Attachment C

Smart Grid Around the World

Selected Country Overviews

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Prepared by SAIC

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General Acronyms

BEMS	Building energy management system	**MDM**	Meter data management
BPL	Broadband power line	**MVA**	Megavolt ampere
CHP	Combined heat and power	**NAS**	Sodium sulfur (battery type)
DSM	Demand side management	**NIST**	National Institute of Standards and Technology
EHMS	Energy hub management	**PLC**	Power line carrier
EV	Electric vehicle	**SCADA**	Systems control and data acquisition
EU	European Union	**T&D**	Transmission and distribution
GSGF	Global Smart Grid Federation	**TOU**	Time of use
HEMS	Home energy management system	**TWh**	Terawatt hours
IP	Internet protocol	**UHV**	Ultra high voltage
ISGAN	International Smart Grid Action Network	**USAID**	U.S. Agency for International Development
IT	Information technology	**USTDA**	U.S. Trade and Development Agency
LTE	Long term evolution	**V2G**	Vehicle to grid

Country Agency Acronyms

Australia	**AEMC**	Australian Energy Market Commission
	AEMO	Australian Energy Market Operator
	DCCEE	Department of Climate Change and Energy Efficiency
	DRET	Department of Resources, Energy and Tourism
	SGA	Smart Grid Australia
Canada	**CED**	Clean Energy Dialogue
	NEB	National Energy Board
	NRCan	Natural Resources Canada
	NSERC	Natural Sciences and Engineering Research Council of Canada
	SCC	Standards Council of Canada
	SGC	Smart Grid Canada
China	**CEC**	China Electricity Council
	NDRC	National Development and Reform Commission
	NEC	National Energy Administration
	SERC	State Electricity Regulatory Commission
	SGCC	State Grid Corporation of China
	SGEPRI	State Grid Electric Power Research Institute
Germany	**BMU**	Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety
	BMWi	Federal Ministry of Economics and Technology
	DKE	The German Commission for Electrical, Electronic, & Information Technologies

India	**CEA**	Central Electric Authority
	CPRI	Central Power Research Institute
	DST	Department of Science and Technology
	MCIT	Ministry of Communications and Information Technology
	Mescom	Mangalore Electricity Supply Company
	MNRE	Ministry of New and Renewable Energy
	MOP	Ministry of Power
	PFC	Power Finance Corporation
	R-APDRP	Re-Structured Accelerated Power Development and Reforms Program
	SGTF	Smart Grid Task Force
Japan	**ARIB**	Association of Radio Industries and Businesses
	METI	Ministry of Economy, Trade and Industry
	NEDO	New Energy and Industrial Technology Development Organization
South Korea	**KSGI**	Korea Smart Grid Institute
Spain	**NOBEL**	Neighborhood Oriented Brokerage Electricity and monitoring system
	REE	Red Electrica de Espana
United Kingdom (UK)	**DECC**	Department of Energy and Climate Change
	DNO	distribution network operators
	LCN	Low Carbon Networks
	Ofgem	Office of the Gas and Electricity Markets

Introduction

Smart grid initiatives are gaining traction, not only in the United States but in many other countries around the world. Utilities around the globe are investing billions of dollars to deploy smart grid technologies. The number of smart meters deployed worldwide is expected to rise from a level of 76 million in 2009 to more than 250 million in 2015, representing approximately 18 percent of all electric meters globally.[1] Just as the $4.5 billion investment under the American Recovery and Reinvestment Act (ARRA) is a significant factor in driving smart grid growth in the United States, other countries are also investing significant resources in the creation of their own financial and policy incentives to spur smart grid development. A report released in January 2010 by ZPryme Research & Consulting ranks the top 10 countries by smart grid federal stimulus investments.[2] The report showed that China exceeded the United States in federal smart grid subsidies for the first time in 2010, with over $7.3 billion invested, compared to $7.1 billion in the United States. Table 1 shows the list of countries ranked by federal smart grid investment in 2010.

Table 1. Top Ten Smart Grid Federal Stimulus Investments by Country, 2010

Country	Invested (U.S. Million Dollars)
China	$7,323
United States	$7,092
Japan	$849
South Korea	$824
Spain	$807
Germany	$397
Australia	$360
United Kingdom	$290
France	$265
Brazil	$204

Source: ZPryme, http://zpryme.com/news-room/smart-grid-china-leads-top-ten-countries-in-smart-grid-federal-stimulus-investments-zpryme-reports.html, accessed September 27, 2011

Although the definition of smart grid varies from country to country, the underlying concept is the same: an electricity system that uses information technology (IT) to connect those who generate and transmit electricity with those who consume it. The approach to establishing such a system varies by country and region. Smart grid activities in the United States and the European Union (EU) illustrate this variation. For example, in Europe smart meter roll-outs and other smart grid initiatives are largely driven by policy mandates to meet environmental and climate goals. This differs from the United States, where the primary drivers for smart grid development are stimulus money for job creation and utility-based efforts to add value and increase system efficiencies. The two regions also show a fundamental difference in the systems used to enable two-way communication for smart meters, a key element of a smart grid. The United States is generally leaning toward wireless mesh technology, while many European countries

[1] KEMA. Smart Grid Development Is Not Limited to the U.S. http://www.kema.com/services/consulting/utility-future/smart-grid/smart-grid-not-limited-to-US.aspx, accessed September 27, 2011

[2] ZPryme, http://zpryme.com/news-room/smart-grid-china-leads-top-ten-countries-in-smart-grid-federal-stimulus-investments-zpryme-reports.html, accessed September 27, 2011

are choosing power line carrier (PLC) technology, a communication system that uses existing power lines to send and receive information. Wireless mesh is the choice in the United States primarily because of the Federal Communications Commission's (FCC) flexible regulations regarding the use of public, unlicensed radio communications bands. Because these bands are more heavily regulated in Europe, PLC is the initial preference in that region. Among EU countries, however, there have been concerns about the reliability of PLC; this has lead to recent pilots in Europe using wireless mesh technology.[3]

In spite of these differences in approach, there are some lessons to be learned from the smart grid approaches and projects under development in other countries. This report provides a brief overview of smart grid activities in select countries, highlighting the key aspects and potential lessons learned from each country's general smart grid approach or from a specific project or program. Countries were selected according to the following criteria:

- Their relative smart grid advancement
- Their noteworthy progress
- Their pilot projects or programs of particular interest to the United States

Among the countries that met those criteria, an attempt was made to represent different regions, utility structures, and transmission and distribution (T&D) configurations. The most important reason for inclusion, however, is whether the smart grid activities in a particular country could offer any lessons learned to the United States.

The information contained in these country-level profiles was obtained through Internet searches of open-source material. No attempt was made to contact the governments or utilities highlighted in these overviews. New developments since the original release on March 31, 2011 are included in the final section of each country profile, "Updates as of September 2011."

Table 2 provides national-level electricity (and renewable energy) statistics for the countries included in this study; Table 3 provides basic economic statistics and smart grid federal investment. Both tables also include statistics for the United States as a point of reference. Table 4 compares the relative maturity of smart grid activities in each country by identifying the primary drivers. Table 5 highlights smart grid projects/programs and the respective partners for each of the countries profiled in this report. Light blue hatched cells highlight the nine new projects/programs added during the September Update.

A description of the efforts to develop international smart grid standards follows the individual country profiles.

[3] Giglioli, Encrio, et al., How Europe is approaching the smart grid, McKinsey & Company, http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_Europe_VF.aspx, accessed September 27, 2011

Table 2. Electricity Statistics and Utility Structure for Selected Countries, 2008

Country	Net Electricity Consumption (GWh)	Total Net Electricity Generation (GWh)	Total Installed Electricity Capacity (GW)	Installed Renewable Electricity Capacity (GW)	Net Renewable Electricity Generation (GWh)	Electricity Capacity Utilization	Renewable Capacity as Share of Total Installed	Renewable Net Generation as Share of Total	Utility Structure		
									National Monopoly	Commercial/ Vertically Integrated	Deregulated/ Partially Deregulated
Australia	225,376	242,224	55.5	10.5	17,780	50%	19%	7%			X
Canada	549,476	632,227	127.6	78.4	390,367	57%	61%	62%		X	
China	3,016,550	3,221,181	797.1	186.8	537,298	46%	23%	17%	X		
Denmark	33,414	34,317	12. 5	4.1	10,333	31%	33%	30%			X
Germany	544,467	594,685	139.3	37.8	91,252	49%	27%	15%			X
India	600,649	785,529	177.4	51.4	128,098	51%	29%	16%	X		
Japan	963,852	1,015,165	280.5	27.8	103,990	41%	10%	10%		X	
South Korea	402,049	418,155	79. 9	2.4	4,358	60%	3%	1%	X		
Spain	267,464	293,503	93.5	33.7	60,434	36%	36%	21%			X
United Kingdom	344,669	361,842	85.6	6.8	22,287	48%	8%	6%			X
United States	3,906,443	4,119,387	1,010. 2	117.4	392,736	47%	12%	10%			X

Notes: All data for 2008. Renewable energy includes hydropower.
Source: EIA, International Energy Statistics, http://www.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=92&pid=46&aid=2, accessed September 27, 2011

Table 3. Economic and Smart Grid Statistics for Selected Countries

Country	Population (Millions, mid-year 2008)	Population (Millions, mid-year 2010)	Gross Domestic Product (GDP) (Billion $ U.S. 2010)[a]	GDP per Capita ($U.S./person, 2010)	Electricity Consumption per Capita (kWh/person, 2008)[b]	Federal Funding for Smart Grid (Million $U.S., 2010)	Year Smart Grid Development was Started	Communication Technologies Deployed	
								BPL/PLC	Wireless
Australia	21.0	21.5	$890	$41,395	10,728	$360	2004		X
Canada	33.2	33.8	$1,335	$39,497	16,544	N/A	2006		X
China	1,317.1	1,330.1	$9,872	$7,422	2,290	$7,323	2007	X	
Denmark	5.5	5.5	$201	$36,545	6,092	N/A	2005	X	X
Germany	82.1	81.6	$2,960	$36,275	6,635	$397	2008	X	X
India	1,140.6	1,173.1	$4,046	$3,449	527	N/A	2008	X	X
Japan	127.3	126.8	$4,338	$34,211	7,572	$849	1990s		X
South Korea	48.4	48.6	$1,467	$30,185	8,310	$824	2009	X	X
Spain	45.9	46.5	$1,376	$29,591	5,826	$807	2007	X	X
United Kingdom	61.6	62.3	$2,189	$35,136	5,591	$290	2009	X	X
United States	304.4	310.2	$14,720	$47,453	12,834	$7,092	2001		X

Notes: [a]Gross domestic product calculated at purchasing power parity.
[b]Calculated from 2008 population since electricity consumption data available for 2008 .

Sources: U.S. Census Bureau, International Data Base, Population, http://www.census.gov/ipc/www/idb/rank.php, accessed September 21, 2011
Central Intelligence Agency, World Fact Book - GDP, https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html, accessed September 21, 2011
Energy Information Administration, International Energy Statistics, http://www.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=92&pid=46&aid=2, accessed September 21, 2011
Zpryme Research and Consulting, Smart Grid Snapshot: China Tops Stimulus Funding, http://www.zpryme.com/SmartGridInsights/2010_Top_Ten_Smart_Grid_Stimulus_Countries_China_Spotlight_Zpryme_Smart_Grid_Insights.pdf, accessed September 21, 2011

Table 4. Drivers for Smart Grid Development

Country	Government Policies/ Mandates	Environmental Goals	Electric Vehicle Integration	Renewable Integration	Reliability Concerns	Financial Incentives	Energy Efficiency Goals	Increasing Demand	Economic Competitiveness	Geographic Grid Constraints	Energy Security Goals	Energy Theft Reduction
Australia	●	●		●	●	●	●					
Canada		●					●	●		●	●	●
China		●		●		●	●	●	●	●		
Denmark	●	●	●	●								
Germany	●	●		●		●		●			●	
India					●		●	●	●	●		●
Japan		●	●	●		●						
South Korea		●		●		●	●					
Spain	●		●	●		●		●				
United Kingdom	●	●				●			●		●	

Notes:

- **Government Policies/Mandates** - The individual country government or region in which the country is a part (e.g., EU) has policies in place or has issued mandates specific to smart grid development.
- **Environmental Goals** – The country has a strong focus on environment and climate goals and the advancement of smart grid initiatives is seen as a key factor in meeting those goals.
- **Electric Vehicle Integration** – The integration of electric vehicles is seen as a major component of smart grid development in the country.
- **Renewable Integration** – The country is focused on rapidly increasing the integration of intermittent renewable energy sources which is driving the need for an advanced grid infrastructure.
- **Reliability Concerns** – The reliability of electric power supply to end use customers is a concern and smart grid development is seen as a main way to mitigate this.
- **Financial Incentives** - The country is supplying a large amount of government subsidies targeted specifically to smart grid development. The country is ranked as one of the top ten in government investment on smart grid.
- **Energy Efficiency Goals** – The country has a focus on the improvement of efficiency in the electric power sector and smart grid initiatives are seen as a way to accomplish this.
- **Increasing Demand** – The country is seeing a rapid increase in energy demand due to increasing population or expanding industry. Smart grid development is seen as a primary means to manage the growing energy demand related to this growth.
- **Economic Competitiveness** – The country views smart grid development as a key way to spur industry growth and improve global economic competitiveness.
- **Geographic Grid Constraints** – Sources of energy supply and centers of energy consumption are separated by long geographic distances or challenging terrain putting strain on the energy delivery system. More effectively managing the energy delivery through smart grid upgrades is seen as a key method of alleviating this issue.
- **Energy Security Goals** – Improving energy security and reducing imports is a key smart grid driver in these countries.
- **Energy Theft Reduction** – Energy theft is widespread and the development of a smart grid, especially smart meters, is viewed as a way to manage these non-technical losses.

