Energy 2.0

Smart Grid Roadmap, 2012 – 2022

The path forward, toward abundant, clean and affordable energy.

Zpryme Research & Consulting

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May 2012

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Executive Summary

The 2012 to 2022 Smart Grid Roadmap presented in this report offers a general framework intended to enhance collaboration efforts that can spur the innovative technologies and progress that puts nations around the world on a path toward abundant, clean and affordable energy. The Energy 2.0 vision and technology progression represents the possibilities when Smart Grid integrates with other forms of urban infrastructure – water, gas, roads, transit, public safety, waste management, etc. – to help build and run smarter cities. Global urbanization is accelerating rapidly, and all of these elements will need to be more centrally managed to keep pace. These needs create significant opportunities for technology companies, especially those with strength in networking and IT. However, the next five years will be make-or-break years for entrepreneurs and technology vendors as their equipment, solutions, software and systems will be expected to yield positive returns to utilities.

The foundation for Smart Grid growth has been solidified by world government commitments to increase the overall reliability of the electricity transmission and distribution systems. Further, an increasing awareness about global warming and a strong desire to protect the environment are further driving the demand for clean energy technologies. In 2009, 1.3 billion people around the world did not have access to electricity. Further, global utility losses totaled 1.7 trillion kWh or about 9% of all global generation. Smart Grid and clean technologies can bring billions of dollars back into world economies and reduce the need to build fossil fuel power plants.

Next, entrepreneurs, investors, and major technology vendors are aggressively developing and investing in technologies and companies that provide proprietary solutions for the Smart Grid industry. From 2007 to 2011, venture capitalists invested $2.2 billion in Smart Grid oriented firms. From 2010 to 2011 another $6.0 billion in mergers and acquisitions was spent by major technology vendors to purchase Smart Grid specific firms.

Between 2009 and 2011, world governments announced $123 billion in Smart Grid financial support of deployments to take place from 2009 to 2020. These same government targets are aimed at deploying 685 million smart meters and 20 million EVs by 2020. As of 2012, 31 governments have initiated 267 Smart Grid projects around the world.

The world is becoming increasingly connected, thus increasing the demand for energy information over the internet and mobile devices. Further, the connected economy will leverage new platforms, such as the cloud computing, to deliver new and cost effective energy applications to utilities and their customers.

Given the global government and private sector support for the Smart Grid, the possibilities for two-way, real-time communications are vast, and we are still in the early days of mobile Internet, cloud, cybersecurity and Big Data analytics. These technologies will lay the foundation for widespread demand response programs, renewables-based microgrids, more accurate demand forecasting and new revenues from smart energy applications, especially around electric vehicles (EVs) and energy storage. Last, emerging applications and technologies such as 'Beyond LTE', wireless sensor networks, wireless power transfer (WPT), and M2M will give utilities the agility and processing power they need to rapidly deploy next-generation Smart Grid technologies and systems.

Major Findings

Although multiple Smart Grid pilots, demonstrations and national deployments are currently underway in the U.S. and across the globe, Smart Grid technology is still in a relatively introductory phase.

- **2007 – 2012:** With the exception of a handful of utilities, this phase of Smart Grid technology implementation can be characterized as a period of Planning, Pilots, Design, Research and Installation. Even though billions of dollars have been poured into Smart Grid technology to date, the majority of these efforts are just now moving past an installation phase.
- **2012 – 2017:** The next five years will define the future of the Smart Grid. This phase can be characterized as one of Testing, Installation, Validation and Verification. The next five years will be make-or-break years for entrepreneurs and technology vendors as their equipment, solutions, software and systems will be expected to yield positive returns for utilities.
- **2017 – 2022:** If all goes according to plan, this phase can be characterized as Grid Optimization and Advanced Technology Integration. During this phase, utility systems and customers will start to truly reap the benefits of Smart Grid technology. An optimized grid will allow utilities to maximize asset utilization, control, and monitor and manage their entire electric system, and allow their customers to embrace advanced energy management applications.

Smart meter and AMI deployments are the first step in creating an intelligent and advanced Smart Grid.

Overall, utilities can be classified into two categories when it comes to Smart Grid technology implementation: Early Adopters and Late Movers.

