Voltage Area



Laboratory Monitoring Area
(Isolation while Testing)



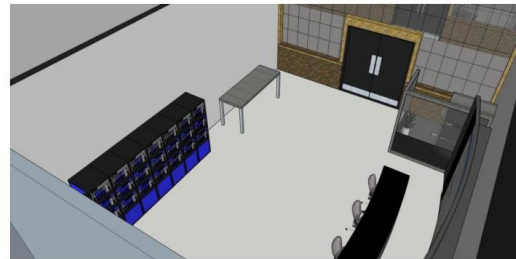
View into Testing Area and Medium Voltage Area



Real Time Digital Simulation (RTDS),
EMS/SCADA, System Operations and
Relaying/Automation/PMU Area



View from Entrance into Lab



View from Prototype Area Door Entrance



Expanded Vision – the Energy GRID Institute

The Challenge:

Electric utilities across the U.S., as well as North America and many parts of the developed world that possess established legacy-based electrical power and energy infrastructure, are facing a dynamic period of change and uncertainty. This stems from the recent proliferation and expected continued growth of distributed and renewable energy resources, microgrid and related developments, increased consumer participation, and many other disruptive technological and regulatory paradigms that are affecting utility planning, design, operations, and policy.

The Goal:

A modern reliable grid, innovative customer solutions, and even cleaner energy.*

The Vision:

Create an international consortium focused on the electric utility industry to evaluate and assess both major industry-wide and individual utility issues, and work in collaboration with various partners towards the development, demonstration, and first-generation deployment of solutions across a broad area of grid technologies, systems, designs, operations, and regulation, as well as addressing market forces and business considerations.



Expanded Vision – the Energy GRID Institute

Background:

The University of Pittsburgh's Center for Energy and the Swanson School of Engineering are investing nearly \$9-million towards renovations for establishment of new off-campus facilities and laboratories at the Pittsburgh Energy Innovation Center (EIC). A significant part of these plans includes an extensive high-power/high-capacity AC and DC networked Electric Power Technologies Lab, which is being supported by various industry and community constituents through in-kind contributions and financial assistance.

Overview:

An expanded vision for this facility, beyond these initial plans, is to establish an "Energy GRID Institute" at the EIC for energy and power grid related research, development, demonstration, and deployment – creating value-added impact and national/international prominence. A world-class enterprise with comprehensive infrastructure and advanced capabilities for research, development, commercialization and related activities, in the form of expanded plans for the EIC labs and facilities, is instrumental in realizing this vision and creating opportunities the partner organizations.



Expanded Vision – the Energy GRID Institute

Impact and Need:

Part of the plan to achieve the vision set forth will be to expand upon and attract significant industry participation and corporate engagement at the EIC, to work in close collaboration and partnership with University programs, faculty researchers and graduate students, and other supporting academic personnel.

The **regional impact** will be to leverage activities towards economic growth and job creation, as well as enhancing incubator, start-up, and technology commercialization potential. The **national impact** will be an opportunity to collectively move industry forward in key areas of energy and power grid related activities.

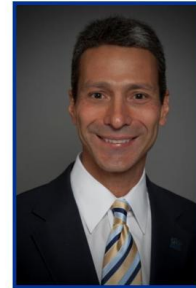
A comprehensive strategy to realize this vision will require large-scale funding from both public and private entities, including opportunities to partner with federal, state, and local government; regional, national, and global industry organizations; the foundation community; and the University.



Contact Information

Dr. Gregory Reed

Director, University Center for Energy
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<http://www.engineering.pitt.edu/cfe/>
<http://www.engineering.pitt.edu/power>