Source: SAIC

Table 5. Smart Grid Projects, Programs, and Partners in Selected Countries

Country	Smart Grid Champions	Project/Program	Location	Partners
Australia	Smart Grid Australia	Smart Grid, Smart City	Newcastle, Scone, Ku-ring-gai, Newington and Sydney	EnergyAustralia, Australia Department of Resources, Energy, and Tourism, Intel, Grid Net, IBM, General Electric, and Better Place
		Victoria Smart Meter Project	Victoria	State Government of Victoria, Powercor Australia, Singapore Power Group Ausnet, United Energy Distribution, Citipower, and Jemena
		Solar Cities Program	Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Perth, and Townsville	Australia Department of Climate Change and Energy Efficiency, Adelaide, Alice, Blacktown, Central Victoria Solar City Consortiums, Sustainability Victoria, Moreland Energy Foundation, and Western Power
		Advanced Electricity Storage Technologies Program	Australian Capital Territory (ACT), New South Wales (NSW), Queensland (QLD)	Department of Resources, Energy and Tourism, Wizard Power (ACT), Lloyd Energy Systems (NSW), ZBB Technologies (NSW), RedFlow Pty Ltd (QLD), Smart Storage Pty Ltd (NSW)
Canada	SmartGrid Canada	Ontario London Hydro Phase II	London, Ontario	London Hydro Smart Meter Consortium, Ontario Hydro, and London Hydro
		NSERC Smart Microgrid Network	British Columbia	British Columbia Institute of Technology
		British Columbia Green Energy Plan	British Columbia	British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Hydro, British Columbia Transmission Corporation, Fraser Basin Council, and First Nations
		Advanced Metering Infrastructure pilots, full-scale rollout	Boucherville, Montreal, and Memphrémagog, Quebec	Hydro-Québec, Landis+Gyr, and Elster
China	State Grid Corporation of China	Smart Community Demonstration Project	Langfang, Heibei Province	North China Power Grid
		Smart Grid, Demand Side Management Pilot	Nationwide	State Grid Electric Power Research Institute and U.S. Trade and Development Agency
		MW class VRB™ Energy Storage System	Zhangbei, Hebei province	Prudent Energy, National Wind Power Integration Research and Test Center of China (NWIC), State Grid Corporation of China, China Electric Power Research Institute (CEPRI)
		Eco-City	Sino-Singapore Tianjin	State Grid Corporation of China (SGCC), Duke Energy, ENN Group
		Smart Grid Project	Fujian Province	Fujian Electric Power Company, Sanming, Nanping and Longyan
Denmark	European Commission, Global Intelligent Utility	Holsted Smart Grid Test Project	Holsted	Energinet.dk, Syd Energi Net, Spirae Inc., Energynautics GmbH, and Siemens

Country	Smart Grid Champions	Project/Program	Location	Partners
	Network Coalition, EU Smart Grid Task Force	SEAS-NVE Cell Project	Eastern region	SEAS-NVE and Eltel Networks
		Bornholm Test Site	Bornholm	EcoGrid (European Union), Østkraft, Siemens, IBM, Technical University of Denmark, Australian Institute of Technology, Energinet.dk, and Research Group Energy and Communication Technology GmbH
Germany	European Commission, Federal Ministry of Economics and Technology, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, EU Smart Grid Task Force	Yello Strom/Cisco Smart Meter Pilot	Nationwide	Yello Strom and Cisco
		Smart Meter Project	Hassfurt	Stadtwerk Hassfurt and Echelon
		Model City Mannheim Project	Mannheim and Dresden	MVV Energie
India	India Smart Grid Forum	Bangalore Pilot Project	Electronic City	Bangalore Electricity Supply Company, Center for Study of Science, Technology and Policy, Central Power Research Institute and Public Affairs Committee
		Distribution Reform, Upgrades and Management Projects	North Delhi, Bangalore, Gujarat, and Maharashtra	U.S. Agency for International Development and the India Ministry of Power
		Joint Clean Energy Research and Development Center	India and United States	Indian Ministry of Science and Technology, U.S. Department of Energy
		Smart Meter Installations	New Delhi	Grinpal Energy Management
Japan	Japan Smart Community Alliance	Ministry of Economy, Trade and Industry Smart Grid Trial	Kyoto, Yokohama, Toyota City, and Kitakyushu City	Kansai Research Institute and the Japanese Ministry of Economy, Trade and Industry
		Sodium Sulfur Battery (NaS) System	Tsukuba, Ibaraki Prefecture	National Institute of Advanced Industrial Science and Technology (NAIST)
		V2X, Electric Vehicle Smart Grid Pilot	Nagoya	Mitsubishi Motors Corporation, Mitsubishi Electric Corporation, and Mitsubishi Corporation
		Maui Smart Grid Project	Maui, Hawaii, United States	Japan's New Energy and Industrial Technology Development Organization (NEDO) and Hawaiian Electric Company
South Korea	Korean Smart Grid Association	Jeju Smart Grid Test Bed	Jeju Island	Korea Smart Grid Institute and Korea Electric Power Corporation
		Collaboration with State of Illinois	Gyeonggi-do, Republic of Korea	Illinois' Department of Commerce and Economic Opportunity and Korean Ministry of Knowledge Economy
Spain	European Commission, EU Smart Grid Task Force	Bilbao and Portugalete Smart Grid Pilot	Bilbao and Portugalete	Iberdrola and the Basque regional government

Country	Smart Grid Champions	Project/Program	Location	Partners
		Málaga SmartCity Project, Smart Community System Demonstration Project	Málaga, Andalusia	Endesa, Enel, Japan's New Energy and Industrial Technology Development Organization (NEDO)
		Castellón Smart Grid Project	Castellón	Iberdrola, Itron, and Current Group
United Kingdom	European Commission, United Kingdom Department of Energy and Climate Change, Ofgem, EU Smart Grid Task Force	North East and Yorkshire Smart Grid Project	Yorkshire, Durham, Leeds, Newcastle and Sheffield	CE Electric UK, British Gas, Durham University and EA Technology
		Energy Demand Research Project	Nationwide	EDF Energy, Scottish and Southern Energy, E.ON, and Scottish Power
		Smart Meter Installations	Nationwide	First Utility, OPower, Department of Energy and Climate Change (DECC)
		Switch EV Trial	Newcastle, Gateshead, and North East areas	Technology Strategy Board, Nissan, Simon Bailes Limited, Avid Vehicles, Liberty E Cars, Smith Electric Vehicles, The Transport and Operations Research Group at Newcastle University, One North East, and Future Transport Systems

Note: Light blue hatched cells indicate projects/programs added during September 2011 Update.
Source: SAIC, 2011.

Australia			
Population	21.5 Million	**GDP**	$890 Billion U.S.
Electricity Consumption per Capita	10,728 kWh	**Federal Funding for Smart Grid**	$360 Million U.S.

Smart Grid Drivers

- Energy efficiency goals
- Renewable integration (especially solar)
- Reliability concerns
- Financial Incentives
- Government policies/mandates
- Environmental Goals

Smart Grid Development Status

Both smart grid and energy efficiency programs are in the relatively early stages of development in Australia, with government efforts focused on establishing goals, determining the course of action, defining terms, establishing data needs, developing objectives, developing pilot programs, and seeking to remove barriers to participation. Like most countries developing smart grid infrastructure, Australia has no one agency overseeing smart grid development. As a result, smart grid activities are administered separately from energy efficiency programs. The Australian Energy Market Commission (AEMC) serves as the regulator of the National Electricity Market (NEM). The Australian Energy Regulator (AER) and the Australian Energy Market Operator (AEMO) work in conjunction with AEMC to enforce rules and ensure the smooth operation of the electricity markets. Additionally, the AEMO is responsible for planning the transmission grid. The Department of Climate Change and Energy Efficiency (DCCEE) and the Department of Resources, Energy and Tourism (DRET) set climate change and energy policy nationally. These agencies work together to define policy framework and develop the smart grid.[4] In addition, Smart Grid Australia (SGA) was created as a non-profit, non-partisan alliance dedicated to an enhanced, modernized electric system. The SGA holds meetings, organizes committees, assists with government initiatives, and issues communications to accelerate progress on smart grid development.[5]

Key Projects/Programs

- **Solar Cities program:**[6] Designed by DCCEE to test new sustainable models for electricity supply and use. These models combine solar power, smart metering, energy efficiency, and cost-reflective pricing. The goals of the program include cuts in peak electricity demand, testing of sustainable energy options, the development of better information on environmental and economic costs and benefits of the various energy options, and the reduction of greenhouse gas emissions. The seven cities participating are Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Perth, and Townsville. The first cities joined the program in 2006 and the last in 2008.

[4] IEEE, http://smartgrid.ieee.org/public-policy/australia, accessed September 21, 2011
[5] Smart Grid Australia, http://www.smartgridaustralia.com.au/, accessed September 21, 2011
[6] Australia Department of Climate Change and Energy Efficiency, Solar Cities, http://www.climatechange.gov.au/government/programs-and-rebates/solar-cities.aspx, accessed September 21, 2011

- **Smart Grid, Smart City program:**[7] DRET committed up to $100 million to develop and test a commercial scale project that will gather robust information about the costs and benefits of smart grids to inform future decisions by government, electricity providers, technology suppliers and consumers. The Australian Government launched Smart Grid, Smart City in Newcastle in October 2010. The technology introduced through the program will allow residents to see real-time analysis of electricity usage for their households and for individual appliances. The smart grid demonstration will also test real-time, complex information about grid performance in order to improve control over the network for Australian energy transmission and distribution companies. EnergyAustralia is leading the demonstration project and will become the first utility to use long term evolution (LTE) for its 4G communications network.[8]

- **Victoria Smart Meter Project:**[9] Large-scale project to replace all residential and small business meters in the province of Victoria, a total of 2.5 million smart meters. Although the project is currently under review by the new Victorian Government, installation of smart meters is continuing. The Government is commissioning an independent cost-benefit analysis to determine whether, and under what circumstances, the program can deliver value for consumer costs. This analysis, and a review of other parts of the program, will inform the Government's decision on the future of the smart meter program.[10]

- **EnergyAustralia PowerSmart Program:**[11] Time-of-use (TOU) pricing system for small and medium sized business customers that use less the 40 MWh of electricity per year. A large number of businesses have had smart meters installed, allowing them to take advantage of the program.

- **Advanced Electricity Storage Technologies Program:**[12] An Australian Government initiative that has awarded $20.4 million through DRET. This program seeks to increase the use of variable renewable energy sources, such as wind and solar, by promoting the development and demonstration of efficient electricity storage technologies. Such technologies include batteries, electro-mechanical, chemical, and thermal storage technologies, in either on- or off-grid configurations. So far, the program has funded five projects:

    - **Wizard Power:** A solar energy storage project using technology based on ammonia dissociation and re-association into hydrogen and nitrogen.
    - **Lloyd Energy Systems:** A solar thermal energy storage system demonstration involving concentrated solar energy and graphite blocks.
    - **ZBB Technologies**: An integrated zinc-bromine flow battery project at CSIRO's National Solar Energy Centre in Newcastle.

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[7] Australia Department of Resources, Energy and Tourism, Smart Grid, Smart City, http://www.ret.gov.au/energy/energy_programs/smartgrid/pages/default.aspx, accessed September 21, 2011

[8] Energy Source & Distribution, January - February 2010, EnergyAustralia's Smart Grid to Use LTE, http://en.calameo.com/read/00037349524f74e4b1f68 , accessed October 3, 2011.

[9] State Government of Victoria, Smart Meters, http://www.new.dpi.vic.gov.au/energy/projects-research-development/smart-meters, accessed September 21, 2011

[10] Victoria Department of Primary Industries, Smart Meter rollout is continuing while the program is under review, http://www.new.dpi.vic.gov.au/smart-meters, accessed September 21, 2011

[11] EnergyAustralia, PowerSmart time-based pricing, http://www.energyaustralia.com.au/State/NSW/Business/Small-and-medium-business/Business-products-and-services/Electricity/PowerSmart-time-based-pricing.aspx, accessed September 21, 2011

[12] Australian Government, Department of Resources, Energy and Tourism, Advanced Electricity Storage Technologies Program, http://www.ret.gov.au/energy/clean/cei/advanced_electricity_storage_technologies_program/Pages/AdvancedElectricityStorageTechnologies.aspx, accessed September 21, 2011

- **RedFlow Pty Ltd**: A zinc bromine battery demonstration in grid and fringe-of-grid solar photovoltaic systems.
- **Smart Storage Pty Ltd:** An UltraBattery system project located at the end of an 11-kV rural grid attached to a 660-kW wind turbine.

Potential Lessons Learned for the United States

Australia's SmartGrid, SmartCity project will be the first to use a 4G LTE network in a smart grid application.[13] This will be an important project to follow, as 4G networks are expanding in the United States. The 4G network will transmit data between 12,000 smart monitoring devices, 3,000 mobile field computers and 200 zone substations. Trials will begin on an LTE platform at 15 sites, with the plan to move to a full LTE network.

In addition, Australia recently launched one of the largest research efforts on green telecommunications in the world, the Centre for Energy-Efficient Telecommunications, a partnership with Alcatel-Lucent Bell Labs, the University of Melbourne, and the Victorian State Government. The Centre will take advantage of the University of Melbourne's world-class research in telecommunications network infrastructure.

Australia's energy storage technology deployments also warrant watching.

Updates as of September 2011

The government of Australia has recently implemented significant smart technology policies and environmental policies. The government's Department of Broadband, Communications and the Digital Economy launched the National Digital Economy Strategy on May 31, 2011, setting a goal of providing smart technology to a majority of Australian households, businesses, and organizations by 2020 to better manage energy use.[14] In addition, Australia launched a carbon pricing scheme, known as "Clean Energy Future," in July 2011. Under the carbon pricing mechanism, about 500 of the country's largest polluters will be required to pay for each metric ton of pollution released into the atmosphere.[15] Both of these policies are certain to impact the development of smart grid in Australia in coming years.

At least two of Australia's existing smart grid projects have reported significant updates. DCCEE's Solar Cities program reported that it is beginning to achieve some of its goals. As of June 2011, 20,174 smart meters were installed, 10,945 home energy assessments were given, and 5,301 kW of solar photovoltaic capacity were installed. Participants in Townsville were able to reduce peak demand at the busiest time of the year on Magnetic Island by 33 percent compared to business as usual projections. Participants in a dynamic peak pricing trial in Blacktown reduced average daily demand by 24 percent on peak demand days, and an air conditioner remote cycling trial reduced daily energy consumption on hot days by 29 percent. In Perth, 211 participants have undertaken direct load control trials.[16] A mid-term review of the project found that the program is in good shape financially and that Solar Cities are on track to meet their objectives. According to the report, consumers and communities are willing to adopt and pay for new technologies. The report also found that the Solar Cities program was able to drive network

[13] Energy Source & Distribution, January - February 2010, EnergyAustralia's Smart Grid to Use LTE, http://en.calameo.com/read/00037349524f74e4b1f68, accessed October 3, 2011.
[14] Australia Department of Broadband, Communications and the Digital Economy, National Digital Economy Strategy, http://www.nbn.gov.au/the-vision/digitaleconomystrategy/, accessed September 21, 2011
[15] Australian Government, Clean Energy Future, The benefits of a carbon price, http://www.cleanenergyfuture.gov.au/the-benefits-of-a-carbon-price/ and Smart Grid Australia, News, http://www.smartgridaustralia.com.au/SGA/News/September_2011/SGA/3_News/News_-_September_2011.aspx?hkey=73f8da02-71e6-4655-a2f7-0332721f43c1, accessed September 21, 2011
[16] DCCEE, Solar Cities Achievements, http://www.climatechange.gov.au/en/government/programs-and-rebates/solar-cities/achievements.aspx, accessed September 21, 2011

planning responses and immediately provide a beneficial impact for communities that had clear problems facing them related to present or looming network constraints.[17]

The government of Victoria is still reviewing the previous government's smart meter policy, and meters continue to be installed, with every home and small business in the state due to receive a smart meter by the end of 2013.[18] To help inform its program review, the government solicited public submissions on issues associated with the smart meter program and released an issues paper. Based on about 400 submissions, the public expressed concern about a variety of issues, including costs imposed on households by smart meters and TOU tariffs, health issues, smart meter accuracy, and the inability of some disadvantaged groups to change energy consumption patterns if TOU tariffs were implemented.[19]

[17] DCCEE, Mid-Term Review of the Solar Cities Program, http://www.climatechange.gov.au/government/programs-and-rebates/solar-cities/publications-resources/mid-term-review-solar-cities.aspx#t3, accessed September 21, 2011
[18] Victoria Department of Primary Industries, Smart Meters, http://www.new.dpi.vic.gov.au/energy/environment-and-community/smart-meters, accessed September 21, 2011
[19] Victoria Department of Treasury & Finance, Review of the advanced metering infrastructure program, http://www.dtf.vic.gov.au/amireview, accessed September 21, 2011

Canada			
Population	33.8 Million	**GDP**	$1,335 Billion U.S.
Electricity Consumption per Capita	16,544 kWh	**Federal Funding for Smart Grid**	N/A

Smart Grid Drivers

- Increasing demand
- Energy efficiency goals
- Energy security goals
- Geographic grid constraints
- Environmental goals
- Canadian-U.S. cooperation/coordination
- Energy Theft Reduction

Smart Grid Development Status

In Canada smart grid developments are underway at both the national and provincial levels. Although Canada lacks a fully formulated federal policy regarding the development of the smart grid or a set timetable for the rollout of smart meters, it nonetheless aims to reduce its carbon emissions by 17 percent over 2005 levels by 2020.[20] Much of the smart grid activity in Canada takes place at the provincial level, with Ontario the clear leader in efforts to develop and deploy smart grid applications. Ontario enacted the Energy Conservation Responsibility Act in 2006, which mandated the installation of smart meters in all Ontario businesses and residences by 2010. By early 2010, more than 3.4 million meters had been installed, and the program was on track to have 350,000 customers using TOU metering by the summer of 2011.[21] In 2009, the Green Energy Act[22] was adopted with the stated purpose of encouraging development of renewable generation, providing investment opportunities and some measure of cost recovery, and establishing the basis for future developments related to smart grid. These programs mean that Ontario has arguably one of the world's most advanced smart grids, with more than 1 million smart meters installed and reading data.

