GLOBAL SMART GRID FEDERATION REPORT

LETTER FROM THE CHAIR

Dear Colleagues,

I am extremely pleased to present findings from the Global Smart Grid Federation smart grid comparison work. In the following pages, you will find insightful analysis of the member's energy markets and project summaries reflecting leading edge deployments of smart grid technology around the world. This report clearly articulates a key goal of our organization, namely how global collaboration can help accelerate the critical transformation of our energy infrastructure. Creating and sharing international best practices is the best way to maximize consumer involvement, apply both proven and new technologies, and adapt policy and regulatory structures to support this new environment. We believe you will find this analysis highly instructive as you attempt to navigate a course toward a technology and public policy path to advance smart grid deployment.

Sincerely,

Guido Bartels
Chair, Global Smart Grid Federation

ABOUT THE GLOBAL SMART GRID FEDERATION

The Global Smart Grid Federation is committed to creating smarter, cleaner electricity systems around the world. By linking the major public-private stakeholders and initiatives of participating countries, the federation shares practices, identifies barriers and solutions, fosters innovation, and addresses key technical and policy issues. These and other activities help member organizations initiate changes to their countries' electric systems to enhance security, increase flexibility, reduce emissions, and maintain affordable, reliable, and accessible power.

In addition, the Global Smart Grid Federation works with the International Smart Grid Action Network as well as with national and international government policymakers to address the broad challenges of deploying smarter grids. This nexus provides a forum for communication and collaboration, which will advance smart grids around the world and facilitate consensus-building within the international community to address electricity system and climate change concerns.

KSGA
Korea Smart Grid Association

ACKNOWLEDGEMENTS

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We want to thank the GSGF members who participated in this study for sharing their experiences with us. We would like to extend a special thanks to their individual representatives who provided invaluable insight and information: Matthew Futch of Gridwise Alliance, Paul Budde of Smart Grid Australia, Max Bryan of Alcatel-Lucent (Australia), Susan Hwang and Jin-Kyung Im of the Korea Smart Grid Association, various contributors from the Japan Smart Community Alliance represented by Naoko Fujino, Liam O'Sullivan (UK Power Networks), Toby Peters and Solmaz Moshiri (Highview Power), Dora Guzeleva of the Low Carbon Networks Fund, and Florian Chapalain of EDSO for Smart Grids.

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INTRODUCTION

The term “smart grid” is a flexible concept which can be very simple or very ambitious in its expression. The European Union Commission Task Force for Smart Grids defines “smart grid” as an electricity network that can cost-efficiently integrate the behaviour and actions of all users connected to it in a manner which ensures an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety. The U.S. Department of Energy Smart Grid Task Force goes into further detail, specifying that smart grids anticipate and respond to system disturbances in a self-healing manner, enable active consumer participation, accommodate all generation and storage options, enable new eco opportunities, optimize asset utilization and efficient operation, and provide the power quality needed in a digital economy. The smart grid brings together the idea of grid modernization and the closer integration of all actors in our electricity system.

These ambitious definitions reflect a range of possibilities which have captured the imagination of policymakers, regulators, operators and innovators around the world. Many of these characteristics are no longer mere possibilities, but have been actualized in products and systems which are integrated into live electrical systems with positive results. In all the countries we profile, governments have made energy security, economic growth and environmental sustainability key national objectives. The smart grid is a key enabler for achieving these objectives. As a result, governments and industry are collaborating on making the smart grid a reality. Most of these projects are in their early stages of planning or implementation, but some have advanced far enough along to provide useful insight into the benefits of the smart grid. The smart grid has not yet captured the popular imagination, but no national awareness campaigns have yet been undertaken in the countries we profile.

In this report, we survey the smart grid activities undertaken by the Global Smart Grid Federation (GSGF) membership and discuss some of the key opportunities and challenges faced by these projects. To provide some context for the reader, we also describe the policy and sector backdrop against which these activities take place. This report will illustrate that, as the global grid evolves, there are unique and important opportunities for information sharing and collaboration, which will ensure that investments made serve the global society well into the future.

RESEARCH METHODOLOGY

For this report, we asked participating GSGF members to submit country profile reports and project profile reports on smart grid activities taking place in their jurisdictions. We then conducted interviews with representatives from each participating member based on the results. Taking the results of these sessions and conducting research of other relevant primary and secondary sources, we put our findings down on paper and distributed them to the various participating members, asking for comments and confirmation on the portions of our work pertaining to them and incorporating the feedback we received. The final product of our efforts is set out in these pages.

EXECUTIVE SUMMARY

1. At its simplest, the "smart grid" refers to a more efficient, modernized electrical grid. It allows users to manage their electrical demand or output in a way that is most cost-effective for them and beneficial for the power system.

2. In each of the countries we profile, the smart grid forms a vital part of government strategy to achieve the common goals of energy security and low carbon economic growth. Only the smart grid can integrate distributed renewable generation into the power system, which permits countries to bolster their energy independence while reducing their carbon footprint. The smart grid fosters innovation and economic growth fueled by skills development and higher employment levels. It presents unique economic opportunities for industry and individuals to profit by engaging in behaviours which help achieve important societal goals like energy security and decarbonisation.

3. The smart grid forms part of government strategy at a time when utilities need to refresh and modernize their operating infrastructure. In the developed world, most electrical grids were built in the post-World War II period. In all the countries surveyed in this report, electricity demand is growing and load profiles are changing, putting strains on aging infrastructure.

4. The smart grid can be built. The projects highlighted in this report evidence the fact that smart grids exist. This report profiles the leading grid modernization projects in the world, nearly all of which are still in the development or pilot stage.

5. Most of the profiled smart grid projects are complex. They attempt to incorporate multiple smart grid elements. The more complex a project, the more inherent risk there is to its successful implementation. A step-by-step approach could mitigate this risk.

6. The most difficult challenge to a successful smart grid lies in winning consumer support. Without it, the smart grid cannot exist and it cannot deliver its promised benefits. Ultimately, the consumer is paying for the smart grid. The smart grid does yield important benefits for consumers, but they come at a significant cost and, at the individual level, the need for these benefits may feel less immediate.

7. Winning consumer support hinges on a radical change in thinking by utilities about their customers and by consumers about electricity. Utilities risk taking their customers for granted, being overly technocratic in their relationship with them, and possibly alienating them. They would be well-advised to engage with consumers on a new level, perhaps borrowing from the best practices of more competitive, consumer-centric industries. Likewise, in many developed countries, consumers risk taking electricity for granted as a low-cost commodity, which is always available, rather than a commodity subject to market swings in a manner similar to gasoline. Active consumer engagement in the power system will depend on a change in this perspective.

8. The government is best positioned to educate consumers on the value of the smart grid. The smart grid is really part of government strategy to achieve societal goals. The electricity sector is highly regulated by government. The government has the resources and skills needed to mount large scale smart grid messaging campaigns. It is also the best advocate for citizens on consumer-oriented issues such as affordability, privacy, cyber-security, health and safety.

9. Government can be an effective mediator between the consumer and the power system. Governments can (a) better persuade consumers of the benefits of smart grid, (b) better represent and protect their interests in smart grid developments, and (c) provide an effective framework of incentives (and disincentives), which induce the desired behaviours while still empowering consumers with choice.

CHAPTER I

KEY THEMES

SMART GRID

THE OPPORTUNITY

The smart grid is an important enabler of energy security and low carbon economic growth, which are key national policy objectives for each of the countries we profile. For these countries, “energy security” means having sufficient energy resources to meet the present and future needs of its citizens and industry. Fossil fuels meet the majority of the world’s energy needs, but are a limited resource. With the rising cost of fossil fuels, instability in the major exporting countries, and concerns that “peak oil” is approaching, governments are attempting to diversify their energy sources and bolster their energy independence by increasing renewable energy in their energy supply mix. Electricity generated by photovoltaic and wind sources is intermittent in nature, and existing power grids are not well-equipped to handle intermittent power the way smarter grids can. Smart grids also enable the more efficient use of electricity, shaving losses incurred during delivery and encouraging more efficient energy behaviour by customers.

The smart grid helps foster economic growth by helping meet the electricity requirements of industry. For some countries, it can help manage the long-term cost increases of electricity. The UK government believes that electricity sector reform will actually reduce the price of power for the United Kingdom, that increasing domestic green energy in the supply mix will be cheaper in the long run.

The smart grid is also an industry in itself which presents governments with an opportunity to invest and support initiatives that foster (a) innovation (both technological and intellectual) and (b) economic development through skills development and jobs growth, while addressing its energy security needs. Not surprisingly, some governments like those of the U.S.A., South Korea and Japan are approaching the smart grid as the next big opportunity for their economies to become global leaders in an industry – in this case, the new energy technology sector. Also, smart grids can empower individuals to participate and even profit from the power system in a manner that was not possible before. For these reasons, particularly in times of global austerity where governments may seek to sustain economic growth levels through fiscal measures, the smart grid appears to be a particularly sound investment choice.

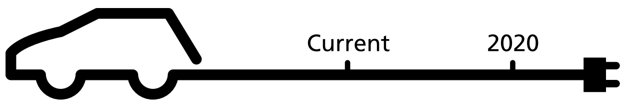
2011 Retail Electricity Price for Households (US cents per kWh) [1]		Key Trend Factor
CANADA	¢ 9.5	Aging infrastructure
US	¢ 11.6	New natural gas reserves
GREAT BRITAIN (UK)	¢ 19.9	More imported natural gas
IRELAND	¢ 23.3	Wind energy integration
JAPAN	¢ 23.2	Nuclear decommissioning
KOREA	¢ 8.3	Encourage energy efficiency

[1] *Key World Energy Statistics 2011.* International Energy Agency, 2011.

Nearly all of the countries we profile have decarbonisation targets, either under an international instrument or domestic legislation. The Kyoto Protocol came into force in February 2005 and legally binds signatories to their stated decarbonisation targets. Developed countries must cut GHG emissions by at least 5% between 2008 and 2012, while developing countries are not required to reduce emissions at all. In 2007, the European Union obligated its membership meet climate and energy targets by 2020: a 20% reduction in greenhouse gas emissions (GHG), a 20% increase in energy efficiency, and 20% of EU’s energy consumption from renewable energy. Through additional directives, the EU has imposed additional obligations relating to renewable energy, smart meters and smart grids on its membership. The smart grid furthers these goals by integrating renewable energy sources and electro-mobility into the existing power system and introducing new efficiencies through grid modernization.

The electrification of transportation (sometimes referred to as "electro-mobility") presents both a challenge and an opportunity for the power industry. Electro-mobility brings a fundamental shift of economic opportunity away from the oil industry to the electricity industry. Using existing infrastructure, utilities can serve the power needs of electric vehicles (EVs) during periods of low demand, providing EV users with a lower cost alternative to gasoline while increasing the utilities' asset productivity and revenue levels. To capitalize on this opportunity, key smart grid investments must be made.

It is clear that the smart grid can yield significant benefits and address pressing needs. But there are challenges to realizing it.



Number of Electric Vehicles

	Current	2020
CANADA	<500	500,000
GREAT BRITAIN	1055	1,700,000
IRELAND	2000	150,000
JAPAN	2000	15,000,000
KOREA	<500	152,000
USA	10,000	<500,000

CHALLENGES TO SMART GRID SUCCESS

1. BUILDING THE SMART GRID

Can a smart grid be built? The various projects profiled in this report provide evidence that smart grids are possible. In fact, they prove that smart grids in their infancy now exist. Complex smart grid projects in Miyako-Island and Hachinohe, Japan, and Jeju Island, South Korea are operational. Similar projects are underway elsewhere. The building blocks for smart grids are all there. There are a number of jurisdictions which have implemented smart metering and EV infrastructure. There are both utility-level and consumer-level energy storage systems operational and integrated into the power systems in Great Britain, Japan, and South Korea. Modular energy management systems for homes and buildings are in development, and different utilities are implementing centralized and decentralized network control systems.

Still, there are challenges to smart grid development. Technological developments are outpacing standards development and regulatory frameworks, creating risk that new technologies may not meet evolving standards or regulation. Conversely, any regulations or standards, which are developed to address issues specific to the smart grid, risk losing relevancy if outpaced by technological development. How meaningful are these risks? Assuming that they cannot be eliminated, what are some effective risk mitigation strategies? A stable regulatory environment is critical to attracting investment in the smart grid space. Clear standards – for example, interoperability standards – could encourage investment while promoting competition, which theoretically increases choice and reduces costs for consumers. How do we balance the seemingly competitive interests of certainty and innovation? Arguably, the risk of a disconnect forming between technological development, standards development and regulatory evolution is low because of the high level of collaboration and consultation between relevant stakeholders in the electricity sector. Procedural safeguards facilitating this type of collaboration and consultation seem like the most prudent approach to balancing the interests of separate, but related processes. For these reasons, the ongoing work of groups such as the GSGF, its constituent members, the International Energy Association, and various standards associations to promote information-sharing and collaboration across projects and countries is critical to smart grid development and success.

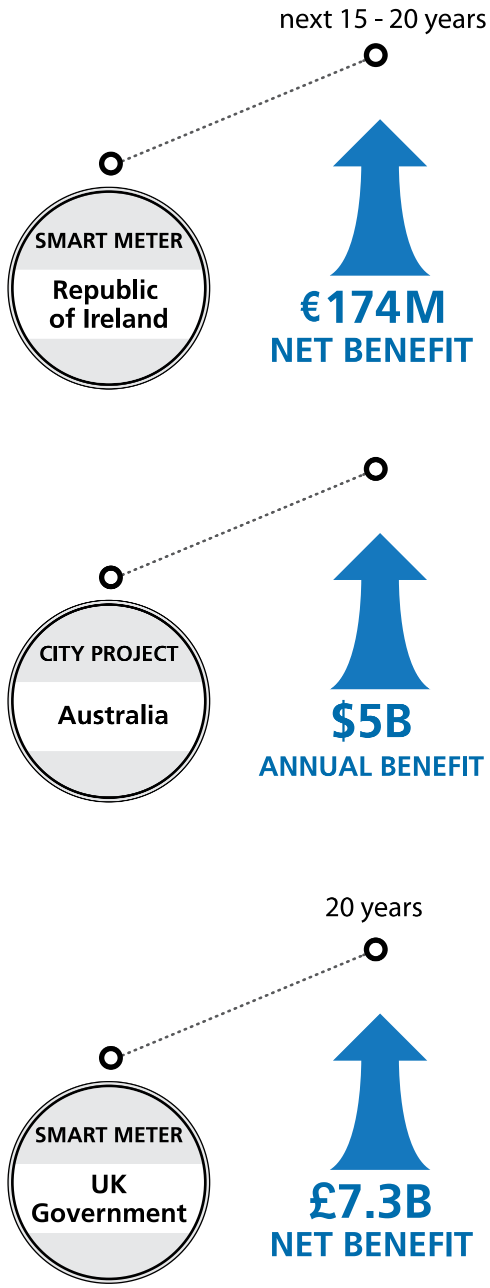
Another possible challenge to innovation is a commonly cited obstacle to innovation in other industries: protectionist attitudes towards intellectual property. The tension between intellectual property rights, innovation and standards development is a well-canvassed topic beyond the scope of this report. It is worth noting, however, that many power systems designed in the past have been based on proprietary standards. The exponential increase in the number of interconnected devices on the power system underscores the importance of developing interoperability standards, similar to those developed in the telecommunications and consumer electronic industries as the power system becomes enriched with intelligent devices.

