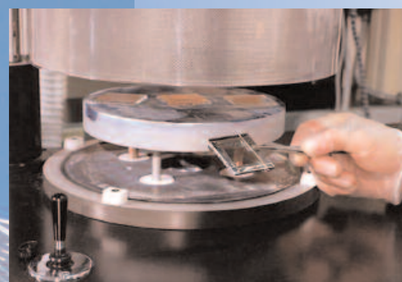
Poised for Profit in Clean Energy **Report**



Powering Up the Smart Grid:

A Northwest Initiative for Job Creation, Energy Security and Clean, Affordable Electricity

A Special Report from
Climate Solutions

By Patrick Mazza
Research Director

www.climatesolutions.org

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About This Paper

In 2001 and 2003 Northwest energy and economic development organizations joined in the Poised for Profit partnerships to identify the region's leading opportunities for developing clean energy technology industries. This paper focuses on practical steps to fully realize the potential of one of the top prospects uncovered by Poised for Profit, smart energy, the convergence of information technology and electric power. The paper is the outcome of a year-long collaborative process that began in summer 2004 which engaged regional and national energy and economic development experts in interviews, meetings and peer reviews. Following is a partial listing of people who contributed their insights and expertise to this effort. The listing in no way indicates endorsement of this paper or the proposals it makes. Climate Solutions takes all responsibility for the content and policy positions of this document, and for any errors.

Climate Solutions extends its grateful appreciation

to all who participated in developing this paper, and looks forward to your continued involvement in unfolding the smart grid vision it details.

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Executive Summary

Fast forward to a sizzling summer afternoon on the Western power grid sometime in the not too distant future. A main Oregon-California transmission line is sagging under stress. Inch by inch it sinks until a high voltage spark jumps toward a nearby tree branch with a crackle and flash, shutting down the line and cutting off much of the power flow from the Northwest to the Golden State. In the old days, before the grid was rebuilt, this would have meant a blackout. It did twice in 1996. But now the smart grid kicks into action. The sudden drop in juice flowing to the California grid comes as an instantaneous signal to literally millions of refrigerators, hot water heaters, air conditioners and other appliances to cycle down demand. Networks of small-scale local generators distributed throughout the affected grid receive signals to come on line and provide power supplies to stores, offices and factories. At the same time a sophisticated grid-wide control system, senses the trouble and scales back Northwest generation to preserve system stability. The combination relieves the grid long enough to bring in replacement power from the Southwest, averting a blackout. The lights stay on and the economy continues to function unaffected. This future is not only possible – It is coming.

Smart energy technologies provide solutions to grid problems.

A host of new smart energy devices and systems are emerging that can take pressure off overloaded grid infrastructure and power costs, dramatically improve grid reliability and security, and accelerate the growth of cleaner power generation.

Smart energy is the application of digital information technology to optimize the electrical power system. The smart grid is the product of applying smart energy technology to electrical power delivery and generation. Smart energy technologies are beginning to transform the power network into a smart grid capable of meeting 21st century economic, security and environmental challenges. But the smart grid still faces hurdles, in particular the need for extensive field testing to prove new energy systems and regulatory reform to remove financial disincentives to adopting new technologies.

A host of new smart energy devices and systems are emerging that can take pressure off overloaded grid infrastructure and power costs, dramatically improve grid reliability and security, and accelerate the growth of cleaner power generation.

Places that lead in smart grid deployment will gain a competitive edge in the smart energy industry and build their overall employment base.

The smart energy industry already accounts for $15 billion in annual sales. The Pacific Northwest is a global center with a $2 billion share of the industry and a series of world-class smart energy companies marketing around the world. A partnership of leading Northwest economic development, energy and research organizations identify smart energy as the region's leading opportunity to develop a job-rich energy technology sector on the scale of current regional leaders such as aerospace and computers.

The Northwest has a huge economic interest in breaking through smart grid deployment barriers. If the region sets a high priority on accelerating the transition to the smart grid, the effort will demonstrate the value of new technologies as well as regulatory and financial models that provide incentives for all players.

Regional smart grid success will create launching pads for Northwest smart energy companies to build their global marketplace leadership and generate new jobs in the region. Power reliability and rate control offered by smart energy technologies will also help protect and grow the overall base of Northwest employment dependent on affordable electricity.

> ***Regional smart grid success will create launching pads for Northwest smart energy companies to build their global marketplace leadership and generate new jobs in the region.***

The Northwest should undertake a high-profile smart grid acceleration initiative.

Certainly, with the economic and security needs for power reliability, development of the smart grid should become a federal priority. But if the Northwest leads with its own smart grid initiative it will play a vital role in setting the national agenda and federal grid investment priorities. To fully catalyze smart grid deployment and realize its many economic and environmental benefits the region should boldly undertake a coordinated **Northwest Smart Energy Initiative.** It should draw in state governments, local governments, public and investor-owned utilities, research and educational institutions, technology companies and investors, market transformation organizations and labor unions. Governors and the Northwest Congressional Delegation have pivotal roles to play.

➤ **Governors should:**

- Appoint blue ribbon commissions to create smart grid roadmaps for their states.
- Ask utility commissions to build smart energy incentives into regulations.
- Build energy centers of excellence in public universities and colleges.
- Forward smart energy companies in trade policies.
- Make public facilities into smart energy models.

➤ **Northwest Congressional Delegation members should:**

- Work to secure federal funding for regional smart energy technology demonstrations.
- Champion a national grid modernization fund.

The Northwest has an unequalled depth of public and private smart energy resources that make it one of the world's best places to accelerate the smart grid.

To its private sector leadership the region adds a track record of internationally-recognized energy policy leadership and world-class public and nonprofit energy organizations including university energy programs, innovative utilities and technology accelerators. Some Northwest organizations are already engaged in nationally-significant smart grid initiatives:

- **Bonneville Power Administration** is mounting one of the transmission industry's most advanced efforts to replace costly line upgrades with smart energy technologies.
- **Pacific Northwest National Laboratory** is a national smart energy research center and a major player in national smart grid acceleration efforts.
- **Pacific Northwest GridWise Testbed** joins the above two organizations with regional utilities in smart grid field tests.
- **Northwest Energy Efficiency Alliance** is pilot testing digital technologies that dramatically improve power distribution efficiency.

Tens if not hundreds of billions will be invested in the U.S. power grid over coming decades to modernize it and keep up with growth. The region will put itself and its companies in line to gain a substantial portion of these billions with a **Northwest Smart Energy Initiative** that accelerates smart grid growth. The smart grid will generate huge additional economic benefits to the Northwest as well. Digital management of power loads will significantly reduce the need for expensive power infrastructure needed to serve peak demands, a key strategy to keep power rates under control. Power disturbance costs will decline. Energy efficiency will improve. Connecting renewable and cleaner small-scale generators to the grid will become more economical.

How will the smart grid work? A scenario for comprehensive smart grid deployment throughout an entire community.

The community begins with 1,500 residences, a mall with 50 retail businesses, 100 other storefront shops, an office center with 50 tenants, and a large factory. When a new development adds 500 new homes the local utility is faced with a choice – Either build a new substation or create a 21st century power network rich in information technology and telecommunications bandwidth. Since the utility already has a fiber optic network and is looking for ways to fully employ it, the decision is tipped to the advanced technology route.

Customers paid to help the grid – To manage power demand all customers are equipped with smart meters that can report moment-to-moment power use to the utility. Residential customers are provided rebates for buying smart appliances that can cycle up and down in response to grid needs and signals. These technologies enable customers to participate in a voluntary demand response program which gives them credits on their bills for limiting power use in peak demand periods or when the grid is under stress. Smart appliances accomplish this automatically so customers do not have to make manual adjustments, though they can override the system if they wish by controlling their appliances over the Internet. Since peak demand is lower, fewer poles, wires and distant power plants are needed.

Power distribution automated – Local substations and other power infrastructure are fitted with electronic controls and sensors. So tasks that formerly were done manually on site now can be ordered from remote locations. This allows more intensive use of infrastructure. For example, one transformer which served the residential area was underutilized during the day when people were at work. Another transformer serving the factory was underutilized at night when the factory was closed. Now it takes only one automated transformer to serve both areas. During the day it shifts capacity to the factory, while at night it switches it over to residences. Automation also helps restore service quicker in case of a blackout, and allows better control of voltages in ways that make overall power use more efficient.

Local power generation added – Adding to local power supplies also takes stress off the grid. The utility worked with the office center to install a microturbine with a heat exchange unit, so it can supply heating and cooling as well as electricity. Recycling generator heat effectively doubles fuel use efficiency. The turbine has surplus electrical generating capacity. A Northwest energy systems firm builds a community digital quality power network around the turbine so it can provide power to other customers who require high reliability power. The utility also made a deal with the factory owner to link an existing diesel back-up generator into the grid, and to convert it to biodiesel so it can run for more hours without bumping up against air quality limitations. The generator kicks on when hot or cold days place high demands on the grid. Another move to increase local power generation is siting solar photovoltaic modules on homes and businesses to handle summer peak loads. These local power sources help eliminate the need for expanded transmission capacity into the area. This avoided power line expense makes money available to buy down costs of solar modules and other local generation.

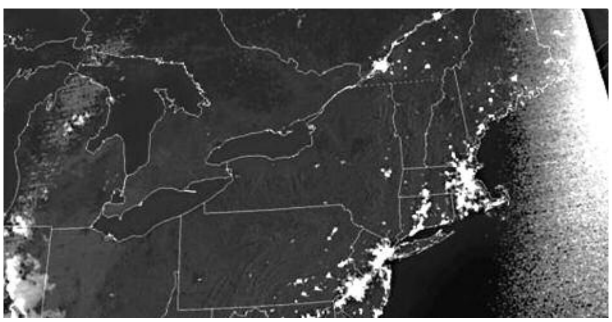
Jobs and skills grow – As with most of the electrical power industry the utility was faced with another problem, an aging workforce with a large proportion retiring in the next few years. So it views the community smart grid deployment as an opportunity to solve two problems at once. It joins with electrical worker unions and the local community college to create a new Digital and Distributed Power Systems Training Program to upgrade skills of existing workers and train future workers. Presence of the program attracts several smart energy technology installation companies with a total of 150 workers to the utility service area. The smart grid community itself attracts a new data processing firm employing another 45 people. Local availability of high reliability power means the firm does not need to buy its own expensive backup power system. That makes the case for the location. Last but not least the energy systems firm that built the innovative community digital power network leverages its successful experience to gain new customers in North America and East Asia. In a year it grows from 21 to 160 employees.

The 21st century smart grid – Time for the Northwest to take the lead.

A Northwest Smart Energy Initiative to accelerate the smart grid will provide the Northwest with secure regional power supplies that are the foundation of economic prosperity and job creation. At the same time it will build up the Northwest's world-class smart energy companies and position the region at the forefront of the electrical power sector's global transformation. For the Northwest's economic future, it is hard to imagine a more important or rewarding step. If Northwest states take the initiative in smart grid demonstration and deployment, our reward will be thousands of good, new jobs and a central role in meeting the world's growing electric power demands with the 21st century's smart energy technologies.

Introduction

On August 14, 2003, the lights went down from Broadway to Detroit, throwing the lives of 50 million people into temporary chaos and costing an estimated $6 billion. It was the latest evidence that that U.S. power grid is becoming increasingly overloaded and unstable. Columbia University power grid researcher Roger Anderson notes that "since 1998, the frequency and magnitude of blackouts has increased at an alarming rate . . . Blackouts in Chicago, Delaware, Atlanta, New Orleans, and New York in 1999, San Francisco and Detroit in 2000, and the infamous California 'problems' of 2001 deviated from the predictable behavior of the 1980s and early 1990s… If present trends continue, a blackout enveloping half the continent is not out of the question."[1]



Satellite photo shows much of region from Midwest to Northeast, including New York City, blacked out around 9 p.m. on Aug.14, 2003.