Government agencies and programs that play a role in the electricity network and smart grid activities in Canada include the National Energy Board (NEB), Natural Resources Canada (NRCan), the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Clean Energy Fund. At the federal level, NRCan is overseeing the coordination of smart grid activities. In addition, CanmetENERGY, Canada's clean and renewable energy research centre and an agency of NRCan, in collaboration with the Standards Council of Canada (SCC) and other partners, have established a national smart grid Technology and Standardization Task Force. The SCC is overseeing the standardization process while the Canadian Standards Association is actively developing standards for the smart grid.

[20] Ernst & Young, Canada: tackling geographical challenges with smart, http://www.ey.com/GL/en/Industries/Power---Utilities/Seeing-energy-differently---Geographical-differences---Canada--tackling-geographical-challenges-with-smart, accessed September 21, 2011

[21] Ontario Ministry of Energy and Infrastructure, The Green Energy Act and the Smart Grid in Ontario, http://energy.mcmaster.ca/CES_presentations/green_energy_act_NORMAN.pdf, accessed September 21, 2011. See also, Independent Electricity System Operator, Smart Meters and Time-of-Use Rates, http://www.ieso.ca/imoweb/siteshared/smart_meters.asp, accessed September 21, 2011

[22] Ontario Ministry of Energy and Infrastructure, Ontario Legislature Passes Green Energy Act, http://news.ontario.ca/mei/en/2009/05/ontario-legislature-passes-green-energy-act.html, accessed September 21, 2011

The electricity grids of Canada and the United States are highly interconnected. There are at least 33 major transmission interconnections between Canada and the United States, with nearly 70 terawatt hours (TWh) of electricity exchanged in 2009.[23] As a result of this integration, Canada and the United States have formed the Electricity Grid Working Group focused on bilateral collaboration to facilitate the transition to a modernized electric grid. The Clean Energy Dialogue (CED) [24] was also formed to enhance joint collaboration on the development of clean energy science and technologies to reduce greenhouse gas emissions. The integrated nature of the electricity grid with the United States is also a main driver for Canada's participation in the international coordination of smart grid standards.

Numerous federally funded, smart grid-related programs are underway or in the planning stages throughout Canada. A large number of programs and pilots fall under the Clean Energy Fund, part of the recovery act under NRCan. In addition, like a number of other countries, Canada has established a public/private group, known as Smart Grid Canada (SGC), to promote smart grid developments. SGC consists of utilities, vendors, technology and service providers, academia and other industry associations.[25]

Key Projects/Programs

- **Ontario London Hydro Phase II project**:[26] Involves installation of 1.8 million meters. All utilities participating in the project were assigned specific weighting factors to their individual technical requirements, supplied meter population data, and provided utility-specific cost and productivity factors. An unbiased scoring procedure then weighted the raw data to derive a life-cycle system cost for each participating vendor. Miscellaneous factors, such as experience and customer satisfaction, were also examined.

- In February 2011, the NSERC announced grants to support research projects. Two of the projects are related to smart grid applications:
    - **University of Ottawa, Intelligent Vehicular Networks and Applications** (DIVA):[27] The School of Information Technology and Engineering will lead research efforts to design network protocols and applications for vehicular ad hoc and sensor networks that allow high-speed communication among vehicles and ground-based infrastructure.
    - **British Columbia Institute of Technology, NSERC Smart Microgrid Network:**[28] The project, the first smart grid research network in Canada, is composed of researchers from a number of government research laboratories and universities. The project will focus on three themes: operation, control and protection of smart microgrids; smart microgrid planning, optimization and regulatory issues; and smart microgrid communication and information technologies. The program also targets energy security, conservation and reduced carbon footprints.

[23] U.S. EIA, Electric Power Industry – U.S. Electricity Imports from and Electricity Exports to Canada and Mexico, 1998-2009, http://www.eia.doe.gov/cneaf/electricity/epa/epat6p3.html, accessed September 21, 2011
[24] Government of Canada, Electricity Grid Working Group, http://www.climatechange.gc.ca/Dialogue/default.asp?lang=En&n=F68970F9-1, and NRCan, Key Energy Legislation, http://nrcan.gc.ca/eneene/polpol/keycle-eng.php, accessed September 21, 2011
[25] SmartGrid Canada, http://sgcanada.org/, accessed September 21, 2011
[26] Sensus Metering Systems, FlexNet Makes Impact in Ontario, http://www.ngpowereu.com/article/FlexNet-makes-impact-in-Ontario/, accessed September 21, 2011
[27] University of Ottawa, University of Ottawa-led smart car technology research awarded $8 million, http://www.research.uottawa.ca/news-details_2235.html, accessed September 21, 2011
[28] NSERC, NSERC Smart Microgrid Network, http://www.nserc-crsng.gc.ca/Partners-Partenaires/Networks-Reseaux/NSMGNet-NSMGNet_eng.asp, accessed September 21, 2011

- **Ontario, City of Windsor, Water Systems:** [29] In August 2010, the City of Windsor announced that it would connect the city water and waste water systems to the Ontario Smart Grid as part of a pilot program to allow entities that operate large electric equipment with a consistent workload and some process flexibility or functional range to be tied into the smart grid. The water and wastewater systems constitute a significant load on the electricity supply system. The city anticipates that participating in the program will result in both cost reduction and increased reliability.

- **British Columbia Green Energy Plan:**[30] The plan targets greater conservation, energy efficiency and clean energy. A major feature is to achieve the goal of electricity self-sufficiency by 2016, and an eventual surplus in years with normal water flows. Another goal is to enable the export of more electricity to neighboring jurisdictions, either in Canada or the western United States than current capabilities allow.

- **Projects funded under the Clean Energy Fund:**[31]
    - **Electricity Storage Demonstration:** The project consists of a utility-scale storage demonstration using both new and re-purposed lithium ion automotive batteries. The project is located in Toronto and Cornwall, Ontario, and in Manitoba.
    - **Wind and Storage Demonstration:** Located in Cowessess First Nation, Saskatchewan.
    - **Energy Storage and Demand Response:** The goal of the project is to demonstrate the feasibility of energy storage as a mechanism for reducing electricity demand at near-peak capacity substations. Located at BC Hydro at Golden and Field, British Columbia.
    - **Interactive Smart Zone Demonstration:** Hydro-Québec will deploy infrastructure for charging electric and hybrid rechargeable vehicles at its Institut de recherché in Boucherville, Québec.
    - **New Brunswick Power Corporation Electricity Load Control Demonstration:** The project will be conducted in four maritime communities in New Brunswick, Nova Scotia and Prince Edward Island, with the focus on the integration between smart grid technologies, customer loads, and intermittent renewable energy sources in a region with potentially significant renewable electricity capacity. It will involve real-time demand balancing in up to 750 buildings.
    - **Prince Edward Island, Wind Technology Research and Development Park**: The Wind Energy Institute of Canada will develop a 9-MW wind park which will be the first wind/storage combination in Prince Edward Island. The project will provide a base for supporting additional wind research.

Potential Lessons Learned for the United States

The highly integrated nature of the electricity grids of the United States and Canada will mean that smart grid development in both countries will be highly cooperative. Canadian companies have been working with U.S. companies for many years to collaborate on power issues. For example, the Canadian company Energent has been working with U.S. utilities to develop smart grid solutions since 2007. The

[29] Enbala, City of Windsor to connect Water Systems to Ontario's Smart Grid, http://enbala.com/media/newsarticles/City%20of%20Windsor%20to%20Connect%20Water%20Systems%20to%20Ontario's%20Smart%20Grid.pdf, accessed September 21, 2011

[30] NEB, Canada's Energy Future: Infrastructure Changes and Challenges to 2020, http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2009/nfrstrctrchngchllng2010/nfrstrctrchngchllng2010-eng.pdf, accessed September 21, 2011

[31] NRCan, Clean Energy Fund Renewable Energy and Clean Energy Systems Demonstration Projects, http://www.nrcan-rncan.gc.ca/media/newcom/2010/201001a-eng.php, accessed September 21, 2011

company is currently developing an Energy Hub Management System (EHMS).[32] The system consists of three elements: a hub (defined as a single, static location, such as a home), a central core module, and a web-based portal. The system will provide an effective way to connect the home to the grid. This will be an important program to watch, given the close physical proximity and integrated nature of the United States and Canadian power sectors. Canada is also a member of ISGAN, and therefore will be working together with the United States to develop international standards for smart grid technologies and interoperability.

Updates as of September 2011

Smart meter deployments are making significant progress in Canada. A majority of meters in Ontario are now smart meters, and a majority of Ontario customers are being phased onto TOU pricing. Full roll outs of smart meters are taking place in British Columbia and Quebec, while pilot programs are taking place in Alberta, Manitoba, and Saskatchewan.

BC Hydro is currently installing smart meters for 1.8 million of its customers in British Columbia by 2012. Costing about $930 million, the program is expected to save $70 million over three years. According to the utility, the smart meter deployment will detect and reduce energy theft, which costs BC Hydro about $100 million each year.[33] BC Hydro emphasizes on its Web page that its smart meters will protect customers' privacy and not impact their health.[34]

Hydro-Québec is planning to install 3.8 million smart meters in Quebec by 2017. Hydro-Québec's roll out will be the largest deployment of smart meters in Canada, and one of the largest in North America. Hydro-Québec entered into a $350 million deal with Landis+Gyr for about three million of its smart meters, with the balance provided by Elster. Hydro-Québec will first implement three pilot programs between June 2011 and 2012 in Boucherville (6,000 meters), Montreal (19,000 meters in the Villeray area), and Memphrémagog (2,000 meters), before installing smart meters across the entire province (starting in the Montreal area) in 2012.[35]

[32] Energent, Energy Hub Research Project, http://www.energent.com/about-energent/research-projects/energy-hub-research-project, accessed September 21, 2011
[33] BC Hydro, Smart Meters Are Here, http://www.bchydro.com/energy_in_bc/projects/smart_metering_infrastructure_program.html, accessed September 21, 2011
[34] BC Hydro, Smart meters: Privacy, security of your information a priority, http://www.bchydro.com/news/articles/conservation/2011/smart_meters_security.html, and Quick facts – smart meters and wireless networks, http://www.el.bchydro.com/mediabulletins/bulletin/community/quick_facts_smart_meters_and_wireless_networks, accessed September 21, 2011
[35] Ernst & Young, Canada: tackling geographical challenges with smart, http://www.ey.com/GL/en/Industries/Power---Utilities/Seeing-energy-differently---Geographical-differences---Canada--tackling-geographical-challenges-with-smart, accessed September 21, 2011, and Hydro-Québec, Installation of next-generation meters: Meter Rollout, Pilot Projects, http://www.hydroquebec.com/residential/nouveau-compteur/cheminement-a-venir.html, accessed September 21, 2011

China			
Population	1,330.1 Million	**GDP**	$9,872 Billion U.S.
Electricity Consumption per Capita	2,290 kWh	**Federal Funding for Smart Grid**	$7,323 Million U.S.

Smart Grid Drivers

- Increasing demand
- Energy efficiency goals
- Renewable integration
- Geographic grid constraints
- Economic competitiveness
- Financial Incentives

Smart Grid Development Status

In 2010, Chinese Premier Wen Jiabao announced that construction of a smart grid was a national priority, with completion planned for 2020. Subsequently, the State Grid Corporation of China (SGCC), which controls electricity distribution, announced that construction will begin on major nationwide grid upgrades in 2011. Cost of the projects is estimated to be $100 billion through 2020.[36] As a result of the increased spending, China surpassed the United States in 2010 in total smart grid expenditures, and is anticipated to spend more than any other country on smart grid developments for several years at least. As China establishes standards, seeks equipment, and develops its own technologies, it will play a central role in setting the tone of smart grid development worldwide, through the sheer size of its smart grid activities.[37]

Despite China's centralized structure, a number of government agencies share responsibilities for smart grid development. The State Electricity Regulatory Commission (SERC) oversees regulatory policies and rate structures. The National Development and Reform Commission (NDRC), is the central planning authority for all significant national initiatives of any description. The National Energy Administration, a superagency of the NDRC, has responsibility for administering energy related programs. China's Energy Conditions and Policies, announced in 2007, established energy policies and targets to be achieved in the 11th Five Year Plan and beyond, as well as a number of measures and targets focused on smart grid measures to achieve policy goals. In addition, like many other countries, China created a hybrid governmental/industrial organization, the China Electricity Council (CEC) to promote research and development of smart grid applications. Operating under the CEC, the SGCC, which controls the T&D network, coordinates and guides smart grid developments in China.[38]

[36] IEEE, China, http://smartgrid.ieee.org/resources/public-policy/china, accessed September 21, 2011. SustainableBusiness.com News, China Smart Grid Market To Hit $61B by 2015, http://www.sustainablebusiness.com/index.cfm/go/news.display/id/21724, accessed September 21, 2011. Siegel, Jeff, Chinese Smart Grid: Will China Control Smart Grid Too?, Green Chip Stocks, http://www.greenchipstocks.com/articles/chinese-smart-grid/991, accessed September 21, 2011

[37] Xu, David, et al., Evolution of the smart grid in China, McKinsey, http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_China_VF.aspx, accessed September 21, 2011

[38] Information Office of the State Council of the People's Republic of China, China's Energy Conditions and Policies, http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File229.pdf, accessed September 21, 2011

The energy policies established in 2007 underlie China's plans for moving forward on smart grid in seven key areas:[39]

- Rationalization of power grids
- Strengthening of regional power grids and power T&D networks
- Development of an emergency response system for power safety and reliability
- Strengthening of demand-side management (DSM)
- Control of power use to conserve energy and increase energy utilization efficiency
- Strengthening of the Renewable Energy Law and policies for renewable energy electricity
- Renovation of the rural energy grid.

The SGCC, the largest single electric power entity in China, in 2009 announced a multi-stage ten-year plan for the deployment of smart grid. The initial phase of the plan calls for pilot programs and planning initiatives through 2010. The second phase, undertaken concurrently, consists of development of standards through 2014 and construction projects beginning in 2011 and running through 2015. The final phase of the plan focuses on system upgrades that will begin in 2016 and culminate in 2020.[40]

In 2010, China's smart grid investment surpassed that of the United States to make it the world leader in smart grid spending ($7.3 billion compared to $7.1 billion in the United States).[41] The vast potential of the smart grid market in China has resulted in a number of joint ventures with companies from outside China such as Siemens, General Electric, IBM, Nissan, and General Motors.[42] One indication of the scale of China's announced plans is the effort to link remote energy resources to energy markets through construction of major transmission lines that will make China the world's largest consumer of copper.[43]

Key Projects/Programs

- **Smart Community Demonstration Project:**[44] The project, consisting of 655 households and 11 buildings, is the first demonstration community built by North China Power Grid as well as the first project constructed under SGCC's guideline on smart communities. The project is located at the Xin'ao Golf Garden residential complex in Langfang, Heibei province, and was completed in September 2010. The project includes a low-voltage electricity network, power usage information collection, an interactive service platform, smart household installment, electric automobile charging facilities, distributed power generation and energy storage, automatic electricity distribution, integrated network using low-voltage fiber optic cables, and AMI meters for electricity, gas and water.