Interviews we conducted for this report provided important insights on other challenges to smart grid implementations. We heard that in complex projects covering multiple aspects of the smart grid, teams should focus on one or two functions at a time, advancing only when those functions are implemented successfully, and their value is proven. We learned that properly defining stakeholder needs was challenging. Part of the difficulty lay in defining appropriate categories of stakeholders (particularly, consumers) and then failing to really understand their needs. For instance, not properly and adequately communicating the anticipated benefits of a project to stakeholders was cited as a reason for the unpopularity of the Boulder City SmartGridCity project. We also heard that utilities risk being overly technocratic in their approach to a project and undervaluing the consumer, even in projects which aim to modify or rely on certain consumer behaviours. Coupled with near monopoly status, this type of technocratic attitude can alienate consumers from utilities, with negative consequences, particularly against a backdrop of rising electricity rates. Poor consumer responses to smart metering trials in Australia and Europe and low consumer participation in other smart grid projects were referenced as examples. In each instance, our respondents underscored that better communications with stakeholders and prioritizing consumer-centric benefits could have mitigated or altogether avoided these results. For the consumer segment, one interviewee noted that real-time dialogue in community forums was far more effective in communicating information than mailing out informational brochures.

2. A CHALLENGING BUSINESS CASE FOR POWER SYSTEM PARTICIPANTS: WHAT IS THE VALUE PROPOSITION?

We know that smart grids provide benefits, but are they sound investments for power system participants? From the perspective of existing utilities, if everything in the power system remained the same, there might be little reason to undertake a smart grid project. Smart grid projects typically involve big capital investments and long implementation cycles. The return on investment for the distribution network operators is not clear and is highly disruptive to the day-to-day business of the utilities.

We know, however, that power systems all over the world are changing because of government initiatives and, in some cases, consumer demand. To further their goals of greater energy independence, efficiency and decarbonisation, in all the countries we profile, governments have enacted some type of feed-in-tariff program that establishes a premium price for renewable energy. They have implemented or are implementing advanced metering infrastructure (AMI) in



some subset of their populations with a view to promoting changes in consumption patterns and greater consumer participation in the power system. In Japan, the Great East Japan Earthquake pushed power system reform to the forefront of popular debate, making consumer empowerment and the restoration of consumer trust in the power system high profile issues with the populace and top priorities for Japanese policymakers. In the U.S.A., Canada and Europe, consumer interest in independent power generation and EVs has grown. Electricity consumption is expected to increase with the electrification of transportation, ultimately displacing at least some of the transportation sector's demand for oil.

These changes have altered the operating landscape of utilities. They are no longer responsible solely for the inexpensive delivery of reliable power. They are now seen as agents of economic growth and environmental policy. Many utilities in the developed world are operating with aging infrastructure, and many have undertaken infrastructure improvements to address these new mandates. Using new tools to analyze intelligence collected real-time from smart devices, utilities can lengthen the useful life of assets. For Manitoba Hydro in Canada, a transmission dynamic line rating project avoided the need to increase the utility's planned transmission capacity. For developing countries, accommodating the load growth associated with fast growing economies is challenging enough. Current grid modernization technology can help them attain operational efficiencies such as improved voltage stability and reduced network losses. At this stage, the cost of modernization can outweigh direct benefits to the utility in many projects. However, when societal benefits are factored in, projects can have positive business cases. Including societal benefits into the business case for these projects seems only reasonable as these projects are really intended to further larger economic and environmental policy objectives.

At the societal level, the smart grid can yield substantial benefits. This is evidenced by the various reports on smart metering and smart grid in Ireland, Australia, and the UK which document positive results or estimates. But for consumers, at the individual level, the need for the smart grid feels less immediate. We found that, in the vast majority of the projects surveyed for this report, costs flowed through to the consumer either as a taxpayer or as a ratepayer through higher electricity prices. For many consumers, who have probably taken electricity for granted as a low cost, abundant commodity, the smart grid imposes this financial burden and added inconveniences, which aim to modify existing behavioural patterns. This presents the most difficult and important challenge we see to realizing the smart grid vision: How do you convince electricity consumers to change their behaviour and pay more for it?

3. WINNING POPULAR SUPPORT WITH THE RATEPAYER – CONSUMER ENGAGEMENT

Consumer engagement is critical to the smart grid's success. Consumer support is also critical to smart grid's survival because, without the support of the ultimate payor, smart grid initiatives would not exist. To illustrate, in a 2011 Canadian provincial election, the citizens of the Province of Ontario were presented with an opportunity to abandon the incumbent government's ambitious green energy strategy of which smart meters and the smart grid formed a part. The electorate gave the Ontario Premier another term in office to pursue this ambitious strategy, under a minority win.

For these reasons, consumer engagement should be a critical part of any smart grid strategy. For consumers to be engaged, they must be (a) motivated and (b) enabled. Voluntary engagement is ideal and preferable, particularly given that smart grids can only exist with government support and governments depend on popular support. Consumer participation in the power system is relatively new as a popular concept. There are consumer movements towards energy autonomy – "living off the grid", so to speak – but they are limited in number, and early adapters alone cannot form the consumer base needed to effect change.

Because motivation is not always organic, external stimulus is sometimes necessary. Of the countries we profile in this report, most have already introduced or intend to introduce some form of time-of-use (TOU) pricing which is meant to induce the desired behavioural changes. Project teams have seen reductions in energy usage ranging anywhere from 2.5% to 15% by introducing smart meters, in-home-display units (IHDs), and, in some cases, TOU billing. As one project manager we interviewed for this report noted, "green" does not matter as much as money when it comes to consumer choices. Relying on this type of observation, projects such as "ADDRESS" and "EcoGrid EU" in the European Union are experimenting with additional financial incentives by making consumers vendors in the electricity market, giving consumers the opportunity to sell power back into the grid or sell additional balancing and ancillary services to network operators.

To enable consumer participation in the power system, consumers must have the information they need to make decisions. AMI is the basic infrastructure needed to enable effective consumer participation in the power system because AMI gives data on electricity price and consumption to customers and utilities. Together with IHDs and customer web portals, AMI communicates information about customer energy consumption, price signals (including TOU pricing information), and improved energy diagnostics from more detailed load profiles. These solutions act as an intermediary between the power system and the consumer, and they are being implemented in nearly all of the projects profiled in this report. Outfitting consumers with energy management systems (including energy storage solutions) and distributed generation resources further empowers them to become more independent and even active as vendors in the electricity market.

By using (a) financial incentives or disincentives to motivate consumers and (b) new technology to enable consumers, can you achieve the consumer engagement needed to make the smart grid a reality? Not really. There have been very negative consumer reactions and even resistance to projects incorporating versions of TOU pricing and demand response technologies. In the Netherlands, a smart metering implementation was halted in response to consumer protests based on privacy concerns. It eventually resumed, albeit in a modified form which allowed customers to refuse smart meter installations. In the Australian State of Victoria, consumer resistance to mandatory smart meters and the planned TOU scheme became well-publicized. Class action suits in the U.S. States of California and Texas alleged overbilling and raised health and privacy concerns. Poor communications with stakeholders contributed to the negative response to the SmartGridCity project in Boulder, Colorado, U.S.A. Consumer-centric concerns have fueled the debate in Great Britain as to whether smart meters should be mandatory.

From these examples, we see that (a) the failure to be sensitive to consumer-centric issues like privacy and security can jeopardize a project and (b) concerns about whether consumers can bear the cost of renewable energy and the grid updates required to deliver renewable energy may be well-founded. How then is it best to bolster consumer support and therefore engagement in the smart grid? In our interviews, we heard a common message regarding the need for a national consumer engagement strategy. In some smart grid projects, the utilities involved are attempting to mount consumer awareness campaigns for what are essentially societal or national policy goals. Utilities are typically monopoly providers which lack experience in winning over consumers. While many have government relations departments, few utilities have consumer-oriented marketing departments. Notably, for its planned smart meter deployment, the UK government just recently released a draft consumer engagement strategy for comment. Generally, we did not find this in other countries.

ROLE OF GOVERNMENT

Significant government investment enabled nearly all of the AMI and smart grid initiatives we surveyed for this report, taking the form of cash expenditures, regulatory reforms and/or rate recovery intended to enable smart grid investments. In all of the countries we profile, the electricity industry is typically dominated by monopoly providers and is highly regulated. Government determines who the industry participants are and exercises significant price controls through regulating bodies. In short, governments have set the smart grid agenda for their respective electricity sectors and are financing its development. Because governments control so many of the factors the smart grid depends on, they bear significant responsibility for the smart grid's success or failure. Because they control prices and the regulatory framework, it is incumbent on governments to provide a stable and transparent environment to encourage investment and facilitate cooperation between regulatory authorities and industry.

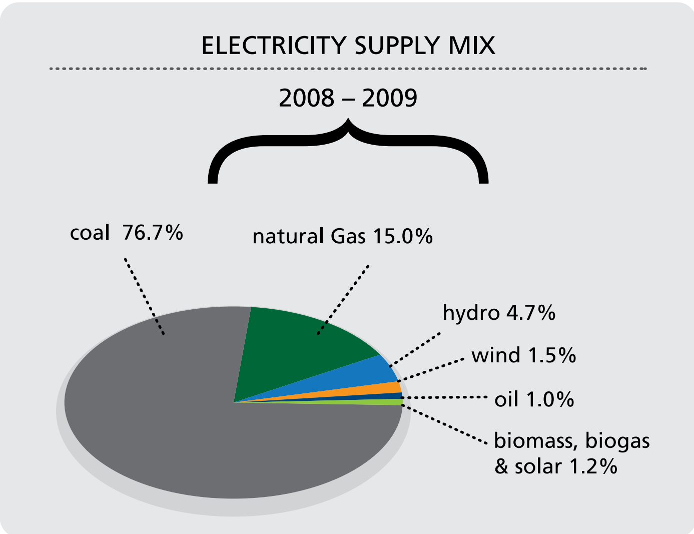
For these reasons, the government, in collaboration with the industry, is arguably in the best position to tackle what may be the most difficult yet critical factor for success: consumer support. Governments have adopted AMI and the smart grid as key tools to further policy objectives which are ultimately important to the individual, but the pressing need for which is not necessarily felt at the individual level. Smart grid project teams are trying to convince consumers of the importance of these objectives and the benefits of the smart grid with mixed results. In some cases, consumers appear to have pitted themselves against utilities in response to rising prices and pressures that they attribute to utilities. For the smart grid to succeed, governments need to play a leading role in mediating this relationship, better communicating with consumers and protecting and advocating consumer interests in smart grid development.

CHAPTER II

COUNTRY REPORTS

In this chapter, we profile leading smart grid projects nominated by participating GSGF members. To provide context for the reader, we also describe the policy and industry background for these projects. By doing so, we hope to encourage continued information-sharing and dialogue between project teams, industry and consumer associations, and policy makers, as they tackle common challenges to further common interests in the smart grid.

01 AUSTRALIA



A. ENERGY POLICY

Focusing on demand management, energy security, and energy efficiency, Australia has set an ambitious national target to integrate 20% renewable energy by 2020. Australia is a federal parliamentary democracy comprised of states and territories. Generally, energy policy falls within state jurisdiction but is coordinated nationally through a framework established by the Council of Australian Governments (COAG). The COAG has agreed upon guiding principles such as energy security and reliability, appropriate investment in generation and networks, commercial adoption of demand side response solutions, and consistent approaches to electricity market reforms and clean energy. The Ministerial Council on Energy (established by the COAG in 2001), provides national oversight and coordination of policy development and leadership on broader convergence issues, such as the environmental impact of energy policy. Australia is a net exporter of energy, coal being its primary export in this area and domestic energy consumption representing a third of total energy production.

In 2006 and 2007, Australia suffered severe energy problems caused by energy shortages. An invigorated focus on demand management and energy security followed. Electricity tariffs increased as long-delayed network investments were finally made. Objectives for reducing dependency on oil in the energy supply were set. Australia also set national decarbonisation, energy efficiency, and renewable targets. Under the Kyoto Protocol, Australia committed to slow CO2 emissions between the years 2008 to 2012 so that they are no greater than 8% higher than 1990 levels. In 2009, the Australian government implemented the Renewable Energy Target scheme to meet Parliament's "Expanded Renewable Energy Target" of 20% renewable energy sources by 2020.

B. ELECTRICITY SECTOR

The Australian electrical grid is comprised of many different grids, some of which are not interconnected. There is the grid referred to as the National Electricity Market (NEM) in Eastern and Southern Australia. It is comprised of five state-based fully interconnected transmission networks covering Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia, and Tasmania. The NEM has 13 major electricity distribution networks and also functions as the wholesale electricity market. There are transmission and distribution networks in Western Australia and the Northern Territory that are not interconnected to each other or to the NEM network; they are regulated separately.

2.5%

1999 — 2009

Annual Electricity Demand Growth

The electricity sector is governed by energy policies established by the Ministerial Council on Energy and the relevant state government. The Australian Energy Market Commission (AEMC) sets policy and governance structure for the energy markets, which set the operating requirements and obligations of market participants. The AEMC is accountable to the COAG. The Australian Energy Regulator (AER) oversees economic regulation of the NEM, which also serves as the wholesale market and compliance with the National Electricity Law and Rules. The Australian Energy Market Operator (AEMO) manages the NEM. AEMO also oversees the security of the NEM electricity grid and is also responsible for national transmission planning. AEMO was established by the COAG and developed under the Ministerial Council on Energy. Together, AEMC, AER and AEMO are the entities responsible for regulating and operating the electricity market for the NEM. Western Australia and the Northern Territory have their own independent regulators for the electricity sector: the Economic Regulation Authority and the Utilities Commission respectively.

With the exception of the State of Victoria, the electricity sector in Australia is largely dominated by state-owned vertically integrated monopolies, which policymakers hope to deregulate in the future. As a result of market reforms initiated in 2003, the NEM territories have free market competition in generation and the electricity retail market. There has been difficulty attracting investment in new power plants due to Australia's low electricity prices and debates on introducing additional supply costs such as carbon taxes.

Transmission and distribution services are mostly provided by government or government-owned entities. The networks comprising the NEM are mostly state-owned and operated. The distribution networks are owned and operated by either the government (e.g. Queensland, Western Australia, Northern Territory), the private sector (Victoria), or both the government and private sector together (e.g. New South Wales and the ACT). They are monopoly providers in their designated areas. It is not uncommon to see distribution and retailing vertically integrated in these territories. AER exercises retail price controls. There are plans to proceed with further market reforms to open up the electricity supply industry to more competition.

In Western Australia and Northern Territory, the governments have retained ownership over the electricity distribution sector, and the transmission, distribution, and retail businesses are vertically integrated.

C. SMART METER / SMART GRID INFRASTRUCTURE

In Australia, smart meters have become a controversial political issue. In response to the 2006-2007 energy shortages, the COAG committed to a national smart meter roll-out where "benefits outweighed the costs." A series of cost-benefit analyses were subsequently performed. Consultants determined that benefits could range anywhere from ~$299M up to $3.3B in net present value over a 20 year period, based on a variety of defined scenarios. The State of Victoria commenced a mandatory roll-out of smart metering infrastructure and, with it, new time-of-use pricing. All costs associated with this deployment were passed along to consumers, including the cost of the smart meter itself. Against the backdrop of already increasing electricity prices, consumer reaction to the project was extremely negative. There was a temporary moratorium put on the rollout. It has since resumed in the face of consumer opposition. New South Wales has also proceeded with a smart meter trial deployment.