The power grid today is straining under a weight of interconnected problems each of which make resolution of the others more difficult.

Growing power demand and restructured power markets have soaked up excess power transmission capacity built up in previous decades. Meanwhile regulatory uncertainty over how grid operators will be financially rewarded has depressed grid investments even as new infrastructure is needed. More uncertainties are created by growing concerns over power plant pollution, its impact on climate and how it will ultimately be regulated. Attempts to resolve these issues at the federal level have run into roadblocks. A "one size fits all" solution for the complexities of U.S. power grids has proven difficult to uncover.

Smart energy technologies provide solutions to grid problems.

A host of new smart energy devices and systems are emerging that can take pressure off overloaded grid infrastructure and power costs, dramatically improve grid reliability and security, and accelerate the growth of cleaner power generation.

> ***Smart energy is defined as the application of digital information technology to optimize electrical power generation, delivery and end use.***

Smart energy is defined as the application of digital information technology to optimize electrical power generation, delivery and end use. The smart grid is the product of applying smart energy technology to systematically optimize power delivery and generation. This paper will overview a number of smart energy technologies and how they are beginning to transform the electrical power network into a smart grid capable of meeting 21st century economic, security and environmental challenges.

But the smart grid still must overcome significant hurdles.

➤ **Two barriers stand out in particular:**

- New technologies always must prove themselves – In the electrical power industry where "keeping the lights on" is top priority, the burden of proof is even greater. New power technologies require extensive field testing before widespread integration into power grids.
- Smart energy technologies can yield phenomenal gains in energy efficiency and local power generation, but this can have disruptive impacts on standard utility business models that base revenue flows on gross energy throughput. Dated regulatory

[1]Anderson, Roger and Albert Boulanger, "Smart Grids and the American Way," *Mechanical Engineering*, March 2004

and ratemaking frameworks create disincentives for adopting new technologies and push utilities to older "business as usual" equipment.

If the Gordian knot restraining progress is to be cut, it will be states and regions that first slice through the obstacles. The Pacific Northwest is in a strong position to take the initiative.

In the final analysis, the national interest in deploying power technologies that improve grid reliability, security, economics and environmental performance will demand a greater federal priority. For now, states and regions will have to take the lead in development, demonstration and deployment of the 21st century smart grid. The Northwest has a singular array of resources as well as a unique set of opportunities and challenges that make it a strong candidate to move to the head of the pack. The region has a record of energy innovation and a series of world-class public and private institutions in the energy field. Many are already staking out forward positions in the smart grid.

This paper will overview regional assets and efforts, and propose a **Northwest Smart Energy Initiative** to coalesce regional smart grid leadership through public policies to unleash one of the world's largest and most advanced deployments of smart grid technologies. Northwest governments, businesses, universities, laboratories and nonprofits should together work to mount coordinated technology testbed/demonstration efforts and to update public policies and regulations in order to realize smart grid benefits.

The Northwest is already a globally significant center for smart energy technologies.

The smart grid will deliver the high-quality, reasonably-priced electrical power that is the foundation of economic development and job creation in all sectors. That alone would justify a high regional priority. But the Northwest has a particular interest in driving forward smart grid technologies – A disproportionate share are made and marketed by Northwest companies.

The region has a record of energy innovation and a series of world-class public and private institutions in the energy field. Many are already staking out forward positions in the smart grid.

With at least 225 smart energy enterprises that hold a $2 billion share in the $15 billion per year global smart energy industry, the Northwest is already a global heartland for the digital energy management technologies that will shape and secure the grid of the future.
The Poised for Profit II Partnership of leading Northwest economic development, energy and research organizations in 2003 identified smart energy as the region's leading opportunity to develop a job-rich energy technology sector on the scale of current regional leaders such as aerospace and computers.

Other regional high technology sectors provide abundant cross-fertilization opportunities. The smart grid will be software-driven, infused with semiconductors and linked with broadband communications. Regional leaders such as Microsoft, Intel and the wireless communications industry could find new markets.

With at least 225 smart energy enterprises that hold a $2 billion share in the $15 billion per year global smart energy industry, the Northwest is already a global heartland for the digital energy management technologies that will shape and secure the grid of the future.

The Northwest's smart grid opportunity is driven by crucial regional, national and global needs for reliable, economical, clean electric power.

➤ **Benefits of deploying the smart grid will be significant at all scales:**

- an intelligent, self-healing grid that anticipates and thwarts disruptions and dramatically reduces costly blackouts and power disturbances,
- a more economical grid that has far less need for expensive peak power generators and delivery infrastructure,
- a cleaner grid that can more rapidly bring on line renewable and cleaner distributed generation.

Self-healing grid – As Anderson notes, "The problems that have caused the recent spate of blackouts will propagate cascading failures of the grid more and more frequently, unless we create a more intelligent grid control system. The system must become automated, because decision speeds increasingly are becoming too fast for humans to manage. This is a vital national security interest… The management of the smart grid will require digital control, automated analysis of problems, and automatic switching capabilities more familiar to the Internet."[2] Those capacities will let the grid automatically route power flows around trouble spots and bring back on line equipment that now must be manually re-started.

Economical grid – That power costs represent a growing economic challenge is reflected in a 5.2% rise in average U.S. power prices in the 12 months ending in April 2005. This is "one of the highest recorded for the United States," said NUS Consulting Co-President Richard Soultanian.[3] Digital management capabilities will contribute to power rate control by making everyday grid operations more economical. Today's power grid is built to supply the highest expected power demands. So billions are invested in poles, towers, wires and power plants that are used only part of the time. The overall utilization rate of U.S. power grid infrastructure is barely over 50%. But each piece of the infrastructure will be fully utilized at some point, even if for only a few hours a year. If such low usage infrastructure could be eliminated, the power grid would operate more economically. Digital technologies enable widespread management of end-use demands in ways that reduce the need for peaking infrastructure. Studies quoted in this paper show a vigorous effort to deploy smart grid technologies could eliminate $46 billion-$117 billion in U.S. peaking infrastructure investments over the next 20 years.

Cleaner grid – Smart energy technologies will also serve crucial environmental goals for reduced emissions from the power sector, now the nation's largest source of air pollution:

- *Energy efficiency* – Digital control systems will constantly monitor and adjust building systems, equipment and appliances for top efficiency, thus reducing power needs.
- *Distributed generation* – Automated grid management will make it possible to operate a multitude of small-scale distributed energy resources in coordination with the grid, including pollution-free sources such as solar modules and wind turbines, and cleaner gas-fired technologies including microturbines and fuel cells. Such local generation also opens the way to recycle waste heat into building systems, making for far more efficient use of fuels than in central generating stations.
- *Mass-scale renewables* – Meeting goals for renewable energy will eventually require that a large share of power supplies come from wind and solar resources whose intermittency and less than 100% predictability poses special grid operation problems. These will be addressed by digital management technologies that flexibly and automatically balance mass-scale intermittent generation with local distributed generation, energy

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[2] Anderson, Roger and Albert Boulanger, "Smart Grids and the American Way," *Mechanical Engineering*, March 2004
[3] Average U.S. Electricity Price Rises," NUS Consulting Group, May 17, 2005

storage and control of end-use demands. In addition, computer modeling will continue to improve wind, sun and water resource forecasting, making renewables easier to integrate by making them more predictable.

- *Clean power market* – Smart equipment, appliances and buildings will have capacities to automatically seek out cleaner power options offered on the market. These functions could be set to come on line during air pollution alerts, or could operate at all times to express owner desires for green power options.

The smart grid will be able to integrate and manage mass-scale renewable energy production from intermittent and varying sources such as wind farms.

While the United States failed to enter the Kyoto Protocol to reduce global warming pollution when it went into effect Feb. 16, 2005, U.S. states and regions can nonetheless contribute to stabilizing the global climate by leading in actions to deploy a smarter, cleaner power grid.

The purpose of this paper is to provide an overview of smart energy technology and its smart grid applications, how this will benefit the Northwest, and what the region needs to do to become an international smart grid deployment leader.

➤ **The paper is structured as answers to a series of questions:**

- What is the smart grid?
- Who is working on the smart grid?
- What technologies make up the smart grid and what do they offer?
- What are benefits of smart energy and the smart grid?
- What assets does the Northwest have to become a world smart grid center?
- How will the smart grid happen?
- What is the Northwest doing to make the smart grid happen?
- What's holding back the smart grid?
- What regulatory and policy changes will unleash the smart grid?
- How can the Northwest help overcome smart grid obstacles?

What Is the Smart Grid?

Information technology is beginning to infuse itself throughout the power grid. This represents the most profound electrical power revolution in a century.

Today's grid is primarily composed of central generating stations and electromechanical power delivery systems operated from control centers. Nineteenth century electrical pioneers Thomas Edison and George Westinghouse would find most of it familiar. But now the system is transforming itself into a smart grid that integrates a multitude of distributed energy resources, uses solid state electronics to manage and deliver power, and employs automated control systems. The power industry, trailing behind economic sectors from retailing to manufacturing already revolutionized by computerization, over coming decades will see cheap computing power and low-cost bandwidth infuse every element of the grid with digital intelligence.

The vision of a smart grid rich in information technology is coming into full view.

GridWise Alliance – "... information technology is the key catalyst and enabler for realizing the potential of new energy technologies to transform the electric power system. Information technology is vital to transforming the electric power system from a rigid, hierarchical system to a collaborative, distributed, commerce-driven 'society' of devices that would enhance the utilization of expensive assets and simultaneously increase reliability and security."[4]

U.S. Department of Energy Grid 2030 – "... a fully automated power delivery network ... ensuring a two-way flow of electricity and information between the power plant and the appliance, and all points in between. Its distributed intelligence, coupled with broadband communications and automated control systems, enables real-time transactions and seamless interfaces among people, buildings, industrial plants, generation facilities and the electric network."[5]

A national panel of leading electrical grid experts notes that the smart grid is primarily defined by abilities far in advance of the traditional grid.

➤ The Smart Grid Working Group convened by the bipartisan Energy Future Coalition writes: "The key attributes of the 21st century power grid include the following:

- **The grid will be 'self-healing.'** Sophisticated grid monitors and controls will anticipate and instantly respond to system problems in order to avoid or mitigate power outages and power quality problems.
- **The grid will be more secure from physical and cyber threats.** Deployment of new technology will allow better identification and response to manmade or natural disruptions.
- **The grid will support widespread use of distributed generation.** Standardized power and communications interfaces will allow customers to interconnect fuel cells, renewable generation, and other distributed generation on a simple 'plug and play' basis.
- **The grid will enable customers to better control the appliances and equipment in their homes and businesses.** The grid will interconnect with energy management systems in smart buildings to enable customers to manage their energy use and reduce their energy costs.

[4] http://gridwise.pnl.gov/foundations/history.stm

[5] U.S. Department of Energy Office of Electric Transmission and Distribution, *Grid 2030: A National Vision for Electricity's Second 100 Years*, July 2003, p17

- **The grid will achieve greater throughput, thus lowering power costs.** Grid upgrades that increase the throughput of the transmission grid and optimize power flows will reduce waste and maximize use of the lowest-cost generation resources. Better harmonization of the distribution and local load servicing functions with interregional energy flows and transmission traffic will also improve utilization of the existing system assets."[6]

Who Is Working On the Smart Grid?

A series of complementary efforts to accelerate the smart grid are under way.

