

HOLYOKE *Clean Energy Innovation* **WORKSHOP**



Final Report for the
Holyoke Clean Energy Innovation Workshop:
Energy Innovation, Technology, Policy and Testbeds in Holyoke
Held November 9 and 10, 2011
Open Square, Mill #1
Holyoke, Massachusetts

January 27, 2012

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Thank You to Our Speakers, Panelists, and Organizers

Keynote speakers:

Patricia Hoffman, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, United States Department of Energy

Richard Sullivan, Secretary, Exec. Office of Energy & Environmental Affairs, Massachusetts

Panelists and panel moderators:

Zaid Ashai, General Partner, Point Judith Capital

Richard Baxter, Director of Product Strategy, Premium Power

Brian Beauregard, Electric Superintendent, HG&E

Dwayne Breger, Director, Renewable and Alternative Energy Development, Massachusetts Department of Energy Resources (DOER)

Patrick Cloney, Executive Director, Massachusetts Clean Energy Center

Mathew Commons, Chief Financial Officer, FloDesign Wind Turbine

Daniel Hullah, Principal, Rockport Capital

Paul Jacob, Executive Vice President, Free Flow Power Corp.

James Kenney, Vice President, Lending, MassDevelopment

James Kurose, Distinguished University Professor, University of Massachusetts Amherst

James Lavelle, Manager, Holyoke Gas & Electric

James Manwell, Professor of Mechanical and Industrial Engineering; Director, Renewable Energy Laboratory, University of Massachusetts Amherst

David Miller, Executive Managing Director, Clean Energy Venture Group

Eric Nakajima, Senior Innovation Advisor, Exec. Office of Housing and Economic Development, Massachusetts

Arif Padaria, Managing Director of Investments, Massachusetts Clean Energy Center

Susan Reid, Director, Conservation Law Foundation Massachusetts

Peter Rothstein, President, New England Clean Energy Council

Prashant Shenoy, Professor of Computer Science, University of Massachusetts Amherst

Throop Wilder, President, 24M

Eric Wilkinson, External Affairs Representative, ISO-New England

John Williams, Professor, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology

Organizing Committee:

Brian Beauregard, *James Lavelle (Co-Chair)*, Holyoke Gas & Electric

Claire Christopherson, *John Goodhue*, MA Green High Performance Computing Center

Bill Ennen, *Robert Kispert*, Massachusetts Technology Collaborative

James Kurose (Co-Chair), University of Massachusetts Amherst

Eric Nakajima, Exec. Office of Housing and Economic Development, Massachusetts

Arif Padaria, Massachusetts Clean Energy Center

Stephen Rourke, *Eric Wilkinson*, ISO New England

Organization:

Benjamin Brier, Massachusetts Technology Collaborative

Victoria Rupp, University of Massachusetts Amherst

Workshop Supporters



Executive Summary

The Holyoke Clean Energy Innovation Workshop took place on November 9 and 10, 2011. It was motivated by the exceptional opportunity afforded by the mix of capabilities, assets and resources available within Holyoke Gas & Electric and its partners to develop a testbed to support the development of innovative energy-related technologies and businesses.

The goal of this report is to document the workshop – to capture the key issues discussed during the workshop – and to provide a foundation for launching working groups and implementation activities related to test-bed development.

The Strategic Opportunity

With an innovative municipally-owned utility (HG&E), on-the-horizon innovative clean energy technologies, a talented workforce, a blossoming entrepreneurial environment, broad academic research and education capabilities, and engaged public and private sectors - Holyoke and the Connecticut River Valley region are well-poised to help create, deploy, and leverage the next generation of clean energy system technologies. A unique possibility for the region is that of developing and deploying these technologies in a Holyoke testbed setting. Key to success will be collaboration among engineers, entrepreneurs, policy makers, researchers and educators and the ability to learn from, and leverage, each other's expertise.

Our Approach

The goals of the workshop were to:

- Trigger conversations that result in specific partnerships and collaborations on innovative clean energy technologies, leveraging HG&E expertise and testbed opportunities and setting the foundation for long-term collaborations.
- Identify near-term opportunities for collaboration in entrepreneurial activities, federal-funding partnerships, research/education activities.
- Learn about each other's expertise.

To these ends, the workshop's agenda (see Appendix One) was organized around two crosscutting keynote presentations and five topics areas: *(i) public policy and advocacy (ii) innovators and disruptors, (iii) regulatory, (iv) investment, and (v) university collaborations.*

Key Participants

The workshop brought together more than 130 participants from six key stakeholder groups:

- Advocates, policy makers and regulators working at the intersection of the existing electrical system and the clean energy economy;
- Emerging companies working on new technologies to generate, transmit, distribute, monitor, manage, and/or store power;
- University researchers;
- Educators from community college through doctoral levels;
- Investors in clean energy companies;
- Governmental officials from the local to national levels;

Significant High-Level Findings

In the course of the workshop, two themes emerged through the keynote talks, panel discussions and breakout sessions:

- **Holyoke Gas & Electric is exceptionally well-suited to partner with cleantech and energy entrepreneurs.**
 - Entrepreneurs cited HG&E's responsiveness, size, vertical integration, municipal utility status and in-depth expertise in a broad range of renewable technologies as critically important attributes.
- **An HG&E testbed can offer clean energy entrepreneurs and researchers important resources for advancing their own projects and interests, while helping HG&E itself develop, evaluate, and deploy new technologies:**
 - Entrepreneurs expressed excitement about opportunities to demonstrate and test new technologies in HG&E systems, and to work with the HG&E team. Benefits of this collaboration extend beyond technical validation to better understanding of customer needs and needed attributes in commercial products.
 - Researchers and entrepreneurs alike were excited about the opportunities provided by access to the "real-world" data that HG&E can offer, as an operating utility. HG&E, in turn, is eager to work with researchers and entrepreneurs in mining and fully exploiting this data.

These findings along with additional crosscutting observations resulted in three concrete next steps.

Next Steps

In the panels and breakout discussions, three areas of significant common interest were identified for follow-up: each offering opportunities for immediate collaboration as well as longer term potential:

- **Data** – HG&E has data of great interest to researchers and technology developers. Brian Beauregard will organize a series of follow-on meetings in which HG&E engineers will discuss data that is, or could be, made available as well as seek information from potential data users about their interests.
- **Education** – Clean energy technologies will demand a workforce with new skills and knowledge, ranging from the community college through graduate education levels. Jim Kurose will convene those interested in developing programs to address this anticipated need.
- **Testbed** – The workshop showcased testbed opportunities with HG&E, and HG&E's willingness to partner in testbed activities. Within the first month following the workshop, more than 10 proposals (some formal, some conceptual) have been made to HG&E for testbed activities. Brian Beauregard is coordinating meetings with those interested in development of the testbed from multiple perspectives, including HG&E, investors, entrepreneurs and researchers.

Holyoke Clean Energy Workshop website:
http://cs.umass.edu/energy_innovation_workshop

Origins and Organization

HOLYOKE has many of the attributes and assets needed to become a national testbed city for the next generation of clean energy technology — the topic that drew more than 130 participants from around the country to the Holyoke Clean Energy Innovation Workshop on November 9 and 10. First and foremost, the city of Holyoke has a municipal electric utility, Holyoke Gas & Electric (HG&E) with low electricity costs and high reliability. HG&E generates nearly 65 percent of its power — more than 276,000 megawatt-hours a year — from its own renewable hydroelectric facilities, and is investing in other renewable sources including solar and wind. HG&E also owns a significant fiber optic network infrastructure on which it plans to build out a logical network to the doorstep — one that will accommodate the introduction of smart technologies and meters.



Organizing committee members, John Goodhue of the MGHPCC and James Kurose of UMass Amherst, chat before the workshop. Photo by Dennis Vandal.

Illustrating the value of the Holyoke Gas & Electric's assets and expertise is its role in attracting the Massachusetts Green High Performance Computing Center (MGHPCC). Due to the utility's capacity and renewable energy portfolio "Holyoke, more than any other location in the state, has an abundance of what massive computing systems need - a cheap source of electricity to operate, in this case hydroelectric power..."¹ In turn, several founding members of the workshop's organizing committee met while working on the MGHPCC project and are now prepared to bring their diverse backgrounds to bear on the development of a testbed.

The workshop was organized as a first step in this process in order to assess broader interest and catalyze collaborations. This is reflected in the workshop's goals, to:

- Trigger conversations that result in specific partnerships and collaborations on innovative clean energy technologies, leveraging HG&E expertise and testbed opportunities and setting the foundation for long-term collaborations.
- Identify near-term opportunities for collaboration in entrepreneurial activities, federal-funding partnerships, and research/education activities.
- Learn about each other's expertise.

To these ends, the agenda (see Appendix One) was organized around two crosscutting keynote presentations and five topics areas:

- Public policy and advocacy



Organizing committee members, James Lavelle of HG&E and Robert Kispert of the Massachusetts Technology Collaborative, confer before the workshop begins. Photo by Dennis Vandal.