Speaker Presentation: Mark McGranaghan, Electric Power Research Institute



Grid Modernization Challenges for the Integrated Grid

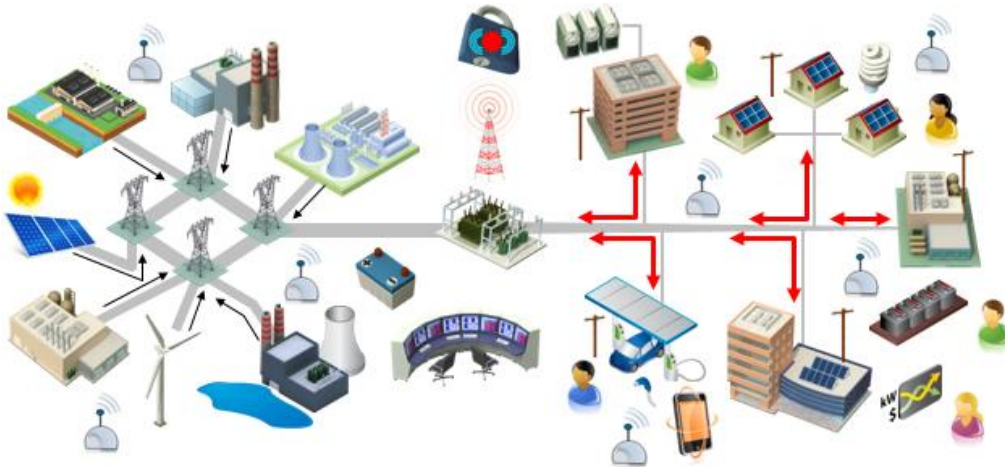


Mark McGranaghan
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U.S. Department of Energy
Mission Innovation Workshop on Grid Modernization
The University of Pittsburgh, Center for Energy
Friday June 24, 2016
Pittsburgh, PA

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The Vision: An Integrated Grid



Power System that is Highly **Flexible, Resilient** and **Connected** and Optimizes Energy Resources

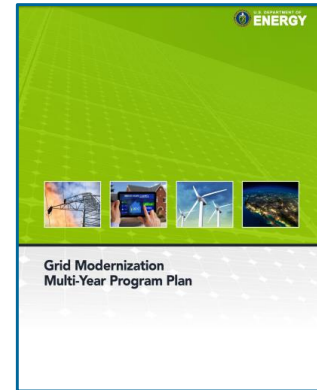
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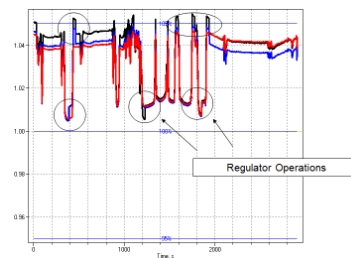
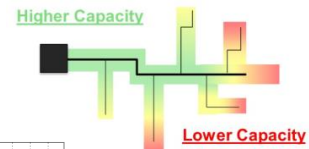
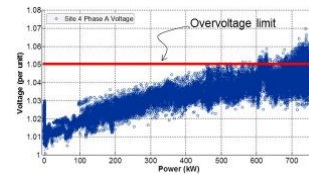
Priority Research Challenges for Grid Modernization

1. Industry coordination and roadmap
2. Planning and Operations for the future
3. Integrating the Customer
4. Communications Infrastructure
5. Grid Infrastructure - Maintaining reliability and resiliency
6. Demonstrations – keeping up with the pace of technology innovation

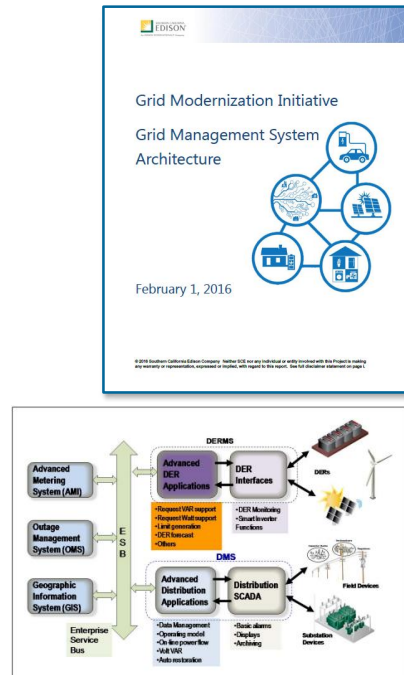


1. Planning Methods and Tools

- Hosting capacity
- Locational and temporal value
- Value of reliability and resiliency
- Protection design
- Probabilistic approaches