- **GridWise** – The GridWise Alliance aims to lead a national development and deployment effort for innovative smart grid technologies.. The Alliance works in coordination with the GridWise Program in the U.S. Department of Energy's (DOE) Office of Electricity and Energy Assurance. Together they aim at a "compelling demonstration agenda" to "prove state-of-the-art by defining a series of demonstrations" that "illustrate the breadth of the transformation," their agreement states. Current Alliance members include multinational technology corporations – Areva, General Electric, IBM, and Schneider Electric; utilities and grid operators – American Electric Power, Bonneville Power Administration, ConEd and PJM Interconnection; research organizations – Battelle, RDS, and SAIC; resource aggregator Nxegen, and venture capital firm RockPort Partners.

GRIDWISE™

- **Intelligrid** – This is an effort to develop software architecture for the smart grid undertaken by the Electric Power Research Institute (EPRI). Intelligrid products are already being used by the Long Island Power Authority, Electricite de France and the California Energy Commission.
- **Other efforts** – DOE is also undertaking related efforts to accelerate energy storage, superconductivity and other grid technologies. Its National Renewable Energy Laboratory is working on technologies and standards for integrating distributed energy resources into the grid. The California Energy Commission and New York State Energy Research and Development Authority are conducting research and development in load management and distributed resources. The Power Systems Engineering Research Center joins 13 universities (including Washington State University) in collaborative research aimed at solving grid problems. Distribution 2010 is a utility effort to supply high-quality power to business customers. These and other efforts are detailed by the Center for Smart Energy at its website.[7]

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[6] Energy Future Coalition, *Report of the Smart Grid Working Group*

[7] *National Grid Initiatives - Part One:* Research Programs, http://www.smartgridnews.com/artman/publish/article_8.html; *National Grid Initiatives - Part Two: Standards Efforts*, http://www.smartgridnews.com/artman/publish/article_32.html; *National Grid Initiatives - Part Three: Demonstration Projects*, http://www.smartgridnews.com/artman/publish/article_41.html

What Technologies Make Up the Smart Grid and What Do They Offer?

A 21st century power grid rich in information technology and telecommunications bandwidth will weave together a collaborative community of smart energy devices working together to optimize grid efficiency.

Distributed Resources

Distributed generation interconnection – At least 60,000 megawatts (MW) of small-scale distributed generators, defined as under 10 MW, are on line in North America.[8] Most are diesel and reciprocating engines, but solar modules, small wind turbines, microturbines and fuel cells are emerging. Almost all distributed generation is used as back-up power and is unconnected to the grid. But communications, control and switching systems that link and operate generator networks in coordination with the grid are beginning to appear. This reduces the need for costly peaking infrastructure and can mitigate blackouts. (Of course, many back-up generators operate with high emissions so hours of usage must be strictly limited. Mass-scale distributed generation will depend on growth of cleaner and zero-emissions technologies.) Electronic intelligence also connects solar modules and other small-scale distributed generators to the grid, making possible net metering through which surplus renewable generation is fed to the grid and generator owners receive credit. These interconnection technologies are a precursor to the "Energy Web," a shift to a power grid with a multitude of localized power units. Integrating these new and emerging clean energy technologies will require a more complex and automated control system than today's grid based on a relatively small number of central generating stations. The Energy Web will offer at least three benefits: high reliability, reduced losses from power lines and improved ability to utilize waste heat from power generation.

Example – Portland General Electric's Dispatchable Standby Program networks on-site backup generators in sites such as office buildings and public facilities in order to meet peak power demands. The utility installs communications, control and switching equipment on customer-owned generators, and provides maintenance and fuel. In return customers allow the utility to run generators up to 400 hours per year. The program aims to supply 100 megawatts of peaking capacity and now has 38 MW on line or under construction.

Energy storage integration – While electricity has been mostly a just-in-time delivery system, the smart grid will integrate increasingly economical energy storage devices that will stabilize power flows and provide grid shock absorbers. For intermittent renewable resources such as sun and wind, energy storage will balance power generation and demand. Automated control systems will dispatch stored energy to the grid when needed. Conventional lead-acid batteries are already common, while utility-scale sodium sulfur batteries are in commercial production and use in Japan, and reversible flow batteries (or cells) are in development and demonstration. Several Superconducting Magnetic Energy Storage units which hold power in a superconducting coil are in operation. Small-scale flywheels are already appearing in on-site backup power systems, while 2005 demonstrations of utility-scale flywheels are planned for California and New York. The smart grid's capacity to integrate a multitude of distributed resources will create greater economic value for energy storage and accelerate development in this area.

[8] Electricity Innovation Institute, *CEIDS Distributed Energy Resources Integration Element Program Plan*, March 6, 2002, p1

Example – Power transmission into Castle Valley, Utah was operating at full capacity. PacifiCorp faced the need to either build a new substation and 16 miles of transmission lines through environmentally sensitive lands or improve local capacity. So the utility in March 2004 brought on line the first Vanadium Redox flow battery in North America to balance power loads in the valley. Cost was $1.3 million, as opposed to $5.6 million for the substation and line.

Power Grid Management

Real-time monitoring – Sensors are embedded throughout the grid from generators and power lines through substations and feeders. The real-time information stream enables a multiplicity of functions including rapid diagnosis and correction of grid problems, and measurements of transmission lines to determine when they are reaching capacity – Lack of such information means transmission operators must under-use wires to make sure they do not overload. Real-time readings will allow fuller utilization of transmission lines, improving grid reliability and economics.

Example – Bonneville Power Administration (BPA) has pioneered the Wide-Area Measurement System (WAMS) a network of sensors located at substations which provide real-time updates on the Bonneville grid 30 times per second. Updates are coordinated through global positioning satellites and sent to a central computer that analyzes disturbances, provides operators with solutions and monitors the results. WAMS systems now operate throughout the western U.S. Similar monitoring networks are being installed in the Northeast in order to avoid a repeat of the August 2003 blackout.

Transmission/Distribution automation – Automation gives grid managers remote control of operations that formerly were done manually on-site at facilities such as substations and feeders. Automation allows faster adjustments to conditions, both preventing blackouts and making for faster recovery. Some power researchers project that automated networks also will have the flexibility to channel electricity to customers that require absolutely reliable service, such as hospitals, during area outages. Automated substations provide capacities not available in traditional substations to link in new smart information and control technologies.

Example – PCS UtiliData of Spokane automated an Inland Power substation, making possible installation of voltage control technology that improves substation efficiency. The company has also installed voltage control at an Avista substation and three Clatskanie PUD substations. Power savings can range to around 5%, a large improvement in the electrical delivery system efficiency.

Demand Response –Two-way communications between power providers and customers opens the way to flexibly adjust power to grid conditions. This "demand response" contrasts with the traditional utility system in which supply adjusts to meet all demands. Customers receive financial incentives for cutting power demand at times the grid is under pressure. They can do this by dropping consumption or replacing grid power with distributed generation. Demand response holds power bills in check by reducing the need for peak power generation and wires infrastructure, the most costly pieces of the power grid because they are used the fewest hours. It could also be employed to help prevent blackouts and brownouts.

Example – BPA operates a Demand Exchange system which uses wireless and web technologies to alert participating customers when the power system is expected to be under stress, for example, when arrival of a cold front is forecast. Customers respond with bids for demand reductions and receive financial compensation in return. Demand Exchange is being employed on the Olympic Peninsula to shave peaks in an effort to defer the need for expanded transmission capacity. BPA is also signing up local back-up generators to offset peak demands.

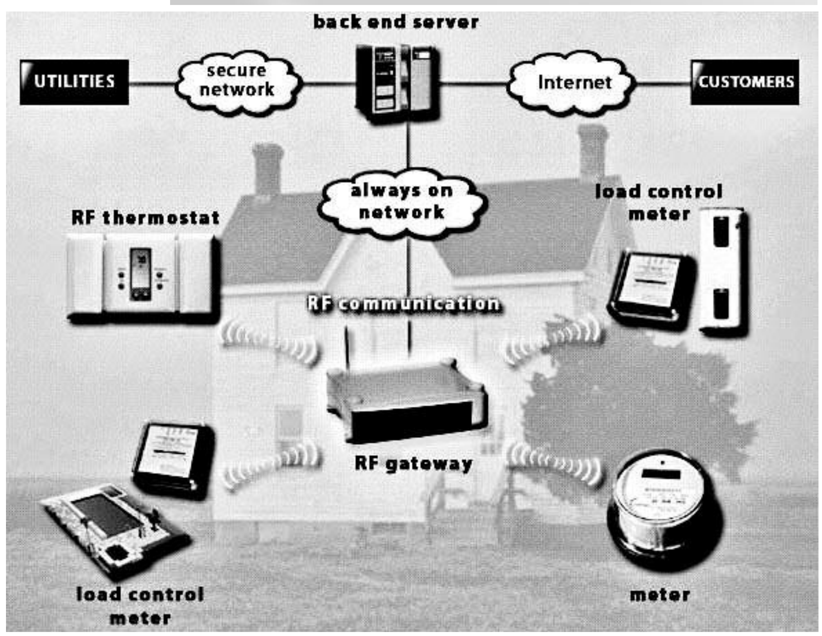
Communications networks – Broadband communications networks including cable, fiber, power line carrier and wireless play a crucial role in linking together the smart grid. They carry information among smart devices that allow them to respond to grid conditions, offer services to the grid and make economic transactions. Customer information gateways provide two-way communications that enable smart devices to connect and transact with the power grid. Communications networks are protected by information security, privacy and authentication software that protects the grid and its participants.

Example – The Ashland, Oregon municipal utility offers the PowerShift program, a demand response program for residential customers that employs an Internet gateway unit to automatically control energy-hungry appliances such as hot water heaters and pool pumps. When the utility needs to curtail load it uses the municipal cable television system to signal the gateway, which then employs wireless RF technology to operate smart switches connected to appliances. Customers can override commands using the Internet. An added benefit for customers is time-based information on electrical use patterns which can help customers adjust those patterns to save energy and money.

Customer Power Management

Smart meters – Smart meters record power usage digitally by time of day and report it by telecommunications. This enables pricing that varies between high and low demand periods, providing economic incentives to shift power use out of peaks. Northwest utilities including Puget Sound Energy and Avista have made large smart meter deployments.

Example – Following the 2000-2001 West Coast power crisis California instituted a Dynamic Pricing Pilot to test the effects of time-based pricing on peaks. Starting in July 2003 smart meters were installed at 2,500 customer locations and several rate structures were tested. Peak reductions on hot summer days when the grid was most stressed reached 13%.[9] With a large majority of participants expressing a desire to continue, the program remains ongoing.



Graphic depicts how communications networks including Internet and local RF signals control end-use energy demands.

[9]Charles River Associates, *Impact Evaluation of the California Statewide Pricing Pilot, March 16, 2005*

Example – In 2001 the One Union Square Building in Seattle drew 15 million kilowatt hours from the grid. By 2004 that figure had dropped 40% to 9 million kWh. The difference was a $3.5 million retrofit that including traditional efficiency measures such as better heating/cooling fans and drives, and smart energy improvements. New lighting controls were installed and mechanical energy management controls were replaced with a digital system made by Redmond, Washington-based Alerton. Annual savings of $450,000 will provide a six-year payback with a 16.5% return on investment.

Smart buildings and equipment – Building energy management systems use sensors and automated controls embedded in heating, cooling, lighting and other equipment to monitor building conditions and adjust for optimal operating efficiency. This intelligence also enables buildings to automatically participate in demand response programs by shutting or cycling down electrical loads.