¹Stan Freeman, "Holyoke Computer Center Chosen for Hydropower and Proximity to Water," http://www.masslive.com/news/index.ssf/2009/06/holyoke_computer_center_chosen.html?category=Energy

- Innovators and disruptors
- Regulatory
- Investment
- University collaborations

For each topic area, an expert panel was assembled to frame issues and to create a common context for all attendees. Each panel was followed by a breakout session that provided an open forum for attendees interested in the topic area. A single individual who was expert in the particular topic area was selected to moderate each panel and its associated breakout discussion. This organization resulted in conversations from multiple perspectives and enabled participants in several groups to identify concrete next steps. In addition, with each attendee able to participate in two breakout sessions, participants carried forward relevant issues across breakout sessions. Thanks to this cross-pollination, key findings emerged.



Left to right: Kathleen Anderson, Holyoke's Director of Planning and Development; Mayor Elaine Pluta; James Lavelle; keynote speaker Patricia Hoffman; keynote speaker Richard Sullivan; and James Kurose. Photo by Dennis Vandal.



Left to right: James Kurose; Eric Nakajima, Senior Innovation Advisor, Executive Office of Housing and Economic Development, Massachusetts; and James Lavelle. Photo by Dennis Vandal.

Session-by-Session Overview and Discussion

Overview: The Clean Energy Opportunity in Holyoke

Speakers:

James Kurose, Distinguished University Professor, U. Massachusetts Amherst

James Lavelle, Manager, Holyoke Gas & Electric

This session welcomed attendees, provided an overview of the agenda (see Appendix 1), and framed expectations for the workshop. Key points:

- **Working together creates new opportunities and advantages for each of us** – The workshop is motivated by the opportunities for collaboration among HG&E (an innovative, nimble, municipally-owned utility interested in emerging technologies), clean energy entrepreneurs, academic researchers with broad interests, educators, and engaged public and private sector participants. HG&E is anticipating increasing demand for clean, price-competitive energy. Collaborations would take advantage of the resources and expertise resident in each group while meeting the needs of each for knowledge, information, perspective, resources and inputs from others.
- **The goals of the Holyoke Clean Energy Innovation Workshop are to create connections and catalyze relationships** – To that end, participants are urged to learn about each other's expertise and identify specific opportunities for collaboration in entrepreneurial activities, federally-supported partnerships and research/educational programs.
- **This workshop is a beginning** – Follow up activities will include creation of a report to capture key findings and to create a reference point for future work, a survey to gather additional input from attendees, and future Steering Committee meetings focus on next steps. Attendees are encouraged to submit suggestions, offer ongoing participation, and highlight success stories by contacting Brian Beauregard at Holyoke Gas and Electric (bbeauregard@hged.com).



James Lavelle of HG&E and James Kurose of UMass Amherst kickoff the workshop. Photo by Dennis Vandal.

The session concluded with thanks to all the panelists and speakers. A complete list is available on page 3 of this report.

HG&E Power Generation and Distribution Systems: Overview & Capabilities

Speakers:

James Lavelle, Manager, Holyoke Gas & Electric

Brian Beauregard, Electric Superintendent, Holyoke Gas & Electric

This session offered attendees an overview of Holyoke Gas & Electric and in doing so provided perspective on the capabilities, assets and expertise that could be available in a testbed environment.

As one of 41 municipally-owned utilities in Massachusetts, Holyoke Gas & Electric provides electricity to 18,000 customers and gas to 12,000 customers. HG&E also owns and operates its own fiber optic network, offering ISP, data, voice and collocation services to businesses in Holyoke, Chicopee, and Springfield.

Unlike many privately-owned electricity distribution companies, HG&E operates as a vertically integrated electric utility, engaging in generation and transmission as well as distribution activities. Its ownership, management structure, scope and scale enable the organization to explore and experiment with emerging technologies with a minimum of bureaucratic and regulatory hurdles.

Holyoke Gas & Electric generates approximately 65% of its electricity from hydroelectric resources and 85% of electricity from non-carbon sources (the latter includes nuclear entitlements). Its goal is to maximize renewable resources by investing in new capacity, such as the Mueller Road solar array, and by adopting other new technologies. HG&E also looks forward to increasing demand based on economic development in Holyoke, including the Massachusetts Green High Performance Computing Center. Accordingly, HG&E leaders are eager to engage with entrepreneurs, university researchers and policy makers in order to support the advancement of new technologies in diverse areas including:

- Hydro, solar, wind, storage
- Other technologies: geothermal, smart grid, smart meters
- Infrastructure for electric cars

To support HG&E's commitment to adding non-carbon resources and supporting the development of new technologies, its leadership is exploring specific and immediate testbed opportunities that enable:

- Aggressive conservation
- Upgrading and expanding hydro
- Solar
- Piloting new technologies on the HG&E grid on a case-by-case basis. HG&E is particularly interested in working with local companies and/or those interested in locating manufacturing or office space in Holyoke.

Tours: HG&E Hydroelectric Facility at Hadley Falls and the Mueller Road Solar Array

The Hadley Falls Hydroelectric facility is HG&E's largest hydro facility; it generates approximately 250,000 MWh per year. Hydroelectric provide approximately 65% of the electricity generated by HG&E's electric generation portfolio. HG&E actively seeks out new turbine technologies for testing and evaluation as part of its ongoing efforts to capture more energy from its water resources. In addition to the dam, attendees visited the control facility.



This dam on the Connecticut River is part of the Hadley Falls hydroelectric facility. Photo courtesy of HG&E.



Workshop participants learn about the Mueller Road solar array from HG&E and Constellation Energy project engineers. Photo by Dennis Vandal.

The Mueller Road solar array project was under development with Constellation Energy and partially operational as of the Workshop tour. Attendees visited an area that recently began operations, where HG&E executives and engineers explained a number of the technical considerations that went into designing the array. This 3.5 MW facility was completed on December 19, 2011 and another 1 MW solar facility was completed in Holyoke

within the Springdale Industrial Business Park on December 27th.

KEYNOTE: Clean Energy Grand Challenges

Our morning keynote speaker was **Patricia Hoffman**, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, United States Department of Energy, <http://energy.gov/oe/office-electricity-delivery-and-energy-reliability>



Keynote speaker Patricia Hoffman. Photo by Dennis Vandal.

President Obama’s clean energy initiatives challenge the nation to have 80% of its electricity coming from clean energy sources by 2035 and 1 million electric vehicles on the road by 2015. Benefits are expected to include economic development and growth; energy security and reliability through diversified generation and storage; and a reduced environmental impact. Key elements of the federal strategy are:

- Advance grid functionality and flexibility through technology, markets and policy
- Build in security and resiliency.

Generation, transmission, distribution and customer behavior are all important.

This context is supportive of development and deployment of a wide range of clean energy technologies to meet our electricity needs. Flexibility is needed to make the most of this array of emerging technologies. Also, market and policy development go hand in hand with technology development.

Important issues that need to be addressed, include:

- Simulation, modeling and control
- Market development
- Solutions for different response time scales
- Energy storage technologies including community energy storage
- Smart grid including discrete elements, integration, and data to support decisions
- Automated demand response
- Understanding customer/user behavior
- Cybersecurity

Testbeds are important resources for the development and evaluation of new technologies that address these issues. Successful testbeds can be found in Hawaii, California, and Oklahoma; each leverages local attributes.

In addition to opportunities to develop specific technologies, there are significant research opportunities related to the integration of high renewable energy penetration from a systems perspective.

Panel: Public Policy & Advocacy

Description: At the state and federal level what is the policy agenda and what are the policy initiatives that strengthen the environment to spur solutions for energy delivery? What barriers do these policies address?

The panelists were:

- **Eric Nakajima**, Senior Innovation Advisor, Executive Office of Housing and Economic Development, Commonwealth of Massachusetts (moderator)
- **Patrick Cloney**, Executive Director, Massachusetts Clean Energy Center (MassCEC)
- **Susan Reid**, Director, Conservation Law Foundation Massachusetts
- **Peter Rothstein**, President, New England Clean Energy Council

The panelists represented three distinct perspectives within the public policy and advocacy domain. The MassCEC's task is to build the Massachusetts clean energy economy. In that capacity, it is concerned with the entrepreneurial process from ideation to commercialization, including market-development incentives. The Conservation Law Foundation addresses environmental concerns and is moving beyond campaigns to shut down coal-fired power plants to advocate the adoption of new technologies that will reduce greenhouse gas emissions and negative public health impacts while leading to responsible economic development and green, cheap power. The New England Clean Energy Council acts as a voice for clean energy companies, advocates for development of the cluster, and invests in programs to accelerate the clean energy economy.

Massachusetts's energy policy is actively encouraging the development of the clean energy economy, including companies commercializing new technologies and incentives for adoption of those technologies. The MassCEC's 2011 Clean Energy Industry Report² documents the progress to date, the diversity of the industry, and the potential for growth. Policies and regulations to build on this progress are needed to enable competition across all different technologies and to develop new market mechanisms such as demand response.

Given the progress and the diversity of the technologies involved, a key challenge going forward is to find ways to systematically encourage collaboration across organizations and technologies. The HG&E testbed would fit into this overall effort by offering a resource for assessment and integration of new technologies within an existing infrastructure and community.

The panel discussion was followed by a breakout session, which gave all interested participants the opportunity to ask questions, raise issues, and engage each other. As moderator, **Eric Nakajima**, Senior Innovation Advisor, Executive Office of Housing and Economic Development,

² <http://masscec.com/index.cfm/page/2011-Massachusetts-Clean-Energy-Industry-Report/cdid/12401/pid/11170> viewed November 20, 2011.