In Australia, the various governments have also demonstrated a keen interest in the smart grid. Smart Grid Australia is a non-profit, non-partisan organization dedicated to modernizing Australia's electrical system. It has played a key role in providing critical information and assistance to the government for smart grid initiatives.

Following the global economic crisis which began in 2008, with the assistance of Smart Grid Australia, the Australian government, initiated the Smart Grid Smart City program as part of its National Energy Efficiency Initiative. Through this program, the Australian government is funding the Smart Grid Smart City demonstration project profiled below. The government is also developing a regulatory reform strategy to remove barriers and improve incentives to smart grid investments, including measures that address demand-side regulation and time-of-use tariffs. It is also engaged in a review process to determine what public initiatives are needed to prepare electricity networks for a higher number of electric vehicles. State governments have also become involved in smart grid activities. The government of New South Wales is examining whether restructuring distribution networks can yield efficiencies, which would relieve price pressures. The Queensland government has also expressed an interest in smart grid, and is seeking advice from industry on smart grid initiatives.

Smart grids are on the agenda of every Australian distribution business, and most are engaged in projects of varying scope and scale. In this report, we profile two illustrative smart grid projects. The Smart Grid Smart City project reflects the high level of coordination and support between government and industry, which appears to be a key characteristic of the Australian smart grid movement. The other reflects the type of network modernization that interests utilities and is critical to smart grid development.

D. NOTABLE PROJECTS

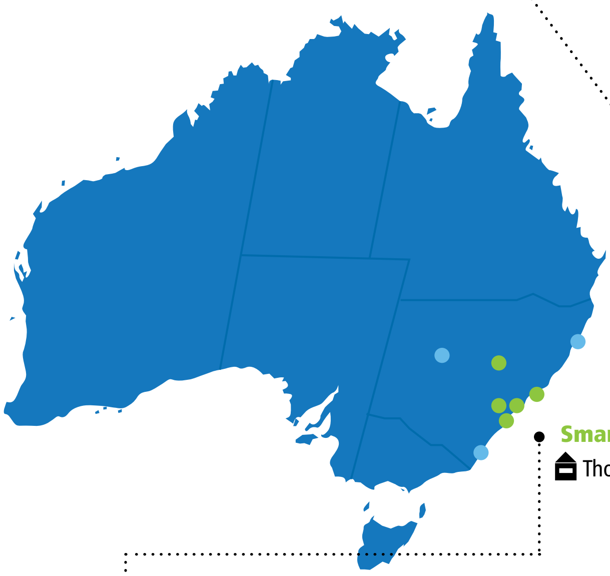
INTELLIGENT NETWORK COMMUNITIES

Organization Essential Energy

Suppliers Landis & Gyr • GE • Gridnet • IBM

Scale *Three 11kV feeders & 4000 consumers*
Type *Multiple Technologies*
Cost *$15 million*

In the Intelligent Network Communities project, the distributor Essential Energy is testing network fault detection, isolation and restoration, power quality monitoring, and distribution automation using a commercial distribution management system. Combined with load control, this substation monitoring and four quadrant interactive inverters for Volt/Var controls, this makes it a complete smart grid project. Customers have also been invited to participate in energy management trials. As part of the project, Essential Energy is also testing advanced metering infrastructure, certain customer products and education, distributed generation, and storage. The project team is taking an objective view of results to ensure project benefits can be confirmed and validated. The project is presently in its implementation stage.



Intelligent Network Communities
Three 11kV feeders & 4000 consumers • $15M

Smart Grid Smart City
Thousands of households • $243M

SMART GRID SMART CITY

Organizations

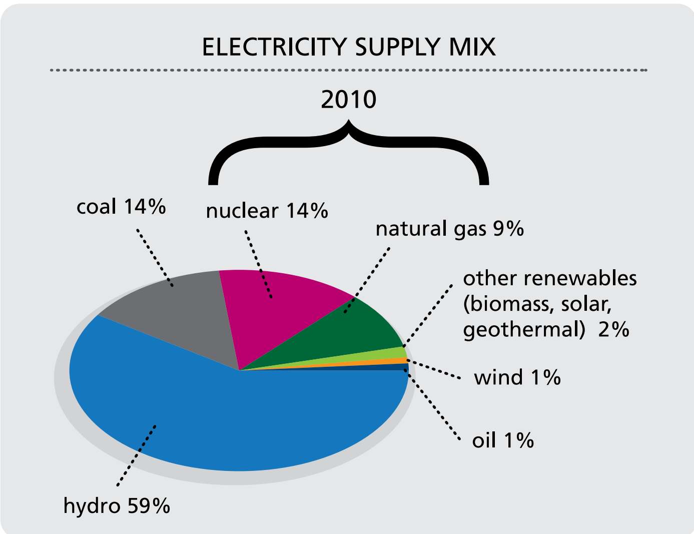
- CSIRO
- Transgrid
- Sydney Water
- Hunter Water
- The University of Newcastle
- The University of Sydney and the municipalities / communities of Newcastle and Lake Macquarie

Suppliers Landis & Gyr • GE • Gridnet • IBM

Scale *Thousands of households*
Type *Multiple Technologies*
Cost *$243M*

Scheduled for completion in 2013, the Smart Grid Smart City project tests demand side response solutions, as well as new supply technologies, in a production environment with actual customers. It is a demonstration project that gathers information about the benefits and costs of different smart grid technologies in an Australian setting. As part of the trial, customers will monitor their energy use and calculate energy costs and greenhouse gas emissions. They will also be enabled with a household energy management system, giving them wireless control of their appliances. On the grid, improved monitoring and measuring devices will improve network reliability and efficiency as well as integrate distributed energy storage, generation, and electric vehicles. The project includes smart sensors, new back-end IT systems, smart meters, and a communications network. The project team will examine performance for operational, environmental, and society/consumer benefits.

02 CANADA



A. CANADIAN ENERGY POLICY

Canada has the third largest proven crude oil reserves in the world, and the federal government views them as key engines of the Canadian economy. The current federal government has avoided and even eliminated binding environmental or energy-related commitments which would require it to embrace green energy or implement any GHG emission controls. In December 2011, the Canadian government announced Canada's withdrawal from the Kyoto Protocol. (Previously, under the Kyoto Protocol, Canada committed to reduce its green house gas emissions to 6% below 1990 levels, but was not on track to meet this obligation.) Canada is a party to the Copenhagen Accord under which it targets a GHG reduction of 17% below 2005 levels by 2020. This target under the Copenhagen Accord is a target only, not a legal obligation. While it has refrained from making any commitments which could constrain its economic development plans, the federal government has made stimulus funds available for green initiatives, such as the Clean Energy Fund and the ecoEnergy Innovation Initiative.

In contrast, the majority of the country's provincial governments have been very proactive in tackling climate change and embracing green energy, setting their own GHG reduction targets, and enacting green energy legislation. The Provinces of British Columbia, Quebec, and Manitoba have introduced carbon taxes. The Provinces of Alberta and Nova Scotia have enacted legislation limiting carbon emissions, and the Province of Quebec is in the process of launching the first cap-and-trade system regulating green house gases.

Despite differences in the level of express commitments made, in their collective ambition that Canada be a global energy leader, the federal, provincial and territorial governments agree on some basic principles: (a) energy supply diversification is important; (b) energy efficiency and conservation improvements are required for economic competitiveness and environmental responsibility, and (c) aging energy infrastructure is a challenge. They also agree that a key objective should be the accelerated development of clean energy technologies and a workforce skilled in those technologies. In relation to smart grid initiatives

Canada exported more than half of its crude oil, marketable natural gas, and coal. It is a net exporter of energy, and the gap between exports and imports is growing.

1.2%

1990 ······ 2010

Annual Electricity Demand Growth

specifically, the federal government cited energy capacity, efficiency, reliability, and sustainability as drivers.

B. ELECTRICITY SECTOR

Electricity generation, transmission and distribution fall primarily under provincial and territorial jurisdiction, so policymaking and regulation occurs at this level. Electricity exports and international and interprovincial power lines fall within federal jurisdiction. In Canada, electricity markets fall along provincial or regional lines and are owned, operated, and regulated by a myriad of provincial agencies or statutory companies.

The Canadian grid is part of a North American transmission system which is comprised of three major interconnected grids: (1) the Eastern Interconnect, which spans the entire eastern and central states, (2) the Western Interconnect, which spans the Pacific Rocky Mountains and southwestern states in the U.S., and (3) the Electric Reliability Council of Texas interconnect which includes most of the U.S. State of Texas. In Canada, only the Provinces of Ontario and Alberta have independent grid managers: the Ontario Independent Electricity System Operator and the Power Pool of Alberta, respectively.

The North American Electric Reliability Council (NERC) is a non-governmental organization based in the U.S. that ensures reliability of the North American bulk power system through standards development and enforcement, system monitoring, forecasting, and training and certification programs (including those for transmission operators, reliability coordinators, balancing authorities, and system operators). NERC coordinates reliability with the Canadian utilities under NERC-signed memorandums of understanding with the National Energy Board of Canada and the Provinces of Ontario, Quebec, and Nova Scotia. NERC has legal authority in the Provinces of Ontario and New Brunswick, where it is overseen by the relevant provincial governmental authorities.

Historically, the electricity sector was monopolized by provincially owned, vertically-integrated electric utilities. Over the past decade, the Provinces of Alberta, Ontario, British Columbia, and New Brunswick broke out generation, transmission and distribution into separate organizations, which are still generally owned by government entities. These reforms vary in their degree, with the reforms undertaken in the Province of Alberta being the most extensive. Alberta has a fully competitive wholesale and retail market with market-based pricing. The Province of Ontario has open access transmission, wholesale and retail markets, but it is still heavily regulated and still has regulated pricing. Some provinces opened up power generation to competition by independent power producers, particularly in renewable power generation. Only Ontario has a feed-in-tariff program in place for renewable energy, and BC Hydro has a Standing Offer Program in place to streamline the sales process for small developers of clean or renewable energy.

C. SMART METER / SMART GRID INFRASTRUCTURE

Several provinces (Ontario, British Columbia, Saskatchewan, Quebec) have implemented or intend to implement a smart meter rollout. Of these provinces, only British Columbia has clearly articulated its intention not to move to a time-of-use pricing system. There are also smart grid pilots being conducted in the Provinces of Ontario and Quebec, and other provinces and utilities are undertaking grid modernization projects which test and incorporate smart grid technologies.

Popular reaction to these initiatives has been mixed. Various groups have protested smart meter implementations based on privacy and health concerns. The Government of British Columbia and the utilities in the Province of Ontario have engaged their respective provincial privacy commissioners to review the privacy impact of these meters. Canadian consumers benefit from some of the lowest electricity prices in the developed world, particularly in provinces where hydro-electricity is the primary source of electricity. The introduction of these projects coincides with increases in electricity prices. Some argue that they are the cause of the price increases. Electricity pricing and, by association, smart metering and green energy initiatives generally have become politicized.

SmartGrid Canada is an association which engages stakeholders and academia from across multiple industries in an effort to build smart grid awareness, promote research and development of new and innovative energy technologies, and advocate for policies that support smart grid development.

The following projects reflect Canada's early adoption of smart grid technologies. They are notable for their scale and the fact that they are either completed or near completion. With so many markets around the world starting their smart meter implementations, the Canadian experience provides a great benchmark from which to learn, as Canada has already implemented smart meters and time-of-use rates for millions of customers.

D. NOTABLE PROJECTS

TRANSMISSION DYNAMIC LINE RATING

Organization Manitoba Hydro

Suppliers The Valley Group • a Nexans company

Scale *45km section of 115kV transmission circuit*
Type *Network Monitoring & Telemetry*
Cost *~$200K per 26 km line section*

Manitoba Hydro used static rating (232 A) for a transmission circuit that had intermittent loading constraints that caused them to curtail low cost hydro generation. They installed a Dynamic Line Rating (DLR) System to optimize transfer capability in 2002. After installation, the line rating was lifted 30% of the static rating for 90% of time. By implementing this technology, Manitoba Hydro did not need to increase its planned transmission capacity.

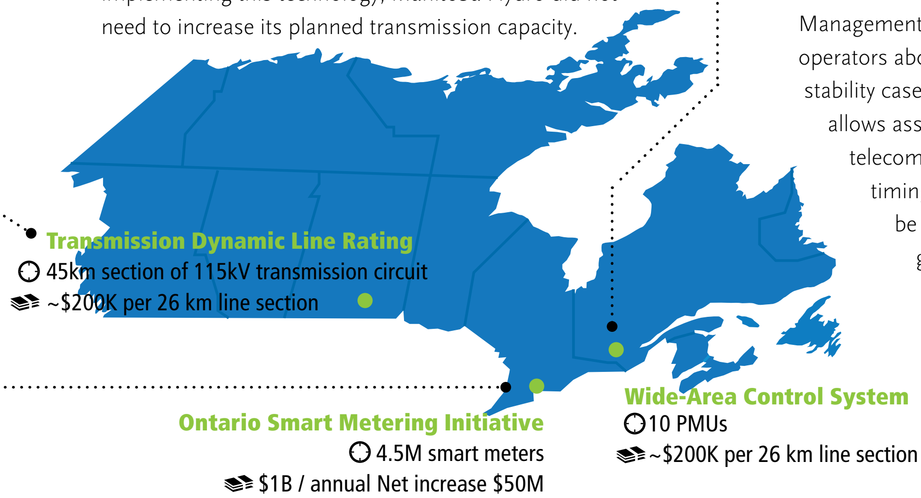
WIDE-AREA CONTROL SYSTEM

Organization Hydro Quebec

Suppliers IREQ • Cooper • AREVA • ABB

Scale *10 PMUs*
Type *Network Monitoring & Telemetry*
Cost *~$200K per 26 km line section*

Hydro Québec is voltage stability limited in the Montréal area, and this creates major constraints on power exchanges with the United States. As Hydro Québec was already equipped with a modern Wide-Area Monitoring System, its own fast and reliable communication network, they looked to establish a Wide-Area Control of their voltage through the installation of truly interoperable multi-vendors relays, PMUs and IEDs. The Hydro-Québec Wide-Area Monitoring System is connected to the Energy Management System and preemptively advises system operators about geomagnetic storms. Playback of voltage stability cases, simulated using PSS/E and ASTRE, allows assessment of the performance of the overall telecommunication chain, and the control signal timing and accuracy across the different boxes can be traced. The project resulted in big immediate gains in voltage stability constrained transfer limits and power exchanges with the United States as well as served to defer capital investments in dynamic reactive power compensation infrastructure.