Smart appliances - Home appliances contain onboard intelligence that receives signals from the grid and reduces demand when the grid is under stress. The intelligence can also be programmed to operate appliances when power rates are lower. A fleet of smart appliances reduces the need to build costly peak load and reserve power infrastructure and dramatically increases grid reliability. Smart hot water heaters and air conditioners have for some time been able to cycle down to reduce peak loads. Now smart refrigerators, dishwashers and clothes washers/dryers are being developed.

Example – Pacific Northwest National Laboratory is developing inexpensive computer chips that enable appliances to detect drops in the 60 hertz frequency that is standard on U.S. power lines. Since such drops indicate trouble on the grid appliances automatically reduce their loads. This systemwide response could prevent blackouts and brownouts. Pacific Northwest GridWise Testbed plans a summer 2005 demonstration. (See "What is the Northwest doing to make the smart grid happen?" below.) PNNL offers a virtual tour at http://gridwise.pnl.gov/technologies/gfa-tour/Gridwise_web.htm.

Customer Voltage Regulation – Most electrical equipment is geared to take a standard voltage. But power is delivered through the grid at varying voltages. Essentially the "pressure" forcing electrical current, voltage is boosted at substations in order to maintain sufficient voltage at a distance. So customers closer to substations are actually receiving higher voltage than they need, wasting energy and wearing out motors faster. Regulation units sited at the customer location step down voltage to the basic level needed for service, thus saving energy and equipment life. These regulators also can adjust upwards in low-voltage situations. (Grid-level voltage regulation is covered above in "Transmission/Distribution Automation.")

Example – Klickitat PUD was faced with unexpected low voltage problems in 2003 when two municipal water pumps were added to a line. Those problems affected several customers. The PUD was in a bind. It needed to add a substation but was financially strapped. Tiding it over until it could afford to bring the substation on line were MicroPlanet voltage regulators which firmed up voltage at two customer locations. The devices made by the Seattle-based company combine a programmable PC board with a transformer to keep power flow to 114.5 volts. They are still operating successfully.

What Are the Benefits Of Smart Energy And the Smart Grid?

The smart grid will accelerate adoption of new technologies, create jobs, lower power delivery costs, reduce blackouts and brownouts, improve energy efficiency, cut pollution, and promote growth of distributed and renewable resources.

Accelerated adoption of new technologies – Emerging energy technologies have value at more than one level. Not only do they offer services at the specific location where they are employed – They also provide benefits that radiate across the grid. For example, the value of local solar photovoltaic generation in terms of reduced grid operation costs is up to 20 cents/kilowatt hour, a report to the California Public Utility Commission reveals.[10] The communications and control capabilities of the smart grid make it possible to fully integrate new energy devices into the grid. So the smart grid can realize and reward the total value that a particular technology has for the entire system, no matter where it is located or who owns it. When the business case for a new system includes both its local and system benefits it can tip the decision in favor of purchase and installation. In this way the smart grid can accelerate adoption of the range of smart energy technologies, helping create economies of scale which bring down costs and build markets.

Job creation in the smart energy sector – The Northwest, as noted in the introduction, also has special job creation potentials in deployment of the smart grid. The Poised for Profit I Partnership, which included Bonneville Power Administration, BC Hydro, and lead economic development and energy agencies in Oregon, Washington, and British Columbia, in 2001 concluded that the Northwest could create over 32,000 jobs in advanced clean energy technologies over the next 20 years with public policies to aid emerging businesses. The Partnership identified power systems (smart energy) and fuel cells as areas where the Northwest can develop globally competitive industry clusters.[11]

> ***The region "can gain an industry of distinction to rival current mainstays such as aerospace, biotech, forest products and software. The Pacific Northwest has the assets to become a global center in smart energy."***

The follow-on Poised for Profit II Partnership, with many of the same partners, was convened to focus best opportunities in the five-year timeframe. The Partnership in 2003 targeted smart energy as the Northwest's best immediate prospect to create an energy-sector economic powerhouse. It found at least 225 companies in the region already representing nearly 14% of the $15 billion global smart energy market.[12] They include industry leaders such as Itron, world's largest smart meter maker; Areva T&D, a global power grid automation presence; Schweitzer Engineering Laboratories, maker of solid-state power controls, and Celerity, a pioneer in building distributed generation networks. The high regional concentration of software, semiconductor and wireless companies could also find new opportunities and speed innovation in the energy sector. The Partnership noted that, "smart energy is already much larger than better-known sectors such as wind ($5 billion), solar ($1.5 billion) and fuel cells ($0.5 billion). It shows every sign of widening the gap."[13] The region "can gain an industry of distinction to rival current mainstays such as aerospace, biotech, forest products and software," the Partnership reported. "The Pacific Northwest has the assets to become a global center in smart energy."[14]

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[10]Americans for Solar Power, http://www.forsolar.org/?q=node/98
[11]*Poised for Profit: How Clean Energy Can Power the Next High-Tech Job Surge in the Northwest*, 2001, p5
[12]*Poised for Profit in Smart Energy*, Executive Summary, p18
[13]*Poised for Profit II: Prospects for the Smart Energy Sector in the Pacific Northwest*, 2003, p8
[14]Ibid, p8, 16

Reduced power infrastructure costs – Today's power grid is dramatically underutilized compared to its capacity:

- *Generation* - U.S. power plants number over 9,000 and have a 2001 book value of $570 billion. They can produce up to 819 gigawatts of power but are only utilized at 53% of that capacity.
- *Transmission* - The U.S. transmission network, over 700,000 miles of line worth $64 billion, is used at 50% of capacity.
- *Distribution* - Local wire networks totaling over one million miles and worth $160 billion have utilization rates under 30%.[15]

"The power venue is saddled with an aging infrastructure, approximately 60% of which will need to be replaced in the next 10-15 years at a huge cost to companies."

Smart energy technologies have multiple potentials to significantly increase power system productivity, in the process reducing costs. For instance, sensors in power lines give grid operators real-time information on line temperature and other conditions. Knowing exactly how much stress lines are under allows higher utilization.

"The power venue is saddled with an aging infrastructure, approximately 60% of which will need to be replaced in the next 10-15 years at a huge cost to companies," notes Harbor Research. "Because of this the utility market is motivated by a desire to better optimize the existing infrastructure through the management and monitoring of power generation, distribution and quality." As a result, "Pervasive Internet technology holds a place in the power market."[16]

In particular, digital technologies seeded throughout the power grid can control end use power demand and coordinate local, distributed generation with the grid, thus reducing peak loads and providing new flexibility in responding to unexpected contingencies. When digital technologies are infused into the power grid, end-use demands can be adjusted to available power supplies, and local generation can take stress off power lines. This ability to manage and reduce peak demands reduces the need for costly peaking and "just-in-case" power infrastructure. Huge smart grid saving potentials are uncovered in studies of the GridWise vision. A Pacific Northwest National Laboratory (PNNL) study found that over 20 years significant amounts of U.S. power infrastructure additions could be avoided. Net present value figures are:

- *Generation* - $19 billion-$49 billion
- *Transmission* - $5 billion-$12 billion
- *Distribution* - $22 billion-$56 billion
- <u>*Total*</u> - $46 billion-$117 billion.[17]

RAND Corporation conducted an independent evaluation of the GridWise vision. With widespread application of smart grid technologies, RAND found net present value of $57 billion in generation- transmission-distribution savings over 20 years.[18]

PNNL also projects a 1% reduced cost of capital, for an additional $11 billion savings, because smaller-scale smart energy technologies can be added incrementally to meet power demands. This imposes smaller financial risks than large plants and power lines that must be brought on line well before demand has fully materialized.

These savings figures do not take into account capital costs of deploying new technologies. But, as PNNL researchers note, "bits are cheaper than iron." For example, they note, smart appliances costing $600 million can provide as much reserve capacity to the power grid as power plants worth $6 billion.

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[15]Kannberg, L.D., et al, *GridWise™: The Benefits of a Transformed Energy System*, Sept. 2003, Pacific Northwest National Laboratory, p3
[16]Harbor Research, *Smart Power: Pervasive Internet Technology in a Changing Energy Market*, Feb.2005, p2
[17]Kannberg, p25
[18]Baer, Walter S et al, *Estimating the Benefits of the GridWise Initiative*, *Phase 1 Report*, RAND Science and Technology, May 2004

Fewer blackouts and power disturbances – Figures on the 2003 cost of power outages to the U.S. range from $30 billion-$120 billion. The range reflects the fact that overall economic ripple effects are not fully understood. But at any level, smart grid technologies significantly improve power system reliability. A nominal scenario developed by RAND placing annual losses at $50 billion shows them reduced by $15 billion annually with a 50% penetration of GridWise technologies in transmission and 25% in distribution. With assumption of $100 billion in outage impacts and a slightly higher rate of technology penetration, losses could be cut by $49 billion annually.[19]

Improved energy efficiency – Building energy management systems that constantly monitor and adjust smart equipment and appliances yield significant energy efficiency gains. RAND projects that in 20 years these systems could reduce annual power demand by 52-106 billion kilowatt hours annually, for a savings of $3 billion-$7 billion per year.[20]

Reduced use of polluting plants – Peak power plants tend to be among the most polluting because they tend be less efficient and because cycling plants up and down creates more pollution than running them at a steady rate. Spinning reserve plants, typically 10-15% of overall load, are left running even if power is not needed. The grid needs this reserve to meet surges in power demand. Smart energy technology smoothes peaks and surges, and so reduces the need for peak and spinning reserve plants and the pollution they produce.

Clean power market – Today power customers have the option to pay a small premium to cover their electrical use with Green Power. Also today, during serious air pollution alerts, power plants and heavy industries sometimes shut down. The smart grid will be able to automate those functions and combine them. Smart equipment, appliances and buildings will have communication capacities that tell them when smog alerts are taking place. Polluting equipment such as dirtier central and backup power plants will be instructed not to operate. Smart devices will take bids and execute purchases for cleaner power options offered on the market. These search functions could also operate at all times to express owner desires for green power options. Providing owners of clean power generators an e-commerce-style market into which they could bid will open new opportunities and drive forward addition of renewables and clean distributed generation to the grid.

Large-scale renewables integration – Major new additions of renewable energy capacity are coming to the West. The Western Governors Association targets 30,000 MW in new renewables by 2015. California aims at a 20% share of renewable electricity by 2010. A renewables plan in development in Oregon aims at 25% by 2025. Northwest utilities including PacifiCorp and Puget Sound Energy are making major windpower additions. The West Coast Governors Climate Initiative is exploring a global warming pollution cap that would further drive new renewables additions. This poses real challenges for grid operators. Wind and solar power are intermittent and cannot always be predicted. So far, power grids in Denmark, Spain and Germany have been able to manage up to 20% presence of intermittent renewables on the grid. But meeting ambitious renewables goals and reducing global warming pollution will increase the share of intermittent generation and accompanying challenges. Smart energy technologies will offer new capacities to manage mass intermittent renewables:

- With all elements of the grid tied together by communications systems and automated controls, the grid will instantly respond to spikes and valleys in intermittent energy generation by:
  - drawing on energy storage resources
  - balancing resources over diverse geographies (for instance when wind is blowing one place and not another)

[19]Baer, p23-4
[20]Baer, p26

- cycling down end-use demands
- kicking on networks of local distributed generators and other power generation resources.