Commonwealth of Massachusetts, facilitated group introductions that revealed the following interests:

- Public acceptance and outreach/education related to it
- Integration of new technology into the regional grid
- Formulation of state policies to move innovation forward
- Regulatory barriers
- Impact of inconsistent and unreliable funding at the state and federal levels on companies
- How can Holyoke help fund startups?
- What is the mix of resources and efforts available in Holyoke?
- How can the Verizon network be leveraged?
- What are the market constraints on innovation?

Participants were also curious about HG&E's plans for achieving zero-carbon-emissions with storage and its plans for electric vehicles.

Regulatory barriers, as well as policies that could be beneficial and should be advanced, were discussed. These are primarily related to technology and market development as well as the availability of funding for companies. Each of these elements is important to the development of the clean energy economy.

Educational programs are needed to create a culture of clean energy and to train workers for the clean energy economy. Educational institutions from the primary schools to graduate degree programs have roles to play.

Unquestionably, HG&E and others present have the opportunity to play a significant role in the development of the clean energy economy.

Panel: Innovators and Disruptors

Description: Technologies driving innovation in clean energy require prototyping, small-scale trials, and understanding of their utility in the marketplace. Early-stage and established firms would benefit from a “real-world” laboratory for these purposes. Holyoke’s assets, including Holyoke Gas and Electric provide the necessary infrastructure for this environment. What are the emerging technology trends in clean energy and their respective market opportunities relative to Holyoke? How can a “test-bed” in Holyoke advance the development and maturation of these technologies? How would emerging and established clean technology companies benefit from a test bed?

The panelists were:

- **Brian Beauregard**, Electric Superintendent, Holyoke Gas & Electric (moderator)
- **Richard Baxter**, Director of Product Strategy, Premium Power
- **Matthew Commons**, Chief Financial Officer, FloDesign Wind Turbine
- **Throop Wilder**, President, 24M

A key challenge is that the industry is unforgiving of failure and wary of the risks associated with adopting new technology. This panel brought together entrepreneurs leading companies at stages ranging from research to early deployment to discuss how a HG&E testbed could help them advance their technologies and provide the validation needed as a precursor to wide spread adoption. Emerging clean energy technologies and companies require prototyping and a real

world “laboratory” to make progress. An HG&E testbed that allows access to and collaboration with its expertise and assets could be precisely such a “laboratory.”

Municipal utilities and coops are seen as desirable partners because they are easy to work with, deploy technology quickly, are focused on customer services, and make good long-term partners. The ability to make decisions quickly was stressed as critical. HG&E’s decision making is well-suited to this, with Brian Beauregard and Jim Lavelle able to say “yes” or “no” to requests. HG&E was also cited as having a desirable profile as a partner based on its clear public support for renewable energy technologies, compatibility with funding programs, vertical integration and portfolio of capabilities.

A testbed would offer innovators and disruptors opportunities to conduct research and development activities that would yield an understanding of technology performance in a real-world context including integration issues and customer needs.

The panel discussion was followed by a breakout session, which gave all interested participants the opportunity to ask questions, raise issues, and engage each other. As moderator, **Brian Beauregard**, Electric Superintendent, Holyoke Gas & Electric, facilitated group introductions that revealed the following interests:

- Integrating new technologies into the grid while keeping prices low
- Connecting with clean energy companies throughout Massachusetts
- Testing new technologies in the real-world
- Impact of electric vehicles on the infrastructure
- Secure handling of data generated by testbed experiments
- Leveraging a testbed and regional educational institutions for workforce development
- Structuring university researcher collaborations with utilities and the industry (with or without a testbed)

The discussion ranged across many issues including HG&E’s plans for its own development, research and technology development collaborations, and issues related to technology integration into the grid.

There was great interest in the testbed, in working with HG&E, and in understanding how HG&E selects new technologies. Data sharing was seen as an immediate basis for collaborations. In general, HG&E looks for new technology with a five-to-ten-year payback and a minimum 15 to 20 year life. There is a willingness to stretch these criteria where it is possible to combine technologies to bring down costs.



Keynote speaker
Richard Sullivan. Photo
by Dennis Vandal.

The discussion made clear that a HG&E testbed would be attractive to companies and academic researchers based on the engineering expertise it would bring to bear, its hydro and other resources, and the data it collects. There was broad interest in HG&E making its data available to researchers and to exploration of opportunities for collaboration based on data.

KEYNOTE: Massachusetts Clean Energy Landscape

*Our lunch keynote speaker was **Richard Sullivan**, Secretary, Executive Office of Energy and Environmental Affairs, Commonwealth of Massachusetts, <http://www.mass.gov/eea/>*

Secretary Sullivan praised Holyoke and Mayor Pluta’s commitment to clean energy and the city’s activities as a Commonwealth “Green Community.”

Noting HG&E's contributions he highlighted the role of hydroelectric resources and the new Mueller Road solar array, which began operating the day of the workshop as the largest such facility in the Commonwealth. More broadly, he placed the city's and HG&E's efforts within the context of Massachusetts' efforts:

- The Commonwealth is implementing the most aggressive greenhouse gas reduction effort in the country. As a former mayor, he recognized the importance of local commitments, leadership and action in this effort.
- Massachusetts' combination of laws, policies and programs create and encourage focus on opportunities to grow the clean energy economy while improving greenhouse emissions.
- Governor Patrick's 2008 policies are working. The Green Communities Act continues to be a great resource for communities.
- Massachusetts was recently recognized at the National Press Club as leading the way to the clean energy economy.

Panel: Regulatory

Description: What are the regulations that affect industry's ability to deploy clean energy technologies in novel ways?

The panelists were:

- **Eric Wilkinson**, External Affairs, ISO-New England (moderator)
- **Patricia Hoffman**, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy (DOE)
- **Dwayne Breger**, Director, Renewable and Alternative Energy Development, Massachusetts Department of Energy Resources (DOER)

It is important for clean energy companies that regulation at the national and state levels encourage establishment of a marketplace for renewable energy in general. In Massachusetts, the Renewable Energy Portfolio Standard and the Green Communities Act are contributing to market development and are encouraging investment in the sector. At both the state and federal levels, regulatory innovation is an important tool for encouraging companies and investors to develop new technology and business models.

Regulatory challenges include better synchronization of regulatory timelines with technology development timelines and encompassing new classes of technology on a timely basis.

Crafting effective incentives to provide financing for projects is another challenging area in light of uncertain and short-term energy price/revenue predictability and investor requirements for long-term price certainty, consistent incentives, and thoughtful structuring of new approaches such as net metering.

Nonfinancial regulatory issues include site selection for transmission as well as wind and other technologies.

The US Department of Energy is working to coordinate these issues across all federal agencies and intends to extend that integrative effort to the states in the future.

The panel discussion was followed by a breakout session, which gave all interested participants the opportunity to ask questions, raise issues, and engage each other. As moderator, **Eric**

Wilkinson, External Affairs Representative, ISO-New England, facilitated group introductions that revealed the following interests:

- Assessing the real value of innovation. How and when can an innovation go to a regulatory body?
- Defining and specifying non-wired connections to the grid, For example batteries need not be electrical but do need to be incorporated.
- Policies are also needed to further the use of thermal and electrical storage at homes.

Utilities and transmission companies are bound by some tariffs that were put in place to protect companies and customers from past problems. These need to be reframed to be friendlier to new needs and to encourage innovation.

System integration and integration of renewables into the grid raises technical challenges. From ISO New England's perspective the first priority is grid reliability.

Smart meters have the potential to give more control to the customer by providing information that can be used to change behavior. Dynamic pricing will be needed to incentivize these behavior changes.

Availability of HG&E transmission and substation data was of interest. The group discussed the complexities of releasing this data. For example, HG&E is not allowed to release certain bulk power system information according to ISO market rules.

Panel: Investment

Description: This panel is focused on understanding the factors in Holyoke and the Pioneer Valley that attract investment (public and private), drive company formation, and support opportunities/challenges associated with the region's investment ecosystem. The Massachusetts Green High-Performance Computing Center, Holyoke Gas & Electric, and broadband (fiber to the curb and backbone) will provide infrastructure to support company investment in the Pioneer Valley. From an investor's perspective (both private and public), what attracts clean energy investment to Holyoke? What are the kinds of projects that the state wants to invest in and is programmed to invest in? How does the venture capital community (angel, institutional, corporate) view investment opportunity in the region? Where do companies fit into this framework? What are the barriers to investment? What are the additional local and regional assets that would attract investors? What existing incubation activities successfully model investment behaviors? What challenges do these initiatives face?

The panelists were:

- **Arif Padaria**, Managing Director of Investments, Massachusetts Clean Energy Center (moderator)
- **Zaid Ashai**, General Partner, Point Judith Capital
- **Daniel Hullah**, Principal, Rockport Capital
- **James Kenney**, VP Lending, MassDevelopment
- **David Miller**, Executive Managing Director, Clean Energy Venture Group

Investment is required to fund clean energy companies beginning with research and development through to growth/commercial deployment. The panelists observed that there is currently an imbalance of investment opportunities, with more investment worthy companies seeking funding than can be served by the available capital. There is concern that the shortage of early stage

capital is impacting national competitiveness as investors are looking to India and China as better bets.