ONTARIO SMART METERING INITIATIVE

Organizations Hydro One • Toronto Hydro • Powerstream among others

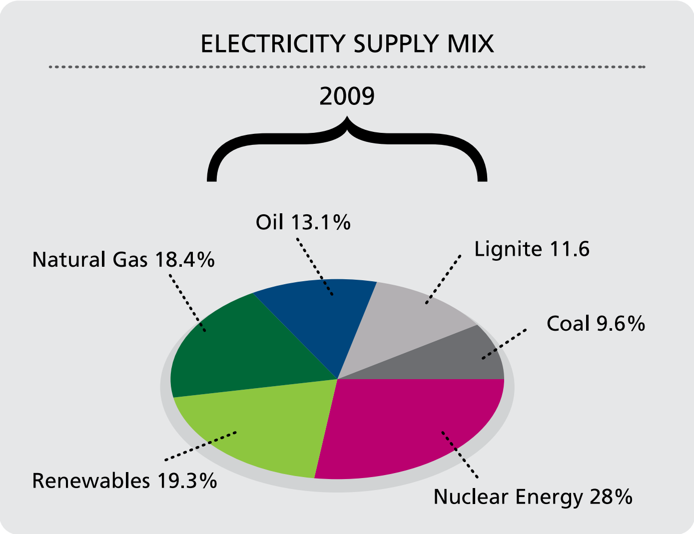
Suppliers Trilliant • ITRON • eMETER among others

Scale *4.5M smart meters*
Type *Advanced Metering Infrastructure*
Cost *Estimated capital costs of $1 billion - net increase in annual operating costs estimated at $50 million*

The government of the Province of Ontario has adopted green energy as a key pillar of its economic growth strategy and has become a leader in renewable energy, smart meters, and smart grid adoption. The government initiated the country's first smart metering deployment, the Ontario Smart Metering Initiative, which will install smart meters province-wide and is nearing completion with almost 4.5M smart meters installed. Along with smart meters, the government introduced mandatory time-of-use pricing. Ontario is the largest electricity market in the world with mandated time-of-use rates.

Pilot programs at the start of the implementation show peak shaving of around 5-8%. The Ontario Power Authority is currently assessing the mass market response to time-of-use rates, with a report due later this year that is eagerly anticipated by the smart grid industry worldwide. The increase in electricity prices precipitated by time-of-use pricing and "green" project cost recovery has raised the ire of some consumers. In response, the Ontario government introduced a rebate program to assist with rising electricity costs.

03 EUROPE



A. ENERGY POLICY

Under the common goals of secure, competitive and sustainable energy supply, the European Union is determined to set its progressive energy policy at the macro level. The European Union is an economic and political union of twenty-seven countries that operate through supranational institutions and intergovernmental agreements. Its constitutional basis can be found in various documents, most notably the *Maastrict Treaty* (1993) and the *Lisbon Treaty* (2009). EU priorities are set by the European Council. Policies and laws are created through a process involving the European Parliament, the Council of the European Union and the European Commission. The EU is made up of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

The Lisbon Treaty formally codified the EU members' common energy goals of ensuring security of supply, competitiveness and sustainability, reflecting a determination to set energy policy at the EU level. These umbrella goals have laid out in a series of directives, which are ambitious and far-reaching in scope. In 2007, the European Council adopted the 20:20:20 objective of reducing GHG emissions by 20%, increasing the share of renewable energy to 20%, and making 20% improvements in energy efficiency by year 2020. The GHG emissions and the RES targets are binding. Specific to the electricity markets, the EU introduced the *Third Legislative Package for Further Liberalisation of the Electricity and Gas Markets* (July 2009) (2009 Third Legislative Package), which obligated states to further deregulate their electricity markets to facilitate greater supplier competition and consumer choice. These and other EU directives form the framework in which EU member countries develop their own laws and policies pertaining to the electricity markets.

B. ELECTRICITY SECTORS

Most of the electrical grids in Europe are interconnected, which requires efforts between various jurisdictions to harmonize policy and regulation of the electricity sector. Some wholesale electricity markets encompass several countries. An example is the NordPool Spot exchange, which encompasses Norway, Denmark, Finland, Sweden and Estonia. Each EU member state has its own regulatory agency for its respective electricity sector. The Council of European Energy Regulators and the Agency for the Cooperation of Energy Regulators (ACER) were created to facilitate, oversee, and improve cross-border regulatory cooperation for gas and electricity transmission between member states. While ACER does not have any regulatory authority at a national or supranational level, it is empowered to intervene if national regulators fail to cooperate effectively. At the operational level, the European Network of Transmission System Operators for Electricity was established to harmonise grid access standards and ensure proper network planning and investments in order to prevent blackouts.

Historically, European electricity markets were dominated by national or regional vertically-integrated monopolies. After significant liberalization efforts beginning in the 1990s, it is more common to find the generation and retailing segments open to competition and unbundled from transmission and distribution. However, many markets are still dominated by near-monopoly suppliers. The 2009 Third Legislative Package requires EU member states to liberalize their electricity markets by 2011, if they have not already. In 2003, EU directives established common rules for internal electricity markets. At the time of writing, electricity network codes were being drafted at the EU level in order to guarantee a fair distribution of cost and responsibilities among market players.

C. SMART METER / SMART GRID INFRASTRUCTURE

The EU has enacted legislation regarding the smart grid and smart metering, most notably Electricity Directive 2009/752/EC, which requires EU member states to implement smart metering systems by 2020 where economic assessments of smart meters are positive. Because of the varying characteristics of their respective electricity sectors, EU members are addressing smart meter rollout and cost-recovery individually. Other notable pieces of legislation specific to smart metering include the 2009 Third Legislative Package, Directive 2005/89/EC (Security of Supply), Directive 2006/32/EC (Energy End-use Efficiency and Energy Services), and Directive 2004/22/EC (Measuring Instruments). In 2011, 10% of the EU households had some sort of smart meter installed. It is expected that this number will reach 100 million by 2016.

The EU is actively developing smart grid deployment plans. In January 2009, the European Commission launched a Task Force on Smart Grids which is to advise on policy and regulatory direction and to coordinate the first steps towards smart grid implementation under the provisions of the 2009 Third Legislative Package. In nearly all EU member states, significant investments have been made to test the integration of smart grid technologies and applications into the energy framework. The EU itself has invested approximately 300 million in smart grid projects in the last decade. In 2010, at the recommendation of transmission and distribution network operators, the European Commission established the European Electricity Grid Initiative (EEGI), a 9-year, €2 billion research and development program.

The EDSO for Smart Grids is an association of distribution system operators from seventeen EU member states, covering 70% of the EU points of electricity supply. The association is committed to promoting modernization of the electricity grid to achieve the EU's targets for energy efficiency, GHG reduction, and renewable energy. It liaises between public authorities and its membership on matters pertaining to the smart grid. The projects profiled below are a sample of the initiatives that the EDSO for Smart Grid has enabled or supported through its activities.

D. NOTABLE PROJECTS

1 *ADDRESS (ACTIVE DISTRIBUTION NETWORK WITH FULL INTEGRATION OF DEMAND AND DISTRIBUTED ENERGY RESOURCES)*

Organizations

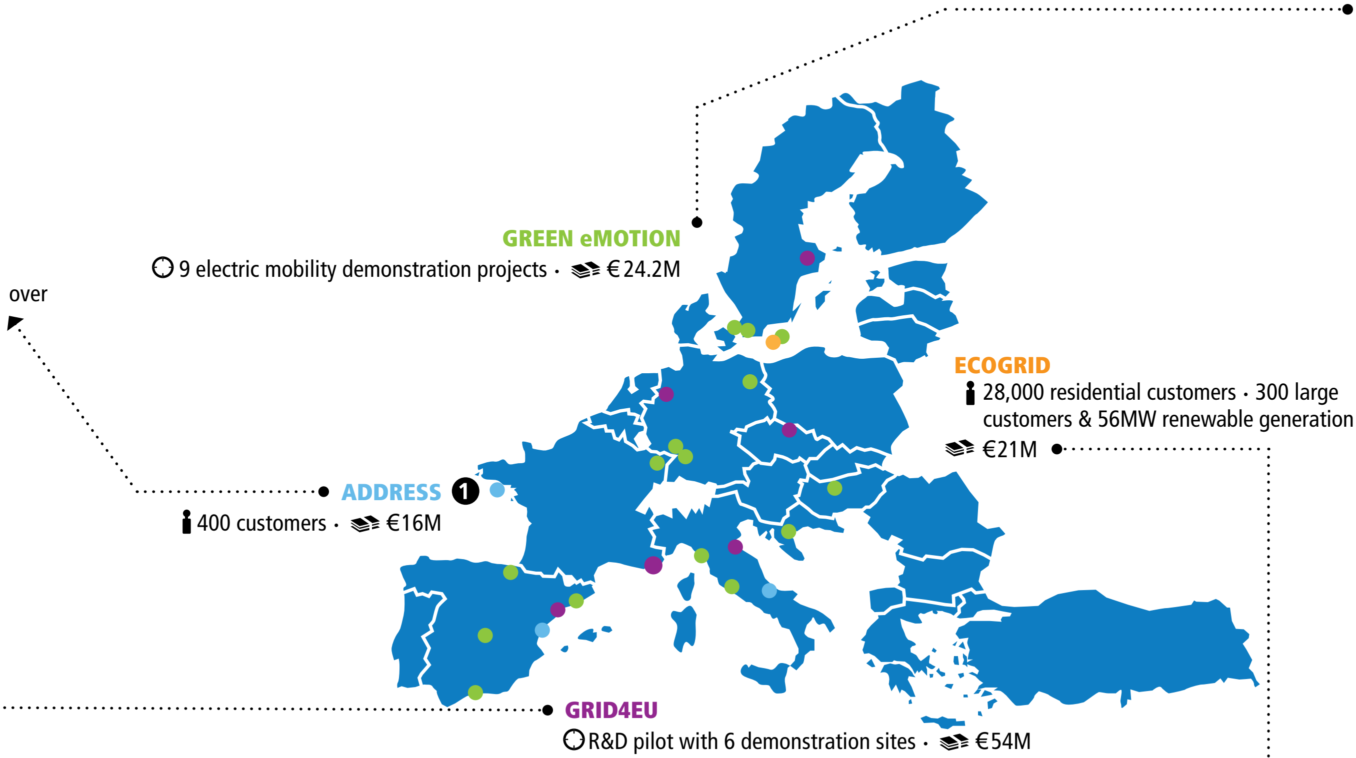
- The utilities UK Power Networks
- Enel Dustribuzione
- Iberdrola Distribucion
- Vattenfall
- the energy suppliers Enel Distributie Dobrogea and Electricité de France
- the universities and research institutes of Università degli Studi di Cassino
- Universidad Pontifical Comillas
- Consentec
- Enel Ingegneria ed Innovazione SpA - Research division
- Kema Nederland
- Fundación Tecnalia Research & Innovation
- University of Manchester
- Università degli Studi di Siena
- VITO NV
- VTT

Suppliers

- ABB
- Landis & Gyr
- ZIV PmasC
- Electrolux Italia
- Philips Electronics Nederland
- RLtec
- Alacatel Lucent Italia
- Current
- Ericsson Espana

Scale *Demonstration project involving 400 customers.*
Type *Multiple Technologies*
Cost *€16 million.*

ADDRESS is a demonstration project scheduled for completion in June 2012. The project adopts a "demand approach" (rather than "generation approach") in an attempt to draw small and commercial consumer participation in the power system through innovative commercial arrangements. It encourages consumers to provide services to different power system participants based on price and/or volume signal mechanisms. This exchange is facilitated by a technology installed at the customer property or at the aggregator. The project aims to improve flexibility in consumer behavior; enhance system reliability, safety and efficiency; and create the foundation for profitable power economy, which leads to more competition and lower energy prices.



GRID4EU

Organizations

- ERDF
- Enel
- Vattenfall Eldistribution
- Cez Distribuce
- Rwe
- Iberdrola
- EDF
- Iberdrola Generacion
- Cez

Scale *R&D pilot with 6 demonstration sites.*

Type *Multiple Technologies*

Cost *€54 million*

Suppliers

- ABB
- Alstom Grid
- Cisco
- Current
- Emeter
- Itron
- Landis&Gyr
- Ormazabal
- Selta
- Siemens
- Telvent
- Ziv
- the universities / research institutes Armines
- Comillas
- Tud
- Rse
- Kth
- Kul

Scheduled for completion in 2016, the Grid4EU project is intended to showcase Europe's "state of the art" smart grid developments. In six demonstration sites, the project will integrate increased distributed generation, provide active demand into distribution networks, and improve distribution networks. The project hopes to: (1) contribute to the integration of distributed generation into medium and low voltage networks, achieving higher reliability, shorter recovery times and avoiding unknown overloads; (2) evaluate losses (technical and non-technical) by comparing substation totals with the accumulated customer totals, hour per hour; (3) improve information distribution to customers and study consumer behavior in the face of system constraints (particularly during peak photovoltaic hours); (4) reinforce high voltage network controls through monitoring and effective fault detection and automatic restoration; and (5) demonstrate that existing networks with smart metering and combined heat & power units can be upgraded to allow automatic islanding.

GREEN eMOTION

Organizations

- Danish Energy Association
- EDF
- Endesa
- Enel
- ESB
- Eurelectric
- Iberdrola
- RWE
- PPC and the municipalities of Barcelona
- Berlin
- Bornholm
- Copenhagen
- Cork
- Dublin
- Malaga
- Malmö
- Rome

Suppliers

- Alstom
- Better Place
- Bosch
- IBM
- SAP
- Siemens
- BMW
- Daimler
- Micro-Vett
- Nissan
- Renault
- Cartif
- Cidaut
- CTL
- DTU
- ECN
- Imperial
- IREC
- RSE
- TCD
- Tecnalia
- DTI
- FKA
- TÜV Nord

Scale *9 electric mobility demonstration projects across Europe*

Type *Multiple Technologies*

Cost *€24,2 million*

The Green eMotion project will connect ongoing regional and national electric mobility initiatives leveraging the results and comparing different technology approaches to ensure the best solution is used for Europe. The project intends to create a virtual marketplace which permits transactions in this area, complete with billing functionalities. The nine demonstration projects acorss Europe all have different scope and they include hybrid vehicles, DC charging stations, optimized bidirectional charging, V2G, B2G, kWh billing systems, cross-border roaming, battery swapping, electric mobility service citizen officers, e-motorbikes, EVS27, and alternative business model testing. The project also intends to demonstrate the integration of electro-mobility into electrical networks and contribute to the improvement and development of new and existing standards for electro-mobility interfaces. As part of the project, the team will assess different EV charging solutions and the impact of various EVs on the grid. The hope is that new business models based on consumer behavior will develop from this system-level approach . The project is scheduled for completion in 2015.

ECOGRID

Organizations

- DSOs Energinet.dk
- ELIA
- EDP
- Østkraft
- EANDIS (+ORES)
- Center for Electric Technology
- DTU
- Austrian Institute of Technology
- Tallinn University of Technology (TUT)
- SINTEF ER
- Tecnalia
- ECN
- TNO

Suppliers Siemens • IBM • Landis+Gyr

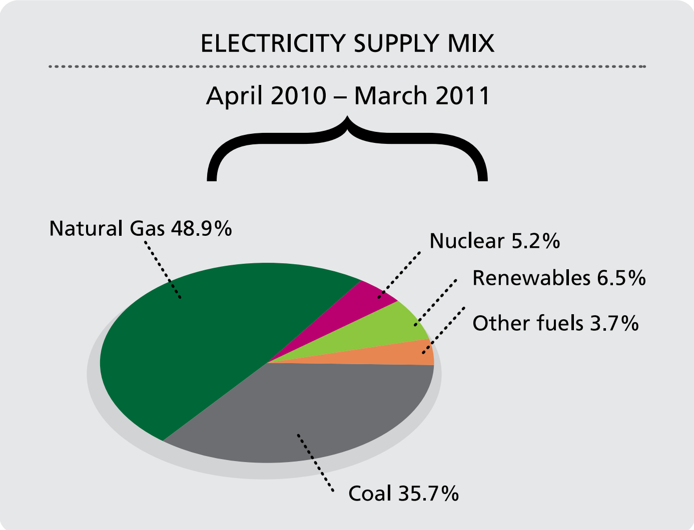
Scale *28,000 residential customers, 300 large customers & 56MW renewable generation*

Type *Multiple Technologies*

Cost *€21 Million*

The project is a “fast-track” initiative to implement market-based smart grids. Two thousand residential consumers will be equipped with residential demand response devices using gateways and “smart” controllers. These devices will present real-time prices to consumers and allow them to pre-program their automatic demand response preferences. A real-time market concept will be developed to give small end-users of electricity and distributed renewable energy sources new options and potential economic benefits for offering network operators additional balancing and ancillary services. The first area to implement it is the Nordic power market system. Scheduled for completion in 2014, this project is the first of its kind on a power system with more than 50% renewable energy sources. It aims to offer network operators better balancing services and provide consumers and producers greater opportunities to participate in the power market through real-time operation, energy storage and savings.