- Advanced computer modeling will enable improved predictions of wind, sun and stream flow availability for power generation. Seattle-based 3Tier Environmental Forecast Group already offers these services to renewable energy industry clients. 3Tier's Pascal Storck notes, ". . . a 10 percent increase in next hour forecast accuracy is roughly equivalent to a savings of $1 million per year for a 100-megawatt wind farm."[21]

"Cutting-edge technologies will be required to create what we call the smart grid of the future that can accommodate the additional power from massive, remote solar and wind farms," Columbia's Roger Anderson says. "These sources are environmentally benign, but erratic and unpredictable in their generation capacity."[22]

Martin Hoffert, a New York University scientist who led a team which identified energy development needs to stabilize atmospheric global warming gases, concludes, "A broad spectrum Apollo-like program is needed. Nominal goal is generating 3-10 terawatts emission free from renewable sources by 2050. Typical projects should include demonstration of smart transmission grids and components."

Distributed generation integration – Today home and business owners who want to install a solar panel, electrical engine or other distributed generation at their location and interconnect it to the grid must jump through a series of hoops imposed by their utility. Utilities have legitimate concerns. Power flow from large numbers of distributed generators has potential to imbalance local grids, so utilities require switching equipment and other protocols to protect system stability. Standards vary among utilities. The effect is to make each distributed generation installation a custom job and the resulting increase in costs stops many installations before they start. Standardized plug and play interconnection of distributed generators, whether they are reciprocating engines, fuel cells, solar modules or small wind turbines, is a target of smart grid development. This will reduce installation costs and thus help create a virtuous cycle of market growth and economies-of-scale cost reductions.

Fuel cell provides reliable digital quality power to the First National Bank of Omaha credit card processing center. Today's digital economy increasingly demands premium quality power, driving growth in distributed generation.

Reduced costs for digital-quality power – Today's digital economy is increasingly demanding high-quality power that is free of surges, spikes and interruptions. Electric Power Research Institute projects that by 2020 nearly 10% of U.S. power use will require top-grade power available 99.99999% of the time. Some observers project that the smart grid will be able to supply such power. Whether or not this ultimately proves true, the improved distributed generation interconnection capacities of the smart grid will make quality power more economical. Installations requiring high-availability power typically maintain backup power systems which mostly remain unconnected to the grid, as noted in the "Distributed Generation Interconnection" item above. If backup units can be hooked to the grid and supply power when it is not needed on site, increased

[21]Storck, Pascal, "Squeezing more out of renewable energy," *Seattle Daily Journal of Commerce*, July 13, 2003
[22]Anderson and Boulanger, "Smart Grids and the American Way," *Mechanical Engineering*, March 2004

utilization and resulting revenue streams translate into reduced backup system costs. So places with the smart grid interconnection's capacities will have an edge in creating digital economy jobs.

Microgrids - Smart energy management technologies also open up possibilities for microgrids not connected to the larger grid. They might supply DC power instead of standard AC, which is a tremendous energy and cost saver since digital equipment which typically runs on DC contains expensive, energy-wasting power conversion equipment. Electronic intelligence will automatically operate microgrids in conjunction with building energy management systems and smart equipment, thus reducing operating costs.

Reduced line losses – By making local generation more financially rewarding, smart energy technology offers significant gains in overall efficiency of the power system. Typically nine percent of electricity leaks from wires between generation and end use. Distributed generation reduces that figure to around two percent – That occurs when distributed generators are off line and grid power supplies the backup. Other smart energy technologies installed within grid infrastructure, such as voltage control, also have great potential to reduce line losses.[23]

Combined Heat and Power – Local generation also enables recycling of heat into building heating and cooling systems in Combined Heat and Power (CHP) operations. Thomas R. Casten, chair of the World Alliance for Decentralized Energy, notes that power industry efficiency peaked around 1910. At that point power plant efficiency was only 15%, but most plants were in populated areas so waste heat was channeled into local heating systems, bringing overall efficiency to 65%. Since then plants have grown larger and, to mitigate the environmental impacts, moved to remote locations. Heat now goes up stacks. So even though the best plants now reach 50% efficiency, the industry overall average is 33%. CHP efficiencies range from 65-97%.[24]

"No other industry wastes two-thirds of its raw material; no other industry has stagnant efficiency; no other industry gets less productivity per output in 2004 than it did in 1904 Casten says. "Many technical advances make local or distributed generation technically and economically feasible and enable society to return to energy recycling, displacing boiler fuel and doubling net electric efficiency."

[23]Casten, Thomas R. and Brennan Downes, "Critical Thinking About Energy: The Case for Decentralized Generation of Electricity," *Skeptical Inquirer*, Jan/Feb 2005, p30
[24]Casten, p27

Charts: Smart Energy Technologies and Benefits

Distributed Resources

	distributed generation interconnection	energy storage integration
Improved utilization, economics - renewable & distributed resources	X	X
Improved grid efficiency - reduced line losses	X	
Reduced costs for digital-quality power	X	X
Elimination of costly peaking infrastructure	X	X
Improved utilization of wires and delivery infrastructure	X	X
Reduced use of polluting plants	X	X
Improved reliability - reduced blackouts	X	X
Capacity to recycle generator heat to building systems	X	
Ratepayer rewards for adjusting demands to help grid	X	X

Power Grid Management

	real-time monitoring	transmission-distribution	demand response automation	communications networks
Improved utilization, economics - renewable & distributed resources		X	X	X
Improved grid efficiency - reduced line losses	X	X	X	X
Reduced costs for digital-quality power	X	X	X	
Elimination of costly peaking infrastructure	X	X	X	X
Improved utilization of wires and delivery infrastructure	X	X	X	X
Improved reliability - reduced blackouts	X	X	X	X
Ratepayer rewards for adjusting demands to help grid	X		X	X

Customer Power Management

	smart meters	smart buildings/ equipment	smart appliances	voltage regulation
Improved utilization, economics - renewable & distributed resources	X	X		X
Improved end use energy efficiency	X	X	X	X
Reduced costs for digital-quality power		X		X
Elimination of costly peaking infrastructure	X	X	X	X
Improved utilization of wires and delivery infrastructure	X	X	X	X
Reduced use of polluting plants	X	X	X	X
Improved reliability - reduced blackouts	X	X	X	X
Capacity to recycle generator heat to building systems		X		
Ratepayer rewards for adjusting demands to help grid	X	X	X	

A Smart Energy Scenario

Envision a comprehensive deployment of advanced electrical power technologies throughout an entire community.

The community begins with 1,500 residences, a mall with 50 retail businesses, 100 other storefront shops, an office center with 50 tenants, and a large factory. When a new development adds 500 new homes the local utility is faced with a choice – Either build a new substation or create a 21st century power network rich in information technology and telecommunications bandwidth. Since the utility already has a fiber optic network and is looking for ways to fully employ it, the decision is tipped to the advanced technology route.

Smart meters such as this model from Spokane-based Itron allow customers to participate in power demand management programs and receive credit on their bills.

Customers paid to help the grid – To manage power demand all customers are equipped with smart meters that can report moment-to-moment power use to the utility. Residential customers are provided rebates for buying smart appliances that can cycle up and down in response to grid needs and signals. These technologies enable customers to participate in a voluntary demand response program which gives them credits on their bills for limiting power use in peak demand periods or when the grid is under stress. Smart appliances accomplish this automatically so customers do not have to make manual adjustments, though they can override the system if they wish by controlling their appliances over the Internet. Since peak demand is lower, fewer poles, wires and distant power plants are needed.

Power distribution automated – Local substations and other power infrastructure are fitted with electronic controls and sensors. So tasks that formerly were done manually on site now can be ordered from remote locations. This allows more intensive use of infrastructure. For example, one transformer which served the residential area was underutilized during the day when people were at work. Another transformer serving the factory was underutilized at night when the factory was closed. Now it takes only one automated transformer to serve both areas. During the day it shifts capacity to the factory, while at night it switches it over to residences. Automation also helps restore service quicker in case of a blackout, and allows better control of voltages in ways that make overall power use more efficient.

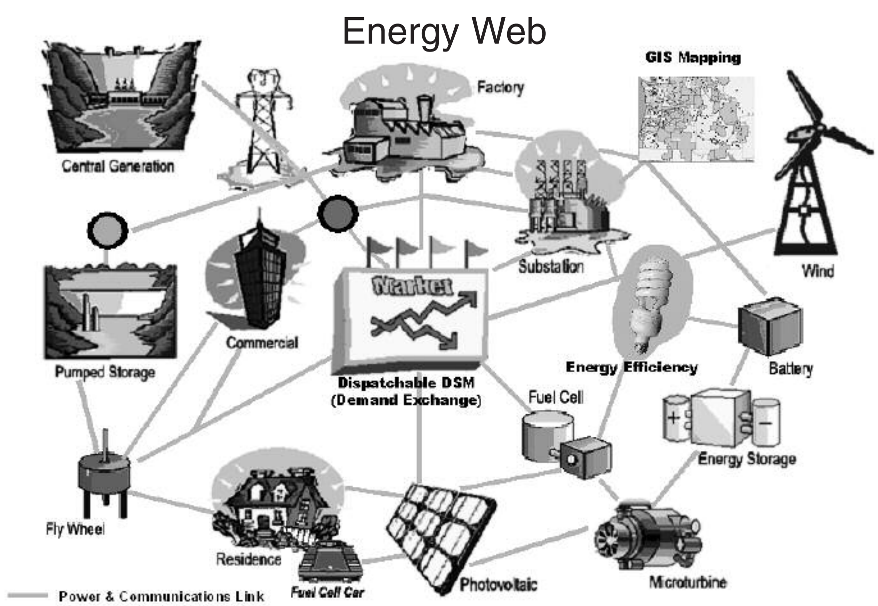
Local power generation added – Adding to local power supplies also takes stress off the grid. The utility worked with the office center to install a microturbine with a heat exchange unit, so it can supply heating and cooling as well as electricity. Recycling generator heat effectively doubles fuel use efficiency. The turbine has surplus electrical generating capacity. A Northwest energy systems firm builds a community digital quality power network around the turbine so it can provide power to other customers who require high reliability power. The utility also made a deal with the factory owner to link an existing diesel back-up generator into the grid, and to convert it to biodiesel so it can run for more hours without bumping up against air quality limitations. The generator kicks on when hot or cold days place high demands on the grid. Another move to increase local power generation is siting solar photovoltaic modules on homes and businesses to handle summer peak loads. These local power sources help eliminate the need for expanded transmission capacity into the area. This avoided power line expense makes money available to buy down costs of solar modules and other local generation.

Jobs and skills grow – As with most of the electrical power industry the utility was faced with another problem, an aging workforce with a large proportion retiring in the next few years. So it views the community smart grid deployment as an opportunity to solve two problems at once. It joins with electrical worker unions and the local community college to create a new Digital and Distributed Power Systems Training Program to upgrade skills of existing workers and train future workers. Presence of the program attracts several smart energy technology installation companies with a total of 150 workers to the utility service area. The smart grid community itself attracts a new data processing firm employing another 45 people. Local availability of high reliability power means the firm does not need to buy its own expensive backup power system. That makes the case for the location. Last but not least the energy systems firm that built the innovative community digital power network leverages its successful experience to gain new customers in North America and East Asia. In a year it grows from 21 to 160 employees.

What Assets Does the Northwest Have to Become a World Smart Grid Center?

The Pacific Northwest is one of the world's best places to accelerate deployment of the 21st century smart grid. A number of regional energy organizations are already taking the lead.

➤ **World-class regional resources include the emerging Northwest smart energy cluster discussed above and a host of other regional institutions with a track record of energy innovation:**



Bonneville Power Administration's vision for the Energy Web, a smart power network rich in distributed energy resources.

World-class transmission operators – Bonneville Power Administration operates a major transmission system that sends power throughout the West, and is a home to leading edge energy innovations. Since 1999 it has formed a collaborative around Energy Web concepts, made one of the world's most extensive deployments of utility fuel cells, and shaped a Non-Wires Solutions process that represents one of the transmission's industry's most advanced efforts to replace costly line upgrades with smart energy technologies. BC Hydro has major initiatives to serve growing loads with clean energy and efficiency.