- **Smart Grid, Demand Side Management Pilot:**[45] The project, to be developed and implemented by Honeywell, will be China's first smart grid pilot project and feasibility study to monitor and manage electricity use in commercial buildings. The project will focus on DSM, and will utilize

[39] IEEE, China, http://smartgrid.ieee.org/resources/public-policy/china, accessed September 21, 2011. Information Office of the State Council of the People's Republic of China, China's Energy Conditions and Policies, http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File229.pdf, accessed September 21, 2011.
[40] Ibid.
[41] Zpryme, Smart Grid: China Leads Top Ten Countries in Smart Grid Federal Stimulus Investments, Zpryme Reports, http://zpryme.com/news-room/smart-grid-china-leads-top-ten-countries-in-smart-grid-federal-stimulus-investments-zpryme-reports.html, accessed September 21, 2011
[42] Reitenbach, Gail, Smart Grid 2011: More than Meters, Power News, http://www.powermag.com/smart_grid/Smart-Grid-2011-More-than-Meters_3265.html, accessed September 21, 2011
[43] Financial Times, State Grid views Brazil as another smart move, http://www.ft.com/cms/s/0/16cc2100-0d2b-11e0-82ff-00144feabdc0.html#axzz1EzB8cgSS, accessed September 21, 2011
[44] State Grid Corporation of China, First Smart Community Demonstration Project by North China Power Grid Company Completed, http://www.sgcc.com.cn/big5/ywlm/mediacenter/corporatenews/10/236660.shtml, accessed September 21, 2011
[45] Greenbang, Honeywell to bring smart grid to China, http://www.greenbang.com/honeywell-to-bring-smart-grid-to-china_16645.html, accessed September 21, 2011

Honeywell's state-of-the-art smart grid technology, including automated demand response, advanced energy management, and sub-metering. The project is part of an agreement between the U.S. Trade and Development Agency (USTDA) and the State Grid Electric Power Research Institute (SGEPRI), a subsidiary of the SGCC.

- **National Wind Power Integration Research and Test Center of China:**[46] The project centers on the development of renewable energy and clean energy storage. Toward that goal, the SGCC is installing 30 wind turbines with at least 78 MW of generating capacity, 640 kW of solar photovoltaic (PV) capacity, and 2.5 MW of energy storage. Prudent Energy is providing vanadium redox batteries. When it is completed, the testing center will be the largest facility of its kind in the world.

- **Power System Digital Real-Time Simulation Device:**[47] This research project developed the first large-scale power system real-time simulation device. The device can simulate a power system with up to 1,000 generators and 10,000 bus bars. The development of this device will contribute to the safe operation of the power grid by researching the access of new large-scale equipment and enhancing power system incident analysis. The device will also allow equipment tests such as the safe and stable operation and control of a large AC/DC hybrid transmission system.

- **1000-kV Jindongnan Nanyang-Jingmen Ultra High Voltage (UHV) AC Pilot Project:**[48] Construction of a single circuit line of 640 kilometers, with a capacity of 6,000 MVA, and an operational voltage of 1,100 kV.

- **Xiangjiaba-Shanghai +/-800-kV UHV DC Transmission Pilot Project:**[49] Construction of an advanced UHV DC high capacity, long distance, DC transmission line.

- **Ningdong-Shandong +/-660-kV DC Project:**[50] Approved in November 2010 as a key project in the development of the West to East transmission project designed to move both hydro and thermal power from generation sites in the West to demand centers in the East.

- **Qinghai-Tibet 750-kV/+/-400-kV AC/DC Grid Interconnection Project:**[51] Construction of a 750-kV AC project and a +/-400-kV DC power transmission project from Qinghai to Tibet, allowing the integration for the first time of all provinces in SGCC's service area. The project is expected to be put into operation by the end of 2011 or in 2012.

Potential Lessons Learned for the United States

China surpassed the United States in smart grid investments in 2010 and will see further gains in spending over the next five years.[52] This is important for U.S. companies leading the way in smart grid

[46] Electric Light & Power, Prudent Energy installs MW class VRB energy storage system for CEPRI, March 2, 2011, accessed October 3, 2011.
[47] State Grid Corporation of China, Power System Digital Real-time Simulation Device won First Prize of National Science & Technology Awards, http://www.sgcc.com.cn/ywlm/gsyw-e/218927.shtml, accessed September 21, 2011
[48] SGCC, Projects, 1000kV Jindongnan-Nanyang-Jingmen UHV AC Pilot Project, http://www.sgcc.com.cn/big5/ywlm/projects/brief/12/237188.shtml, , accessed, September 21, 2011
[49] SGCC, Projects, Xiangjiaba-Shanghai +/-800kV UHV DC Transmission Pilot Project, http://www.sgcc.com.cn/big5/ywlm/projects/brief/10/237089.shtml, accessed September 21, 2011
[50] SGCC, Projects, Ningdong-Shandong +/-660kV DC Project, http://www.sgcc.com.cn/big5/ywlm/projects/brief/10/237087.shtml, accessed September 21, 2011
[51] SGCC, Projects, Qinghai-Tibet 750-kV/+/-400-kV AC/DC Grid Interconnection Project, http://www.sgcc.com.cn/big5/ywlm/projects/brief/10/237088.shtml, and SGCC, Xinhua: "Heavenly Road of Electricity" to Be Put Into Operation, http://www.sgcc.com.cn/ywlm/mediacenter/inspotlight/03/242178.shtml, accessed September 21, 2011,
[52] Zpryme, Smart Grid Research, http://smartgridresearch.org/, accessed September 21, 2011

development because these companies will also be able to make progress in China, where a large portion of the new infrastructure will be installed. The Honeywell project is an example. The company will develop and implement China's first smart grid pilot project for managing energy use in commercial buildings. The installation of DSM technologies in selected commercial and industrial pilot sites will demonstrate the feasibility of adopting U.S. smart grid solutions to China's grid infrastructure. China is ahead of the curve on smart grid development according to a recent report by ZPryme, and has been "building strategic global relationships, aggressively building electric infrastructure, and more importantly making the smart grid initiative a national policy."[53]

Updates as of September 2011

China's large-scale deployment of smart grid technology is continuing. According to a report by In-Stat, China is currently on track to deploy 280 million smart meters by 2016, making China the largest smart meter consumer in the world.[54]

The development of China's "Strong and Smart Grid" has been in its comprehensive construction phase since March 2, 2011, which, according to Xinhua News Agency, includes demonstration projects, electric vehicle recharging and switching facilities, new energy connections, and residential smart appliances. SGCC plans to implement 11 different types of smart grid projects, including building smart substations, installing 50 million smart meters, accommodating the integration of 20 GW of wind power, increasing electric vehicle recharging facilities by seven-fold, formulating 88 standards on smart grid, and completing construction of the integrated smart grid demonstration project in Sino-Singapore Tianjin Eco-City.[55] The Eco-City, which is being developed in partnership with Singapore as an environmentally friendly city, is located east of Tianjin's city center.[56]

One recent smart grid project highlighted by SGCC is the Fujian Electric Power Company's 15.77 billion Yuan ($2.47 billion) investment in smart grid projects in the inland areas of Fujian province. In addition to 35 110-kV substations, the investment will include nine electric vehicle battery replacement stations, nine battery distribution stations, and 1,070 AC charging poles.[57]

[53] Ibid.
[54] In-Stat, China to Deploy 280 Million Smart Meters by 2016, Competing Technologies vie for Position, http://www.instat.com/press.asp?ID=3257&sku=IN1104731WH, accessed September 21, 2011
[55] Xinhua News Agency, State Grid: China's Smart Grid in Comprehensive Construction, http://www.sgcc.com.cn/ywlm/mediacenter/inspotlight/03/243905.shtml, accessed September 21, 2011
[56] Sino-Singapore Tianjin Eco-City, http://www.tianjinecocity.gov.sg/, accessed September 21, 2011
[57] Xinhuanet, Fujian Invests 15.77 Billion Yuan to Build Smart Grid in Inland Areas During the Twelfth Five-Year-Plan, http://www.sgcc.com.cn/ywlm/mediacenter/inspotlight/06/248443.shtml, accessed September 21, 2011

Denmark			
Population	5.5 Million	**GDP**	$201 Billion U.S.
Electricity Consumption per Capita	6,092 kWh	**Federal Funding for Smart Grid**	N/A

Smart Grid Drivers

- Renewable integration
- Electric vehicle integration
- Environmental goals
- Government policies/mandates

Smart Grid Development Status

Denmark is one of the largest users of renewable energy in the world, with wide integration of co-generation sources. The country has aggressive electric vehicle (EV) goals and a target to be completely free of fossil fuels by 2025. These factors will require a change to the power system structure in Denmark. As host to one of the largest smart grid test projects in the world, Denmark is already ahead of the curve, a leader in smart grid development.

The integration of renewable energy is a key focus of smart grid development. Although wind energy already accounts for 20 percent of Denmark's power needs, there are enough turbines already built to bring that total up to 40 percent. The introduction of smart grid technology and energy storage will help the country take full advantage of the wind resources available.

A unique aspect of Denmark's energy sector is the large-scale use of the combined heat and power (CHP) sources. In the mid 1990s, in order to increase system efficiencies and reduce GHG emissions, Denmark required all non-wind electricity generators to not only produce electricity, but also heat. Denmark has since developed new policies creating a market for thermal energy.

Key Projects/Programs

- **Holsted Smart Grid Test Project:**[58] The project is one of the world's largest smart grid test sites. The initial phase of the project involves a distribution network with 13 substations between the 60-kV and 10-kV networks, four CHP plants and 47 wind turbines. The test area involves a complete prototype of a SCADA system capable of automatically operating an entire distribution network with wind turbines, CHP plants, and substations that communicate with each other. The test area measures around 50 kilometers from north to south, and has approximately 28,000 electric meters.

- **SEAS-NVE Cell Project**:[59] In 2008, SEAS-NVE, Denmark's largest consumer-owned utility, awarded a smart metering contract to Eltel Networks A/S for more than 380,000 homes. As of

[58] EnergyMAP, The world's largest smart grid tested in Denmark, http://energymap.dk/Newsroom/The-world-s-largest-intelligent-grid-tested-in-Den, accessed September 21, 2011

[59] Echelon, Danish Utility SEAS-NVE Achieves Nearly 100% Reliability Using Echelon Based Smart Grid Solution, http://www.businesswire.com/news/home/20110209005679/en/Danish-Utility-SEAS-NVE-Achieves-100-Reliability-Echelon, accessed September 21, 2011

February 2011 over 200,000 meters have been installed. The project focused on customer engagement from the beginning, including educating installers as to how to speak to customers in their homes. In addition, a plan for an advanced meter data management system was designed early on. The multi-purpose energy control network has thus far achieved a 99.5 percent favorable rating and is saving customers 16 percent in energy use.

- **EcoGrid EU**, **Bornholm Test Site:**[60] The island of Bornholm is the location for this smart grid test project. Renewables already account for almost 50 percent of power consumption, making the island a unique test site for a smart grid project. EVs will be a major component of the project. New vehicle-to-grid (V2G) experiments will use batteries within the electric cars to store excess wind power that will be fed back into the power grid when wind production is low.

Potential Lessons Learned for the United States

The SEAS-NVE smart grid project is an important example of a successful smart grid project. The large energy savings achieved (16 percent) are attributed not only to the performance of the advanced technology, but to the thoughtful customer engagement process specifically designed to prevent the types of customer frustration seen from some projects in the United States. In addition, the advanced EV systems being tested as part of certain smart grid projects in Denmark will be valuable test cases as the United States develops its own EV infrastructure.

Updates as of September 2011

Many smart grid-related projects are ongoing in Denmark.[61] For example, the Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks (EDISON) project is an international research project partly funded by Energinet.dk. It is meant to develop systems to integrate electric vehicles into the electric grid.[62] However, the Holsted Smart Grid Test Project and EcoGrid EU project on the island of Bornholm remain the most significant smart grid projects in the country.

As part of the Holsted project, Energinet.dk is undertaking what it calls the Cell Project. The project is designed to increase the extent of system control and monitoring to ensure that power generation and consumption are balanced. As part of the project, Energinet.dk planned to test its "Cell Controller" from June 14 to July 1, 2011. The test was designed to simulate a cut in power in order to determine whether the Cell Controller could maintain the supply of electricity to customers by operating the area as an independent island. Energinet.dk plans to complete evaluations of the test in fall 2011, with project completion expected in November 2011. Lessons learned from the Cell Project will be used at the EcoGrid EU project on Bornholm.[63]

After receiving final approval from the EU Commission, the EcoGrid EU project started up in the middle of 2011. It will run through spring 2015. Among other components of the project, about 2,000 residential customers will participate in a real-time pricing demand response program, making use of

[60] Energinet.dk, EcoGrid EU, http://energinet.dk/en/forskning/EcoGrid-EU/sider/EU-EcoGrid-net.aspx, accessed September 21, 2011
[61] SmartGridNews, Denmark smart grid playbook: The road to happiness?, http://www.smartgridnews.com/artman/publish/Business_Global/Denmark-smart-grid-playbook-The-road-to-happiness-3779.html, accessed September 21, 2011
[62] EDISON, About the EDISON project, http://www.edison-net.dk/About_Edison.aspx, accessed September 21, 2011
[63] Energinet.dk, The world's largest intelligent power system undergoes final testing, http://www.energinet.dk/EN/FORSKNING/Nyheder/Sider/Verdensstoersteintelligenteelsystemsluttestes.aspx, and The Cell Project, http://www.energinet.dk/EN/FORSKNING/Energinet-dks-forskning-og-udvikling/The-Cell-Project/Sider/The-Cell-Project.aspx, accessed September 21, 2011

residential demand response devices/appliances and smart controllers.[64] At its peak, the overall project will include a distributed grid with resources of up to 60 kV, 28,000 customers, 55 MW peak load, and 268 GWh of electricity consumption.[65]

[64] Energinet.dk, EcoGrid EU, http://www.energinet.dk/EN/FORSKNING/EcoGrid-EU/Sider/EU-EcoGrid-net.aspx, 2011, and Way Paved for Unique Energy Project on Bornholm, http://energinet.dk/EN/FORSKNING/Nyheder/Sider/VejenbanetforuniktenergiprojektpaaBornholm.aspx, accessed September 21

[65] EcoGrid, EcoGrid EU: A Prototype for European Smart Grids, Guide to the large-scale project, http://www.e-pages.dk/energinet/229/, accessed September 21, 2011

Germany			
Population	81.6 Million	**GDP**	$2,960 Billion U.S.
Electricity Consumption per Capita	6,635 kWh	**Federal Funding for Smart Grid**	$397 Million U.S.

Smart Grid Drivers

- Renewable integration
- Increasing demand
- Energy security goals
- Environmental goals
- Government policies/mandates
- Financial Incentives

Smart Grid Development Status

Germany is a world leader in both renewable energy and energy efficiency. However, a large surge in energy demand and diminishing natural resources are presenting challenges for the German energy sector. In addition, the EU has set ambitious energy and climate goals for member countries. In order to tackle these challenges, the Federal Ministry of Economics and Technology (BMWi) in cooperation with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) are working to foster a new field of innovation called E-Energy.[66] E-Energy stands for the comprehensive digital networking and optimization of the energy supply system, encompassing everything from generation and distribution to consumption. The German Commission for Electrical, Electronic & Information Technologies (DKE) is acting as the central contact for standardization for E-Energy in Germany, and has prepared a Smart Grid Standardization Roadmap with numerous recommendations and approaches for implementation.[67] The document serves as a strategic and technically oriented roadmap that represents the standardization requirements for the German vision of the smart grid.