Investment decisions are complicated by the long development times required by many clean energy companies, fluctuations in energy prices, and competitions from natural gas. New approaches may be needed for both early stage equity funding and later stage debt financing to make the most of opportunities. As a gateway city, Holyoke is of special interest to MassDevelopment.

Investors are looking for scalable projects that solve significant problems and have the potential for 'huge' ROI to offset risks. As well, teams and technical expertise are both critical considerations in investment decisions. An ongoing challenge for small venture funds is the downstream capital requirements of companies as they make progress.

The panel discussion was followed by a breakout session, which gave all interested participants the opportunity to ask questions, raise issues, and engage each other. As moderator, **Arif Padaria**, Managing Director of Investments, Massachusetts Clean Energy Center, framed the discussion by noting that the breakout session was an occasion to see how this opportunity in Holyoke could help firms in attendance and that the discussion would inform next steps in the efforts to create a dynamic environment that would support emerging cleantech and energy companies. He encouraged the companies that were present to think along the entire technology/business development process – from inception to large-scale commercialization and challenged them by asking what challenges and opportunities they foresaw.

Discussion focused on the participants' challenges of matching technology/company development stages with funding programs and sources. A number of resources were discussed including venture capital, financing based on receivables, and the Clean Energy Center's investment programs (<http://www.masscec.com/index.cfm/page/Programs/pid/11174>), which are designed to span all phases of development from inception to expansion.

HG&E was asked about its interest in investing in emerging companies. Jim Lavelle indicated that on a case-by-case basis they are willing to facilitate connections between a company and potential investors. HG&E does not typically invest, although it would be interested in becoming an equity partner if the investment provided a long-term source of power.

Panel: University Collaborations – Research & Education

Description: Based on emerging industry trends at the global, regional, and local levels, what are the ways that researchers can collaborate with industry to align research agendas to address clean energy market opportunities? What are the points of intersection for shared opportunity?

- **Jim Kurose**, Distinguished University Professor, University of Massachusetts Amherst (moderator)
- **Brian Beauregard**, Electric Superintendent, Holyoke Gas & Electric
- **James Manwell**, Professor of Mechanical and Industrial Engineering; Director, Renewable Energy Laboratory, University of Massachusetts Amherst
- **Prashant Shenoy**, Professor of Computer Science, University of Massachusetts Amherst
- **John Williams**, Professor, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology

The clean energy sector offers many opportunities for industry-academic collaboration for educational and research programs in a wide range of fields.

Some educational connections are already in place with HG&E offering internships to engineering students. HG&E is interested in adding research projects within academic fields to expand its work with students. Current educational programs operate relatively isolated from one another. The testbed has the potential to be a real-world classroom for undergraduate and graduate students alike.

Clean energy offers research opportunities in areas such as smart buildings as well as renewable technologies. Important areas span the generation, transmission and distribution of electricity and include smart buildings, smart grids, simulation, renewables, storage, privacy and security. Many of these areas are interdisciplinary and call for collaboration across different academic departments as well as between industry and academic researchers. An HG&E testbed could be an attractive resource for such teams. More broadly, HG&E data was seen as a key asset by both academic and industry researchers.

Challenges of building a testbed that is useful to academic researchers include HG&E's need for reasonable business case and designing research so that it does not interfere with HG&E's customers or the production environment.

The panel discussion was followed by a breakout session, which gave all interested participants the opportunity to ask questions, raise issues, and engage each other. As moderator, **James Kurose**, Distinguished University Professor, University of Massachusetts Amherst, facilitated group introductions that revealed the following interests:

- Cooperation on educational programs within and among educational institutions
- Funding for research
- More education on hydro power (and renewables)
- Internships and broader education
- Massachusetts Green High Performance Computing Center as a system
- System design and multidisciplinary models
- How can researchers access HG&E data?
- How can HG&E tap into academic resources?

The group then decided to focus remaining discussion on data and cooperative education.

The discussion of data revealed interest in a wide range of data including solar generation, residential loads, industrial loads, SCADA data, pricing data, generation and consumption data. Possible uses include transmission analysis, modeling, education, and policy development. Brian Beauregard explained the challenges HG&E faces in making data available. For example, there are both privacy and security concerns that require expensive and time-consuming data extraction and anonymization.

Pecan Street Inc. (<http://www.pecanstreet.org/>) was cited as good model for cooperation between a municipal utility, university and the local community.

The discussion on cooperation on education identified "seamless talent delivery" as a long-term aspiration. In the near term, there is interest in finding ways to facilitate collaboration within UMass, across MGHPCC partner schools, and including other regional institutions such as community colleges.

The discussion concluded by committing to two future meetings:

- HG&E and academic researchers will meet to discuss data collection
- UMass, ISO New England, and HG&E personnel will work together to set an open meeting to discuss development of an interdisciplinary course.

Findings

Holyoke Gas & Electric is exceptionally well-suited to partner with cleantech and energy entrepreneurs.

- Entrepreneurs cited HG&E's responsiveness, size, vertical integration, municipal utility status and in-depth expertise in a broad range of renewable technologies as important attributes.

An HG&E testbed can offer clean energy entrepreneurs and researchers important resources for advancing their own projects and interests, while helping HG&E itself develop, evaluate, and deploy new technologies:

- Entrepreneurs expressed excitement about opportunities to demonstrate and test new technology on HG&E's system, and to work with the HG&E team. Benefits of this collaboration extend beyond technical validation to better understanding of customer needs and needed attributes in commercial products.
- Researchers and entrepreneurs alike were excited about the opportunities provided by access to the "real-world" data that HG&E can offer, as an operating utility. HG&E, in turn, is eager to work with researchers and entrepreneurs in mining and fully exploiting this data.

Additional crosscutting observations:

- Educators and workforce development specialists expressed interest in creating new educational programs that would provide "seamless talent development" for the clean energy economy in general and to testbed activities in particular.
- Organizations interested in clean-energy-related economic development stand to benefit as the testbed attracts technology companies (both new and established) to the region and raises opportunities for competitive differentiation.
- Interests of the individual stakeholder groups were often complementary, offering opportunities for collaboration.
- State and federal programs, regulations and policies can significantly encourage or discourage development of energy technologies. Massachusetts' commitment to building its clean energy economy and Holyoke's participation as a Green Community offer advantages to new and emerging ventures.
- New ways to educate, empower, and incent changes in the behavior of electricity consumers (home and business) are needed to maximize the value of cost effective carbon reducing energy technologies. Demand-side activities were seen as a particularly fruitful area for future growth.

The Massachusetts Green High Performance Computing Center (MGHPCC) is a new and exciting institution that enhances HG&E's visibility, highlights its green energy portfolio, and offers a vehicle for industry-university collaboration.

For more background, visit the Holyoke Clean Energy Workshop Web site:

http://www.cs.umass.edu/energy_innovation_workshop/index.htm

Next Steps

In the panels and breakout discussions, three areas of significant common interest were identified for follow-up: each offering opportunities for immediate collaboration as well as longer term potential:

- **Data** – HG&E has data of great interest to researchers and technology developers. Brian Beauregard will organize a series of follow-on meetings at which HG&E engineers will discuss data that is, or could be, made available as well as seek information from potential data users about their interests.
- **Education** – Clean energy technologies will demand a workforce with different/additional skills and knowledge. This will create employment opportunities from the community college through graduate education levels. Jim Kurose will convene those interested in developing programs to address this anticipated need.
- **Testbed** – The workshop showcased testbed opportunities with HG&E, and HG&E's willingness to partner in testbed activities. Within the first month following the workshop, more than 10 proposals have been made to HG&E for testbed activities. Brian Beauregard is coordinating meetings with those interested in development of the testbed from multiple perspectives, including HG&E, investors, entrepreneurs and researchers.

Other areas that are anticipated for future discussion include regulation, policy and investment to enable the development of clean energy technologies and the clean energy economy.