04 GREAT BRITAIN



A. BRITISH ENERGY POLICY

On July 12, 2011, the British government published its Electricity Market Reform white paper. In this document, the government identified principal drivers for reform, such as (1) expected increases in electricity demand and electricity prices, (2) the threatened security of the nation's electricity supply, and (3) the government targets of 15% renewable energy by 2020, 80% carbon reduction on 1990 levels by 2050, and decreased reliance on imported fossil fuels.

As electricity prices have continued to rise since 2005, the British government focused on green energy and energy sector reform. The long-term strategies are designed to mitigate future price increases as well as to secure an energy supply that continues to meet the needs of industry and the general population. Some of the reform measures the government has taken, or is considering, include new feed-in-tariffs, a carbon price floor, and emissions performance standards for new fossil-fuel power stations.

The government's concern regarding energy security is based in part on declining North Sea oil and gas reserves, the anticipated closure of coal-fired capacity around 2015 due to tighter environmental regulation, and the anticipated closure of certain nuclear power stations as they reach the end of their productive lives. Around 20 GW of existing electricity generation facilities will be lost by the end of this decade.

The government's renewable and decarbonisation targets reflect the United Kingdom's obligations under various EU instruments and under the Kyoto Protocol to reduce CO_2 emissions by an average of 12.5% from base year levels between 2008 and 2012. The UK *2008 Climate Change Act* set a target to reduce CO_2 emissions by 34% by 2020 and 80% from 1990 levels by 2050.

The British Parliament is considering legislation based on the 2011 Electricity Market Reform white paper, which is expected to be enacted in 2013. It sets out the government's commitment to transform the electricity system in order to ensure that future electricity supply is secure, low-carbon, and affordable.

B. ELECTRICITY SECTOR

Energy policy is set by the Department of Energy and Climate Change (DECC). The Office of Gas and Electricity Market (Ofgem) is the national regulator. Ofgem exercises price controls over electric transmission and distribution services, through a process that involves approving operations and investment expenditures. The National Grid Electricity Transmission plc is the system operator and is responsible for ensuring operational security. It is part of an international group of companies owned by National Grid plc, a publicly-traded energy company.

The electricity sector in Great Britain has undergone significant deregulation. Great Britain is the first European country to privatize state-owned entities in the industry and separate transmission from generation. The transmission

28%

Import dependency

Together with Northern Ireland, Great Britain is a net importer of energy with a dependency level of 28%. The British government expects electricity demand to rise due to the anticipated electrification of transportation, heating and other carbon-intensive sectors furthering its dependency on energy imports.

network for England and Wales is owned and operated by National Grid Electricity Transmission plc. The Scottish transmission grid is mostly owned by SP Transmission Limited and Scottish Hydro Electric Transmission Limited. The National Grid operates some high voltage transmission networks in Scotland. The distribution networks are owned by various companies that have geographic monopolies over their service territories. In Scotland, distributors are vertically integrated with the transmitters and generators. This is not the case in the rest of Great Britain. The retail market for electricity is private and competitive. Pricing is fixed and competitive between the retailers. A variety of pricing schemes are available for consumers to choose from, including fixed, variable, and based on a time-of-use schedule (day/night rates referred to as "Economy 7" pricing).

C. SMART METER AND SMART GRID INFRASTRUCTURE

As an EU member, the United Kingdom is subject to all of the EU directives, including the 2003 EU Electricity Market Directive that requires member states to define implementation plans and timetables for smart metering systems by September 3, 2012. It also indicates that member states should address regulatory incentives for smart grids.

The British government is undertaking a nation-wide rollout of smart meters, which is to begin in 2014 and end in 2019. Specifications are in the process of being finalized. It is anticipated that 53 million gas and electricity meters will be installed during this time. There has been public consultation on the planned smart meter implementation. The government has refrained from making smart meters mandatory and is presently considering how to best address the privacy of electricity usage data.

The previous British government signaled its commitment to smart grid through the publication of its 2009 paper, "Smart Grids: The Opportunity". While the current British government has not yet adopted a formal overarching policy on the smart grid, it assembled an Electricity Future Networks Strategy Group in 2009. Chaired by the DECC and Ofgem, the group facilitates discussion and cooperation between government and stakeholders in electric networks. They have published a smart grid vision and roadmap to test the feasibility, costs, and benefits of smart grid technology. In addition to this, DECC and Ofgem launched the Smart Grid Forum in 2011, bringing together industry experts to look into the key policy, commercial, and technical challenges facing the deployment of smart grid in Britain.

The government is also actively encouraging smart grid investments through a handful of government funds. In 2005, Ofgem introduced the Innovation Funding Incentive to encourage distribution network operators to invest in research and development in the technical development of their distribution grids. Ofgem also manages the Low Carbon Networks Fund that provides grants through innovative commercial arrangements to distribution network operators to implement carbon technologies into their distribution networks. These initiatives are driving considerable interest in smart grid development in the United Kingdom.

Industry is engaged with the government on smart grid matters; for example, the six major British retailers are working closely with Ofgem on a customer engagement strategy for the smart meter rollout. Consumer engagement is limited to only discrete parts of the smart grid, but not the smart grid as a whole concept. Increasingly, industry participants believe that this must change for the smart grid to succeed.

SmartGrid GB, launched in 2011 by the Minister of State for Energy and Climate Change, is a membership organization for stakeholders involved in smart grid development in Britain. Its membership includes three of the big six energy retailers, two network operators, and a host of large technology and professional services companies. DECC, Ofgem, and Consumer Focus are members of the group. SmartGrid GB serves as an important independent forum for information sharing and consultation, which helps shape government policy and make the British smart grid a reality.

The two projects we profile below are very different. The first is an ambitious project in a global capital, which encompasses all players in the power system and requires impressive coordination between many different players. The second involves the integration of an innovative energy storage solution into the distribution network as a discrete piece of smart grid technology.

D. NOTABLE PROJECTS

LOW CARBON LONDON

Organizations

- UK Power Networks
- Mayor of London
- Transport for London
- Greater London Authority
- Institute for Sustainability,
- Imperial College London
- National Grid
- Imperial College London
- EDF Energy

Suppliers

Logica • Siemens •Smarter Grid Solutions • EnerNoc • Flexitricity

Scale *5000 smart meters, 100 electric vehicles, 1500 electric vehicle charging posts, 10 active network management units, 60 distributed generators, 24 MWs demand*

Type *Multiple Technologies*

Cost *£30 million*

The Low Carbon London Project is a four-year demonstration project integrating a number of low carbon technologies into the distribution network and taking a holistic view of the distribution network operator's business, while still focusing on the customer experience. Technologies include photovoltaic installations, residential smart meters, electric vehicles and charging stations, heat pumps, and a centralized distribution management system working with decentralized active network management units. The integration and interaction between these technologies and the distribution network will be closely studied. As part of this demonstration project, the utility UK Power Networks will also be piloting 3 separate retail tariff systems: static (pre-determined rates based on static time frames), dynamic (reflecting actual power availability), and dynamic wind twinned (reflecting near real-time dynamic load patterns). The design stage of the project is coming to a close, and there are some early technology deployments already in place. The team has concluded that a heat/gas perspective must be taken into consideration when trying to achieve low carbon goals. The distribution network operator was also able to establish trust with industrial customers and commercial generators, providing UK Power Networks with active network management ability over the distributed generation output. The project team intends to have all trials fully deployed by June 2012. For the period up to June 30, 2014, the project is expected to yield total benefits of almost £2 million through avoided and deferred network reinforcement.

CRYOGENIC ENERGY STORAGE PILOT

Organizations

Slough Heat & Power • The University of Leeds • NTR

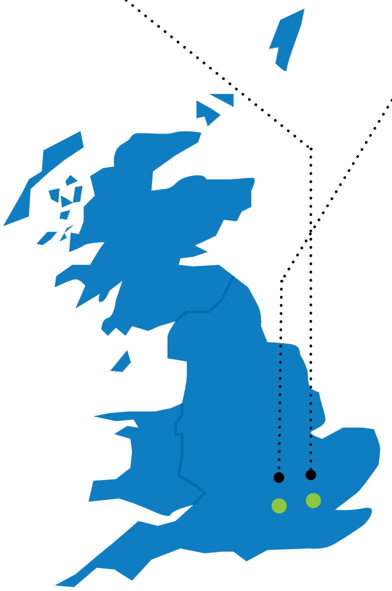
Supplier Highview Power Storage

Scale 350kW/2.5MWh cryogenic energy storage

Type Energy Storage

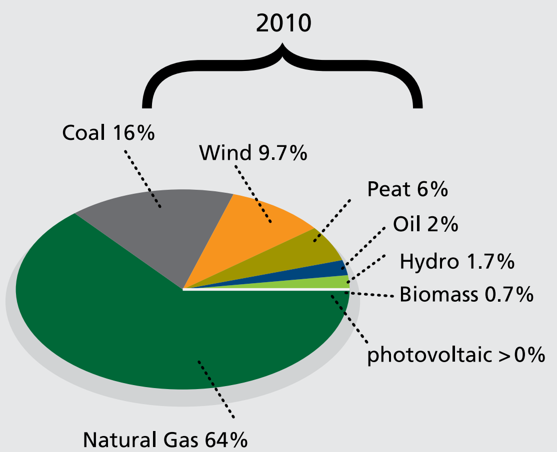
Cost £7.6 million

Slough Heat & Power has integrated into the National Grid the world's first cryogenic energy storage solution at its power station in Reading, Berkshire. Designed by Highview Power Storage, the pilot demonstrator is currently operational and regularly exports electricity to the National Grid at system peaks. The solution takes electricity from a nearby biomass plant, stores it at a low pressure in above ground tanks, and uses it to liquefy air by cooling it to -200°C. Energy is then released and supplied back to the National Grid by evaporating the cryogenic fluid and using the resulting gas to drive turbine generators. Waste or ambient heat can be used in the evaporation process, and the cold energy from the exhaust can be stored and reused to liquefy more air. The full system returns about 50-70% of the energy put in, depending on its use of waste heat. This is similar in efficiency to compressed air storage, however, cryogenic energy storage is modular, scalable, portable, and highly configurable, using commercially available components in an innovative manner that is not subject to geological constraints. This is the first cryogenic storage unit in the world connected to a grid and in compliance with regulations.



05 REPUBLIC OF IRELAND & NORTHERN IRELAND

ELECTRICITY SUPPLY MIX



A. ENERGY POLICIES

In this report, we have opted to address the Republic of Ireland and Northern Ireland in the same section because, while they are separate states, their grids are interconnected and their respective governing bodies are attempting to harmonize their regulation and coordinate energy policies. Northern Ireland is a distinct self-governing division of the United Kingdom with its own devolved government (Northern Ireland Executive) and parliament (Northern Ireland Assembly).

For both governments, energy policy is driven by security, sustainability, and competitiveness of energy supply for the economy and society. As members of the EU who are also subject to the Kyoto Protocol, their energy policies are very much shaped by international commitments, in addition to these drivers. Under the Kyoto Protocol, the Republic of Ireland is bound to limit its greenhouse gas emissions to 13% above 1990 levels. And as a member of the EU, the Republic of Ireland is also subject to EU Directives. Energy policies are set out in a series of energy policy documents, including the *Energy White Paper* (2007). As part of the United Kingdom, Northern Ireland is bound by the UK's commitments made under the Kyoto Protocol and as an EU member. Northern Ireland's energy policy is set out in the *Northern Ireland Strategic Energy Framework* (2010).

The governments' all-island renewable energy policy is presented in the document entitled "All-Island Energy Market-Renewable Electricity: A 2020 Vision". Both have set a target of 40% electricity consumption from renewable sources by 2020. Significant growth in onshore wind resources is keeping them on track to achieve this goal. Each government has already introduced premium pricing for renewable generation – the "Renewables Obligation" in Northern Ireland the "Renewable Energy Feed in Tariff" in the Republic of Ireland.

B. ELECTRICITY SECTOR

On the Island of Ireland, trends point to an all-island, deregulated electricity sector. However, the electricity sectors are highly integrated. Their governing energy policies are closely coordinated by the Republic of Ireland Department of Communications, Energy and Natural Resources and the Northern Ireland Department of Enterprise, Trade and Investment. Policy is informed by the planning arm of the Republic of Ireland government, the Sustainable

Energy Authority of Ireland. The Republic of Ireland regulator, the Commission for Energy Regulation (CER), and the Northern Ireland regulator, Northern Ireland Authority for Utility Regulation (NIAUR), are involved in a joint initiative called "The All-Island Project" to better harmonise their respective energy sectors. There is a single wholesale electricity market for the entire Island in which participation is mandatory. All electricity generated, imported, or consumed on the Island must be purchased or sold in the Single Electricity Market. Previously, Northern Ireland's electricity market operated as part of the UK electricity market. The Republic of Ireland government-owned EirGrid plc operates the Single Electricity Market through its subsidiary SONI Ltd and is the system operator.

Both electric grids are interconnected to each other, but have very little interconnection to grids off the island. EirGrid plc acquired the System Operator of Northern Ireland in 2009, which should better enable harmonisation efforts. EirGrid owns and operates transmission assets in the Republic of Ireland, and the Republic of Ireland government-owned Electricity Supply Board (ESB) owns and operates the transmission assets in Northern Ireland (through its subsidiary Northern Ireland Electricity). ESB directly and indirectly (through Northern Ireland Electricity) owns and operates distribution assets in both the Republic of Ireland and Northern Ireland. The Electricity Regulation Act 1999 purportedly liberalized the electricity sector in the Republic of Ireland. There are multiple independent power generators and retailers across both jurisdictions. Transmission and distribution services are provided by state-controlled companies for regulated charges. Retailers (including the ESB) are free to set their own tariffs.