The integration of renewable energy sources is a key driver for smart grid development in Germany. The first Electricity Feed-In Law, passed in 1990 and later modified in the Energy Supply Industry Act of 1998 and the 2000 Renewable Energy Sources Act, requires utilities to connect small renewable energy generators to the grid and buy back the electricity produced at rates differentiated by renewable energy type, size and site.[68] The Renewable Energy Act of 2004 further requires that grid operators give priority to clean forms of energy when feeding electricity into the grid.[69] In January 2007, the EU Commission published a Renewable Energy Roadmap requiring 20 percent of the EU energy sources consist of renewable energies by 2020.[70]

[66] BMU and BMWi, E-Energy – Smart Grids made in Germany, http://www.e-energy.de/en/, accessed September 21, 2011
[67] German Commission for Electrical, Electronic & Information Technologies, The German Roadmap: E-Energy/Smart Grid, http://www.e-energy.de/documents/DKE_Roadmap_SmartGrid_230410_Engllish.pdf, accessed September 21, 2011
[68] BMU, Act on Granting Priority to Renewable Energy Sources, http://www.solarpaces.org/Library/Legislation/docs/EEG%20English.pdf, accessed September 21, 2011
[69] Spiegel, Building the Internet of Energy Supply, http://www.spiegel.de/international/business/0,1518,694287,00.html, accessed September 21, 2011
[70] EurActiv.com, EU renewable energy policy,http://www.euractiv.com/en/energy/eu-renewable-energy-policy/article-117536, accessed September 21, 2011

Several directives currently support the development of smart grid in Germany. As of early 2010, all new and remodeled buildings in Germany are required to be equipped with smart meters connected to a central control station via the Internet. Other legislation requires that utilities offer variable rates to customers starting in 2011.[71] Several EU directives are also shaping the smart grid. Directive 2009/72/EC requires an increase in energy security, reduction of carbon output, and improved competitiveness in the energy sector.[72] Smart meter implementation is recommended as a first step in this directive. The M/441 Mandate on Smart Metering issued March 2009 requires the standardization of utility meters to enable interoperability. The EU Task Force Smart Grids will identify strategic decisions, make regulatory recommendations, and produce a strategic roadmap for the implementation of smart grids by June 2011.[73]

Key Projects/Programs

- **Yello Strom/Cisco Smart Meter Pilot**:[74] Cisco and Yello Strom collaborated on the pilot in 2009 to enable 70 selected homes to use smart metering to communicate with the power company over an Internet Protocol (IP) network. The project also made use of the Google PowerMeter application to enable consumers to monitor energy consumption. A home energy management system and smart plugs allowed customers to set appliances to operate during off-peak periods. Since 2008, Yello Strom GmbH has offered its nationwide customers a smart meter known as the Yello Sparzähler online. Unlike most utilities in the United States that do not charge customers directly for smart meters, Yello Strom sells meters to customers for about $5.60 to $11.24 a month, which has reduced the scale of deployment.[75]

- **Stadtwerk Hassfurt Smart Meter Project:**[76] The project provides all of the utility's customers in Hassfurt (approximately 10,000) with AMI and no rate increase. Electricity meters are accessed via a web-based network operating system over an IP networking infrastructure. The project used Echelon's NES advanced metering infrastructure. Unlike systems with a dedicated radio per metering point, multiple NES meters can share a single IP connection through the use of Echelon's standards-based power line networking technology.

- **MIRABEL Project**:[77] The main goal of SAP's Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution (MIRABEL) Project in Dresden is to develop a system that allows energy distribution companies to balance the available supply of renewable energy sources and the current demand. Household micro-requests with time shifts are aggregated on a regional level for production and consumption to be scheduled more efficiently, which could result in peak-demand reductions of approximately 8-9 percent.

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[71] International Business Times, Smart Grid comes costly for households in Germany, http://www.ibtimes.com/articles/43468/20100815/smart-grid-fail.htm, accessed September 21, 2011
[72] A.T. Kearney, The Smart Meter Mandate, http://www.atkearney.de/content/misc/wrapper.php/id/51252/name/pdf_the_smart_meter_mandate_12888660420e69.pdf, accessed September 21, 2011
[73] European Commission, Legislative proposal for a regulatory framework on smart grids, http://ec.europa.eu/governance/impact/planned_ia/docs/56_ener_smartgrids_legal_proposal_en.pdf, accessed September 21, 2011
[74] Cisco Systems, Cisco and Yello Strom Launch Energy-Saving Smart Grid Pilot in Germany, http://newsroom.cisco.com/dlls/2009/prod_100509e.html, accessed September 21, 2011
[75] Ricketts, Camille, German utility Yellow Strom steals the smart grid spotlight – at least for today, VentureBeat, http://venturebeat.com/2009/07/02/german-utility-yello-strom-steals-the-smart-grid-spotlight-at-least-for-today/#, accessed September 21, 2011
[76] Echelon, Echelon Announces First Advanced Metering Deployment in Germany, http://www.businesswire.com/portal/site/google/?ndmViewId=news_view&newsId=20080903005219&newsLang=en, accessed September 21, 2011.
[77] MIRABEL Project, http://www.mirabel-project.eu/, accessed September 21, 2011

- **SAP's SmartHouse/SmartGrid Project**:[78] Based in Karlsruhe, this project validates and tests how aggregations of Smart Houses, defined as information and communication technology-enabled homes, will achieve higher levels of energy efficiency required by the EU's 20 percent by 2020 objective.

- **Model City Mannheim Project**:[79] Energy supplier MVV Energie is developing a micro-grid communications network using the existing BPL network to manage electricity supply from large numbers of decentralized and centralized generators. Variable pricing is implemented in the project. The network consists of cellular energy grid structures, communicating closely with their surroundings to enhance supply security across the collection of grids. In 2011, the micro-grid pilot will include approximately 1,300 pilot users in Mannheim and Dresden.[80]

- **Energy Storage Initiatives:** Germany has been a leader in energy storage technology for decades, and is home to a variety of storage projects.

    - **Compressed Air Energy Storage System**:[81] The first facility of its kind was built in Hunsdorf, Germany in 1978. It can discharge 290 MW over two hours to meet peak demands. The Hunsdorf facility was the model for the only other one ever built, which was in 1991 in Mcintyre, Alabama.

    - **Berliner Kraftund Licht Battery System**:[82] Built in 1987 and operated until 1995, this was the world's largest stationary battery energy storage system. Located in Berlin, it consisted of over 7,000 lead acid flooded cells with a capacity of 14 MWh. It was the model for Southern California Edison's Chino facility, built in 1988, as well as the Puerto Rico Electric Power Authority's system, which was installed in 1994.

    - **Evonik Industries AG 1-MW/700-kWh Lithium Ion Prototype Battery:**[83] In support of Germany's current focus on producing mega batteries for renewable energy applications, the German Government has funded this project. The system is installed at the Völklingen power plant in Saarland. In addition, Evonik plans to develop a 10-MW unit.

    - **The Fraunhofer Consortium:**[84] The consortium is currently developing large-scale redox flow batteries with a capacity of 20 MWh. In 2010, the technology was still bench-scale, achieving a few kW output.

[78] Seventh Framework Program, About the Project, http://www.smarthouse-smartgrid.eu/index.php?id=43, accessed September 21, 2011
[79] MVV Energie, The "Model City Mannheim" project, http://www.mvv-energie.de/cms/konzernportal/en/mvv_energie_gruppe/mvv_energie_/innovation/modellstadt_mannheim/projektbeschreibung/projekt_moma_1.jsp, accessed September 21, 2011
[80] IBM, The Smart Micro Grid: IT Challenges for Energy Distribution Grid Operators, http://www.ibm.com/smarterplanet/global/files/us__en_us__energy__thesmartmicrogrid_schiller_fassmann.pdf, accessed September 21, 2011
[81] Bine, Projektinfo 05/07, http://www.bine.info/fileadmin/content/Publikationen/Englische_Infos/projekt_0507_engl_internetx.pdf, and Ridge Energy Storage & Grid Services, CAES Technology, http://www.ridgeenergystorage.com/caes_history.htm, accessed September 21, 2011
[82] Doughty, Daniel, et al., Batteries for Large-Scale Stationary Electrical Energy Storage, The Electrochemical Society's Interface, Fall 2010, http://www.electrochem.org/dl/interface/fal/fal10/fal10_p049-053.pdf, accessed September 21, 2011
[83] Factclipper, Germany's Evonik is building a 1-MW lithium-ceramic energy-storage battery, the world's largest, http://factclipper.com/abs/tech/energy-storage/2010-03-03/germanys-evonik-is-building-a-1-mw-lithium-ceramic-energy-storage, accessed September 21, 2011.
[84] Fraunhofer, Hannover Messe: Giant batteries for green power, http://www.fraunhofer.de/en/press/research-news/2010-2011/15/giant-batteries-for-green-power.jsp, accessed September 21, 2011.

Potential Lessons Learned for the United States

Germany has a very active market for both smart grid and energy storage technologies. The continued growth of renewable energy sources in Germany has created a demand for innovative energy storage technologies. Germany's aggressive renewable goals will make the country a prime location for the development of storage technologies. The German Government has set a goal to have renewables as 35 percent of the country's electricity portfolio by 2020 and 80 percent by 2050.[85] U.S. partners have been – and will continue to be – well positioned to leverage the expertise gained from these efforts.

Updates as of September 2011

Germany, Austria and Switzerland have agreed to work together to promote energy grid research and development.[86] However, while a wide range of smart grid and smart meter pilots are currently underway across Germany, Pike Research reports that little progress has been made towards large-scale deployment.[87]

The E-Energy program is continuing, with BMWi and BMU identifying six model regions to carry out research and development activities, including the Model City of Mannheim.[88] In July 2011, the Model City Mannheim Project was due to complete its second practical test, related to flexible electricity tariffs for 200 households with new electricity meters. The project's third and final practical test, known as the Energy Butler SmarTest, will investigate to what extent electricity customers can contribute to increasing their energy efficiency, as well as the integration of renewable energy into the power grid. The Energy Butler SmarTest is set to begin in fall 2011 and run through mid-2012.[89]

In Hassfurt, the Stadtwerk Hassfurt Smart Meter Project is also continuing. The deployment of 10,000 smart meters is due to be complete by 2012.[90]

[85] Rhein, Eberhard, Germany defines sustainable energy policy up to 2050, Blogactiv.eu, http://rhein.blogactiv.eu/2010/09/13/germany-defines-sustainable-energy-policy-up-to-2050/, accessed September 21, 2011
[86] BMU and BMWi, Smart Grids for Germany, Austria and Switzerland, http://www.e-energy.de/en/1247.php, accessed September 21, 2011
[87] Pike Research, 238 Million Smart Meters to Be Deployed in Europe by 2020, http://www.pikeresearch.com/newsroom/238-million-smart-meters-to-be-deployed-in-europe-by-2020, accessed September 21, 2011
[88] BMU and BMWi, E-Energy Model Regions, http://www.e-energy.de/en/32.php, accessed September 21, 2011
[89] Modellstadt Mannheim, SmarTest energy butler, http://www.modellstadt-mannheim.de/moma/web/en/feldtest/praxistest_3/praxistest3.html, and Flexible electricity rates, http://www.modellstadt-mannheim.de/moma/web/en/feldtest/praxistes_2/Praxistest_2.html, accessed September 21, 2011
[90] Echelon, EVB Energy Solutions, http://www.echelon.com/partners/nespartners/partner_highlight/evb.htm, accessed September 21, 2011

India			
Population	1,173.1 Million	**GDP**	$4,046 Billion U.S.
Electricity Consumption per Capita	526 kWh	**Federal Funding for Smart Grid**	N/A

Drivers

- Increasing demand
- Energy efficiency goals
- Reliability concerns
- Energy theft reduction
- Geographic grid constraints
- Economic competitiveness

Smart Grid Development Status

India is developing a smart grid policy as part of a larger nationwide energy policy. Efforts underway encompass both the national and state governments, and include representatives from industry, academia and various organizations. The efforts focus on three principal areas of concern:

- Accommodation of load growth in a fast-growing economy
- A goal of extending electricity to rural areas
- Load management and loss mitigation[91]

Losses from operation and theft are major concerns in India. Overall standards for the type of network are being drafted. In 2010 and 2011, India boosted the level of announced expenditures, placing it among the top 10 countries in the world in terms of smart grid spending.[92]

Primary responsibility for the grid in India lies with the Ministry of Power (MOP). Under MOP jurisdiction are the Central Power Research Institute (CPRI), the Central Electric Authority (CEA), and the Power Finance Corporation (PFC). In addition, the government has also created the Smart Grid Task Force (SGTF), an inter-departmental group that not only includes the MOP and its organizations, but reaches out to the Ministry of New and Renewable Energy (MNRE), the Ministry of Communications and Information Technology (MCIT), and the Department of Science and Technology (DST). Like several other countries, India has set up a public-private partnership, the India Smart Grid Forum, which brings together utilities, industry, academia, and others interested groups.[93] India is also a member of the Global Smart Grid Federation (GSGF) and the International Smart Grid Action Network (ISGAN).

The *IT Task Force for Power Sector* report in 2002 and the 2008 report titled *Technology: Enabling the Transformation of Power Distribution* developed much of the underlying groundwork setting the stage for India to move forward on three key areas of grid development:

[91] IEEE, India, http://smartgrid.ieee.org/public-policy/india, accessed September 21, 2011
[92] Innovation Observatory, Ten countries will account for 80% of global smart grid investment by 2030, http://www.innovationobservatory.com/sgpress2, accessed September 21, 2011
[93] Ibid.

- Advanced metering to reduce unacceptably high level of losses
- Improving system reliability on a near real-time basis
- Developing a smart grid to manage loads, congestion and shortfall

The Electricity Act of 2003 and National Energy Policy of 2005 established the following national objectives:[94]

- To provide access to electricity for all households
- To eliminate shortages and establish adequate spinning reserves
- To develop standards to address reliability and quality
- To increase per capita availability
- To establish minimum lifeline consumption level
- To make the power sector commercially viable
- To protect consumers' interests

Losses from operation and theft are major concerns in India. Overall standards for the type of network are being drafted. In 2010 and 2011, India boosted the level of announced expenditures, placing it among the top 10 countries in the world in terms of smart grid spending.[95]

Key Projects/Programs

- **Mangalore pilot project:**[96] The Mangalore Electricity Supply Company (Mescom) initiated this project in December 2010 with the following objectives – load management and real-time metering for each of 250 installations, including industrial, residential, and street lighting.

- **Bangalore pilot project:**[97] The Bangalore Electricity Supply Company (BESCOM) recently initiated this project in Electronic City, where it will reach 2,000 residential and commercial customers. Among its features are two-way communication nodes, transformers to control power consumption, private-public partnership, increased customer choice, and the flexibility to extend to other parts of the country.

- **Maharashtra Project:**[98] Includes GIS-based indexing and asset mapping and GIS network analysis based on a distribution management system on a web based platform. The project is designed to provide baseline data and IT applications for energy accounting, auditing and IT-based consumer service centers. The project will be carried out in 95 towns under R-APDRP. The objective is to reduce losses from operational issues and theft in project areas.

[94] Ibid.
[95] Innovation Observatory, Ten countries will account for 80% of global smart grid investment by 2030, http://www.innovationobservatory.com/sgpress2, accessed September 21, 2011
[96] The Hindu, state's power grid set to get smart, http://www.hindu.com/2011/02/23/stories/2011022359620100.htm, accessed September 21, 2011
[97] Daily News & Analysis, Smart grid for Electronic City, http://www.dnaindia.com/bangalore/report_smart-grid-for-electronic-city_1331838, accessed September 21, 2011
[98] Telvent, Telvent to Implement Smart Grid Project for Maharashtra India, http://www.telvent.com/en/business_areas/smart_grid/news_center/2010/Telvent-to-Implement-Smart-Grid-Project-for-Maharashtra-India.cfm, accessed September 21, 20p11

- **Kerala:**[99] Kepco Knowledge, Data & Network, an affiliate of state-owned Korea Electric Power Corp, is developing an IT system to prevent energy theft and increase efficiency of energy supply.

- **Distribution Reform, Upgrades and Management (DRUM) Projects:**[100] Was a joint venture between the U.S. Agency for International Development (USAID) and the Ministry of Power (MoP) from 2003 to 2010. Pilot programs were focused on improving the quality of electricity services, especially to India's rural energy sector. Four pilot programs were begun (North Delhi, Bangalore, Gujarat, Maharashtra), focusing on extending electricity to areas currently not served, reducing loss, and improving reliability. Over 25,000 electric utility staff were trained in distribution business and technical skills.

- **Rabirashmi Abasan Housing project:**[101] The first instance of net metering in India (2008), this project involves rooftop solar installations.

- **SA Habitat and Valence Energy:**[102] This distributed generation project is located in Hyderabad (2009) and involves roof-top solar micro-grid.

Potential Lessons Learned for the United States

India's power sector is one of the largest in the world, ranking sixth in terms of electricity consumption.[103] As a member of ISGAN, India coordinates with members, including the United States, to help develop a global Smart Grid Technology Roadmap and to identify opportunities for collaborative technology and policy development efforts. In addition, the potential for India to leapfrog to an advanced electricity system, much as it did in the telecommunications arena, has been speculated.[104] The developments in information and communication technology, an area of unique capability in India, will be important to follow as India develops its smart grid.