Holyoke Clean Energy Workshop website:

http://cs.umass.edu/energy_innovation_workshop

Appendix One: Workshop Agenda

WEDNESDAY, NOVEMBER 9

2:00pm Registration

2:30pm Welcome & Opening

"The Clean Energy Opportunity in Holyoke"

- **James Kurose**, Distinguished University Professor, Department of Computer Science, University of Massachusetts
 - **James Lavelle**, Manager, Holyoke Gas & Electric
-

2:45pm "The Holyoke Gas & Electric power generation and distribution systems: overview & capabilities"

- **James Lavelle**, Manager, Holyoke Gas & Electric
 - **Brian Beauregard**, Electric Superintendent, Holyoke Gas & Electric
-

3:45pm Tour of Holyoke Gas & Electric

- **James Lavelle & Brian Beauregard**, Holyoke Gas & Electric
 - Tour of Hadley Falls hydroelectric facility
 - Tour of Mueller Road solar array construction site
-

5:30pm Program Ends for the Day

THURSDAY, NOVEMBER 10

8:15am Registration/ Continental Breakfast

9:00am Welcome & Opening

- **Elaine Pluta**, Mayor, City of Holyoke

"The Purpose of the Clean Energy Innovation Workshop"

- **James Kurose**, Distinguished University Professor, Department of Computer Science, University of Massachusetts
 - **James Lavelle**, Manager, Holyoke Gas & Electric
-

9:20am Keynote: "Clean Energy Grand Challenges"

- **Patricia Hoffman**, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy (DOE)

9:45am Panel #1: "Public Policy & Advocacy"

- **Moderator: Eric Nakajima**, Senior Innovation Advisor, Executive Office of Housing and Economic Development
 - **Patrick Cloney**, Executive Director, Massachusetts Clean Energy Center
 - **Susan Reid**, Director, Conservation Law Foundation Massachusetts
 - **Peter Rothstein**, President, New England Clean Energy Council

10:25am Panel #2: "Innovators and Disruptors"

- **Moderator: Brian Beauregard**, Electric Superintendent, Holyoke Gas & Electric
- **Panelists:**
 - **Richard Baxter**, Director of Product Strategy, Premium Power
 - **Matthew Commons**, CFO, FloDesign Wind Turbine
 - **Paul Jacob**, Executive Vice President of Marketing & Trading, Free Flow Power Corporation
 - **Throop Wilder**, President, 24M

11:05am Break

11:20am Breakout Session #1: "Innovators and Disruptors"

- **Moderator:** Brian Beauregard, Holyoke Gas & Electric

Breakout Session #2: "Public Policy & Advocacy"

- **Moderator:** Eric Nakajima, Executive Office of Housing and Economic Development

12:30pm Lunch / Lunch Keynote "Massachusetts Clean Energy Landscape"

- **Richard Sullivan**, Secretary, Executive Office of Energy and Environmental Affairs

1:30pm Panel #3: "Regulatory"

- **Moderator: Eric Wilkinson**, External Affairs Representative, ISO-New England
- **Panelists:**
 - **Patricia Hoffman**, Assistant Secretary, Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy (DOE)
 - **Dwayne Breger**, Director, Renewable and Alternative Energy Development, Massachusetts Department of Energy Resources (DOER)

2:10pm Panel #4: "Investment"

- **Moderator: Arif Padaria**, Managing Director of Investments, Massachusetts Clean Energy Center
- **Panelists:**
 - **Zaid Ashai**, General Partner, Point Judith Capital
 - **Daniel Hullah**, Principal, Rockport Capital
 - **James Kenney**, VP Lending, MassDevelopment
 - **David Miller**, Executive Managing Director, Clean Energy Venture Group

2:50pm Panel #5: "University Collaborations - Research & Education"

- **Moderator: James Kurose**, Distinguished University Professor, Department of Computer Science, University of Massachusetts
- **Panelists:**
 - **Brian Beauregard**, Electric Superintendent, Holyoke Gas & Electric
 - **James Manwell**, Professor of Mechanical and Industrial Engineering, Director, Renewable Energy Research Lab, University of Massachusetts
 - **Prashant Shenoy**, Professor of Computer Science, University of Massachusetts
 - **John Williams**, Professor, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology

3:30pm Break

3:45pm Breakout Session #3: "Regulatory"

- **Moderator:** Eric Wilkinson, ISO - New England

Breakout Session #4: "Investment"

- **Moderator:** Arif Padaria, Massachusetts Clean Energy Center

Breakout Session #5: "University Collaborations - Research & Education"

- **Moderator:** James Kurose, University of Massachusetts

4:55pm Closing Remarks: Workshop Summary & Next Steps

- **James Kurose**, Distinguished University Professor, Department of Computer Science, University of Massachusetts
- **James Lavelle**, Manager, Holyoke Gas & Electric

5:00pm Closing Reception

Appendix Two: Presentation from DoE Asst. Secretary P. Hoffman



U.S. Department of Energy

Office of Electricity Delivery and Energy Reliability

Maximizing Renewable Energy in the US Electric Grid

Patricia Hoffman

Assistant Secretary, Office of Electricity Delivery and Energy Reliability

November 10, 2011

www.oe.energy.gov

U.S. Department of Energy – 1000 Independence Ave., SW Washington, DC 20585

Why Renewable Electricity Generation

Economy—
economic development and
growth; energy costs

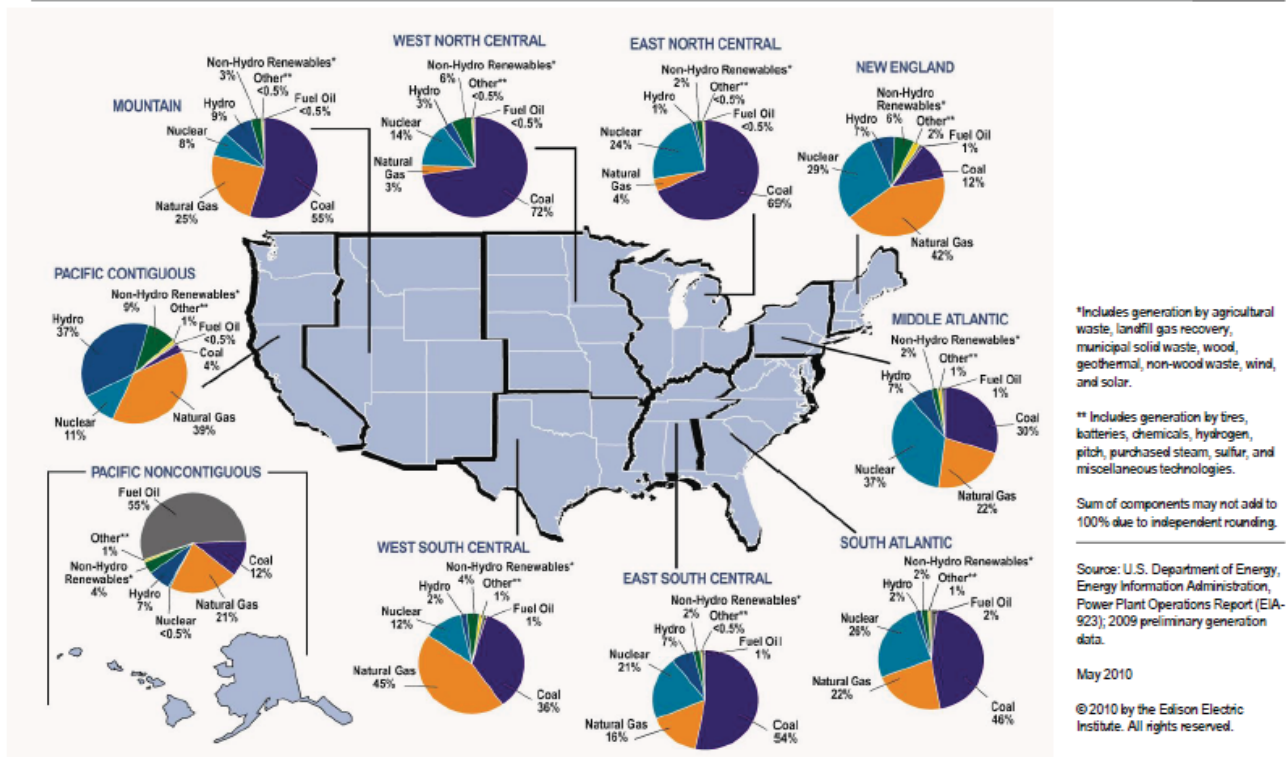
Security—
foreign energy dependence,
reliability, stability

Environment—
local (particulates), regional
(acid rain), global (GHGs)

**President Obama's
clean energy
initiatives to reach:**

- › *80% of electricity from clean energy sources by 2035*
- › *1 million electric vehicles on the road by 2015*

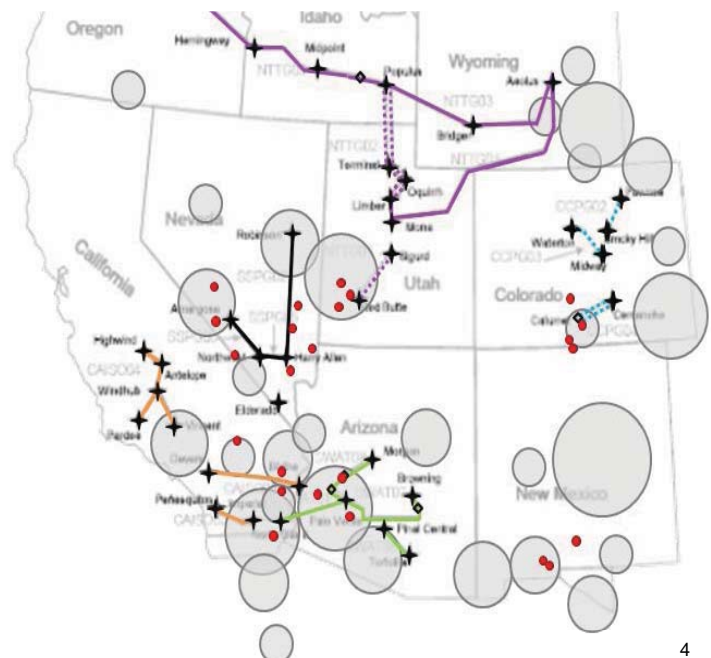
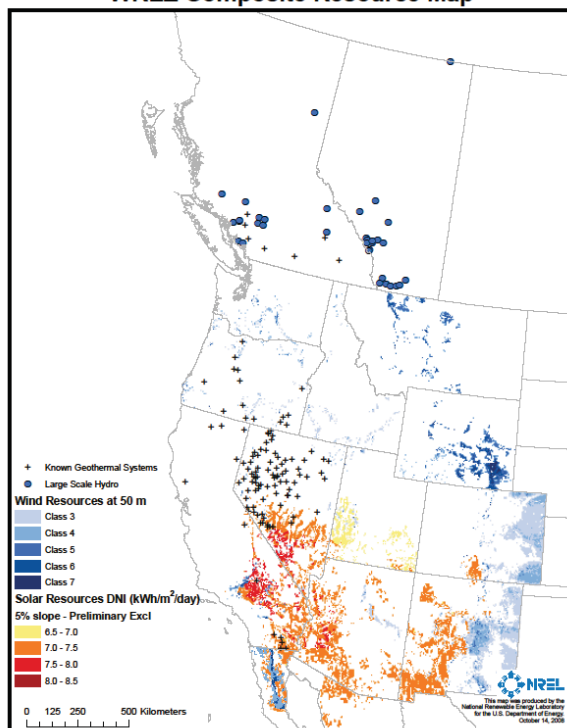
Different Regions of the Country Use Different Fuel Mixes to Generate Electricity