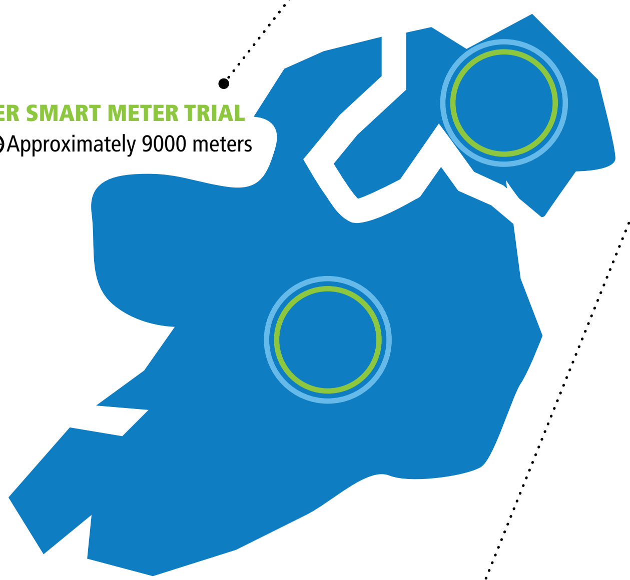
As members of the EU, the Republic of Ireland and Northern Ireland were required to transpose the 2009 Third Legislative Package, which mandates greater deregulation of internal energy markets, into national law by 2011. Both governments are still in the process of transposition and are considering selling state-owned assets in the electricity sector to comply with requirements.

C. SMART METER / SMART GRID INFRASTRUCTURE

The Republic of Ireland government has adopted smart metering and smart grid as key components of its energy policies. The CER is presently in the planning stages of a national smart meter rollout program. The smart grid is also an important component of the Republic of Ireland grid development strategy as set out in *Grid 25: A Strategy for the Development of Ireland's Electricity Grid for a Sustainable and Competitive Future*. There are several smart grid activities taking place in the Republic of Ireland involving dynamic line rating, electric vehicle infrastructure, and renewable connection and control. The Sustainable Energy Authority of Ireland leads a Smart Grid Roadmap steering group which intends to publish a smart grid roadmap for the Republic of Ireland by the end of 2012. The CER, EirGrid, and SmartGrid Ireland are part of this steering group. SmartGridIreland is an industry association based in, or operating out of, Northern Ireland and the Republic of Ireland, which is presently in consultation with Northern Ireland Electricity and ESB to develop a "smart zone" pilot.

The following two projects are the leading projects in Ireland and will establish the basis for a smart grid infrastructure. The CER smart metering trial project is now complete, and the CER has concluded that smart meters could yield net benefits of up to 282 million over 15 to 20 years. eCar Ireland is a cross-jurisdictional project, which presents unique challenges.

D. NOTABLE PROJECTS



CER SMART METER TRIAL

Organizations
- Commission for Energy Regulation
- ESB Networks
- ESB Electric Ireland
- Bord Gais Energy
- The Sustainable Energy Authority of Ireland

Suppliers
- Elster
- EICT
- Vodafone
- SagemCom
- Trilliant
- Iskrameco
- Aclara
- Elster
- Coronis

Scale *Approximately 9000 meters*
Type *Customer Engagement, Demand Response, and Advanced Metering Infrastructure*
Cost *Not Available*

In May 2011, the CER completed a smart meter trial involving approximately 9000 homes and businesses. The project assessed the performance of available smart metering systems and communication technologies and identified risks, issues, and information relevant to a cost-benefit analysis for a national smart metering rollout. The rollout saw single-phase and three-phase meters communicate over PLC, GPRS and 2.4GHz wireless mesh in various rural and urban locations.

Smart-metering-enabled energy efficiency measures were tested for their impact on customer behaviour. Time-of-use tariffs and demand side information management tools such as in-home displays, detailed billing, and an online customer portal were introduced as part of the trial. The project team found that time spent ensuring a "plug-and-play" meter installation process was extremely beneficial, but still saw technical issues in 3% of installations. The trial was completed in May 2011 and the CER published a report highlighting key learning that will be used to inform future decisions regarding electricity smart metering for residential consumers and SMEs in Ireland. The CER reported an overall reduction of 2.5% in residential electricity demand (8.8% reduction during peak times) and an 82% change in consumption patterns. The in-home display was especially effective in reducing peak-time consumption, with 91% of residential customers saying it was important. Based on findings from the trial, the CER concluded that smart meters could yield net benefits of up to 174 million over 15 to 20 years taking into account customer bill reductions, efficiency, and environmental benefits.

ECAR IRELAND

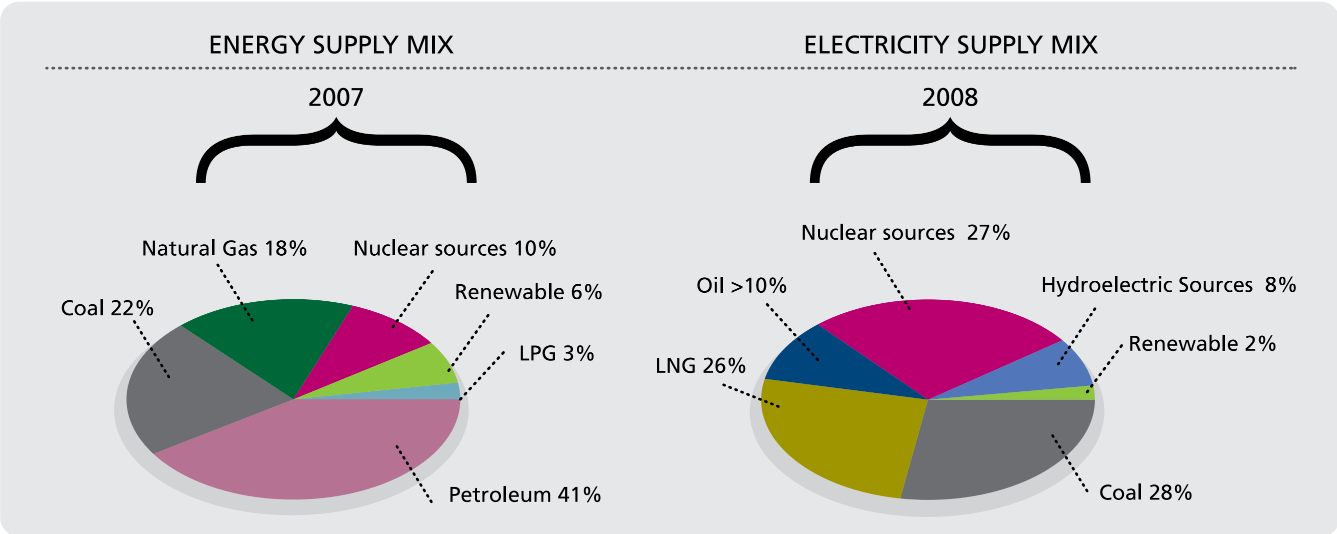
Organizations
- Electricity Supply Board
- North of Ireland Executive
- Northern Ireland Electricity
- Power NI
- several local municipalities

Suppliers
- Renault-Nissan
- Mitsubishi
- PSA Peugeot-Citroen
- Micro-Vett
- Smiths Electric Vehicles
- Allied Vehicles
- Intel
- SAP
- IBM
- M2C
- Ducati
- Elektromotive
- EBG
- Siemens
- Chargemaster
- Podpoint
- SGTE
- AeroVironment
- ABB/Epyon
- Circontrol

Scale
Republic of Ireland *1500 public charging points, 30 to 50 DC fast chargers, 2000 home charging points*
Northern Ireland *121 public chargers, 5 DC fast chargers, 634 home charging points, 127 workplace charging points*
Type *Customer Engagement, Demand Response, Electric Vehicles*
Cost *20 Million in the Republic of Ireland, £2 Million in Northern Ireland*

eCar Ireland is an all-island project that pilots a basic EV charging infrastructure in which drivers pay their nominated electricity supplier (not the charging station) for the electricity the EV consumes and pay a fee to the charging station. This cross-jurisdictional project involves multiple electricity distributors, two currencies, and creates a competitive retail market that is accessible in either country. The project is the first phase of an ambitious national mass roll-out. In the Republic of Ireland, this stage will see 500 public (or semi-public) 22kW chargers (32A, 400V Mode 3) installed in Dublin and at least one in every town with a population of 1500 people of more. Fast Chargers (50kW) will be installed every 60km on the inter-urban routes, mostly at motorway service stations, with similar efforts being made in Northern Ireland. On the Island of Ireland wind makes up 14% of electricity generated (rising to 37% by 2020). EV batteries present an alternative to constraining wind generation. Dynamic smart charging could facilitate electric vehicles without significant investment in generation, transmission, or distribution infrastructure by effectively leveraging constrained wind energy. The project team has developed smart charging algorithms using weather, customer travel plans, wind generation, and real time electricity prices. These will be used through a "cloud" infrastructure to dynamically control EV charging. In the Republic of Ireland installations have started and are expected to be completed by mid-2012, with Northern Ireland following up. The Irish system is an example of how a national EV charging infrastructure can be kick-started. It shows that such an infrastructure can not only serve the electric distribution system but can also support other business models. It is also an example for other jurisdictions of a national infrastructure that facilitates smart charging and roaming across international boundaries.

06 JAPAN



A. JAPANESE ENERGY POLICY

In June 2010, the Japanese government announced a new Strategic Energy Plan focused on principles of energy security, conservation, efficiency, and economic growth based on energy and structural reform of the energy industry. It aimed to make Japan an "environment and energy power through green innovation" under Japan's New Growth Strategy. The Strategic Energy Plan articulated strategies to achieve low carbon growth and ambitious targets for 2030, such as nearly doubling Japan's energy independence ratio and halving residential CO_2 emissions. (Under the Kyoto Protocol, Japan committed to reduce its CO_2 emissions by 6% from 1990 levels.) The plan also targeted 50% nuclear power as part of its energy supply mix. The March 11, 2011 earthquake and disaster at the Fukushima nuclear power plant precipitated a period of soul-searching by Japan on matters national security and energy policy.

Since the March 2011 nuclear disaster, Japanese policy-makers have been struggling to strike a balance between energy independence and national security. The government has not yet established any new policies, but its policy-makers did agree that public safety, restoration of public trust in the energy system, and consumer empowerment and protection should be the primary determinants of future energy policy. Japanese policymakers are seriously considering implementing demand-side controls, smart meter infrastructure, flexible pricing structures, and diversified electricity sources and retail options for consumers. Some argue that this will lead to renewed efforts to deregulate the electricity industry and introduce greater competition to the benefit of consumers.

Japan's commitment to renewable energy investment remains strong. Japan had set itself a target for 10% renewable energy by 2020. Some speculate that this target percentage will double once the government completes its energy policy review and that nuclear power will be phased out completely over time. Japan's feed-in-tariff program for newly installed renewable energy sources will come into effect in July 2012.

B. ELECTRICITY SECTOR

In Japan, the Ministry of Economy, Trade and Industry (METI) is responsible for establishing energy policy. There is no independent regulator in Japan. The government's Agency for Natural Resources and Energy serves this function. A special parliamentary committee is responsible for implementing the FIT system. The Japan Electric Power Exchange (JEPX) is the sector's wholesale power exchange market. JEPX is privately owned and operated, and participation in the JEPX is voluntary. The Electric Power System Council of Japan is an independent, non-profit entity that establishes rules for the industry regarding system development, access and operation of interconnection facilities, and market oversight. It also acts as its dispute settlement forum. The Council's membership is made up of Japan's major electrical utilities, independent power producers, and academics.

The Japanese national electric grid is unique in that it is actually composed of two separate grids that operate at different frequencies and are connected by only three converter stations, which, together, can push only 1.2 GW of power east or west. The eastern grid operates at 50 hertz with most of its legacy equipment originating from Germany. The western grid operates at 60 hertz with equipment sourced from the United States. The eastern grid is divided into four service areas, and the western grid is divided into six service areas. Each service area is basically self-sufficient but is interconnected with adjoining service areas. The Japanese grid is considered very reliable.

Each service area on the Japanese grid is owned and operated by a single electrical power company, which is the monopoly utility that handles everything from generation, transmission, and distribution to retailing. Each power company is the monopoly provider in its allocated service area and is politically powerful. Interestingly, the Japanese electricity supply industry has been privately owned since 1951. In the late 1990s, the Japanese government implemented reforms which liberalized the generation sector somewhat and permitted independent power generators to sell directly to medium and large consumers. Still, the ten power companies account for approximately 85% of generating capacity within specific geographic regions. Retail tariffs are regulated based on cost of production plus a fair rate of return.

Renewed calls to deregulate the electricity sector followed the 2011 Fukushima nuclear disaster. In response to the recent push for renewable energy and more deregulation in the power market, it has been argued that an unstable electricity supply and more major blackouts would result.

C. SMART METER / SMART GRID INFRASTRUCTURE

As consumer empowerment in the power system gained momentum as a political cause after the Fukushima nuclear disaster, the Japanese government adopted smart metering as a tool to improve demand side management. A publicly traded company, Tokyo Electric Power Co. (TEPCO) is the largest of the ten power companies. It also owns the Fukushima nuclear plants and all of the liabilities associated with the 2011 disaster. In early 2012, at the government's instigation, TEPCO announced its intention to commence a smart meter rollout in its service territory in the fall of 2013. This will be the first massive deployment of smart meters in Japan. News reports indicate the Japanese government is in the process of developing smart meter requirements and standards that will apply nationally.

METI promotes construction of the smart grid and its deployment overseas as initiatives supporting Japan's efforts to become a global energy power. Since 2008, the Japanese government has promoted an "Eco-Model Cities" program – next generation energy and social systems using low carbon technology – as key to Japan's energy saving strategy. The program is piloting various systems in a handful of cities in Japan, namely Kansai Science City (electric vehicles and photovoltaic installations in homes), Kitakyushu City (real-time energy management of homes and commercial buildings), Yokohama City (real-time energy management systems for homes and buildings, which integrate photovoltaic installations and electric vehicles), and Toyota City (demand response solutions and electric vehicles).

The Japan Smart Community Alliance is an organization which represents a cross-section of views from industry, the public sector, and academia. It is an important forum for discussion and cooperation on matters concerning the smart grid, including the development of global standards for smart grid technologies. The projects profiled below represent a sample of leading-edge activities undertaken by the membership. They are indicative of the level of Japanese activity and interest in the smart grid.

D. NOTABLE PROJECTS

1

AD HOC COMMUNICATION TECHNOLOGY

ORGANIZATION Kit Carson Electric Cooperative

SUPPLIER Fujitsu

Scale *2100 Smart Meters*
Type *Advanced Metering Infrastructure*
Cost *Not Available*

Fujitsu's wireless technology solution enables Kit Carson Electric to build a network of smart meters for approximately 30 percent less of the cost than other smart meters currently on the market. Kit Carson will be able to provide metering data at an interval of 15 minutes, and the system can provide almost real time meter readings in a more granular manner, so that electricity users can realize their energy consumption patterns and adjust their behaviour to conserve energy. This project provided the foundation for Fujitsu's smart meter business.

HACHINOHE MICROGRID DEMONSTRATION PROJECT

Organizations
NEDO (New Energy and Industrial Technology Development Organization)i • Hachinohe-city

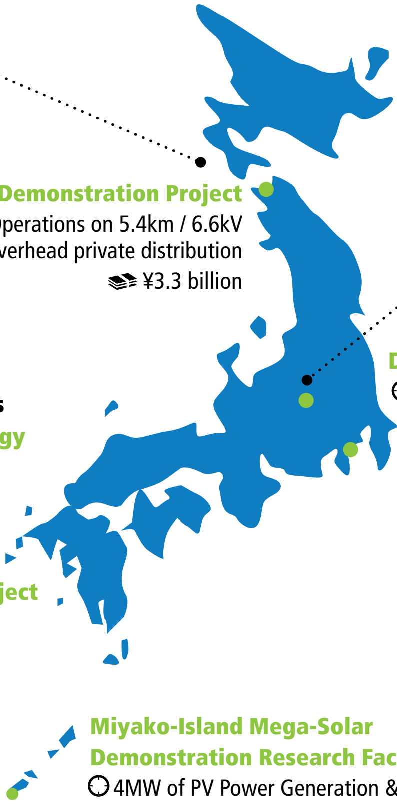
Suppliers
Mitsubishi Electric Corporation • Mitsubishi Research Institute Inc.