World-class research and development labs - Pacific Northwest National Laboratory based in Richland, Washington is a national research and development center for smart energy technologies ranging from intelligent appliances and buildings to fuel cells. A leader in conceptualizing the smart energy network, PNNL operates some of world's most complex power grid computer models and is a major player in the GridWise Alliance. The laboratory is also initiating creation of a Northwest Center for Electric Power Technologies aimed at promoting regional smart energy technology leadership through research, development and training. Powertech Labs in Surrey, BC, associated with BC Hydro, is one of the continent's leading centers for transmission R&D.

World-class universities – University of Washington and Washington State University are home to two of the nation's 15 graduate power engineering programs, and leading-edge energy technology research. Gonzaga is building up its power engineering programs. Oregon State University is a nationally recognized power electronics research center and University of Oregon has notable solar research efforts. In British Columbia important energy technology research is underway at University of British Columbia, University of Victoria and Simon Fraser University.

Innovative technology accelerators – The Northwest is developing networks of organizations aimed at helping start-up companies and accelerating adoption of new technologies. Northwest Energy Technology Collaborative, (described below under "What is the Northwest doing to make the smart grid happen?") is a regional effort targeted to help energy company start-ups. The Power Technology Alliance was formed in March 2005 to accelerate growth of British Columbia's smart energy and distributed energy resources sectors. Other business support efforts also help energy companies. They include the Spokane Intercollegiate Research and Technology Institute, which played a vital role in the launch of Northwest fuel cell leader ReliOn, and Kitsap Sustainable Energy and Economic Development which is developing a clean technology business park in the Bremerton area.

Innovative utilities – The Northwest's public and investor-owned utilities are energy efficiency leaders and some of the nation's largest purchasers of wind power. PacifiCorp became one of the first U.S. utilities to anticipate future costs for climate-disrupting carbon emissions in its long-range plans, and is adding major new clean energy generation as a result. Now such climate risk assessments are becoming standard for investor-owned utilities throughout the Northwest and California. Seattle City Light is becoming the first major U.S. utility to effectively zero out all its global warming emissions by buying carbon offsets. Energy Northwest, a consortium of public utilities, has become a major clean electricity developer. Many public utility districts are also developing broadband communications services that can act as telecom backbones for smart grid operations.

Innovative policies – The Northwest was one of the first places in the world to employ the concept of least-cost power planning. Through this process over the past 25 years it has pioneered the concept of efficiency as a power resource, generating the equivalent of one-third of new load this way and exporting the expertise gained to utilities worldwide. For a total expenditure of $1.75 billion over the past quarter century, the Northwest is saving $500 million in power bills each year, or a load equivalent to two Seattles. The recently adopted fifth regional power plan issued by the Northwest Power and Conservation Council in September 2004 for the first time calls for consideration of demand response as a least-cost alternative to building additional power plants and wires. The plan calls for development of 500 MW of demand response by 2009, as well as 700 MW of new efficiency gains.

Innovative market transformers – The Northwest Energy Efficiency Council and Northwest Energy Efficiency Alliance lead the region's efforts to accelerate use of conservation technologies. The Alliance is moving into the smart grid area with its Distribution Efficiency Initiative. It includes adding meters, automated controls and voltage regulation from PCS UtiliData to local distribution infrastructure, and pilot testing 500 MicroPlanet home and business voltage regulators. Energy Trust of Oregon manages state funding of efficiency and renewables and is undertaking coordinated efforts to deploy these technologies in ways that support the power grid.

How Will the Smart Grid Happen?

The coming of the smart grid is a systems revolution comparable to the deployment of other societal-scale infrastructures such as the Internet, the Interstate Highways and the original power grid itself.

➤ **As with those earlier outbreaks, the smart grid will catalyze in specific places where new concepts are pioneered and from which change will spread everywhere:**

- Before Eisenhower announced the continent-spanning Interstate Highway System in 1955, states such as Pennsylvania, New Jersey and California were building advanced limited access highways that later became links.
- The Internet began in 1969 with four computers at Stanford, University of Utah and University of California campuses in Los Angeles and Santa Barbara. In three years it broadened to 19 computers, in 35 years to tens of millions.
- Power systems, which now serve over 4 billion people, began in 1879 in testbed form at Thomas Edison's Menlo Park, N.J. lab, and were commercially demonstrated with Edison's 1882 electrification of a Manhattan district.
- The smart grid will emerge the same way, from specific geographies that forward themselves as centers of grid innovation. Smart energy technology deployment nodes dispersed across wide areas will grow together, linked by telecommunications into virtual smart grid networks that manage power flow on regional scales.

➤ **This process of emergence will occur in three stages:**

- **Bench test** – Laboratory development of technologies.
- **Testbed/demonstration** – Technologies are field tested under real world conditions of increasing scope and complexity, and in coordination with each other.
- **Deployment** – Proven technologies are disseminated on a mass market basis.

Most of the new smart energy technologies are already operating somewhere on the grid, but in a largely uncoordinated fashion.

No one has put the range of new technologies together in a systematic way. This represents lost opportunities. Much as personal computers did not realize their full potential before they were linked together in the Internet, smart energy devices provide their maximum value when they are working synergistically, when assembled together in systems.

But the fact that comprehensive smart energy systems have not yet been fully deployed is also understandable, since connecting new technologies can be difficult and have unpredictable effects. Deploying new devices in a systematic way requires sweeping changes, and making systematic changes before technologies have proven themselves is a risk few utilities will consider. So benefits remain unrealized and utilities remain skeptical.

Testbed/demonstration projects make the critical linkages, leaping the chasm between laboratory and marketplace.

Particularly in the electrical power industry, where a very high level of reliability is demanded, new technologies must demonstrate they are capable of providing required services. They must show how they work together to create communities of smart devices that provide benefits to all players along the electrical value chain. Testbed/demonstrations help work out the kinks and demonstrate the most effective ways to build integrated smart grid systems.

Robert Pratt, PNNL's GridWise lead, notes, "As technologies are developed and explored, testbeds and demonstration projects will provide experiments of ever increasing scale to prove their worth or reveal their faults. These demonstration projects will help build momentum for the changes that lie ahead and increase the support and reduce the perception of risk, building acceptance of the concept of a transformed energy grid."[25]

As much as they are about proving the functionality of new devices, testbed/demonstrations are also about testing regulatory and market frameworks which unleash economic benefits to both power providers and users.

Smart energy technologies offer ratepayers unprecedented opportunities to participate in the power marketplace by adjusting power demand to grid conditions. This can provide huge cost-saving opportunities for utilities, but customers must have economic incentives to participate. Smart energy also opens the door to tremendous energy efficiency improvements and increases in local generation, but utilities will have little drive to promote them if their revenues are purely tied to kilowatt-hour throughput. Ratemaking that offers utilities financial rewards for deploying the smart grid is one solution.

The critical need for smart grid testbeds is being recognized throughout the electrical power world.

EPRI has called for a federal smart grid research, development and demonstration effort of $1 billion over five years, to be matched by other players. That would stimulate around $100 billion in smart grid investment over a decade, EPRI says.

The Energy Future Coalition's Smart Grid Working Group notes, "A public-private partnership program is needed to support early deployment and demonstration of these innovative technologies . . . The demonstration projects will bring real benefits in power reliability, security and system flexibility that will enhance local and regional economic development. The demonstration program would be designed to field-test the new technologies that will be the building blocks of the smart grid, train the labor force to install and work with these systems, and build a broad base of constituents who are familiar and comfortable with the new technologies and what they can do."

The U.S. Department of Energy Office of Electrical Transmission and Distribution says, "Information technologies for distributed intelligence, sensors, smart systems, controls and energy resources need to be designed, field tested, standardized, and integrated with market operations of electrical transmission and distribution systems, and customer operations."[26]

The Northwest has many points of grid congestion and growing load that can provide opportunities to build nodes from which the smart grid grows, much as those original four computers originated the Internet.

The BPA Non-Wires Solution process is already identifying a set of potential places where advanced technologies can enhance transmission reliability. By concentrating deployments of smart energy technologies on transmission and distribution problem spots, the region will gain practical experience in creating advanced energy networks and begin building a grid capable of meeting 21st century demands. Since communications is the hallmark of the smart grid, deployment nodes that are geographically remote from one another can be operated in coordination to provide smart grid benefits. As the number of nodes increase and the web of communications links thicken, the smart grid will grow to blanket the region.

Testbed/demonstrations and deployments will also spur growth and job creation in the regional smart energy cluster.

Smart grid testbed/demonstrations and deployments that prove new technologies generate value streams for utilities and ratepayers will provide launch pads for Northwest smart energy industry success in the global marketplace. For example, the BPA Non-Wires effort employs Beaverton, Oregon-based Celerity to build distributed generation networks on the Olympic Peninsula that serve peak power needs and thus defer the need for new transmission lines.

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[25] Pratt, Robert G., "Transforming the U.S. Electricity System," Pacific Northwest National Laboratory

[26] U.S. Department of Energy Office of Electric Transmission and Distribution, *National Electric Delivery Technologies Roadmap*, Nov 2003, p.vii

What Is the Northwest Doing to Make the Smart Grid Happen?

The Northwest is already one of the geographies from which the smart grid is beginning to grow.

Previous sections have already outlined a number of steps already being taken by Northwest energy organizations to accelerate the smart grid, including BPA Non-Wires Solutions, PNNL's GridWise commitments and Northwest Energy Efficiency Alliance's Distribution Efficiency Initiative Regional fifth power plan goals for development of a major demand response market represent a further spur to smart grid development. Now the region is taking smart grid acceleration to a new level through alliances of key regional utilities and research outfits aimed at mounting technology testbed/demonstration projects.

Key Northwest testbed/demonstration efforts include:

Northwest Energy Technology Collaborative – works across public, private, nonprofit and research/educational sectors to catalyze growth of energy technology industries in the Northwest. NWETC offers a broad range of services including:

- Assistance in securing research and development funding and venture capital investments
- Connections to the regional network of university/laboratory facilities and business incubators
- Marketing and promotion from regional to international scales, including NWETC's own Northwest Energy Technology Showcase.

NWETC includes BPA, BC Hydro, Puget Sound Energy, Avista Corporation, PNNL, Washington Technology Center, Spokane Intercollegiate Research and Technology Institute, Washington State Department of Community Trade and Economic Development, ReliOn and the Inland Northwest Technology Education Center.

Graphic depicts chip developed by Pacific Northwest National Laboratory that gives home appliances on-board intelligence to respond to grid conditions.

Pacific Northwest GridWise Testbed is a new effort which joins BPA, PNNL, Portland General Electric and PacifiCorp in field tests of smart grid technologies and market frameworks that provide economic incentives for new technologies. Projects operated by the Testbed will be funded by a combination of U.S. Department of Energy, member and project partner resources. The Testbed intends to provide an institutional structure for developing and hosting smart grid demonstration projects, and plans to expand its membership to utilities throughout the Northwest.

The first project slated to launch over summer and fall will test smart appliances with on-board intelligence that senses when the grid is stressed and cycles power demand down in response. The technology developed by PNNL "creates a safety net under the grid," Pratt says. About 200 households in the service territories of participating utilities will be equipped with grid-responsive water heaters and clothes dryers. Whirlpool is participating with some of its latest appliance technology.

What's Holding Back the Smart Grid?

Beyond normal challenges faced by new technological entrants, smart grid technologies confront a regulatory system that often discourages their adoption.