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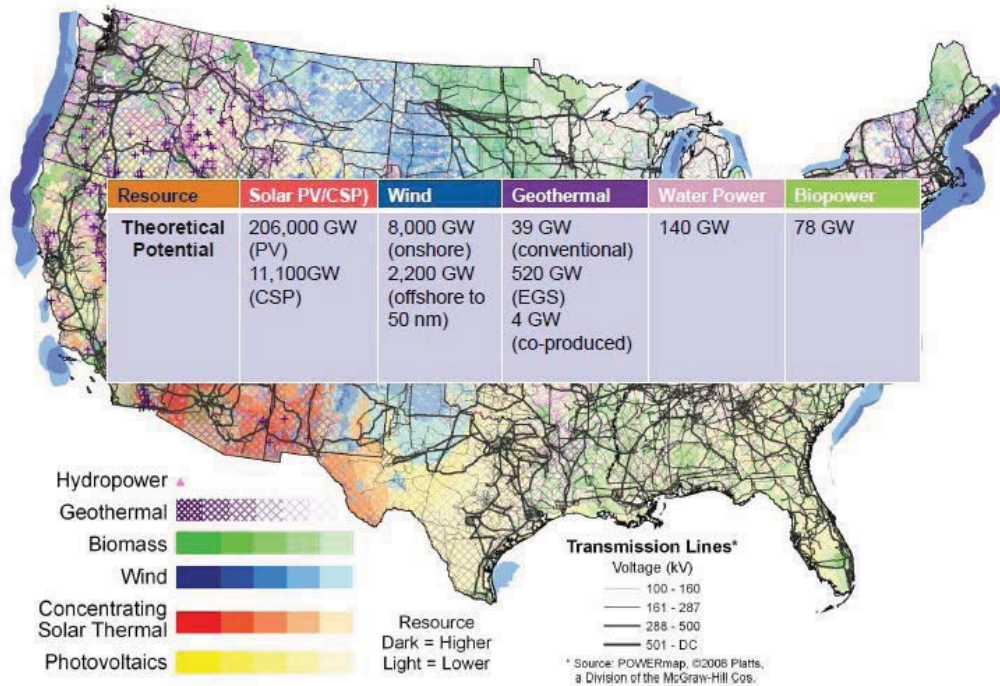
Transmission and Clean Energy Clean Diversified Generation Fleet

WREZ Composite Resource Map



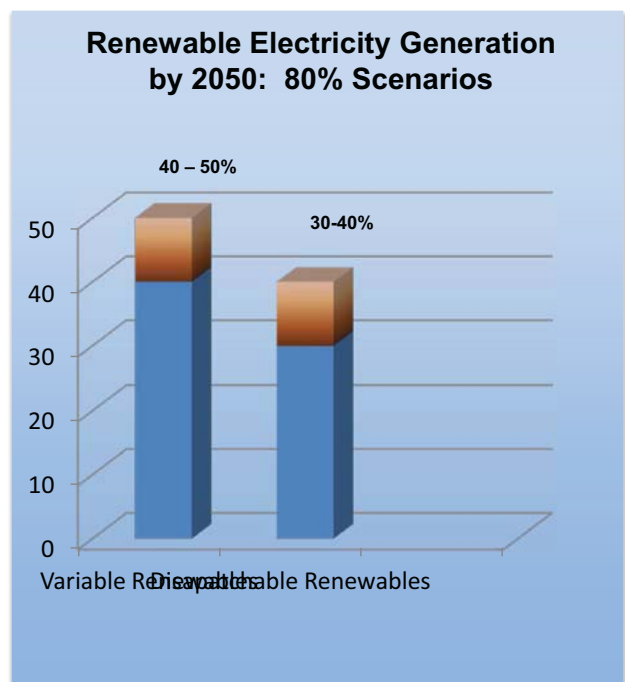
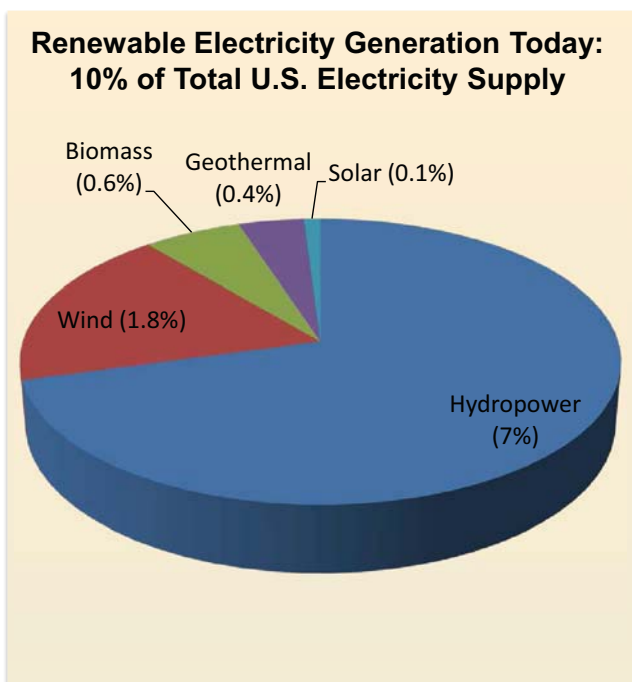
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U.S. Renewable Resources



Source: NREL

Renewable Electricity Futures Study

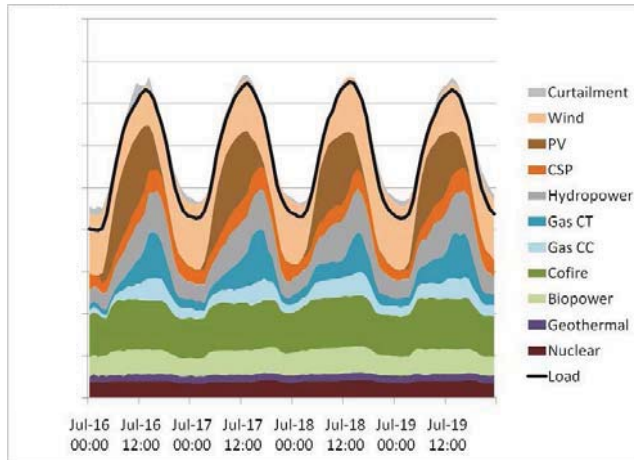


Emerging Technologies

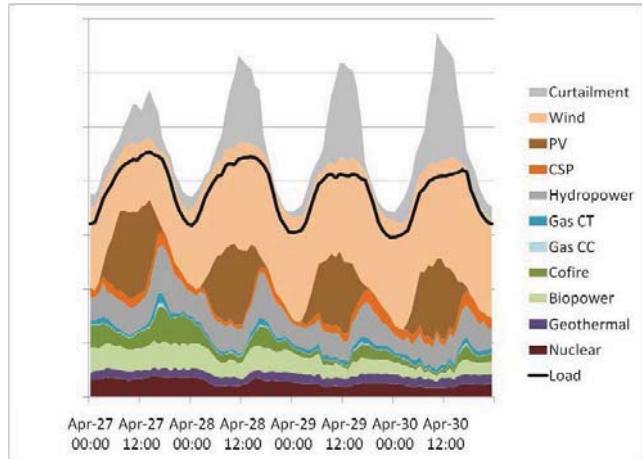
Potential to displace commercial tech up to 4% each