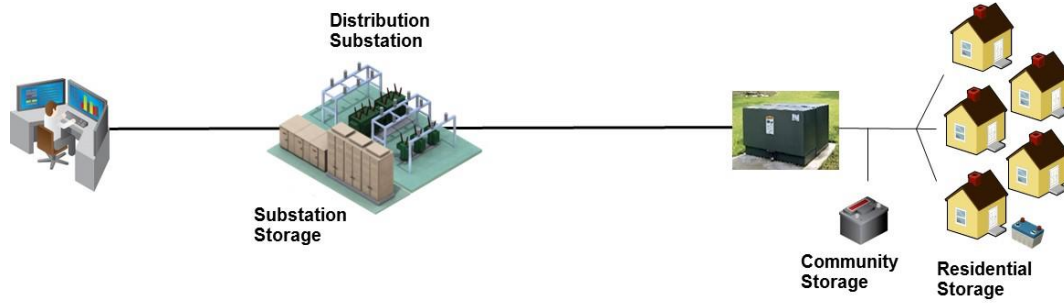
- Developing the architecture
- Integrating distributed resources
- Microgrids
- Protocols and standards (OpenFMB)



3. Integrating Smart Inverters and DER



4. Energy Storage



- Location/location/location
- Controls and Integration
- Economics
- Standards and safety



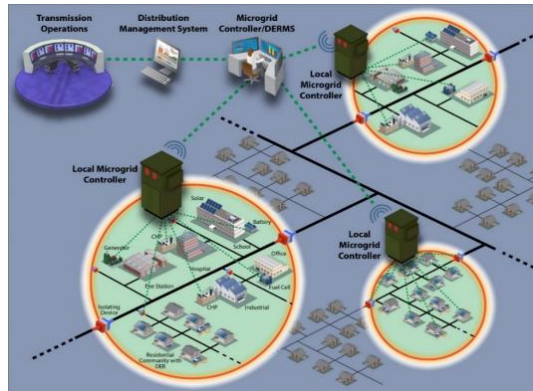
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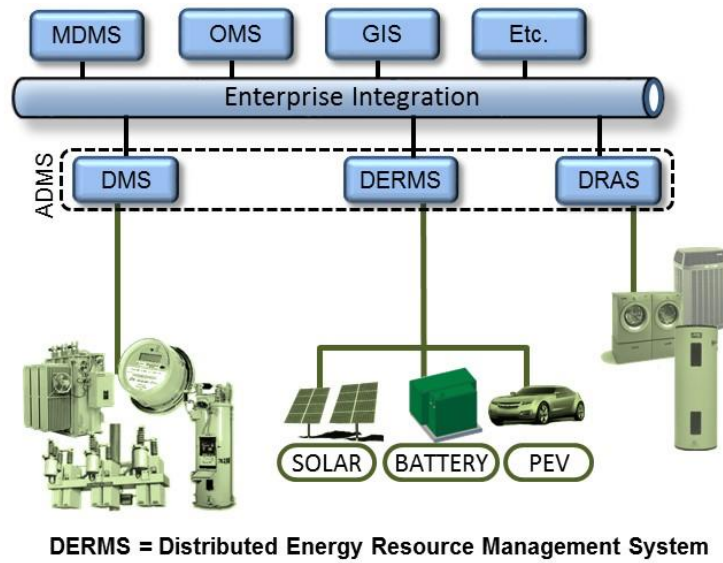
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5. Microgrids

- Controller requirements
- Energy optimization strategies
- Protection approaches and coordination
- Information models and protocols
- DMS integration

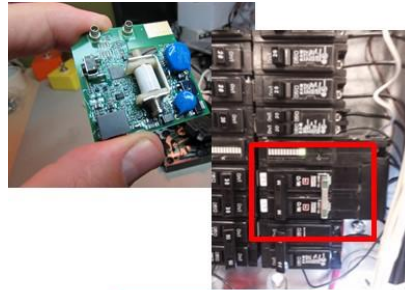


6. Integrating DERMS with DMS

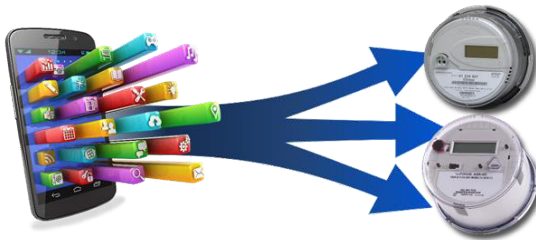


7. Making the customer the center of the universe

- Customer model of the future
- Electrification opportunities
- Customer services
- Integration with Planning and Operations