Scale *Electrical Islanded Operations on 5.4km / 6.6kV overhead private distribution grid*

Type *Microgrid*

Cost *¥3.3 billion*

This project in Aomori tested the performance of a demand-supply control system in managing the impact of renewable energy on a commercial power grid with real end users (605kW demand) for an electrical island. The project successfully conducted one-week of islanded operations relying on 100% renewable energy. Demand-supply control systems and a combination of wind (20kW), PV (130kW), gas cogeneration (510kW), and battery (100kW) were able to adequately supply six end users. The project furnishes technical solutions to islanded operations using renewables. Additional analyses of electric power quality during islanding operation will further the integration of dispersed energy resources.



Hachinohe Microgrid Demonstration Project
Electrical Islanded Operations on 5.4km / 6.6kV overhead private distribution
¥3.3 billion

over

1

New Mexico, United States
Ad Hoc Communication Technology
2100 Smart Meters

Distribution Stabilizing Solution gunma
One HV/MV substation & 2 distribution feeders

Mass introduction of EVs
2000 Electric Vehicles

Energy management system using EVs
Several detached houses • 1 apartment/condominium • 1 commercial building • 1 charging station • 5-10 EVs • EVs subject to the demand response test (Number of EVs is TBD)

Total Energy Solutions Test Bed Project
One Building
Punggol Eco-Town, Singapore

Miyako-Island Mega-Solar Demonstration Research Facility
4MW of PV Power Generation & 4MW Energy Storage System

TOTAL ENERGY SOLUTIONS TEST BED PROJECT

Organization Singapore Government

Supplier Panasonic Corporation

Scale *One Building*

Type *Multiple Technologies*

Cost *Not Available*

In a two-year project that began in August 2011, Panasonic will provide total energy solutions tailored to a building to enable local energy generation for consumption in the building's common facilities. Rooftop photovoltaic systems and lithium-ion batteries will be combined to create and store energy. Demand Response will be implemented by combining smart meters with a Home Energy Management System (HEMS). Each household will have an in-home display (IHD) so that the user can view how much electricity, water, or gas is being used. Demand response will be achieved through Smart Energy Gateway (SEG) which connects the smart meter and home appliances, such as air-conditioners.

DISTRIBUTION STABILIZING SOLUTION

Organization NEDO (New Energy and Industrial Technology Development Organization)

Suppliers Hitachi • CRIEPI (Central Research Institute of Electric Power Industry)

Scale *One HV/MV substation & 2 distribution feeders (testbed)*
Type *Distribution Management System*
Cost *Not Available*

This goal of this project, executed with CRIEPI under NEDO funding, was to maintain voltage stability and power quality in the face of distributed renewable energy integration. The project equipment simulates photovoltaic generation and electricity consumption in-house and on the distribution network. Using two Distribution Static-Var Compensators (D-STATCOMs), one Loop Balance Controller (LBC), and one Step Voltage Regulator (SVR), all controlled by a Distribution Voltage-Var Controller (D-VQC), the project verified the effective voltage regulation of photovoltaic generation. The D-STATCOM provides fast voltage control in situations with rapidly changing generation due to weather conditions. In addition, the project verified cooperative control for fast-control D-STATCOM and slow-control SVR. This project was done in 2004 – 2007.

"MASS INTRODUCTION OF EVS" AND "ENERGY MANAGEMENT SYSTEM USING EVS" AS PARTS OF YOKOHAMA SMART CITY PROJECT

MASS INTRODUCTION OF EVS

Organization Yokohama City

Suppliers N/A

Scale *2000 Electric Vehicles (not limited to Nissan's EV)*
Type *Electric Vehicles*
Cost *Not Available*

ENERGY MANAGEMENT SYSTEM USING EVS

Organization Yokohama City

Suppliers Nissan • Hitachi • ORIX • ORIX Auto

Scale *Several detached houses, 1 apartment/condominium, 1 commercial building, 1 charging station, 5-10 EVs, EVs subject to the demand response test (Number of EVs is TBD)*
Type *Energy Management and Electric Vehicles*
Cost *Not Available*

In addition to the cities participating in the government's Eco-Model Cities program, there are other smart grid projects of note. In Yokohama City, which is participating in the Eco-Model Cities program, a consortium of industry players (Nissan, Toshiba, Panasonic, Meidensha Corporation and others) are in the development stage of smart city programs. One of Nissan related programs will introduce 2000 EVs by the end of FY2014 into the city. The goal is to contribute to reducing CO_2 in transport sector, which accounts for 20% of overall CO_2 emission.renewable generation penetration.

MIYAKO-ISLAND MEGA-SOLAR DEMONSTRATION RESEARCH FACILITY

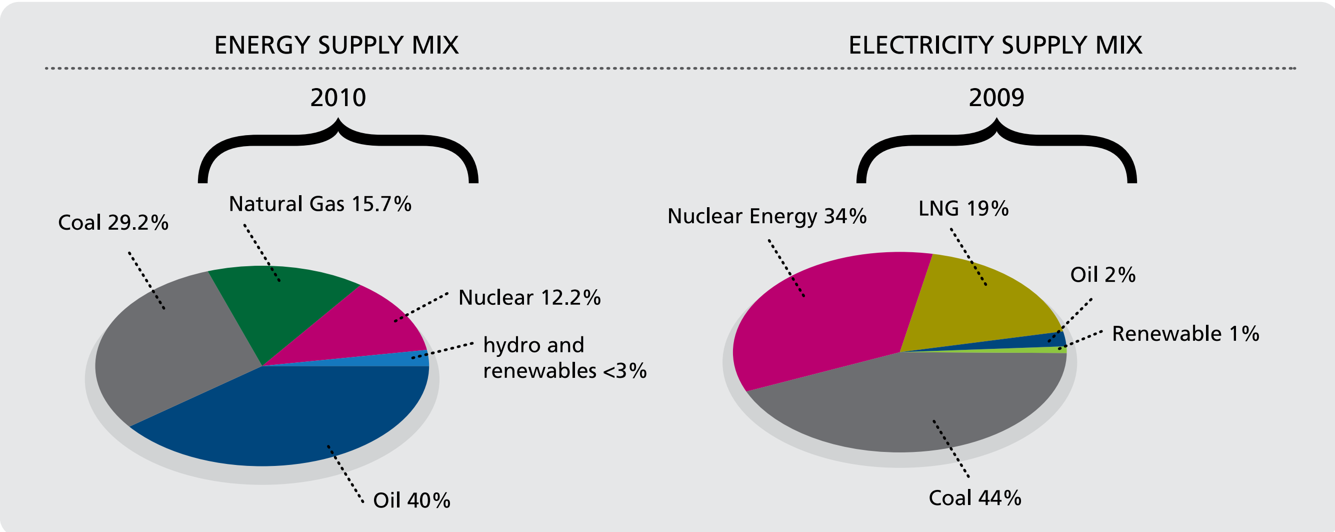
Organization The Okinawa Electric Power Company

Supplier Toshiba Corp

Scale *4MW of PV Power Generation & 4MW Energy Storage System*
Type *Distributed Renewable Generation and Energy Storage*
Cost *Not Available*

This was a pilot project conducted in Okinawa by The Okinawa Electric Company and Toshiba to test the integration of large-scale renewable energy sources into the power system and study the impact of photovoltaic power generation facilities and rechargeable batteries on power system stabilization. The pilot commenced operation in October 2010 for a four-year testing period. Miyako-Island has an existing total demand of 50MW. The goal is the smooth integration of large scale PV generation by using storage batteries and control systems to maintain network stability while preserving the beauty and cleanliness of the Miyako-Island coastline. Studies on frequency control are expected to provide valuable insight in situations of high renewable generation penetration.

07 S. KOREA



A. SOUTH KOREAN ENERGY POLICY

"Sustainable development" is the phrase used by the South Korean government to sum up its energy policy, of which national security and economic growth are the principal drivers. Korea imports almost 97% of total energy consumed with a heavy reliance on oil from the Middle East. South Korea's energy consumption has more than doubled in the past 12 years. In 2010, Korea was the 11th biggest energy consumer in the world and the 5th largest importer of crude oil. As a matter of energy security, the Korean government is attempting to improve the country's energy self-sufficiency by developing and acquiring energy resources in developing countries, often in exchange for development assistance. It also intends to better diversify the nation's energy supply mix, reducing its reliance on fossil fuels in favour of alternative energy sources, principally nuclear power.

For the South Koreans, environmental security also appears to be a matter of national security. The government is acutely sensitive to the adverse impact of environmental change on the country. Over the past several years, South Korea has experienced repeated flooding and droughts caused by extreme weather events (which are expected to worsen), and these occurrences have caused significant human and economic loss. While it is not an Annex-I member to the Kyoto Protocol, South Korea committed to a voluntary emissions reduction target of 30% by 2020, the highest reduction level that the Intergovernmental Panel on Climate Change recommended for developing nations.

The South Korean government is clear in its ambition that South Korea become a world leader in energy technology and the energy market. It has adopted green technology as a pillar of the country's economic growth strategy. It has passed a series of laws promoting low carbon growth and green energy initiatives, including the *Basic Law on Low Carbon Growth and Green Growth* (2010) which earmarks 2% of the country's gross domestic product to stimulate green business and projects and lowering greenhouse gas emissions. Under the Renewable Portfolio Standard passed in 2010 and effective as of 2012, two percent of total electricity generation will come from renewable sources. Currently, South Korea is an exporter of nuclear reactor technology, wind technology, and photovoltaic solar technology.

B. SOUTH KOREA'S ELECTRICITY SECTOR

The South Korean electricity sector is governed by (1) the Ministry of the Knowledge Economy, which is responsible for developing and implementing energy policy, (2) the Korea Electricity Commission (KOREC), which is the regulator for the sector and exercises tight controls over retail tariffs and quality and security matters, and (3) the Korea Electric Power Exchange, which is the system operator and wholesale market coordinator. The Environmental Preservation Committee makes key environmental decisions which impact the electricity sector as well.

Historically, the South Korean electricity sector is dominated by a state-controlled, vertically-integrated monopoly over electricity generation, transmission, distribution and retailing. In 2001, the government began to implement market reforms, intending to divest itself of its generation and electricity distribution businesses and create a competitive retail market, but these efforts met resistance and were ultimately abandoned. As a result of earlier reform efforts, there are some independent power producers and district suppliers. However, state-controlled Korea Electric Power Corporation (KEPCO) still owns and operates most generators, and the country's transmission and distribution assets. The South Korean electricity grid is a closed system, but the government has expressed its hope to move towards a regionally interconnected supply system in North East Asia.

Retail rates are still tightly controlled by the government through KOREC. Currently, retail tariffs only cover approximately 87% of generation costs. KOREC has restricted KEPCO from passing increases in the cost of coal, natural gas and oil to consumers. Presently, electricity tariffs are determined by the class of consumer (industrial, agricultural, or residential), the geographic location of the consumer (urban or rural), and time of use (day or night). In South Korea, industrial users account for up to half of all power consumption.

C. SOUTH KOREA'S SMART METER / GRID INFRASTRUCTURE

Because innovating (and exporting) green technology is a pillar of Korean economic strategy, the South Korean government is very active in smart meter / smart grid activities, both domestically and internationally. The government plans to install smart meters in half of all Korean households by 2016 and to replace all remaining analogue meters by 2020. It has implemented pilot deployments of smart meters and is presently in the tendering stage for the broader rollout. In 2011, the South Korean legislature approved the *Smart Grid Promotion Act* (2010) which provides a framework for sustainable smart grid projects and a plan for smart grid development, deployment and commercialization. The Korean government is actively collaborating with the American government on energy development, smart grid standard development and on cybersecurity and grid trustworthiness projects, skills training and development, and smart building initiatives. Korea was designated as a lead country in smart grid at the Major Economies Forum on Energy and Climate held as part of the July 2009 G8 Summit.

There has been no notable public reaction to the government's smart metering or smart grid initiatives. Smart meters and the smart grid do not have much profile with the general population, and electricity tariffs are not a highly politicized subject matter.

What is striking about the Korean example is the level of coordination and support between government and industry in achieving the objective of economic growth based on green innovation. The Korea Smart Grid Association plays a critical role as a mediator between government and private-sector stakeholders on the smart grid. It helps develop smart grid projects, conducts standardization work, and engages in important research and development.

South Korea's Jeju Smart Grid Demonstration Complex, highlighted below, reflects the massive scale of government and industry investment and high level of cooperation in the smart grid space.

D. NOTABLE PROJECTS

JEJU SMART GRID SYSTEM DEMONSTRATION COMPLEX

Organizations

- KEPCO
- Samsung SDI
- Hyosung
- Omni-system
- AID
- Rootech

Suppliers

- Secui.com
- Hyosung
- ABB
- Samsung SDI
- PCS
- Omni System
- Millinet
- Samsung Electronics

Scale *Demonstration Project*
Type *Multiple Technologies*
Cost *Not Available*

With funding from the government and the private sector, together with a host of other companies, KEPCO is undertaking an ambitious smart grid demonstration project on Jeju Island which incorporates distributed renewable generation (wind and solar), distributed automation, a distribution management system, EV infrastructure, advanced metering infrastructure, energy storage, and network monitoring and telemetry. The first phase of the project is complete. In the first phase, the consortium constructed electric vehicle charging stations and installed solar panel rooftops on residences as well as in-home energy storage systems, in-home displays, smart appliances, and/or smart meters. Jeju Island presents a unique opportunity to test smart grid technologies. Notably, the government and private sector alone have financed this projected with the government contributing a little less than a third of total project costs.

SMART TRANSPORTATION

Organizations

SK Innovation • SK Telecom • Hyundai Heavy Industries • Renault Samsung Motors

Suppliers

- SK Innovation
- SK Telecom
- SK Networks
- Hyundai Heavy Industries
- Renault Samsung Motors
- CT&T
- DH Holdings ILJIN Electric
- EN Tech
- KODI-S

Scale *12 consortiums approximately 600 households, 72 EVs, 89 charging stations, 9 home (3 kWh) and building (150 kWh) storage units, and 1 wind power energy storage system.*
Type *Electric Vehicles*
Cost *$18 million invested by the SK consortium*

In this project, which began in 2009, the project team is implementing an electric vehicle infrastructure that is integrated into the power system and incorporates fast and smart battery chargers, GPS-based charging spots, and emergency information and services. The infrastructure relies on wireless communications. As part of the project, the team will be developing battery energy storage systems (BESS) for buildings and wind power. Data management for the EV infrastructure will be conducted from the Total Operating Centre (network operating centre) in the Jeju Smart Grid System Demonstration Complex. This project is scheduled to finish in 2013, with the hope of furthering the consortium's understanding of smart charging and vehicle-to-grid applications.