Core 80% Renewable Electricity Scenario

Dispatch stack:
summer peak in 2050



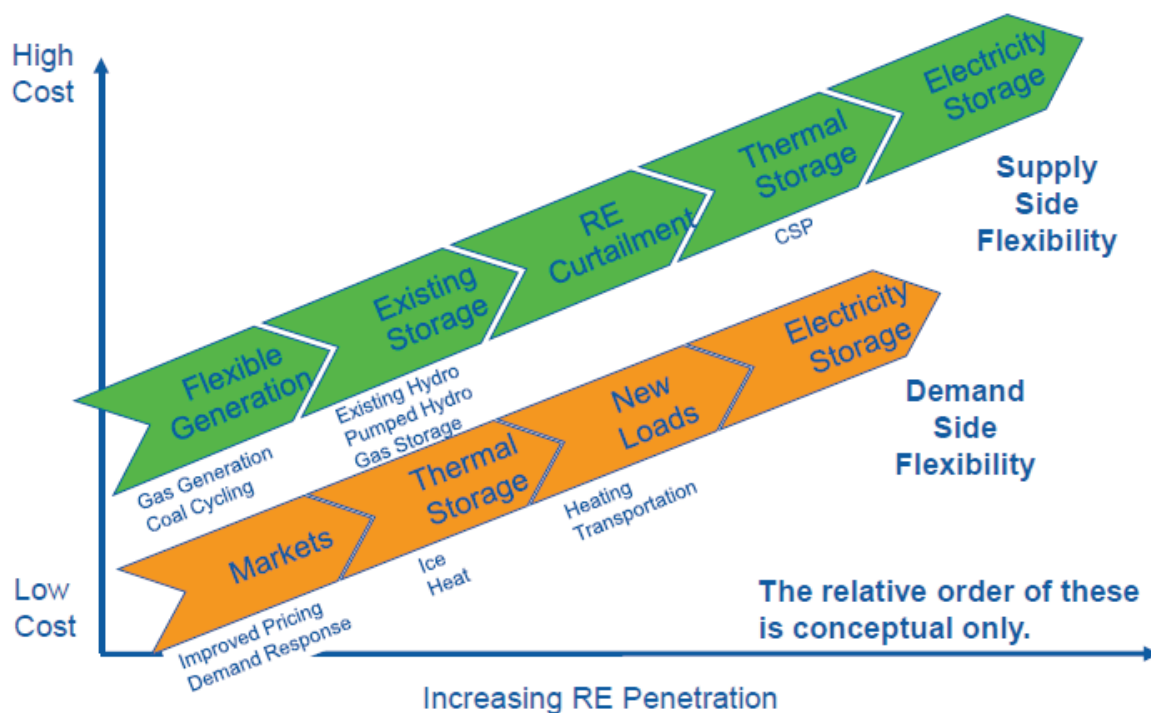
Dispatch stack:
spring (off-peak) in 2050



Source: Renewable Electricity Futures Study: Executive Summary, October 2010

7

Enhanced Flexibility Needed for Electric Grid with Increasing RE Penetration

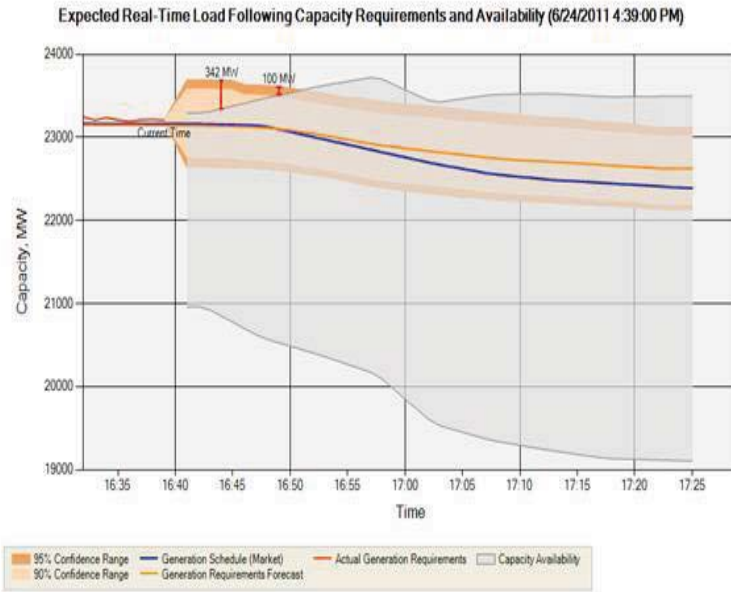


Source: NREL

8

Simulation, Modeling, and Control

Integration of forecasting and renewable energy production tools into grid resource planning and operation tools.

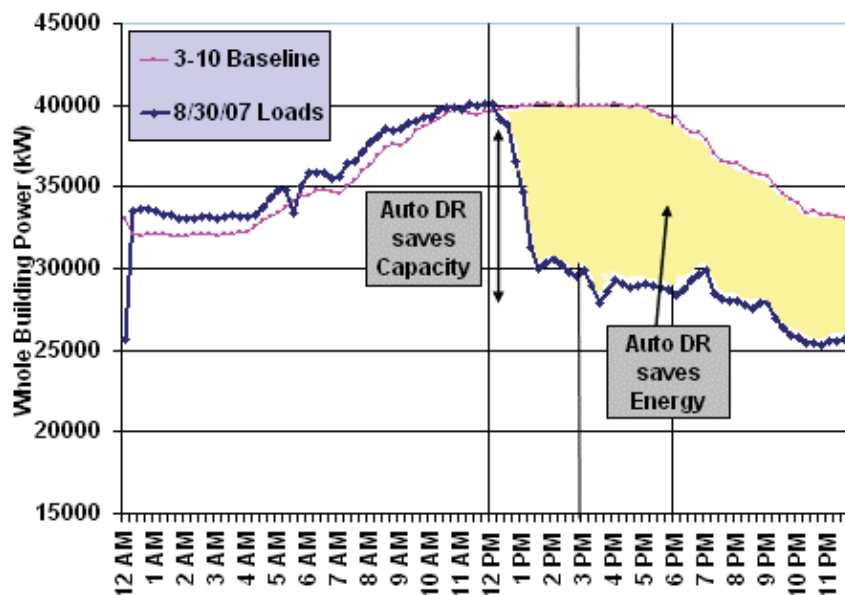


- Forecasting generation capacity and ramp ranges needed to balance the system (orange bands)
- Incorporating all sources of uncertainty/variability: wind and solar generation and demand.
- Example Outcome: predicting generation deficiency above the available range (gray band).
- Tool is installed at the CAISO Control Center to help real-time dispatchers anticipate and address ramping needs. Planned deployment to other ISO's.

9

Automated Demand Response Saves Capacity and Energy

Electric Load Profile of Auto DR Participants on 8/30/2007



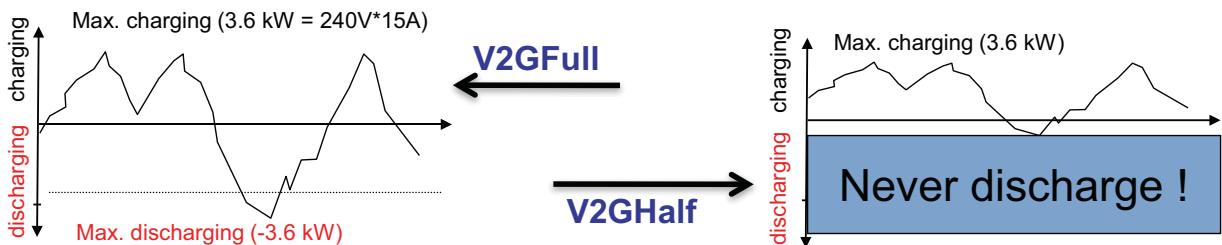
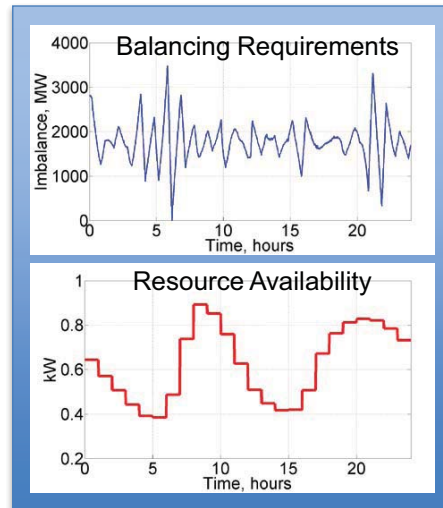
Source: PG&E

10

New Electric Vehicle Load as a Grid Resource

Use plug-in hybrid electric vehicles to aid in renewable generation source integration

- Determine balancing requirements for 10 GW of additional wind
 - NWPP oriented
 - Represents 12% RPS requirement
- Determine resource availability
 - Use 2001 NHTS Data for driving habits and population information
 - Use V2GHalf and V2GFull charging



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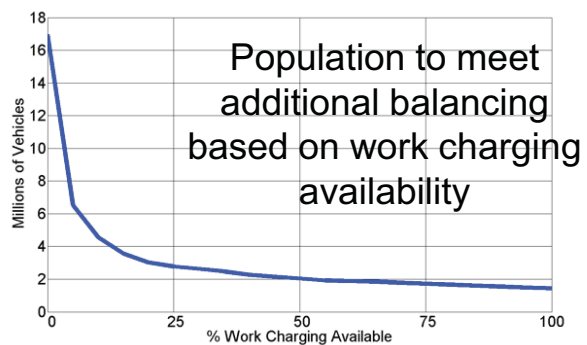
New Electric Vehicle Load as a Grid Resource

Completed report with the following key insights

- All new balancing requirements for 10GW of new wind capacity in NWPP by 2020 could be furnished by electric vehicles
- Small reduction in number of vehicles required when transitioning from V2GHalf to V2GFull
- Solution insensitive to battery size
- Availability of infrastructure during day is essential
- Only 10% of all vehicles need to be able to charge during the day to capture 80% of the value of day-charging