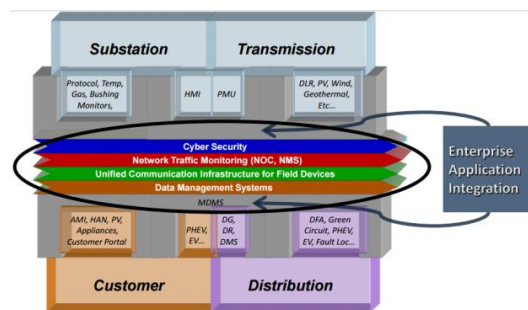


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8. The communications infrastructure to make it work

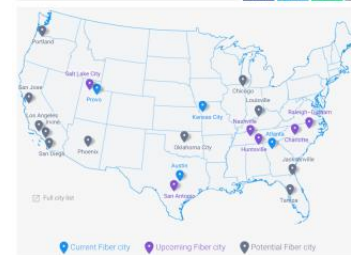
- Communications technology choices
- Integration of different applications on a common communications platform
- Use of public infrastructure
- Wireless spectrum issues
- Moving to fiber?



Google Fiber joins forces with municipal broadband network

Google will offer internet service over city-owned fiber in Huntsville, Alabama.

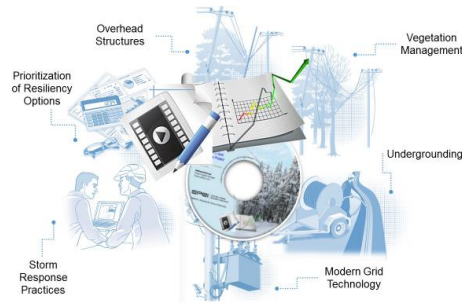
by Jon Brodwin - Feb 22, 2016 12:02pm EST



Salt River Project, Others,
Buying 700 MHz Spectrum for
Smart Grid Applications

9. Grid Infrastructure is still critical

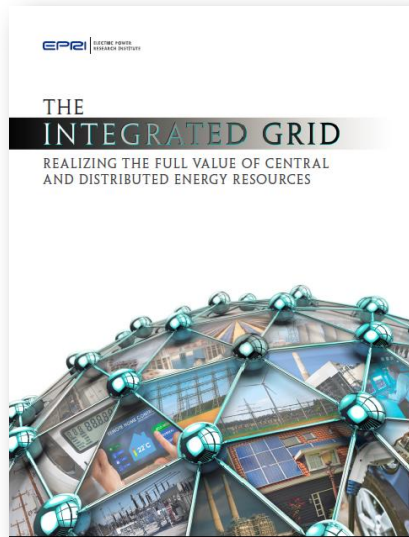
- Distribution grid resiliency
- Automation investments
- Sensors, advanced monitoring applications
- Role of distributed resources in grid investment strategies



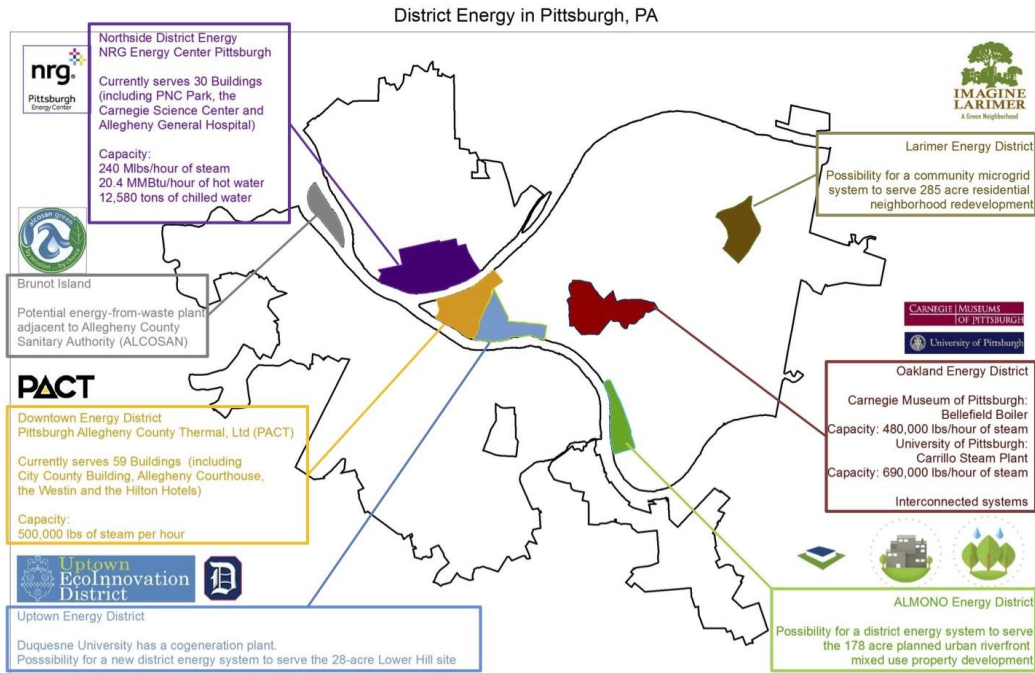
10. Learning from demonstrations and pilots