Jeju Smart Grid System Demonstration Complex

Smart Transportation

12 consortiums approximately 600 households · 72 EVs · 89 charging stations · 9 home (3 kWh) and building (150 kWh) storage units · 1 wind power energy storage system

USD$18 million invested by the SK consortium

Renewable Energy Source Operating System

2 wind generators (750kW) · Energy Storage System 2MVA/500kWh · Lead-Acid Energy Storage System 275kW/137.5kWh

Consumer-participating smart place

600 households

₩33B / USD$30M

RENEWABLE ENERGY SOURCE OPERATING SYSTEM

Organization POSCO ICT

Suppliers

- LG Chem
- Woojin Industrial System
- Daekyung Engineering
- Korea Institute of Energy Research
- Research Institute of Industrial Science & Technology
- Chungbuk University
- Jeju University

Scale *2 wind generators (750kW), Energy Storage System 2MVA/500kWh, Lead-Acid Energy Storage System 275kW/137.5kWh*

Type *Distributed Renewable Generation and Network Monitoring & Telemetry*

Costs *Not Available*

This is a demonstration of a microgrid system that incorporates large-volume wind generation, intelligent output stabilization for this generation, and high volume BESS (2MVA) and various other battery technologies (Li-ion, lead-acid, EDLD, redox flow). The project aims to pilot a microgrid system that can operate independently as well as interconnect with other grids. The project is presently in the testing and demonstration stage.

CONSUMER-PARTICIPATING SMART PLACE

Organisation KEPCO

Suppliers

- Samsung SDI
- Hyosung
- Omni-system
- AID
- Rootech
- ABB
- Secui.com
- Millinet
- Samsung Electronics

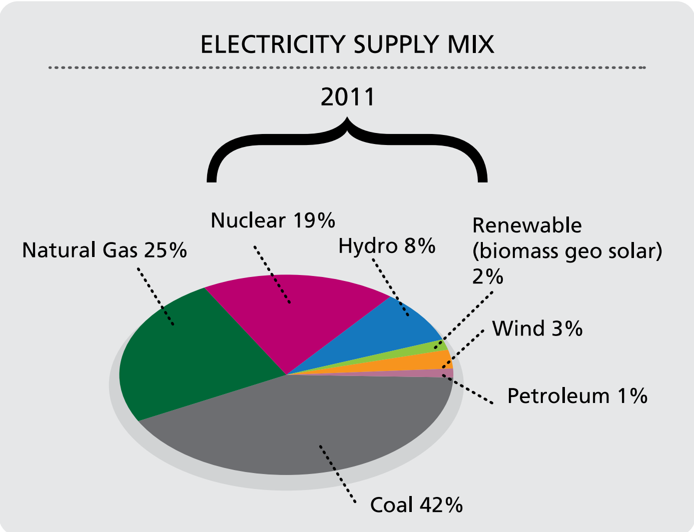
Scale *600 households*

Type *Consumer Engagement, Demand Response, Advanced Metering Infrastructure, Energy Storage, Electric Vehicles, and Distributed Renewable Generation*

Cost *₩33B / USD$30M*

The smart grid green place project outfits houses and buildings with integrated energy management services to better manage their energy use. As part of the project, real-time electricity rates will be introduced, and renewable generation sources and energy storage solutions will be installed at residences together with in-home displays to monitor energy usage. It will be possible to compare electricity use across households. Smart appliances and EVs are also being introduced. The project team is in consultation for the development of regulations which would manage the electricity market created by the demonstration project. Electric car chargers, power storage facilities, and photovoltaic systems have been built. An integrated energy management system for buildings is under development.

08 U.S.A.



A. U.S. ENERGY POLICY

Over the past decade, the U.S. government energy policy has been driven by multiple concerns including security of energy supply, environmental impact of energy production, and the ability to become "energy independent" to reverse the trend toward importing energy over domestic production. This was compounded by the fear of a pending "energy crisis" wherein the nation's energy consumption outpaces its production, threatening its economic growth, standard of living, and energy security. In 2010, energy produced in the U.S. provided approximately three-fourths of its energy needs. Since the mid-1950s, the U.S. has been a net importer of energy, and the U.S. is presently the world's largest importer of crude oil. While the U.S. is not a member of the Kyoto Protocol, it does have carbon reduction targets. Under the Copenhagen Accord, the U.S. agreed to a non-binding target of around 17% below 2005 levels by 2020 in conformity with anticipated U.S. energy and climate legislation.

As part of its effort to address these concerns and reduce energy-related CO_2 emissions, the government invested in expanding its domestic energy resources (including renewable resources) and adopted initiatives to modernize conservation and energy infrastructure. In his January 2012 State of the Union address, President Barack Obama reemphasized the U.S. government's concerns regarding energy security and restated his administration's commitment to clean energy and the smart grid. The last five years have seen U.S. residential electricity bills climb significantly, reflecting increased costs in maintaining and upgrading the aging energy infrastructure and replacing or retiring old coal-fired power plants with new natural gas and renewable energy capacity. In particular, there has been a consistent push for renewable energy production through legislative mandates at the state level; 29 of the 50 U.S. states have a "renewable portfolio standard" or RPS, which mandates a certain capacity of renewable energy on the system by a designated year.

B. ELECTRICITY SECTOR

At the federal level, the U.S. Congress determines energy policies, the Environmental Protection Agency determines environmental policy, and the Department of Energy funds and executes energy policies promulgated by federal law. Finally, the Federal Trade Commission determines consumer protection policy. Transmission and interstate commerce fall within federal jurisdiction and are regulated by the federal government through the Federal Energy Regulatory Commission (FERC). Both the federal and state governments have jurisdiction over the sale of electricity to consumers. Economic regulation of the distribution segment is a state responsibility and is typically performed by Public Utility Commissions.

Independent system operators (ISOs) and regional transmission operators (RTOs) regulated by FERC operate each of the Western, Eastern and Texas Interconnects. FERC does not have jurisdiction over the States of Alaska and

Hawaii because of the isolated nature of their grids. The North American Electric Reliability Corporation (NERC) is authorized by the Federal Power Act to ensure the reliability of the bulk power system by establishing and enforcing reliability standards, monitoring the system, providing forecasts, and offering education, training, and certification programs (including those for transmission operators, reliability coordinators, balancing authorities, and system operators). Some NERC members have formed regional organizations with similar missions (ISOs and RTOs).

Historically, the American electricity sector was dominated by vertically integrated monopolies established by state statutes and regulated through what is known as the "regulatory compact". In many states, sector restructuring has occurred. Presently, the wholesale electricity market is competitive and there is open access to transmission. Ten states have also opened up electricity retailing to competition, while three additional states are currently considering it. In most states, retail rates are regulated and set by the Public Utility Commissions. Electric utilities are owned by the private sector, rural electric cooperatives, or municipal governments. Power marketers buy and sell electricity, but generally do not own or operate generation, transmission, or distribution facilities.

C. SMART METERING / SMART GRID INFRASTRUCTURE

In 2010, 663 U.S. electric utilities had 20,334,525 smart metering infrastructure installations, approximately 90% of which were residential customer installations. In 2011, the national average penetration rate for smart meters was about 14%, with rates in seven states exceeding 25%. Other than a major influx of investment through the Federal Stimulus, much of the cost of these deployments is recovered in the retail tariffs paid by consumers. Public reaction to these deployments has been mixed; for utilities that articulated the benefits of smart metering, the consumer reaction has been positive, such as the deployments for Oklahoma Gas & Electric, San Diego Gas & Electric, as well as CenterPoint Energy in Texas. In other areas there has been major consumer pushback, fueled mostly by health and privacy concerns and a negative response to the increased electricity costs that have accompanied the smart meters. Class action suits were launched against Pacific Gas & Electric in California and against Oncor in Texas alleging health and privacy infringements, as well as overbilling. The suit against Oncor was dismissed in August 2010.

As a result of these developments, the political profile of consumer-sensitive issues related to smart meters is higher in the U.S. In response, there have been a series of initiatives from government and industry to address these concerns. The Smart Grid Consumer Collaborative was formed by private sector companies, utilities and advocacy organizations to focus on smart grid messaging and educational tools for consumers. In California, the government enacted legislation protecting the privacy of consumer energy consumption data, and the California Public Utilities Commission ruled that customers must be allowed to opt-out of smart meter installations (for a fee).

The smart grid is a topic with a lower popular profile than that of smart meters. In 2003, the U.S. Department of Energy formed the Office of Electric Transmission and Distribution (now called the Office of Electricity Delivery and Energy Reliability) to lead a national effort to modernize and expand the electricity grid. In January 2004, the Office produced the *National Electric Delivery Technologies Roadmap*, which articulated an ambitious vision of a smart grid branded "Grid 2030". Grid 2030 envisaged intercontinental power transfers, real-time information flow from consumers, near-zero economic losses from power outages and disturbances, and open competitive markets in all segments of the electricity industry. This roadmap was recently updated, but was not publicly available at the time of this writing.

Since then, the federal government has made significant commitments and funding available to stimulate smart grid activity. Support for the smart grid was codified in the federal *Energy Independence and Security Act of 2007*. The Department of Energy manages an R&D and demonstration program for smart grid technologies that matches funds for qualifying investments. State utility commissions and industry advocates are reviewing the results of the investment program funded by the DOE to identify best practices and cost/benefits to consumers and utilities. Under the *American Recovery and Reinvestment Act of 2009*, the federal government provided approximately $4.3 billion for smart grid investments, such as an electric vehicle component manufacturing program and advanced metering infrastructure implementations. It is anticipated that over the next decade, smart grid activities will continue to attract federal attention in the areas of critical infrastructure and cyber-security. At the time of this writing, the National Institute of Standards and Technology (NIST) was overseeing the development of interoperability and cyber-security standards through a collaborative process involving policy makers, utilities, and industry. While declining to enforce specific standards, the Federal Energy Regulatory Commission (FERC) issued a ruling late in 2011 praising the collaborative process initiated by NIST and requesting an updated family of standards for final ruling and enforcement at the federal level.

The GridWise Alliance is a smart grid stakeholder organization that facilitates dialogue across the electricity sector and academia on matters pertaining to smart grid developments. The projects described below are a sample of the ambitious and innovative smart grid initiatives presently being undertaken by its membership.

D. NOTABLE PROJECTS

PACIFIC NORTHWEST SMART GRID DEMONSTRATION PROJECT

Organizations

- Pacific Northwest National Labs
- U.S. Department of Energy
- Bonneville Power Administration
- Avista Utilities
- Idaho Falls Power
- Inland Power and Light
- Lower Valley Energy
- Portland General Electric
- Milto-Freewater City Light and Power
- Flathead Electric Cooperative
- NorthWestern Energy
- Peninsula Light Company

Suppliers

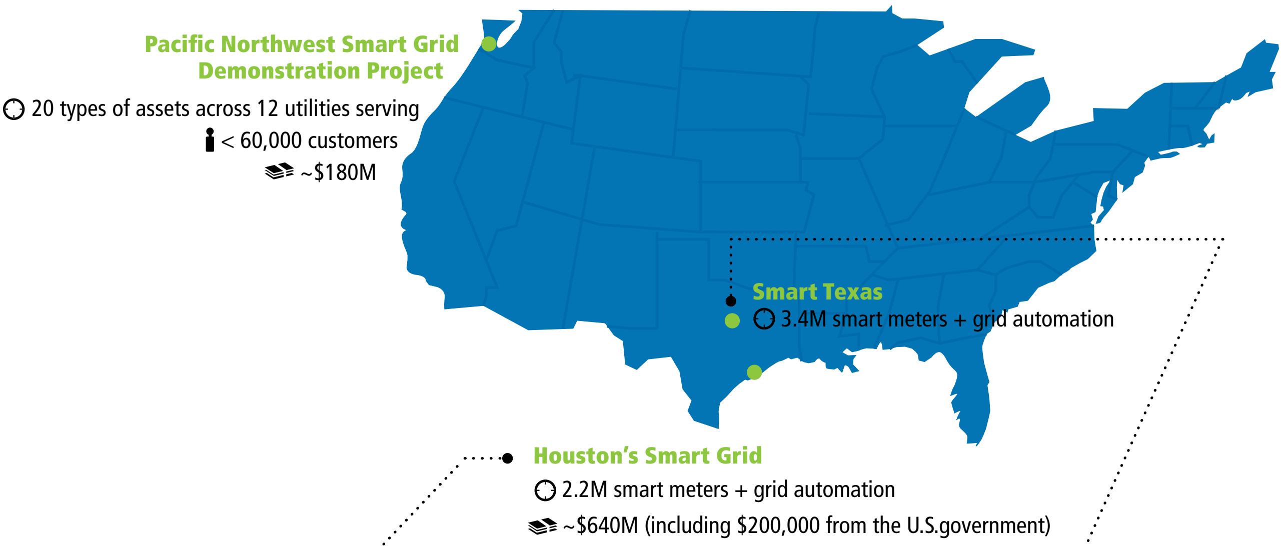
- 3TIER Inc
- AREVA T&D
- IBM
- QualityLogic Inc
- Netezza Corporation
- Drummond Group Inc

Scale *20 types of assets across 12 utilities serving more than 60,000 customers*

Type *Distribution Automation, Distributed Generation, Energy Storage, Advanced Meter Infrastructure, Demand Response*

Cost *~$180M*

The Pacific Northwest Smart Grid Demonstration Project is a large pilot project which spans five states (Montana, Washington, Idaho, Oregon and Wyoming) and involves 22 utilities (vertically integrated, city-owned, and rural cooperatives), as well as lab and university partners. The project intends to demonstrate a single integrated smart grid incentive signaling approach that will allow for the continuous coordination of smart grid assets. It is presently in the testing and validation phase for technologies and will commence demonstration and data collection in summer 2012. All use classes are represented in the demonstration including residential, commercial, industrial, and irrigation customers. The project is targeted to create jobs, improve grid efficiency and reliability, and empower customers to conserve energy. This project is unique both for its geographical reach (five U.S. state territories) and for its comprehensive testing of multiple technologies within all types of utilities.



HOUSTON'S SMART GRID

Organizations
Houston Electric • US Department of Energy

Suppliers
IBM • General Electric • ITRON • eMETER • Quanta Services

Scale *2.2M smart meters and grid automation*
Type *Multiple Technologies*
Cost *~$640M (including $200,000 from the U.S.government)*

In Houston, Texas, Houston Electric (a subsidiary of CenterPoint Energy) is undertaking a large scale smart grid deployment which is funded in part by the U.S. Department of Energy. The drivers behind the project are improving reliability in the hurricane-prone Gulf of Mexico region as well as enabling customer control and conservation. In this project, the utility is implementing a fully integrated advanced metering system, customer web portal, and automatic outage notification application. This, combined with its Intelligent Grid initiative to modernize and strengthen the grid, makes it one of the few large scale end-to-end smart grid projects. A survey of customers reported significant changes in electricity behavior in the majority of respondents. The utility intends to introduce time-of-use pricing in the second phase of the project.

SMART TEXAS

Organization OnCor

Suppliers IBM • EcoLogic Analytics • Landis+Gyr

Scale *3.4M smart meters and grid automation*
Type *Multiple Technologies*
Cost *Not Available*

As part of the Smart Texas initiative, Oncor is implementing a massive smart meter deployment and distribution automation project. Once the project is fully implemented, consumers will be able to track their usage data through a customer web portal or an in-home monitor. Oncor has implemented a solution that leverages the ZigBee Smart Energy Profile to provide data exchange between the smart meter and the in-home display. This, combined with programs such as the consumer-focused "Biggest Energy Saver" contest, has shown reductions in usage by as much as 15%. The project also provides the Electricity Reliability Council of Texas (ERCOT) with usage data at 15 minute increments, allowing for very granular billing. The roll out is targeted to be complete in 2012.

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