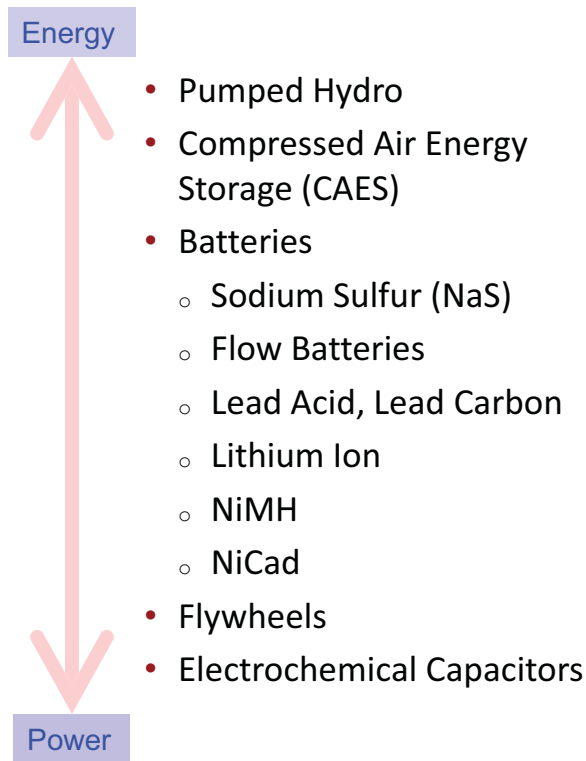
% of NWPP vehicle fleet to meet new balancing requirements

Charging type	Battery Size Scenario			
	PHEV 33		BEV 110	
	Home only	Home and Work	Home only	Home and Work
V2GHalf	180%	13%	126%	12%
V2GHalf and V2GFull	132%	10%	103%	8%
V2GFull	113%	8%	94%	8%



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Energy Storage Technologies



Pumped Hydro (Taum Sauk)
400 MW

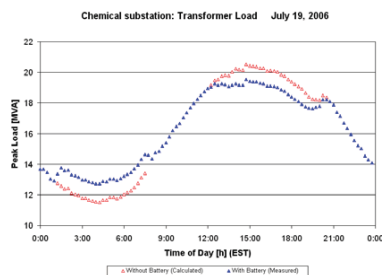


Sodium Sulfur Battery
2 MW



Flywheels
1 – 20 MW

Utility-Scale Storage on the Grid



AEP APPALACHIAN POWER
A unit of American Electric Power

Started Operation on June 26th, 2006

NGK Insulators Ltd
S&C Electric Co
DOE / SANDIA



3x2MW/6hr
In 2009

Concept

Storage defers upgrade;
Opens possibility for regional
islanding, renewables

First 1MW/6hr in 2007, 3 in 2009
+ Duke, First Energy, PG&E

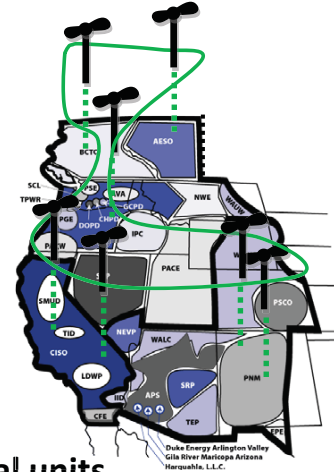
NaS, Flow Batteries, Lead Carbon

3 ARRA Projects -- 53MW

Western Area Interconnect Balancing Area Study

Balancing Area Collaboration Enables More Renewables at Lower Cost

- Study will determine reduced production and balancing costs due to WECC BAs consolidation
- WECC Variable Generation Sub-committee coordinated
- Wind and solar penetration scenarios – 11%, 22%, 33% of WECC energy demand
- Preliminary results for 11% case
 - savings range from \$210 to \$400 million/yr for thermal units production cost
 - average hourly saving of 5 GW of load following capacity and 1 GW of regulation capacity
- Study finished in Spring 2012

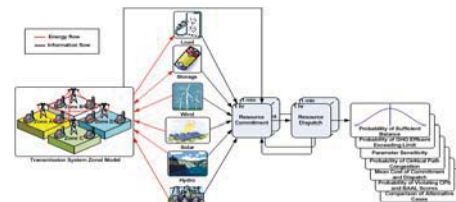


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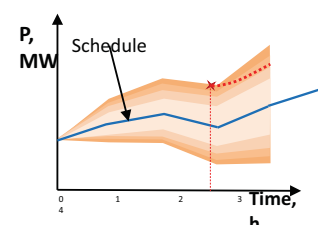
Planned R&D to Address High RE Penetration

OE/EERE collaboration areas on system integration of RE

- Better forecasting to ensure reserves and manage uncertainty
- Developing comprehensive sub-hourly and real-time models for simulation of grid operations and for planning
- Improving scheduling, dispatch and control systems for managing uncertainty
- Developing coordinated wide-area control approaches and algorithms
- Increasing flexibility of existing grid assets, DR, and storage to facilitate RE integration
- Examination of multi-terminal HVDC/AC for offshore wind development
- Adapting foreign RE integration and grid operations experience to the U.S. where prudent
- Characterizing technical issues with potential to affect grid regulatory policies and practices



Renewable Integration Model

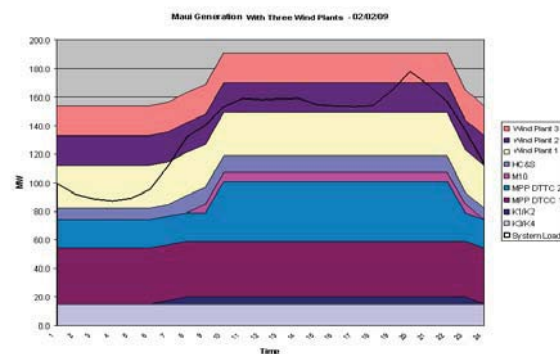
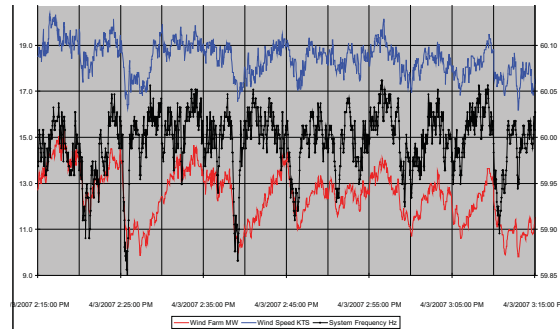


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Hawaii Case Study

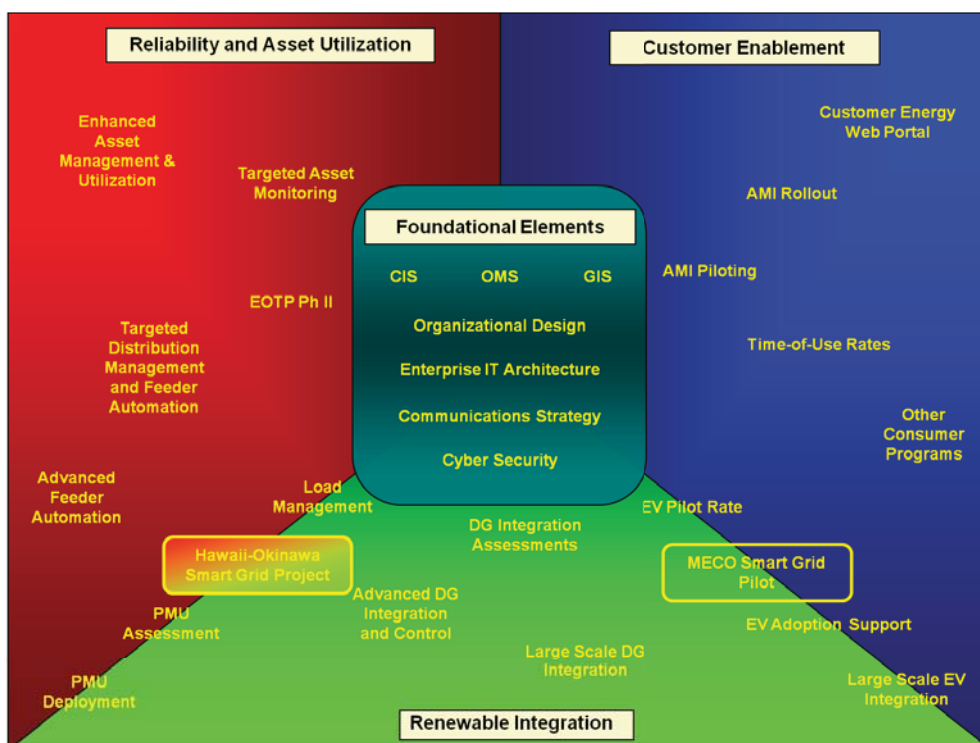
Issues Facing Hawaii Grids

- Balancing and Frequency Regulation
- Ride-Through
- Anti-Islanding
- Reserve Requirements
- Excess Energy



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Hawaii Case Study: Smart Grid Approach to Island Grids



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