Working together!



Additional Presentation: District Energy in Pittsburgh



Overview

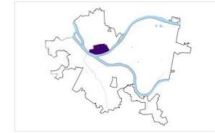
- Two existing commercial district steam systems: NRG & PACT
- Three existing university/institutional systems: Carnegie Museums Bellefield Boiler; University of Pittsburgh Carrillo Steam Plant; Duquesne University Cogeneration Plant
- Four sites for potential new district energy, micro-grid, or energy-from-waste systems

Strategies

- Optimize existing systems with existing built infrastructure
- Support infill development to connect to existing systems
- Create new systems that support new development and redevelopment projects
- Integrate next generation grid and building performance technologies to optimize energy use



Northside District Energy NRG Pittsburgh



- NRG began operations in 1999
- More than 30 buildings
- Over 6.3 million square feet
- Capacity
 - 240 Mlbs/hour of steam
 - 20.4 MMBtu/hour of hot water
 - 12,580 tons of chilled water
- Plans for electric generation

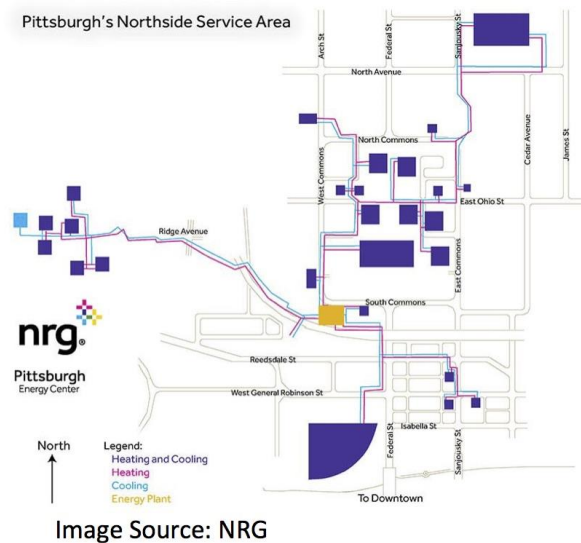
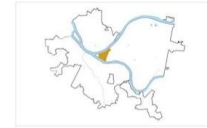


Image Source: NRG



Pittsburgh Allegheny County Thermal



Downtown District Energy

- Established in 1983
- 59 buildings currently on the system, including many local government buildings
- Customer owned
- Capacity
 - 500,000 lbs/hour of steam

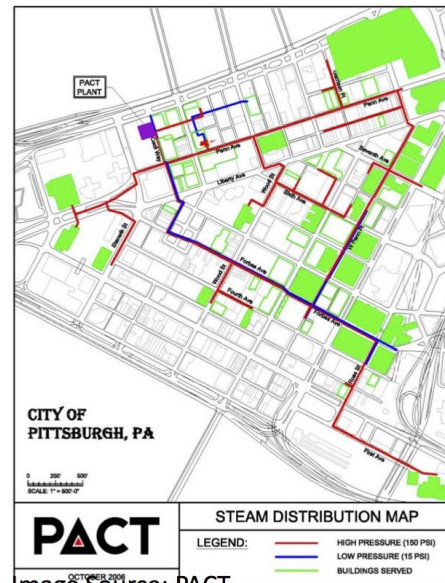
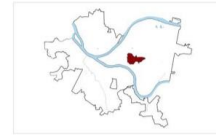