- Early Adopters
  - Over the next 10 years, these utilities will shift from a ratepayer-centric business model to a customer-centric business model.
  - 2012 to 2017 will see these utilities invest heavily in AMI, ICTs, distribution automation technologies, and transmission monitoring technologies.
  - 2017 to 2022 will see these utilities aggressively implement energy storage, ICTs, distributed generation, V2G and B2G, and customer-level networks, devices, applications, software and systems.
- Late Movers
  - 2012 to 2017 will see these utilities closely monitor the progress and results of Early Adopters.
  - 2017 to 2022 will see a portion of Late Movers begin to deploy Smart Grid technology (mainly AMI).

Six major stakeholder groups will design and build the next generation grid. These include government, energy suppliers (utilities), technology vendors, energy demand (homes, transportation, buildings, etc.), entrepreneurs and investors, and consumers.

Government support, in the form of financial incentives, policy goals, and renewable energy targets are creating a thriving environment for utilities, entrepreneurs, and technology vendors to innovate and implement Smart Grid technology.

- Between 2009 and 2011, world governments provided financial support totaling $123 billion for Smart Grid technology being deployed between 2009 and 2020.

- These same government targets are aimed at deploying 685 million smart meters and 20 million EVs by 2020.
- As of 2012, 31 governments have initiated 267 Smart Grid projects around the world.

Major world governments, led by the EU, China, and U.S., have laid out detailed Smart Grid plans for their respective countries. These contributions will build the foundation for the future growth and development of the Smart Grid over the next 10 years. The goals and targets of major governments are summarized below.

- Australia
  - By 2020, the majority of households and businesses will have access to Smart Grid technology.
- China
  - Install 300 million smart meters by 2015.
- European Union (EU)
  - European Union mandate calls for 100% customer smart meter rollouts by 2022.
  - This equates to just over 240 million households with smart meters by 2022.
- United States
  - Goal of 40 million smart meters by 2015.
- Japan
  - Build the world's most advanced next-generation interactive grid network as early as possible in the 2020s.
- South Korea
  - Goal to install smart meters in 50% of households by 2016.
  - Bring Smart Grid into metropolitan areas by 2020.
  - Build a nationwide, intelligent power grid by 2030.

Over the next 10 years, the role of Government should shift from one that provides funding, collaboration, and R&D support to one that mainly provides oversight, regulation, and collaboration support. In other words, they should go from 'Chief Funder' to 'Referee-Coordinator'.

On the Energy Demand side, the next five years will see this stakeholder embrace demand response program participation. Further, they will embrace customer sited renewable energy and energy storage technologies. Between 2012 and 2017, Smart Grid and information and communication technology (ICT) adoption to control and monitor energy usage will progress from a pilot/beta phase to an introductory stage. Such technologies will grow from an introduction to growth stage among Energy Demand stakeholders between 2017 and 2022.

Technology vendors are dominated by a handful of global players such as GE, Cisco, Oracle, ABB, Siemens and IBM. This is important as these vendors must be able to scale their solutions to support the major utilities that drive the lion's share of Smart Grid spending. These solutions are large, complex and expensive, and will define the most successful applications that embody the Energy 2.0 Vision.

From 2012 to 2022, as Smart Grid technology moves from the grid out to the end customers, there will be much more latitude for smaller scale, specialized services and solutions. At this end of the market, there is room for far more vendors, both large and small.

Over the next 10 years, as end market solutions for utilities reach critical mass and maturity, the technology vendor pool will consolidate.

From 2012 to 2017, Smart Grid technology vendors with solutions that enable, support or enhance AMI and distribution automation will see strong revenue gains.

Overall, ICTs will transition from an R&D phase to a growth phase by 2017. This will also be one of most highly contested markets over the next 10 years. There is plenty of room for growth in this market as ICTs must be deployed across the utility value chain to maximize grid optimization.

By 2022, entrepreneurs and investors will take the lead in developing next-generation Smart Grid solutions and technologies. Significant opportunities lie in M2M, V2G, B2G, home area networks, sensors, energy storage and renewable integration systems and software, and mobile energy management applications.

Over the next 10 years, consumer devices and applications such as HEMS/HANs/Portals, Displays, Smart Appliances, and Mobile Energy Apps will progress from an R&D phase to growth phase.