Updates as of September 2011

India is progressing with the development of smart grid by developing standards, reaching out to new partners, and assessing which projects are worth pursuing. In May 2011 a number of significant developments took place:

- IEEE Standards Association introduced its "IEEE P2030 Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS) and End-Use Applications and Loads."[105] Interoperability remains a key concern for smart grid development in India.

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[99] IT Times, Kepco KDN Lands Deal in India, http://www.koreaittimes.com/story/10495/kepco-kdn-lands-deal-india, accessed September 21, 2011

[100] USAID, Activities, Distribution Reform, Upgrades and Management (DRUM), http://www.usaid.gov/in/our_work/health/environment_doc1.htm, CORE International, About the DRUM Project, http://www.coreintl.com/projects/Signature_Projects/DRUM/About_the_DRUM_Project.html, and Narayan, Amit, Smart Grid in India, http://asia.stanford.edu/us-atmc/wordpress/wp-content/uploads/2010/11/SmartGrid_India.pdf, accessed September 21, 2011

[101] Narayan, Amit, Smart Grid in India, http://asia.stanford.edu/us-atmc/wordpress/wp-content/uploads/2010/11/SmartGrid_India.pdf, accessed September 21, 2011

[102] Ibid.

[103] USAID, The Smart Grid Vision for India's Power Sector, http://www.sari-energy.org/PageFiles/What_We_Do/activities/smart_grid_vision_for_india_power_sector_june_2010/White_paper-Th_%20Smart_Grid_Vision_for_India/White_Paper_on_the_Smart_Grid_Vision_for_India_-_final.pdf, accessed September 21, 2011

[104] Gammons, Brad, India Set to Leap-Frog Ahead with 'Smart Grid' Energy Strategy, International Business Times, http://www.ibtimes.com/articles/210618/20110908/india-smart-grid-intelligence-ibm-brad-gammons.htm, accessed September 21, 2011

[105] IT News Online, IEEE Introduces Smart Grid Interoperability Standards Project in India, http://www.itnewsonline.com/news/IEEE-Introduces-Smart-Grid-Interoperability-Standards-Project-in-India/23566/8/1, accessed September 21, 2011

- IBM agreed to work with India's Bureau of Energy Efficiency to conduct a cost-benefit analysis of various smart grid initiatives in India and to explore the country's readiness for smart grid.[106]
- The U.S. Department of Energy committed $25 million over the next five years to support the U.S.-India Joint Clean Energy Research and Development Center.[107]

At least one large smart meter deployment is already underway in India. Grinpal Energy Management began deployment of advanced meters in New Delhi in 2008. The advanced meters include automated meter reading and a prepaid system utilizing PLC technology. According to one company executive, over 500,000 meters have been deployed in the city as of May 2011.[108]

[106] Shyamala, S., IBM, BEE partner for India's first smart grid, http://www.mydigitalfc.com/news/ibm-bee-partner-india%E2%80%99s-first-smart-grid-730, accessed September 21, 2011
[107] U.S. Department of Energy, DOE Announces Funding for U.S.-India Joint Clean Energy Research and Development Center, http://energy.gov/articles/doe-announces-funding-us-india-joint-clean-energy-research-and-development-center, accessed September 21, 2011
[108] SGI Clearinghouse, Grinpal Energy Management, http://www.sgiclearinghouse.org/Asia?q=node/2589&lb=1, and French, Paul, Smart Grids leading to smart cities in Asia, Smart Grid Update, http://analysis.smartgridupdate.com/industry-insight/smart-grids-leading-smart-cities-asia, Energy Metering Project Launched in India, http://www.metering.com/node/12555, accessed October 3, 2011

Japan			
Population	126.8 Million	**GDP**	$4,338 Billion U.S.
Electricity Consumption per Capita	7,572 kWh	**Federal Funding for Smart Grid**	$849 Million U.S.

Smart Grid Drivers

- Renewable integration
- Environmental goals
- Demand management controls
- Electric vehicle integration
- Financial incentives

Smart Grid Development Status

Smart grid activities are centralized and considered to be at the core of Japan's national strategy. This strategy is focused on connectivity, energy efficiency, and the integration of renewable resources into the grid, as well as concerns regarding sustainability and reduction of carbon emissions. Smart grid issues are under the direction of the Ministry of Economy, Trade and Industry (METI). In 2010, METI established the New Energy and Industrial Technology Development Organization (NEDO) as a public management organization to undertake development of new technologies dealing with energy and energy-conservation.[109] METI, in partnership with NEDO, created a working group to coordinate smart grid activities. The group is called the Japan Smart Community Alliance, and its goal is to promote public-private cooperative activities that address issues such as dissemination, deployment, and research on smart grid standardization. [110]

Unlike most other nations, reliability is not considered to be an issue in Japan. The country has already undertaken significant generation and transmission infrastructure improvements as a result of investments of more than $100 billion beginning in the 1990s. A key focus area for Japan is the introduction of advanced integrated controls for DSM and connectivity to the end-use customer, known as the "last mile." The last mile is the final link or leg in connecting the end user to the grid or communications provider. Japan is also focused on integration of intermittent energy sources (particularly solar) and sustainability with the goal of moving toward becoming a low-carbon emission society.[111] Japan has begun establishing standards for smart grid applications. One such standard is the Association of Radio Industries and Businesses ARIB STD-T96 protocol, which is specified for the automatic transmission and measurement of data from remote sources by low-power radio equipment.[112]

[109] Japan Smart Community Alliance, http://www.smart-japan.org/english/tabid/103/Default.aspx, accessed September 21, 2011
[110] Ibid.
[111] McGuire, Kelly, The Smart Grid Movement: Japan vs. U.S., TMCnet, http://smart-grid.tmcnet.com/topics/smart-grid/articles/73301-smart-grid-movement-japan-vs-us.htm, accessed September 21, 2011
[112] Analog Devices, RF Transceiver Enables Secure, Robust and Reliable Transmission of Remote Data for ARIB STD-T96 Systems, http://www.analog.com/en/press-release/3-1-11_RF_Trans_Enables_Secure_Robust_Reliable/press.html, accessed September 21, 2011

Key Projects/Programs

- **METI Smart Grid Trial:**[113] In April 2010, METI announced a large-scale five-year $1.1 billion smart grid trial project. The project will take place in four cities and focus on grid-scale energy storage, plug-in hybrid electric vehicles and vehicle to grid connections, smart homes and networks, and the integration of renewable such as solar power into the grid while maintaining grid reliability. The four project cities are:[114]

    - **Kyoto Keihanna District (Kansai Science City) Project**: PV systems and fuel cells will be installed on 1,000 residential units, grid connected to test load management systems, electric vehicle car sharing programs, and an incentive plan for the use of green energy "Kyoto-eco points" will be tested. The Kansai Research Institute oversees the project, which has a target of reducing CO_2 emissions by 20 percent in the residential sector and by 30 percent in the transportation sector from 2005 levels.

    - **Yokohama Smart City Project**: 4,000 homes will be equipped with smart meters using Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS) to automatically adjust the amount of electricity supplied to each home, while monitoring electricity usage throughout the project. In addition, 27 MW of solar generation will be installed, and 2,000 electric vehicles will be deployed. The project has a target of reducing CO_2 emissions by 30 percent from 2004 levels.

    - **Toyota City Project**: The project will introduce 3,100 electric vehicles in the city to test grid-to-vehicle and vehicle-to-grid connectivity. DSM applications focused on using heat and unused energy will be tested at 70 residential locations. The project has a target of reducing CO_2 emissions by 20 percent in the residential sector and by 40 percent in the transportation sector.

    - **Kitakyushu City Project**: Will deploy energy management equipment using HEMS and BEMS capable of real-time management at 70 commercial and 200 residential locations. The energy system will coordinate DSM with the overall power system and reduce CO_2 emissions by 50 percent from the 2005 level.

- **Energy Storage Initiatives:** It is likely that Japan has more stationary energy storage installed than any other country in the world. The development of sodium sulfur (NAS) and lithium ion batteries has enjoyed government and large industrial support, and this has led to deployment at a number of facilities in Japan and other countries, including the United States and Australia.[115]

    - **NGK Insulators Prototype NAS Battery:** This transmission component manufacturer began testing the battery in 1992 in an actual transmission system at Kawasaki

[113] Ibid. See also, Chan, Tony, Japan set for massive smart grid trials, greentelecomlive, http://www.greentelecomlive.com/2010/04/09/japan-set-for-massive-smart-grid-trials/, accessed September 21, 2011

[114] Ichimura, Tomoya, Renewable Energy and Smart Community, presentation at the METI/NEDO Renewable Energy Opening Asia's Future forum, June 29, 2010, https://app3.infoc.nedo.go.jp/informations/koubo/other/FF/nedoothernewsplace.2009-02-09.3960481985/nedoothernews.2010-07-14.7324681214/Ichimura%20Tomoya.pdf, accessed September 21, 2011. See also, "Japan to launch 5-year, Y100 bil smart grid trial project", Japan Today, April 10, 2010, http://smartgrid.testing-blog.com/2010/04/13/japan-to-launch-5-year-y100-bil-smart-grid-trial-project/, accessed September 21, 2011

[115] Ota, Kenichiro, Status of Japanese Electric Energy Storage Technologies with Stationary Battery Systems, The Electrochemical Society of Japan, http://energy.electrochem.jp/NEDO_WS100702.pdf, accessed September 21, 2011

Substation of the Tokyo Electric Power Company. Since then, NGK has installed these batteries at many electric power and renewable energy installations.

- **Wakkanai Mega-Solar Project**: NEDO funded this 5-MW PV and 1.5-MW NAS battery on Hokkaido island. The Japan Electric Power Exchange installed a 34-MW NAS battery for a 51-MW wind farm in 2008.

- **Mitsubishi Heavy Industries:** The company has been testing lithium batteries in the Nagasaki Research & Development Center since 2004.

- **The National Institute of Advanced Industrial Science and Technology**: The project involves testing a 170-kW Redox flow system installed in 2003, along with 2,000-kW NAS system to support a 1-MW solar power system in Tsukuba. NEDO funded a project in 2005-2008 that tested a 4-MW/6-MWh Redox flow battery designed to stabilize a 30-MW wind farm.

- **Kawasaki Heavy Industries**: The company is currently developing a nickel-hydrogen battery known as GIGACELL.

Potential Lessons Learned for the United States

Japan's electricity grid is already considered to be reliable, so Japan's smart grid activities are more focused. While the United States is focusing on businesses and infrastructure, Japan is focusing its efforts on sustainability goals and moving toward becoming a low carbon society. Key objectives of the smart grid in Japan include advanced integrated controls to facilitate demand response and prepare for the integration of large amounts of renewables, such as PV. While the majority of pilot projects in the United States are smart meter rollouts, this is only one portion of an overall smart grid. Japan's focused efforts on advanced integrated controls and demand response will be important to watch as the United States begins to invest more resources into these elements of smart grid development.

Updates as of September 2011

Model homes were completed for the Toyota City Project by July 2011, and trial operations have now begun.[116]

Electric vehicle/vehicle-to-grid smart grid projects remain popular in Japan. In addition to the Toyota City Project and the Yokohama Smart City Project (which both include vehicle-to-grid components), three of Mitsubishi's core companies announced a joint project in August 2011 to develop smart grid technology to use electric vehicles as "moving batteries." The companies plan to install a test facility and begin collecting data at the Mitsubishi Motors's Nagoya Works by March 2012. The facility will consist of a parking lot with a roof covered with photovoltaic solar panels. Several units will draw direct current power from the electric vehicle charging outlets, convert the power into alternating current, and use the energy to supply factories.[117]

[116] Press Release Network, Toyota City Low-Carbon Project Model Homes Completed, http://www.pressreleasenetwork.com/newsroom/news_view.phtml?news_id=3519, accessed September 21, 2011

[117] The Denki Shimbun, Developing a smart grid utilizing EVs, http://www.shimbun.denki.or.jp/en/news/20110819_02.html, and SmartGridNews, Vehicle-to-grid gets Japanese pilot, http://www.smartgridnews.com/artman/publish/Projects_Demo_Pilots/Vehicle-to-grid-gets-Japanese-pilot-3937.html, accessed September 21, 2011

Japanese companies have also looked to develop smart grid projects abroad. By May 2011, NEDO selected six Japanese companies to work with U.S. project partners to develop and install smart grid technologies on Maui, Hawaii as part of the Hawaiian Electric Company's Maui Smart Grid Project. NEDO will provide approximately $37 million to support the project, which will work to improve integration of renewable energy resources and prepare the electric system for widespread electric vehicle use.[118] NEDO has also entered into an agreement with Málaga, Spain to implement the Smart Community System Demonstration Project, which will focus on establishing electric vehicle infrastructure in the city (see Spain country profile below for more details).[119]

[118] Hawaiian Electric Company, Japan-U.S. Smart Grid project on Maui to demonstrate new technologies, http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=6d9a7368ae500310VgnVCM1000005c011bacRCRD&vgnextfmt=default&cpsextcurrchannel=1, accessed September 21, 2011

[119] NEDO, Conclusion of a Letter of Intent for Smart Community System Demonstration Project in the City of Council Malaga, Spain, http://www.nedo.go.jp/english/whatsnew_20110401_index.html, accessed September 21, 2011

South Korea			
Population	48.6 Million	**GDP**	$1,467 Billion U.S.
Electricity Consumption per Capita	8,310 kWh	**Federal Funding for Smart Grid**	$824 Million U.S.

Smart Grid Drivers

- Energy efficiency goals
- Environmental goals
- Renewable integration
- Financial incentives

Smart Grid Development Status

In August 2008, the National Vision for Low-Carbon, Green Growth plan was announced by South Korean president Lee Myung-Bak, and the plan was initiated in February 2009.[120] The plan would voluntarily reduce carbon emissions by 30 percent from the expected 2020 levels. In the plan, the Korea Smart Grid Institute (KSGI) is responsible for managing the government's Smart Grid Roadmap, and smart grid test-bed, as well as providing policy support for smart grid issues. The roadmap includes an investment of $6.16 billion in smart grid technology and overall the country may spend as much as $24 billion on smart grid projects by 2030.[121] The smart grid roadmap includes five sectors:[122]

- *Smart Power Grid* - Open power grids will be built to allow various kinds of interconnections between consumption and supply sources.
- *Smart Consumer* - Encourage consumers to save energy by using real-time information and producing smart home appliances that operate in response to electric utility rates.
- *Smart Transportation* - Build a nationwide charging infrastructure that will allow electric vehicles to be charged anywhere. It also establishes a V2G (Vehicle to Grid) system where the batteries of electric vehicles are charged during off-peak times while the resale of surplus electricity takes place during peak times.
- *Smart Renewable* - Build a smart renewable energy power generation complex across the nation by rolling out microgrids.
- *Smart Electricity Service* – Improve customer service through energy-saving rate plans and added electricity services.