Smart grid and smart energy technologies face the uphill battles any technological innovation encounters. New devices must prove they operate reliably and offer superior services and/or economics. But emerging power technologies face additional hurdles that represent what most observers regard as the overarching challenge. Traditional regulation sets up significant economic disincentives that do not allow utilities to fully recover investments in new technologies, and financially punishes utilities when customers install their own energy systems. Meanwhile, utility restructuring that aimed at overcoming some of those disincentives is incomplete and its status is uncertain. The overall effect is to place utility investment in both traditional and advanced technologies in a slump.

"The rapid emergence of the digital economy has severely strained our antiquated and inefficient power infrastructure," Harbor Research observes. "Already, power costs and supply problems are actually hampering economic growth in the U.S., and this situation will worsen steadily as power-hungry digital technology, and our dependence upon it, grows exponentially."[27]

Red Herring Magazine wrote a year after the great Northeast blackout, "Despite countless committees, investigations, and pontification that followed, little has been done to improve the flaws of the aged electrical infrastructure. Energy experts know what needs to be done – the problem is how to do it. The long-term answer is a smarter electrical infrastructure with better monitoring and consistent reliability standards in place, a so-called 'smart grid.' But a lack of financial incentives for utilities makes them hesitant to pony up billions of dollars for improvements."

"No one disputes that investment in power technology is at a nadir in the U.S." *Red Herring* said. "This is the lowest level of investment since the Great Depression, when adjusted for inflation," Clark Gellings of EPRI told the magazine."[28] "The technology exists to enable a radical overhaul of the way in which energy is generated, distributed and consumed – an overhaul whose impact on the energy industry could match the Internet's impact on communications," noted *The Economist*. "But unless regulators restore the economic incentives for investment, the future looks bleak. Time to stock up on candles and torches."[29]

The bipartisan National Commission on Energy Policy in December 2004 recommended encouragement of "new technologies to enhance the availability and reliability of the grid, in part by clarifying rules for cost recovery."[30]

"The technology exists to enable a radical overhaul of the way in which energy is generated, distributed and consumed – an overhaul whose impact on the energy industry could match the Internet's impact on communications," noted The Economist. ***"But unless regulators restore the economic incentives for investment, the future looks bleak. Time to stock up on candles and torches."***

The U.S. Department of Energy National Electric Delivery Technologies Roadmap notes, "More effective regulations and business practices are needed to spur innovation and increase testing of new technologies and techniques . . . State agencies need to revise their rules, regulations, codes and standards and revise those that inadvertently reward risk aversion and unnecessarily penalize prudent risk taking and entrepreneurial behavior."[31]

[27] Harbor Research, p13
[28] "Grid block: America's power grid is outdated and inadequate, but power companies are unwilling to dish out the cash for improvements." *Red Herring*, Aug. 16, 2004
[29] "Building the energy internet," *The Economist*, March 11, 2004
[30] National Commission on Energy Policy, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges*, Dec.2004, Summary of Recommendations p16
[31] U.S. Department of Energy Office of Electric Transmission and Distribution, *National Electric Delivery Technologies Roadmap*, Nov 2003, p.viii

What Regulatory and Policy Changes Will Unleash the Smart Grid?

A series of changes in regulations governing investor owned utilities overcome disincentives to, and create incentives for, adoption of smart energy technologies

Provide financial incentives for implementing smart energy technologies – Utilities are often hesitant to apply the latest technologies due to risk factors. One way to overcome this is to provide higher returns for bringing new smart energy solutions on line, including distributed generation, combined heat and power, load management and end-use efficiency. Utility regulators should work with utilities to identify smart energy technologies with ratepayer benefits including improved reliability and efficiency, and environmental benefits in terms of reduced emissions. In recognition of these broad benefits, regulators should allow or provide utilities financial incentives for implementing new technologies sufficient to overcome risk factors.

Break the link between energy throughput and profits – Utilities are hesitant to apply new technologies because they reduce the gross amount of energy throughput, either by improvements in efficiency or customer-side power generation. Utility ratemaking fortifies the hesitancy by setting pricing and revenues on the basis of cents per kilowatt hour. This ratemaking generally gives utilities a financial incentive to increase kilowatt throughput even if measures to reduce throughput reduce the total cost of providing service. Utility regulatory commissions should remove these disincentives by breaking the link between utilities' electricity and gas sales and their profits. This can be accomplished through small annual true-ups in rates to ensure that unexpected changes in sales do not affect the utility's ability to recover costs approved by its regulators. This involves comparing actual sales to those predicted when rates were set, and adjusting rates up or down to ensure that authorized revenues are collected (no more, no less). This is also known as decoupling. Any such system must be carefully designed to avoid unintended consequences and provide returns that are fair to all parties. Decoupling plans can and should be designed to provide win-win solutions for utilities and ratepayers. The Northwest has one operating model of decoupling in gas rates set for Northwest Natural.

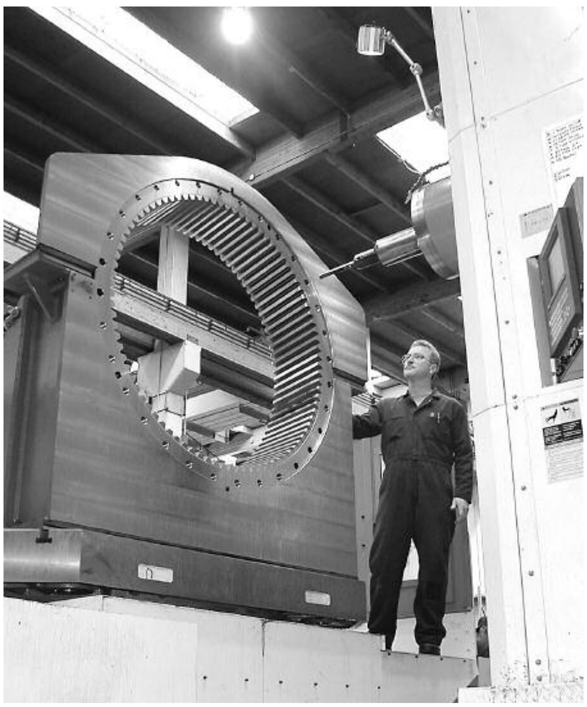
Employ performance-based ratemaking to provide positive incentives – Decoupling removes disincentives for utilities to implement measures that reduce energy throughput. Performance-based ratemaking is a complementary measure that offers positive financial incentives for utilities to promote such measures. Utilities and regulators target specific accomplishments such as an amount of energy to be saved through efficiency programs. For meeting or exceeding goals utilities gain rewards on the bottom line. Rhode Island, Massachusetts, New Hampshire and Kentucky have set up notable efforts in this area.[32]

Improve grid efficiency with incentives to reduce line losses – Power systems generally involve line losses, but if utilities are authorized to collect 100% of line loss costs from customers, there is little incentive to run the grid for top efficiency. Utility regulatory commissions should mandate that utilities optimize transmission and distribution networks for minimum line losses. Commissions should deny cost recovery for losses above this level.

Apply least cost planning to power delivery as it has been applied to generation – Planning to identify least cost options for power supply, whether generation or efficiency, was pioneered in the Northwest. But least cost planning has not yet

[32]These efforts are detailed in "Removing Disincentives: Efforts to Promote Electric Utility Efficiency," Kenneth J. Gish Jr., Preston Gates Ellis, http://www.prestongates.com/images/pubs/Removing%20Disincentives.pdf

fully come to power delivery systems. Utility regulatory commissions should update rules governing Integrated Resource Plans (IRPs) to require gas and electric utilities to apply least-cost planning principles to proposed transmission and distribution investments. Rules should ensure that utilities fairly and transparently assess non-wires options including clean distributed generation, combined heat and power, demand response and peak shaving. The Washington Utilities and Transportation Commission has opened a rulemaking process to update the integrated resource planning rules and request for proposals rules (UE-030311 / UE-030423 / UG-030312). This is a key opportunity for input and influence.



Utility planning that takes the cost of global warming emissions into account is increasing use of wind energy as well as windpower jobs. Shown here is a wind turbine being rebuilt at The Gear Works in Seattle.

Make sure utilities account for climate change and other risks to bottom lines – Integrated Resource Plans are beginning to take into account potential costs for emitting carbon into the atmosphere. Notable examples are IRPs created by PacifiCorp, Puget Sound Energy and Idaho Power. When carbon emissions carry a price, as they now do in Europe and Japan, it levels the playing field for clean generation and efficiency technologies. Utility regulators should insist all IRPs assign a cost to carbon dioxide emissions based on risk of future regulation and take into account fuel price volatility. The WUTC rulemakings mentioned above will also consider inclusion of guidelines for evaluation of additional risk factors such as fossil fuel and wholesale electric market price volatility, fossil fuel supplies, hydroelectric supply and other significant power rate spike threats. The Oregon Public Utility Commission has a rulemaking open to update its IRP rules to include more evaluation of risk (UM 1056).

Public utility governing bodies have policy options to unleash smart energy benefits for their ratepayers.

➤ **Smart energy technologies bring many benefits to ratepayers including improved reliability and rate control. Public utility governing bodies can take a number of steps to secure those benefits:**

- Designate staff to track and recommend emerging technologies of potential benefit to ratepayers including distributed generation, combined heat and power, load management and end-use efficiency.
- Place these "non-wires" technologies on a level playing field when considering upgrades in traditional pole and wire infrastructure. Study all options in a least-cost planning format.
- Place a priority on employing smart grid technologies such as voltage reduction to optimize delivery networks for minimal line losses.
- Work with public utility organizations, clean energy advocates and Bonneville Power Administration to overcome obstacles to local generation created by interconnection rules and losses of BPA power allocations.
- Public utilities involved in fossil-fired generation should assess risk of future costs on carbon emissions in their long-term planning.

How Can the Northwest Help Overcome Smart Grid Obstacles?

A Northwest Smart Energy Initiative will catalyze regional smart grid development and leadership.

The Northwest has an unparalleled set of public and private resources that make it a prime candidate to stage one of the world's most extensive efforts to test, demonstrate and deploy the smart grid. As this paper has documented the region has already taken serious steps in this direction. But to fully catalyze smart grid deployment and realize its many economic and environmental benefits the region must boldly assert leadership and undertake a coordinated, high-profile public effort that overcomes regulatory, technological and financial hurdles. A Northwest Smart Energy Initiative is a vehicle through which this can be accomplished.

Key leadership for the Northwest Smart Energy Initiative must come from the Northwest governors and members of the Northwest Congressional Delegation.

➤ **These public officials should come together to declare that:**

- Pacific Northwest states are joining in a Northwest Smart Energy Initiative to lead the way in smart energy and the smart grid.
- The region will undertake state and regional policy changes to accelerate the smart grid.
- Northwest governors will work with the Congressional Delegation to spur a new national smart grid effort that brings major federal funding to the region.

➤ **This smart grid initiative must coordinate with several related regional energy initiatives:**

- Climate and renewable energy - The Western Governors Association's goals for adding new renewables and the West Coast Governors Climate Initiative are both dependent on a grid that can manage and deliver large amounts of intermittent renewable energy. Meeting West Coast climate goals will also require large efficiency gains. The Northwest Energy Technology Collaborative also targets growth of smart and clean energy. Coordinated efforts by Northwest states to demonstrate and deploy smart energy and smart grid technologies will provide vital support to these environmental and economic goals.

- Grid operations - The Northwest, along with other Western states, is attempting to resolve uncertainties about who will operate and manage the transmission grid. GridWest, proposed as a regional transmission organization, in December adopted bylaws to continue development. The Northwest Power Pool's Technical Advisory Committee is also exploring future regional transmission needs. In addition, the Northwest Center for Electric Power Technologies is beginning to define and assess regional issues not only in grid operations, but in other technology areas related to electricity delivery and use. Northwest Smart Energy Initiative should work closely with all these efforts to make sure smart grid solutions are fully on the table.