Introduction

Zpryme, in partnership with Clasma, has developed a roadmap to assess the progression of the Smart Grid within the context of Energy 2.0. Although the Energy 2.0 Vision is constantly evolving, one thing is certain, the development of the Smart Grid is central to realizing the benefits of Energy 2.0. Thus, the roadmap will assist stakeholders within the Smart Grid ecosystem in aligning their respective goals with existing and future infrastructure, equipment, networks and technologies. Further, the roadmap will assist in building consensus among stakeholders about the short-term and long-term technology, policy, and standards needs that must be met to further the advancement of the Smart Grid. Last, the roadmap will help unify stakeholder collaboration and coordination efforts on Smart Grid pilots and deployments.

Purpose

The purpose of this report is to define key milestones for Smart Grid technology implementation over a 10 year time period (2012 to 2022). The report further identifies the major stakeholders involved in developing the Smart Grid, and describes their role in building the Smart Grid, and identifies milestones for each stakeholder over a 10 year time period. The report also identifies the major drivers and challenges for Smart Grid development over the next 10 years.

Methodology

Report Development

To develop the report, Zpryme employed a primary and secondary research approach.

Primary research involves industry interviews with industry companies, experts, and academic and research institutions, and government officials. Primary research is executed using face-to-face interviews, conference interactions, qualitative phone conversations, and some items or questions are answered over email by the target companies.

Secondary research is conducted by reviewing government industry documents, research institution white papers, company marketing literature, websites, news releases, executive interview articles, syndicated market research reports, industry presentations and reports, and from assessing Zpryme's internal Smart Grid research reports.

Qualitative assessments are made by Zpryme's Smart Grid research team that take into account both the primary research and secondary research findings to assess the respective market topics of interest.

Significant Sources Used to Develop the Roadmap

This roadmap builds off significant work that has been conducted on the Smart Grid technology landscape to date. Along with the primary industry interviews conducted for this report, the major research reports and books listed below played a key role in developing this report.

- 2010 Smart Grid System Report - Report to Congress February 2012, U.S. Department of Energy (2012).
- Technology Road Map - Smart Grids, International Atomic Agency (2011).
- Smart Grid projects in Europe: lessons learned and current developments, JRC European Commission-Institute for Energy (2011).
- Smart Grid Dictionary, 3rd Edition, Christine Hertzog, Managing Director of Smart Grid Library (2011).
- The Advanced Smart Grid: Edge Power Driving Sustainability, Andres Carvallo and John Cooper (2011).
- Understanding the Benefits of the Smart Grid, National Energy Technology Laboratory (2010).
- Southern California Edison Smart Grid Strategy & Roadmap, SCE (2010).
- The European Electricity Grid Initiative (EEGI) - Roadmap 2010-18 and Detailed Implementation Plan 2010-12, EEGI (2010).
- Clasma's expertise and breadth of industry knowledge.
- Zpryme's collective public and private Smart Grid research and studies conducted between 2007 and 2012.

Definitions

The following definitions refer to the technology areas examined in this report. The following definitions are adapted from the U.S. Department of Energy (DOE), smartgrid.gov, the U.S. Smart Grid Information Clearing House, the U.S. Energy Information Administration, and the DOE's National Energy Technology Laboratory (NETL).

Advanced Metering Infrastructure (AMI): Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers.

Customer Side Systems (CS): Customer-side systems are used to help manage electricity consumption at the industrial, commercial, and residential levels. Customer systems include in-home displays, web portals, home area networks, energy management systems, and other customer-side-of-the-meter equipment that enable Smart Grid functions in homes, offices, and factories. Time-based rate programs include different types of electricity pricing options for customers that are made possible by AMI and sometimes include customer systems.

Demand Response (DR): Demand Response can reduce the stress on system assets during peak conditions, reducing their probability of failure. DR is often used in order to reduce customer load during peak demand and/or in times of supply constraint. DR includes programs that are focused, deep, and immediate such as the brief curtailment of energy-intensive processes used by a utility's most demanding industrial customers, and programs that are broad, shallow, and less immediate such as the promotion of energy-efficient equipment in residential and commercial sectors.

Distribution Management Systems (DMS): A Distribution Management System (DMS) is a utility IT system capable of collecting, organizing, displaying and analyzing real-time distribution system information. A DMS can help plan and execute distribution system operations to increase system efficiency, optimize power flows, and prevent overloads. A DMS can interface with other applications such as geographic information systems (GIS), outage management systems (OMS), and customer information systems (CIS) for a full view of distribution operations.