In 2009, the government unveiled its Five-Year Plan for Green Growth, planning to spend two percent of its gross domestic product over the next five years in investments in green technologies, resource and material efficiency, renewable energies, sustainable transport, green buildings and ecosystem restoration.[123] Korea was a co-author of the Smart Grids Technology Action Plan released by the Major Economies Forum on Energy and Climate's Global Partnership in December 2009 and is also part of the Global Smart Grid Federation. Korea, through the KSGI, is currently implementing ten Power IT projects

[120] Kim, Jinho. "Policy Directions for the Smart Grid in Korea." Power and Energy Magazine, IEEE, Feb 2011, http://www.sgiclearinghouse.org/Legislation?q=node/3080&lb=1, accessed March 9, 2011.
[121] GigaOM, http://gigaom.com/cleantech/the-billions-of-dollars-behind-koreas-smart-grid/, accessed March 9, 2011.
[122] Korean Smart Grid Institute, http://www.smartgrid.or.kr/10eng6-1.php, accessed March 9, 2011.
[123] UPI.com, http://www.upi.com/Science_News/Resource-Wars/2010/07/13/Boost-for-South-Koreas-green-sector/UPI-28761279040517/, accessed March 9, 2011.

aimed at enhancing the power grid system through transmission monitoring, distribution system enhancements, and integration of distributed generation.[124]

Korea's future smart grid goals include the implementation of real-time pricing nationwide and integration of energy storage devices.[125] KEPCO announced in February 2011 it would invest $7.18 billion in its smart grid business by 2030, with part of the funds allocated to upgrade power transmission and distribution systems, and switch meters.[126]

Key Projects/Programs

- **Jeju Smart Grid Test Bed:**[127] Korea's largest test project, located on Jeju Island south of Seoul, is the Jeju Smart Grid Test-bed. The project is touted as the world's largest Smart Grid community. The test-bed will consist of about 6,000 households and will feature various prototypes of smart meters, in-home displays, electric vehicle charging infrastructure as well as networks and substations monitored and controlled by SCADA systems, all tested under real-life conditions.[128]

- **Superconductor power cables:**[129] KEPCO has forecasted the wide deployment of superconductor power cables in the Korean grid starting in the 2012-2013 timeframe.

- **Collaboration with State of Illinois:**[130] In 2010, the Illinois' Department of Commerce and Economic Opportunity and Korean Ministry of Knowledge Economy agreed to jointly develop and deploy smart grid technologies and business models. During this collaboration, the Korean government will commit more than $20 million to the development of smart grid hardware and software deployments as well as charging infrastructure for electric vehicles in Illinois.

Potential Lessons Learned for the United States

South Korea's state-managed electric utility, KEPCO, is expected to invest heavily in smart grid initiatives over the next decade. Importantly for the United States, the company also plans to market the smart grid technologies it develops overseas. South Korea could be an important source of smart grid technology and components not already developed in the United States. In addition, direct collaboration with Korea on smart grid projects located in the United States, such as the current project with the State of Illinois, will be important technology-sharing opportunities.

Regarding its communications approach, South Korea has one of the fastest and most reliable broadband internet networks in the world. The use of this system within the context of an emerging smart grid will provide important lessons for the United States as it develops its own broadband plan.

Updates as of September 2011

[124] Korea Smart Grid Institute, 10 Projects, http://www.smartgrid.or.kr/10eng5-2.php, accessed September 21, 2011
[125] Korea Smart Grid Institute, http://www.smartgrid.or.kr/eng.htm, accessed September 21, 2011
[126] Reuters,KEPCO to invest $7.2 billion in smart grid by 2030, http://www.reuters.com/article/2011/02/18/us-kepco-korea-idUSTRE71H0K020110218?feedType=RSS&feedName=GCA-GreenBusiness, accessed September 21, 2011
[127] Korea Smart Grid Institute, Korea's Jeju Smart Grid Test-bed Overview, http://www.smartgrid.or.kr/10eng3-1.php, accessed September 21, 2011
[128] Fehrenbacher, Katie, The Billions of Dollars Behind Korea's Smart Grid, GigaOM, http://gigaom.com/cleantech/the-billions-of-dollars-behind-koreas-smart-grid/, accessed September 21, 2011
[129] Harris, Phillip, and Jack McCall, Nationalizing the Grid, Mechanical Engineering, http://memagazine.asme.org/Articles/2010/December/Nationalizing_Grid.cfm, accessed September 21, 2011
[130] Adica, Smart Illinois, http://www.adica.com/smart_illinois.html, and Electric Light & Power, Illinois smart grid leaders sign agreements, http://www.elp.com/index/display/article-display/articles/electric-light-power/smart-grid/2010/07/Illinois_smart_grid_leaders_sign_agreements.html, accessed September 21, 2011

South Korea's Jeju Smart Grid Test Bed project continues to move forward. Reports indicate that over 2,000 houses on the island have now been revamped with solar panels. Smart meters, energy storage batteries, and tablet computers that allow homeowners to monitor and adjust their energy usage have all been distributed. The basic (infrastructure build up) stage of the project ends this year, to be followed in 2012 by the expansion (integration) stage. This stage will in turn run until the project concludes in May 2013.[131] KSGI has been collaborating with the Illinois Department of Commerce to develop the Jeju project, and there are plans to roll out technologies and business models developed on Jeju in Illinois in the future.[132]

After the Jeju project, South Korea's Smart Grid Roadmap calls for expanding smart grid technology into metropolitan areas from around 2012 to 2020, then completing a nationwide intelligent smart grid from around 2021 to 2030.[133]

[131] Kaye, Leon, Pushing the low carbon boundaries: South Korea's smart grid initiative, The Guardian, http://www.guardian.co.uk/sustainable-business/south-korea-smart-grid-low-carbon, and KSGI, Jeju Progress Schedule, http://www.smartgrid.or.kr/10eng3-2a.php, accessed September 21, 2011
[132] KSGI, Major Smart Grid Initiatives by Countries, http://www.smartgrid.or.kr/10eng8-1.php, accessed September 21, 2011
[133] KSGI, Roadmap Implementation in Five Sectors, http://www.smartgrid.or.kr/10eng4-1.php, accessed September 21, 2011

Spain			
Population	46.5 Million	**GDP**	$1,376 Billion U.S.
Electricity Consumption per Capita	5,825 kWh	**Federal Funding for Smart Grid**	$807 Million U.S.

Smart Grid Drivers

- Government policies/mandates
- Renewable integration (particularly solar)
- Increasing demand
- Electric vehicle integration
- Financial incentives

Smart Grid Development Status

Spain ranks fifth worldwide in the amount of government stimulus funding provided to utilities to launch smart grid projects.[134] The Ministry of Industry, Commerce and Tourism regulates and oversees smart grid projects in Spain. The country currently receives around 35 percent of electricity from renewable resources, but will require additional smart grid infrastructure to accommodate more renewable distributed generation in the coming years. [135]

Much of Spain's smart grid activity has been prompted by EU and Spanish regulations. The EU currently has a directive ordering that smart meters be provided to all consumers by 2022.[136] The EU Energy and Climate Package and Third Energy Package further require reduction of GHG emissions, increased renewable energy resources, and modernization of distribution networks.[137] At the national level, regulation has been passed declaring that electric power distributors cannot charge customers a monthly fee for traditional, electromechanical meters. Distributors do have the option to charge a monthly rental fee of $0.90 for new smart meters. Additionally, Spanish Ministerial Order ITC/3860/2007 requires each Spanish power distributor to install smart meters for consumers with power requirements up to 15 kW. Fifty percent of the smart meters must be installed by 2012, with the remaining portion installed by 2018.[138]

Similar to Germany, Spain has laws regarding electricity feed-in tariffs for renewable resources. The rise in solar thermal electric plant projects in Spain is partially attributed to the tariffs that encourage their development along with storage capacity. Although the high price of PV technology creates additional policy costs, regulators believe this is offset by reduced transmission losses due to the close proximity of installations to end users (e.g., rooftop solar panels).

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[134] Zpryme Research and Consulting, Smart Grid Snapshot: China Tops Stimulus Funding, http://www.zpryme.com/SmartGridInsights/2010_Top_Ten_Smart_Grid_Stimulus_Countries_China_Spotlight_Zpryme_Smart_Grid_Insights.pdf, accessed September 21, 2011

[135] Carrasco, Alicia, Spain reaffirms focus on smart energy demand to support renewables, electric vehicles, eMeter Corp., http://www.emeter.com/2011/spain-reaffirms-focus-on-smart-energy-demand-to-support-renewables-electric-vehicles/, accessed September 21, 2011

[136] King, Chris, Smart Meter Europe: Spain Jumping Ahead, Smart Grid Watch, http://smartgridwatch.wordpress.com/2009/10/07/smart-meter-europe-spain-jumping-ahead/, accessed September 21, 2011

[137] The European Electricity Grid Initiative, Roadmap 2010-18 and Detailed Implementation Plan 2010-12, http://www.smartgrids.eu/documents/EEGI/EEGI_Implementation_plan_May%202010.pdf, accessed September 21, 2011

[138] Carrasco, Alicia, Spain starts installing smart meters, despite new economic wrinkle, eMeter Corp., http://www.emeter.com/2010/spain-starts-installing-smart-meters-despite-new-economic-wrinkle/, accessed September 21, 2011

Smart energy demand and renewable distributed generation integration are key points of Spain's power grid operator, Red Electrica de Espana (REE), strategic plan for 2011-2015. REE hopes to achieve its goals to integrate renewable sources through demand management, reduced electricity consumption, and peak demand reduction. In the REE's business plan, energy efficiency measures, TOU tariffs, energy storage technologies, pumping stations, interruptible service tariffs, and automated load management will be implemented. [139]

The Spanish Ministry of Industry, Tourism and Trade has created draft regulation for a nighttime off-peak tariff to encourage electric vehicle charging in off-peak hours (midnight to 6 AM in the winter, and 1-7 AM in the summer). Spain's government has set a goal to have 250,000 electric vehicles on the road by the end of 2014. Electric vehicle charging will play a key role in flattening the peaks and valleys of the electricity demand profiles in the region.[140]

Key Projects/Programs

- **Bilbao and Portugalete Smart Grid Pilot:**[141] Iberdrola SA and the Basque regional government are planning to adapt 1,100 transformers in the cities of Bilbao and Portugalete for the installation 230,000 smart meters. The project will cost around 60 million euros.

- **Málaga Smartcity Project:**[142] Endesa's Smartcity project in the Playa de la Misericordia section of Málaga, Andalusia was initiated in July 2009 at a cost of around 43.2 million U.S. dollars. The goal of the project is to cut electricity consumption by 20% through the deployment of smart meters, TOU rates, advanced telecommunications, energy storage and distributed generation systems. 300 industrial customers, 900 businesses, and 11,000 households will receive smart meters by 2015.

- **Castellón Smart Grid Project:** [143] Iberdrola selected Castellón, Spain as the first location to participate in its Network Remote Management and Automation Systems project (abbreviated STAR in Spanish). In June 2010, the smart grid project in Castellón was launched with plans to upgrade 600 transformer stations and replace 100,000 electromechanical meters with new Itron smart meters over the next several years. The meters and meter data management software are driven by PLC technology. The city's 175,000 residents will have the ability to monitor usage data in real-time and possibly take advantage of flexible electricity rates.[144] The PLC platform will have adaptive capabilities for future smart grid application needs and evolving protocol standards.

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[139] Carrasco, Alicia, Spain reaffirms focus on smart energy demand to support renewables, electric vehicles, eMeter Corp., http://www.emeter.com/2011/spain-reaffirms-focus-on-smart-energy-demand-to-support-renewables-electric-vehicles/, accessed September 21, 2011.

[140] Carrasco, Alicia, Spain: Time-of-use tariff would encourage electric vehicles, eMeter Corp., http://www.emeter.com/2010/spain-time-of-use-tariff-would-encourage-electric-vehicles/, accessed September 21, 2011

[141] White, Todd, Iberdrola, Basque Government Plan Pilot Smart Grid, Cinco Says, Bloomberg, http://www.bloomberg.com/news/2011-02-15/iberdrola-basque-government-plan-pilot-smart-grid-cinco-says.html, accessed September 21, 2011

[142] Smart Grid Today, Spain's Endesa details smart grid projects, plans, future of EVs, http://www.drsgcoalition.org/news/media/2010-02-03-Delurey_Report_on_Hoffman_Confirmation.pdf, accessed September 21, 2011

[143] Iberdrola, First Smart Grid: Castellón, https://www.iberdrola.es/webibd/corporativa/iberdrola?IDPAG=ENWEBREDDISREDINTCST&codCache=13015092117806108, and Iberdrola, Smart Grids, https://www.iberdrola.es/webibd/corporativa/iberdrola?IDPAG=ENWEBREDDISREDINT&codCache=13173300584422003, accessed September 21, 2011

[144] Regulación Eólica con Vehículos Eléctricos, Iberdrola Launches Spain's First Smart Grid in Castellón, http://www.evwind.es/noticias.php?id_not=6222, accessed September 21, 2011

- **NOBEL (Neighborhood Oriented Brokerage Electricity and monitoring system):**[145] Through funding from the EU, the NOBEL project entails the development of an energy brokerage system connecting consumers to large- and small-scale energy producers. A middleware system will be used to communicate consumption data between the customer and the energy producer. IP (version 6) technology will be employed on additional sensors and device energy meters. It is expected that the system will enable more timely predictions of future demand, and improve energy savings.

- **Sarecar Project:** [146]ZIV Metering Solutions is developing electric vehicle charging and car sharing facilities in Ataun, Guipuzcoa. A total of 15 electric vehicles and 10 parking facilities with grid-interconnected PV canopies will be created. The charging system will provide the owner and the utility with real-time information on the state of the infrastructure, the number of users charging vehicles, and the energy consumption associated with each charging session.

Potential Lessons Learned for the United States

Spanish utility Iberdrola has selected smart meter company Itron to develop the first phase of one of Europe's largest smart metering initiatives, an advanced metering management system which will include not only smart meters, but also head-end and meter data management (MDM) software in Castellón. The meters will use the PRIME telecommunications protocol, Iberdrola's open standards PLC standard. Initially, 100,000 Itron meters will be delivered for the initial phase of the project and could later expand to 10 million meters throughout the country. Important to the U.S. will be the demonstration of an open standard communication system and a project that incorporates end-to-end interoperability. The United States is keeping an eye on PLC pilots used widely in Europe, which will prove helpful for those situations where it may be warranted in the United States.

Updates as of September 2011

Various smart grid projects in Spain have continued to move forward. A new control and monitoring center opened in Málaga as part of the Málaga Smartcity Project on March 25, 2011.[147] In late March, Japan's NEDO and the City Council of Málaga agreed to cooperate in the implementation of a Smart Community System Demonstration Project, which will be aligned with the Málaga Smartcity Project. The demonstration project will focus on the establishment of new infrastructure, including electric vehicle management systems and charging facilities.[148] By 2012, Málaga will have 20 charging stations for electric vehicles. A total of 60 million euros will be invested as part of the project by Spanish and Japanese firms.[149]

In Castellón, smart meters are now being installed. Iberdrola plans to add new cities and provinces to the STAR project in 2011.[150]

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[145] European Commission, NOBEL: Neighborhood Oriented Brokerage Electricity and monitoring system, http://cordis.europa.eu/fetch?CALLER=PROJ_ICT&ACTION=D&DOC=10&CAT=PROJ&QUERY=012e33f54585:bee9:58b28151&RCN=94044, accessed September 21, 2011

[146] SGIC, Smart Grid Projects in Europe, http://www.sgiclearinghouse.org/Europe?order=name&sort=asc, accessed September 21, 2011

[147] Endesa, The SmartCity Consortium, Headed by Endesa, Opens its Control and Monitoring Center in Malaga, http://portalsmartcity.sadiel.es/EN/noticias/documentos/110325_Inauguracion_centro_Smartcity%28def%29ENG.pdf, accessed September 21, 2011

[148] NEDO, Conclusion of a Letter of Intent for Smart Community System Demonstration Project in the City of Council Malaga, Spain, http://www.nedo.go.jp/english/whatsnew_20110401_index.html, accessed September 21, 2011

[149] EuroWeekly News, Electric Car charging stations in Malaga, http://www.euroweeklynews.com/2011091289138/news/costa-del-sol/electric-car-charging-stations-in-malaga.html, accessed September 21, 2011

[150] Iberdrola, Deployment Areas of Remote Management Project, https://www.iberdrola.es/03sica/clientesovc/iberdrola?IDPAG=ESOVD_ZONA_DESPL, and Video Smart Grid in Castellón, https://www.iberdrola.es/webibd/corporativa/iberdrola?IDPAG=ENWEBREDDISREDINTCSTLOC, accessed September 21, 2011

United Kingdom			
Population	62.3 Million	**GDP**	$2,189 Billion U.S.
Electricity Consumption per Capita	5,591 kWh	**Federal Funding for Smart Grid**	$290 Million U.S.