Northwest Smart Energy Initiative Actions

	Governors	Congressional Delegation
Create state Blue Ribbon Commissions to develop smart energy roadmaps	X	
Ask utility regulators to build smart grid incentives into regulations	X	
Develop university centers of energy excellence	X	
Develop energy technology trade strategies	X	
Make public facilities smart energy models	X	
Secure testbed demonstration funding		X
Champion National Power Grid Fund		X

➤ **Key actions to be taken by governors include:**

- **Appoint a bipartisan state-level Blue Ribbon Commission to develop a smart energy/smart grid roadmap**. Draw together leaders from in-state energy technology companies, key power-using industries, electrical worker unions and investor owned utilities; public sector leaders from utility commissions, legislatures, energy agencies, economic development agencies, and public utilities; and representatives of universities, research institutions, market transformation organizations and nonprofit groups. Assign them to develop a state roadmap for accelerating development of the smart grid and smart energy sector which lays out actions for public, private and nonprofit sectors. Direct a high-level staff member to make the Commission one of their top priorities. Commissions should explore the concept of advanced energy technology research trust funds along the lines of the life science fund recently created by Washington state, and identify potential revenue sources. Commissions should also identify changes in state public policy needed to accelerate smart grid deployment. Blue-ribbon commissions should work with utility commissions to identify regulatory changes that create incentives for smart energy technologies.

- **Ask utility regulatory commissions to identify regulations that pose disincentives to advanced energy technologies and test regulatory models that create incentives.** Utility commissions are independent bodies but are also responsive when a governor sets a priority. Governors should ask commissioners and staff to set up a working group to uncover areas where regulations are creating barriers to the growth of the smart grid and related distributed generation technologies, and to explore solutions. An excellent example is the Oregon Public Utility Commission's in-depth study detailing recommendations to overcome barriers holding back distributed generation and Combined Heat and Power.[33] It is especially important to develop consistent least-cost planning guidelines for power transmission and distribution infrastructure paralleling long-term regional practices for generation planning. Governors should encourage commissions to work with utilities to create regulatory pilots that test new frameworks.

[33] Oregon Public Utilities Commission, *Distributed Generation in Oregon: Overview, Regulatory Barriers and Recommendations*, February 2005

- **Work directly with state universities and community and technical colleges to develop and enhance centers of energy excellence.** The power industry is facing a retirement "brain drain" from an aging workforce. By identifying the workforce needs of the 21st century power grid and training the next generation of utility and energy industry technologists and engineers, the region will have an edge in attracting and retaining smart energy companies. In addition, supporting advanced university research in fields such as power electronics and nanotechnology will found new companies and ground the regional smart energy cluster.

- **Develop an energy technology trade strategy aimed at developing nations markets, China and India in particular.** Pacific Rim nations are rapidly building power grids. Much as they have skipped past traditional telephone systems to cellular, they can also be markets for leapfrog smart and clean power technologies that can be deployed more economically than conventional central generation and transmission systems. Governors should direct their trade promotion organizations to promote Pacific Rim market opportunities for in-state energy technology companies, and make energy a central theme of their own trade promotion tours.

Solar photovoltaic modules installed at Puget Sound Electrical Joint Apprencticeship & Training Committee's Renton Training Center in photovoltaics training program.

- **Make public facilities into smart energy models.** Much smart energy technology works on the customer end, and public buildings and infrastructure represent some of the largest power users. So public facilities represent a major opportunity for early deployment of technologies such as advanced energy efficiency and load control systems, and on-site clean power generation.

➤ Key steps to be taken by members of the Northwest Congressional Delegation include:

- **Secure funding for smart grid testbed/demonstrations.** The delegation already has done notable work to secure initial funding for the GridWise NW Testbed. Now as testbed/demonstrations grow in scope and complexity, so should funding. EPRI's call for $1 billion in federal funding over five years represents a well-informed assessment of the need. In the 1980s the Northwest undertook a demonstration project to test the full potential of energy efficiency in a model community, Hood River, Oregon. Involving most residences, the project validated that efficiency could be a significant energy resource, and spurred efficiency programs not only in the Northwest but across the U.S. But the Hood River Project cost approximately $25 million, an amount that would be hard to replicate in today's financially stressed utility world. The Northwest has world-class research and utility assets that equip it to mount similar, broad efforts to demonstrate the potential of smart energy technologies. Benefits of the knowledge gained would address vital national needs, power reliability in particular – Grid vulnerability is an important homeland security risk. So

[34]*Report of the Smart Grid Working Group*, Energy Future Coalition

substantial federal funding is justified. Members of the Delegation should work with such institutions as PNNL and BPA to develop proposals and substantial federal funding for large-scale smart grid testbed/demonstrations.

- **Champion a National Power Grid Security and Modernization Fund.** The public interest in modernizing the grid exceeds the financial capacity of hard-pressed grid operators to make the billions in needed investments. This justifies a national trust fund to accelerate grid modernization. The Energy Future Coalition's Smart Grid Working Group notes, "a major new investment vehicle must be developed . . . In many respects this priority is analogous to the circumstances surrounding the country in the 1950s when a national approach to financing the Interstate Highway system was adopted. We now need a National Electricity Superhighway and are proposing a parallel way to begin the investment to deploy it."[34] The group identifies a number of potential funding sources including fees assessed on power sent through lines and bond issues. Such a fund should be structured to prioritize small-scale technologies that operate near the customer end and offer lower-cost alternatives to traditional pole, wire and central plant infrastructure. A grid trust fund might be perceived as a "new energy tax." But it could pay for itself by just preventing one or two major blackouts. The cost of power disturbances adds as much as 50% to the approximately quarter trillion dollars Americans pay annually for electricity. An unreliable grid represents a hidden tax on all power ratepayers. Targeted public investments in the smart grid will pay for themselves many times over.

The Smart Grid Workforce

The need for training in new grid technologies and to replace an aging utility workforce represents an opportunity to address two critical power industry issues at once.

The infusion of advanced energy technologies into the power grid will demand extensive workforce training. Utility linemen and utility electricians will require familiarity with automated grid systems. Utility planners, reliability coordinators and control room operators will have significantly richer information streams from digital networks throughout the grid that they must learn how to use. Lack of workers qualified in these advanced technologies will create barriers to adoption.

The need to train the smart grid workforce provides an opportunity to resolve a looming problem facing the utility industry, an aging workforce that will substantially retire over coming years without having transferred their knowledge to a new generation of workers. A Carnegie-Mellon University survey of public and investor-owned electric utility human resources departments underscores this is their greatest worry. Of 53 utilities representing more than 383,000 employees, 40 named their aging workforce as their top concern. It was the number two concern for another eight, and was mentioned by the other five.[35]

"It all boils down to money, whether there will be enough trained people to keep the industry going," notes Jim Hunter, International Brotherhood of Electrical Workers Utility Department director.

Regional efforts to advance the smart grid should examine this challenge and identify funding sources to build up regional utility training outfits such as the National Utility Training & Education Center at Hanford.

Also emerging as a crucial need, for utilities, smart energy companies and education/research organizations are skilled scientists and engineers in the power technologies field. A report from Senator Maria Cantwell's office focuses the challenge.

"Both industry and academia are bracing for a critical shortage of engineers in this area. More than half the nation's science and engineering workforce will reach retirement age in the next 20 years. Currently the Institute of Electrical and Electronic Engineers reports 360,000 electrical and 23,000 registered power engineers. Yet today there are only about 500 undergraduate degrees awarded in the area of power engineering – compared to nearly 2,000 in the 1980s – fewer than 200 masters degrees and about 20 PhDs conferred per year."

The Cantwell report calls out the potential opportunities this opens for Washington state. Of 15 U.S. universities offering graduate level power engineering programs, Washington State University and University of Washington are two, while Gonzaga University offers a strong undergraduate program. (Oregon State University, not covered in the Washington senator's report, also has nationally recognized programs in the electrical and power fields.) "Washington state has the beginnings of a competitive advantage in the area of energy technology due to our existing industry and the fact our universities are leaders in the area of power engineering,"[36] the report says. It calls for increased federal support for grants, traineeships and fellowships in energy-related fields.

"Washington state has the beginnings of a competitive advantage in the area of energy technology due to our existing industry and the fact our universities are leaders in the area of power engineering,"

[35]Ashworth, Michael J. *Workforce Aging and Involuntary Turnover in the U. S. Electric Power Industry: Empirical Investigation and Research Agenda* (Working Paper), 2005, Electricity Industry Center, Carnegie Mellon University
[36]Office of Senator Maria Cantwell, *Meeting the National Demand for a Skilled Energy Workforce*, April 15, 2003, p2-3

Conclusion: The 21st Century Smart Grid - Time to Take the Lead

Fast forward to a sizzling summer afternoon on the Western power grid sometime in the not too distant future. A main Oregon-California transmission line is sagging under stress. Inch by inch it sinks until a high voltage spark jumps toward a nearby tree branch with a crackle and flash, shutting down the line and cutting off much of the power flow from the Northwest to the Golden State. In the old days, before the grid was rebuilt, this would have meant a blackout. It did twice in 1996. But now the smart grid kicks into action. The sudden drop in juice throughout the grid comes as an instantaneous signal to literally millions of refrigerators, hot water heaters, air conditioners and other appliances to cycle down demand. Networks of small-scale local generators distributed throughout the grid receive signals to come on line and provide power supplies to stores, offices and factories. The combination relieves the grid long enough to bring in replacement power from the Southwest, averting a blackout. The lights stay on and the economy continues to function unaffected. This future is not only possible – It is coming.

The key question is who lead the way and pioneer the smart grid.

Certainly, with the security issues involved, development of the advanced power grid should become a federal priority. But regions that step up to the plate to develop their own smart grid initiatives will play a vital role in setting the agenda, and be first in line for federal resources. State and local governments, public and investor-owned utilities, research and educational institutions, technology companies and investors, labor unions – All have critical roles to play in assembling regional initiatives. All have resources and expertise they can and must bring to the table.

Tens if not hundreds of billions will be invested in the U.S. power grid over coming decades to modernize it and keep up with growth. With a Northwest Smart Energy Initiative that overcomes the financial, regulatory and technical hurdles to full scale deployment of advanced power technologies, the region will put itself and its companies in line to gain a substantial portion of these billions.

No place is better positioned to lead than the Pacific Northwest.

This is a moment of supreme opportunity when a revolution is emerging in the ways electricity is generated, delivered and used. The Northwest has an unequalled depth of public and private smart energy resources, and possesses singular opportunities and distinct incentives to vigorously move this electrical revolution forward.

A Northwest Smart Energy Initiative will build a new regional economic sector and position the Northwest to lead the transformation of one of the world's largest industries.

Tens if not hundreds of billions will be invested in the U.S. power grid over coming decades to modernize it and keep up with growth. With a Northwest Smart Energy Initiative that overcomes the financial, regulatory and technical hurdles to full scale deployment of advanced power technologies, the region will put itself and its companies in line to gain a substantial portion of these billions.

A comprehensive regional smart grid initiative will provide the Northwest with secure regional power supplies, build up the Northwest's world-class smart energy companies and position the region at the forefront of the electrical power sector's global transformation. For the Northwest's economic future, it is hard to imagine a more important or rewarding step. If Northwest states take the lead in smart grid demonstration and deployment our reward will be thousands of good, new jobs and a central role in meeting the world's growing electric power demands with the 21st century's smart energy technologies.

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