Distribution Automation (DA): Distribution Automation is a family of technologies including sensors, processors, communication networks and switches that can perform a number of distribution system functions depending on how they are implemented. DA is the complete system that enables a utility to remotely monitor, coordinate and operate distribution components in a real-time mode from remote locations. It comprises the distribution SCADA, communication means, as well as all field components downstream that are necessary for feeder automation, voltage control, outage management system, advanced meter reading, and data monitoring for real-time state estimation and control. Some of the key applications for DA area fault detection, localization, isolation, load restoration and loading and thermal limit detection.

Transmission Enhancement Applications (TA): Transmission Enhancement Applications employing advanced sensors such as phasor measurement units (synchrophasors), wide-area monitoring and control systems (WAMS), and new-operator simulation and visualization tools will greatly improve situational awareness. High-speed communications between high-voltage stations and from stations to control centers enable dynamic management of the transmission system, as compared to today's quasi-steady state control. Automated transmission substations, new digital protection systems, and advanced control devices such as Flexible AC Transmission Systems (FACTS) will combine with this high-speed communications capability to give operators new tools that prevent transmission-level cascading outages. Other technologies in this category include Dynamic Line Ratings, High Voltage DC technologies, and High-temperature superconductors.

Asset/System Optimization (AO): Family of technologies and applications that integrate Smart Grid data with system planning tools to greatly increase the accuracy of forecasting when new assets are needed to support growing demand. In addition, information from asset health sensors can be collected and integrated with condition-based maintenance programs to improve the overall health and reliability of assets, reduce their out-of-service times and overall maintenance costs, better predict equipment failure, and extend asset life.

Distributed Energy Resources (DER)/Distributed Generation (DG): Family of devices or technologies that produce electricity, and are connected to the electrical system, either "behind the meter" in the customer's premise, or on the utility's primary distribution system. A Distributed Energy Resource (DER) can utilize a variety of energy inputs including, but not limited to, liquid petroleum fuels, biofuels, natural gas, solar, wind, and geothermal. Electricity storage devices can also be classified as DERs.

Information and Communications Integration (ICT): Underlying communications infrastructure, whether using private utility communication networks (radio networks, meter mesh networks) or public carriers and networks (Internet, cellular, cable or telephone), support data transmission for deferred and real-time operation, and during outages. Along with communication devices, significant computing, system control software and enterprise resource planning software support the two-way exchange of information between stakeholders, and enable more efficient use and management of the grid.

EVs and EV Infrastructure: Includes the integration of electric vehicles and charging stations, and relevant infrastructure (software and hardware, and networks) into the electric grid, and on electricity customer sites. Electric vehicle charging infrastructure handles billing, scheduling and other intelligent features for smart charging (grid-to-vehicle) during low energy demand.

Energy Storage: Technologies that can store electricity to be used at a later time. Storage can be installed at the utility level, industrial and commercial customer level, and at the residential customer level. These devices require a mechanism to convert alternating current (AC) electricity into another form for storage, and then back to AC electricity. Common forms of electricity storage include batteries, flywheels, and pumped hydro. Electricity storage can provide backup power, peaking power, and ancillary services, and can store excess electricity produced by renewable energy resources when available.

Microgrid: A microgrid is an electrical system that includes multiple loads and distributed energy resources that can be operated in parallel with the broader utility grid or as an electrical island.

B2G: Building to Grid (B2G) seeks to reduce energy usage and to develop implementable strategies for load shedding or load shifting in times of high energy demand periods.

Energy Systems, Software, Apps, ICTs: These are a family of technologies that include software, energy management systems, information and communication technology and systems, and mobile applications integrated into the businesses of industrial and commercial customers to control the operation of other energy devices according to customer preferences and objectives such as reducing energy costs, enhance energy efficiency, participate in demand response programs, and/or control customer sited generation and storage.

Smart Thermostats: Thermostats that communicate price or electric system reliability signals from the utilities to the consumers, and can be programmed by the customer to automatically reduce energy consumption through thermostat set-point adjustments. They are useful in integrating the customer's support for pricing, efficiency, and demand response programs into a single interoperable and expandable device. Also, PCTs are envisioned to support dynamic pricing, incentive programs and system reliability.