Smart Grid Drivers

- Environmental goals
- Energy security goals
- Economic competitiveness
- Government policies/mandates
- Financial incentives

Smart Grid Development

The UK has a strong vision for smart grid development. In 2009 the UK Government announced a plan to install smart meters in every home in Britain by 2020.[151] The plan involves installing 47 million meters in 26 million properties and is expected to cost £8.6 billion. The full-scale meter rollout is expected to begin in mid-2012. The plan is managed by the Department of Energy and Climate Change (DECC) with the Office of the Gas and Electricity Markets (Ofgem) tasked with developing the regulatory framework supporting the rollout.[152] The UK Government visualizes the smart grid as the internet of electricity that will help transform the UK into a low carbon economy and reducing greenhouse gas emissions by at least 80 percent by 2050, relative to 1990 levels.

In March 2011 the DECC announced its strategy and timetable for the national deployment of smart meters.[153] The deployment will occur in two phases. During the foundation stage, currently underway, the government works with industry, consumer groups and other stakeholders to make sure the necessary planning preparations have been completed for the second phase, the roll-out itself. The foundation stage will enable the industry to test all the systems required to begin the mass rollout and ensure positive consumer engagement. During this stage the UK Government will also establish the Data and Communications Company, which will provide data and communications services for the nationwide smart meter system.

Ofgem set up the Low Carbon Networks (LCN) Fund to help support smart grid projects. The Fund will provide up to £500 million to support projects sponsored by the distribution network operators (DNOs) to test new technology, operating and commercial arrangements and investigate the opportunities that the smart meter rollout will provide to network companies. GE's Smart Grid Center was opened in December 2009 and serves as a showcase for smart grid technologies that are used to improve energy efficiency across the UK. Following the publication of the National Infrastructure Plan 2010, the

[151] BBC, UK energy smart meter roll-out is outlined, http://news.bbc.co.uk/2/hi/business/8389880.stm, accessed September 21, 2011
[152] BusinessGreen. DECC takes control of smart meter roll out, http://www.businessgreen.com/bg/news/1931718/decc-takes-control-smart-meter-roll, accessed September 21, 2011
[153] DECC, DECC Lays Foundations for Smart Meters Rollout, http://www.decc.gov.uk/en/content/cms/news/pn11_032/pn11_032.aspx, accessed September 21, 2011

Government created an Engineering and Interdependency Expert Group to look into investment in R&D of grid sensor and metering technology.[154]

The Electricity Networks Strategy Group (ENSG), which includes the T&D companies, developed a vision for smart grids that draws together what has been learned from these partnerships and industries. These developments are taking place in the context of international work on the development of smart grid technologies through entities such as the Major Economies Forum Smart Grids Working Group, and the EU's Strategic Energy Technology Plan and Smart Grids Task Force.[155] These EU initiatives were created to ensure that technology development and the regulatory framework for smart grids are pursued by Member States in a coordinated way.

Key Projects/Programs

- **North East and Yorkshire Smart Grid Project**:[156] Plans for Britain's biggest smart grid project include 14,000 homes and businesses and test the impact of new low carbon technologies such as electric cars and solar panels on the electricity grid. The project is a partnership between CE Electric UK, British Gas, Durham University and EA Technology. The total project is valued at £54 million with CE Electric UK and its partners seeking £28 million from Ofgem's LCN Fund. Around 2,500 customers taking part will also be installing solar PV panels, heat pumps or provision for charging electric vehicles.

- **Energy Demand Research Project (EDRP):**[157] The EDRP is a £20 million trial of smart meters and related measures such as real-time display devices, additional billing information, monthly billing, energy efficiency information, and community engagement. The project is jointly funded by the Government and industry and involves around 50,000 households. The trials began in 2007 and finished at the end of 2010. The data is being collected and analyzed and the final results will be available in spring 2011.

Potential Lessons Learned for the United States

The first stage of UK's two-phase approach to smart meter rollout is heavily customer oriented. Known as the foundation stage, it will enable the industry to test all the systems and ensure positive consumer engagement before the mass rollout begins. This is important to the U.S. effort to develop smart grids since several smart meter pilot programs in the United States have resulted in negative customer feedback.

Updates as of September 2011

DECC has set out a detailed policy design for its nation-wide smart metering implementation program, and is currently seeking the opinions of stakeholders as part of its consultations.[158]

Other programs are ongoing as well. First Utility, which already offers its 50,000 customers free smart meters, began working with OPower and in consultation with DECC in July 2011 on a pilot program to

[154] Global Smart Grid Federation. UK looks at smart electric grids, http://www.globalsmartgridfederation.org/news_20101114_uk.html, accessed September 21, 2011
[155] European Commission, SET-Plan. http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm and Smart Grids Task Force. http://ec.europa.eu/energy/gas_electricity/smartgrids/taskforce_en.htm, accessed September 21, 2011
[156] Centrica. Plans for Britain's biggest 'smart-grid project' launched, http://www.centrica.co.uk/index.asp?pageid=39&newsid=2089, accessed September 21, 2011, and Network Revolution home page, http://www.networkrevolution.co.uk/, accessed September 21, 2011
[157] Ofgem. Energy Demand Research Project, http://www.ofgem.gov.uk/sustainability/edrp/Pages/EDRP.aspx, accessed September 21, 2011
[158] DECC, Smart Metering Implementation Programme Consultations, http://www.decc.gov.uk/en/content/cms/consultations/cons_smip/cons_smip.aspx, accessed September 21, 2011

gather ideas regarding future smart meter policy. In the program, data collected by smart meters will be put into a software system, allowing customers to proactively alter their domestic energy usage. Communication with customers will occur through mailed reports, a web portal, email, SMS messages and social media.[159]

In another project, the UK's Technology Strategy Board is supporting an electric vehicle trial program known as the Switch EV trial. As of June 2011, the 44 electric vehicles in the program have completed 50,000 miles across the North East of England.[160]

[159] Taylor, Ann Elise, Smart grid news, First Utility to lower energy bils with smart grid software, http://www.greenwisebusiness.co.uk/news/first-utility-to-lower-energy-bills-with-smart-grid-software--2458.aspx, accessed September 21, 2011
[160] CE Electric, Electric vehicle trial reaches milestone, http://www.ce-electricuk.com/news/50000_electric_miles.cfm, and Switch EV, http://www.switchev.co.uk/, accessed September 21, 2011

International Smart Grid Standards

The international community is currently in the early stages of developing standards for smart grid components and interoperability. A set of standards that allows interoperability of individual technology components is essential to realize the full benefits of a smart grid. However, the process of standards development is time consuming. Hundreds of standards will be required, and developing a single standard in a technology area often takes several years to achieve. It was only in March 2011 that the European Commission delivered a mandate for the development of region-wide smart grid standards. In the United States, the National Institute of Standards and Technology (NIST) is setting aggressive goals to develop dozens of smart grid standards in only a few years. In countries around the world, however, smart grid planning and implementation are taking place despite the lack of standards.

The involvement of utilities, vendors, and stakeholders is vital in the development of standards for a smart grid. Recent initiatives related to international cooperation on smart grid development include the creation of ISGAN, launched at the Clean Energy Ministerial in Washington, D.C. in July 2010. ISGAN facilitates the development and deployment of smart grids around the world through knowledge sharing, technical assistance, peer review, and project coordination. ISGAN complements the Global Smart Grid Federation (GSGF), a global stakeholder organization composed of the U.S. GridWise Alliance, the Korean Smart Grid Association, the India Smart Grid Forum, the Japan Smart Community Alliance, Smart Grid Australia, Smart Grid Canada, Smart Grid Ireland, and other leading smart grid organizations. GSGF brings together smart grid stakeholder organizations from around the world to share best practices, identify barriers and solutions, foster innovation, and address key technical and policy issues.

International Smart Grid Standards Development
International standards related to smart grid technology are currently being developed by several different organizations. Global-scale international organizations involved with smart grid standardization include:

- International Electrotechnical Commission (IEC): Consists of 81 national committees (known as members) from around the world. The U.S. member is the American National Standards Institute (ANSI). Founded in 1906.
- Institute of Electrical & Electronics Engineers (IEEE): The world's largest professional organization for advancing technological innovation. More than half of its nearly 400,000 members hail from the United States. Founded in 1884 in the United States as the AIEE.
- Internet Engineering Task Force (IETF): An open community of network designers, operators, vendors, and researchers. Formed in 1986.
- Third Generation Partnership Project (3GPP): A telecommunications collaborative that provides globally applicable third-generation mobile phone system standards. Formed in 1998.
- International Telecommunications Union (ITU): The United Nations agency for information and communications technology. Founded in 1865; the oldest international organization in the UN family.

In addition to the global organizations, several European organizations with parallel and overlapping missions have also been developing smart grid standards since as early as 2005. These organizations are:

- European Commission (M/441 Standardization Mandate and OPEN meter project)
- Smart Grids European Technology Platform (SG ETP)
- European Telecommunications Standards Institute (ETSI)
- European Committee for Standardization (CEN)
- European Committee for Electrotechnical Standardization (CENELEC)

International Timeline

After the United States adopted the Energy Independence and Security Act (EISA) of 2007, IEEE formed a smart grid standards working group, known as P2030. The purpose of P2030 is to draft a guide for smart grid interoperability with the electric grid and end-use applications and loads. Separate supplemental guides for transportation infrastructure and energy storage systems are also being drafted. As of February 2011, a fifth version of the draft, available only internally, has been developed.

ITU has worked with 3GPP and, indirectly, other organizations on a range of mobile communication standards, including those with smart grid applications. HomeGrid Forum, an organization that works within ITU's G.hn home networking standard, formed in 2009 with a smart grid/smart energy working group. Later, at a meeting of ITU's Telecommunication Standardization Advisory Group (TSAG) in January 2010, TSAG agreed to create a new focus group to investigate existing national standards for their appropriateness as potential international standards, as well as to conduct a gap analysis. Afterwards, the smart grid standards themselves will be developed.

In 2009, IEC formed Strategic Group 3 (SG-3) on Smart Grid to develop the framework for all IEC technical committees related to smart grid technologies. Representatives of 15 national committees[161] are participants in SG-3, and SG-3 also is collaborating closely with NIST. To date, more than 100 specific standards have been considered, with a special focus on interoperability, transmission, distribution, metering, consumers, and cyber security. Key concepts taken from IEC standards 61850 (electrical substation automation), 61968 (information exchanges between electrical distribution systems), and 61970 (application program interfaces for energy management systems) are being standardized for smart grid applications.

Billed as an open community of network designers, operators, vendors, and researchers, IETF conducts its technical work through its working groups. One of these groups is the Smart Power Directorate, which deals with Internet protocols in relation to smart grid communications. In January 2011, IETF released a draft standard for the Constrained Application Protocol (CoAP), a web transfer protocol for machine-to-machine (M2M) applications, including smart grid technologies.

European Timeline

Launched in 2005, SG ETP was Europe's first major initiative related to smart grid standardization, with its aim to provide a vision of how Europe could achieve a smart electricity network by 2020. In that vein, SG ETP's Strategic Deployment Document (SDD) was finalized in 2010. The SG ETP Forum, made up of 12 individuals representing smart grid stakeholders, will continue advocacy to make its SDD vision a reality.

[161] United States, Canada, Brazil, China, Japan, South Korea, and nine European countries.

On January 1, 2009, the Open Public Extended Network (OPEN) meter project, supported by the European Commission's Directorate-General for Research and Innovation, officially was launched. OPEN intends to develop a comprehensive set of public AMI standards for electricity, gas, water, and heat metering, with an added focus on addressing knowledge gaps. The draft standards are expected to be released in summer 2011.

On March 12, 2009, the European Commission issued a mandate, known as M/441, to the European standardization organizations (ESOs). M/441 builds upon mandates issued in 2004 and 2005 concerning utility meters, as well as a 2006 directive on energy end-use efficiencies and energy services. M/441 calls upon CEN, CENELEC, and ETSI to develop a European standard open architecture for bidirectional communication among smart meters. To this end, a working group, the Smart Meters Coordination Group (SM-CG), was established; this working group is working closely with OPEN, as they both are under the European Commission aegis. SM-CG first met in May 2010 and will sponsor a two-day workshop about smart grid standards, with a focus on communications systems, to be held in France in April 2011.

ETSI, along with telecommunications organizations in other regions and countries, is a 3GPP organizational partner. The two organizations are teaming up to develop specifications for Universal Mobile Telecommunications System (UMTS) and Long-Term Evolution (LTE) mobile communication standards. Included in 2011's forthcoming specifications (which include items not related to smart grid) will be a set of enablers that could make a wide-scale smart grid monitoring and control infrastructure a reality.

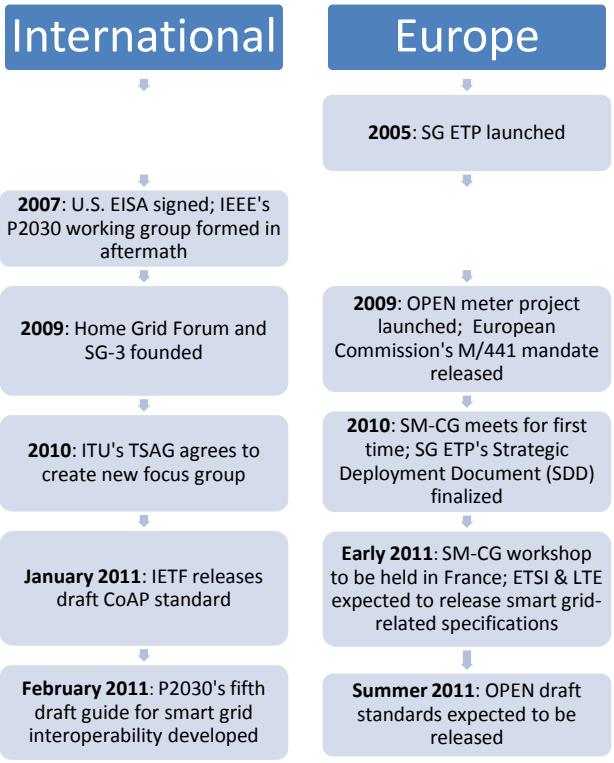
On March 1, 2011, the European Commission presented CEN, CENELEC and ETSI with a mandate to produce a set of consistent standards within a common European framework. The standards are to achieve interoperability and enable or facilitate the implementation of different smart grid services and functionalities. Once accepted, a development prioritization of all the required standards must be presented to the Commission within two months, and a comprehensive work plan must be proposed within six months. The first set of standards must be available by the end of 2012.

Figure 1 illustrates the timing of international and European smart grid standards development. The links for all the international grid standards and organizations follow.

International Smart Grid Standards Resources

- International Electrotechnical Commission (IEC), http://www.iec.ch/
- Institute of Electrical & Electronics Engineers (IEEE), http://www.ieee.org/index.html
- Internet Engineering Task Force (IETF), http://www.ietf.org/
- Third Generation Partnership Project (3GPP), http://www.3gpp.org/
- International Telecommunications Union (ITU), http://www.itu.int/en/pages/default.aspx
- European Technology Platform (ETP), http://www.smartgrids.eu/
- European Telecommunications Standards Institute (ETSI), http://www.etsi.org/WebSite/homepage.aspx
- European Committee for Standardization (CEN), http://www.cen.eu/cen/pages/default.aspx
- European Committee for Electrotechnical Standardization (CENELEC), http://www.cenelec.eu/
- European Commission (M/441 Standardization Mandate and OPEN meter project), http://www.cen.eu/cen/Sectors/Sectors/Measurement/Documents/M441.pdf

Figure 1. International and European Smart Grid Standards Timeline



Source: SAIC

- EU: http://ec.europa.eu/index_en.htm
- Standardization Mandates: http://www.cen.eu/cen/Sectors/Sectors/Measurement/Pages/default.aspx
- OPEN Meter: http://www.openmeter.com/
- IEEE P2030 weblink: http://grouper.ieee.org/groups/scc21/2030/2030_index.html
- European Technology Platform, http://www.smartgrids.eu/