Image Source: PACT

Oakland District Energy Bellefield Boiler Plant

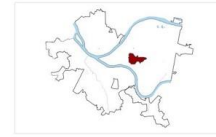


- Built in 1907
- Serves most of Oakland's major institutions
- Capacity
 - 460,000 lbs/hour of steam
- Interconnected with Carrillo steam distribution lines



Image Source: Margaret J. Kraus, 90.5 WESA

Oakland District Energy Carrillo Steam Plant



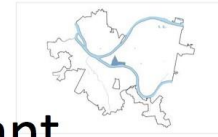
- Began operations in 2009
- Serves the University of Pittsburgh and UPMC
- Capacity
 - 600,000 lbs/hour of steam
- Interconnected with Bellefield Boiler distribution lines



Image Source: University of Pittsburgh



Uptown Energy District Duquesne Cogeneration Plant

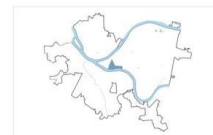


- Began operations in 1997
- Produces 85% of the electricity used on 50-acre campus
- Produces heat for entire campus
- Paired with cooling system



Image source: David Conti, Trib Total Media

Uptown Energy District EcoInnovation District



- 28 acre Lower Hill Redevelopment
- Proposed Users:
 - UPMC Mercy
 - Consol Energy Center
 - Chatham Center
 - US Steel
 - New Development...



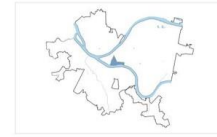
Image Source: Dept of City Planning



Image Source: Sports & Exhibition Authority



Almono Energy District



- 178 acre riverfront property
- Mixed Use Development
- Clean industry
- Applied research & innovation



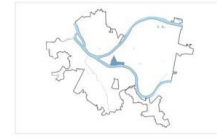
Image Source: ALMONO



Image Source: RIDC



Larimer Energy District



- 285 acre Choice Neighborhood
- Mixed Use Development
- 1,728 residents
- Micro-grid Applications

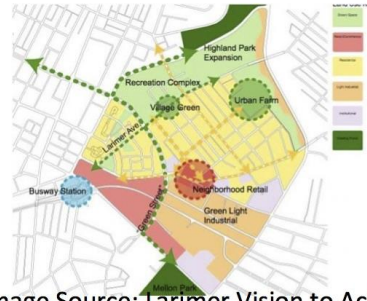


Image Source: Larimer Vision to Action Plan

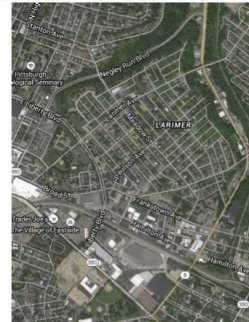
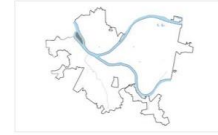


Image Source: Google Maps



Brunot Island



- Current substation
- Close Proximity to ALCOSAN wastewater treatment center and commercial districts
- Possible site for biogas and waste-from-energy plant

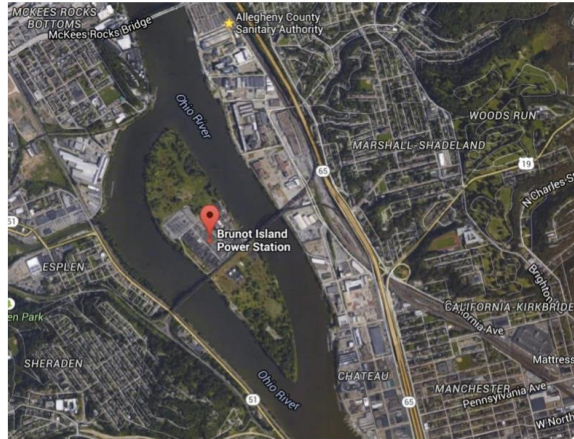


Image Source: Google Maps