V2G: Vehicle to grid (V2G) involves using vehicle batteries to store grid electricity generated at off-peak hours for off-vehicle use during peak hours.

HEMS/HANs, Portals, Displays: Home Energy Management System (HEMS), Home Area Networks (HANS), Web Portals, and In-home Displays allow customers to control the operation of other energy devices according to customer preferences and objectives such as reducing energy costs, or maintaining comfort or convenience. Controlled devices could include, but are not limited to, thermostats, lighting, and smart appliances. Among other control inputs, an energy management system can accept energy pricing signals from a utility or third party energy services provider. A HAN is communication network within the home of a residential electricity customer that allows transfer of information between electronic devices, including, but not limited to, in-home displays, computers, energy management devices, direct load control devices, distributed energy resources, and smart meters. Home area networks can be wired or wireless.

Smart Appliances: Home appliances and devices (i.e., pool pumps, clothes washers/dryers, water heaters, etc.) that use wireless technology (i.e., ZigBee) to receive real-time data from the AMI system to control or modulate their operation.

Smart Grid Benefits: The main benefits discussed in this report refer to the six Smart Grid benefits identified in NETL's 2010 report, Understanding the Benefits of the Smart Grid. The six benefits are listed below. Each of these benefits, to some extent, will be received by utilities, government, society, and electricity customers (commercial, industrial, and residential).

- **Reliability:** Reducing the cost of interruptions and power quality disturbances and reducing the probability and consequences of widespread blackouts.
- **Economics:** By keeping downward prices on electricity prices, reducing the amount paid by consumers as compared to the "business as usual" (BAU) grid, creating new jobs, and stimulating gross domestic product (GDP).
- **Efficiency:** By reducing the cost to produce, deliver, and consume electricity.
- **Environmental:** By reducing emissions when compared to BAU by enabling a larger penetration of renewables and improving efficiency of generation, delivery, and consumption.
- **Security:** By reducing the probability and consequences of

manmade attacks and natural disasters.

- **Safety:** By reducing injuries and loss of life from grid-related events.

Analysis Approach

Six major stakeholder groups will foster in the next generation grid. These include government, energy Suppliers (utilities), technology vendors, energy demand (homes, transportation, buildings, etc.), entrepreneurs and investors, and consumers. This report and roadmap examines key milestones for each of these stakeholders over the next 10 years (2012 to 2022).

- This roadmap takes a global perspective on Smart Grid technology deployment.
- The roadmap approach for each stakeholder is summarized in the following sections.

Government Stakeholder Analysis Approach

Milestones: Major milestones were identified that should be accomplished from 2012 to 2022.

Policies: Major polices were identified that should be put in place from 2012 to 2022.

Industry Financial Support: The level of financial support the government should provide the industry from 2012 to 2022 was rated. Ratings of Low, Medium, and High were used. The ratings are relative to the support received from 2007 to 2012.

Benefits: The main benefits that will be provided to society and industry stakeholders were listed. Please refer to the six benefits listed in the definitions section.

Technology Vendor Analysis Approach

Milestones: Major milestones were identified that should be accomplished from 2012 to 2017 and 2017 to 2022.

Innovation Support: The level of innovation support technology vendors should provide from 2012 to 2022 was rated. Ratings of Low, Medium, and High were used. The ratings are relative to the support received from 2007 to 2012.

Opportunity Level by Area of Solution Need: The opportunity level by solution area of need from 2012 to 2022 was rated. The areas of need were broken up by generation, transmission, distribution, and electricity customer (industrial, commercial, and residential). Ratings of Low, Medium, and High were used. The ratings are used to identify where 'solution gaps' are likely to remain across the utility value chain. For example, a Low rating in the distribution system would signal that new or emerging solutions for this area of the utility value chain are in low demand for a given time period.

Entrepreneur and Investor Analysis Approach

Milestones: Major milestones were identified that should be accomplished from 2012 to 2017 and 2017 to 2022.

Financial Support: The level of financial support that this stakeholder should receive from 2012 to 2022 was rated. Ratings of Low, Medium, and High were used. The ratings are relative to the support received from 2007 to 2012.

Opportunity Level by Area of Solution Need: The opportunity level by solution area of need from 2012 to 2022 was rated. The areas of need were broken up by generation, transmission, distribution, and electricity customer (industrial, commercial, and residential). Ratings of Low, Medium, and High were used. The ratings are used to identify where 'solution gaps' are likely to remain across the utility value chain. For example, a Low rating in the distribution system would signal that new or emerging solutions for this area of the utility value chain are in low demand for a given time period.

Overall Smart Grid Roadmap and Energy Supplier, Energy Demand, and Consumer Stakeholder Analysis Approach

Milestones: Major milestones were identified that should be accomplished from 2012 to 2022.

Technology Progression Criteria: The technology progression rating refers to the level of maturity a given technology has reached across the Smart Grid landscape and among a specific stakeholder. This also refers to the overall acceptance or validation a specific technology has within an industry. The stages of technology or product maturity are Research & Development, Introduction, Growth, Maturity, and Decline. Generally speaking, the R&D phase can be associated with a penetration or adoption of less than 2% of the market. Introduction would equate to less than 15% of the market, growth would be just above a 50% market penetration, and maturity would be up to 85% market penetration.

Benefits: The levels of benefits that will be provided to society and industry stakeholders were listed. Please refer to the six benefits listed in the definitions section. Ratings of Low, Medium, and High were used. The ratings are used to identify the level of benefits that will be received by society and the industry as a whole from a specific stakeholder deploying or integrating a specific technology. For the purposes of this report, a Low benefits rating can be associated only a small fraction(less than 15%) of the population and industry that receive a given benefit. A medium rating would indicate that between 15% and 49% of the population and industry receive a given benefit. A high rating would indicate that 50% or more of the population would receive a given benefit from Smart Grid implementation.

Smart Grid Roadmap Analysis Structure

The table below shows the interactions among stakeholders and shows the major technologies to be deployed by each stakeholder. This report investigates how the respective technologies will be deployed by each stakeholder from 2012 to 2022.

Smart Grid Technology Roadmap Overview – By Stakeholder and Technology to be Deployed

(highlighted areas indicate where technology will be deployed)

Government Stakeholder					
Technology Vendors and Entrepreneurs & Investor Stakeholders (Create and Supply Technology to Energy Supply, Energy Demand and Consumer Stakeholders	Energy Supply Stakeholder			Energy Demand Stakeholder	Consumer Stakeholder
Smart Grid Technology Deployed	Generation	Transmission	Distribution	Industrial & Commercial Customers	Residential Consumers
AMI			■	■	■
CS				■	■
DR			■	■	■
DMS/DA			■		
TA		■			
AO	■	■	■		
DER/DG			■	■	■
ICTs	■	■	■	■	
EVs and EV Infrastructure			■	■	■
Energy Storage			■	■	■
Microgrid				■	
B2G				■	
Energy Systems, Software, Apps, ICTs				■	
Smart Thermostats					■
V2G					■
HEMS/HANs, Portals, Displays					■
Smart Appliances					■

Table 1 - Source: Adapted from Technology Categories from NETL and NIST 2010 Smart Grid Reports

Smart Grid Drivers

The foundation for growth of the Smart Grid across the world has been solidified by world government commitments to increase the overall reliability of electricity distribution systems. Further, an increasing awareness about global warming and a strong desire to protect the environment are further driving the demand for clean energy technologies. Renewable energy targets in place in 66 countries are also playing a key role in developing Smart Grids across the globe. In 2009, 1.3 billion people around the world did not have access to electricity. Further, global utility losses totaled 1.7 trillion kWh or about 9% of all electricity generation. Smart Grid technologies can bring billions of dollars back into word economies and reduce the need build fossil fuel power plants. Next, entrepreneurs, investors, and major technology vendors are aggressively developing and investing in technologies and companies that provide proprietary solutions for the Smart Grid industry. From 2007 to 2011, venture capitalists invested $2.2 billion in firms developing or offering Smart Grid solutions. From 2010 to 2011 another $6.0 billion in mergers and acquisitions was spent by major technology vendors to purchase Smart Grid specific firms. Between 2009 and 2011, world governments provided financial support totaling $123 billion for Smart Grid projects being implemented between 2009 and 2020. These same government targets are aimed at deploying 685 million smart meters and 20 million EVs by 2020. As of 2012, 31 governments have initiated 267 Smart Grid projects around the world. The world is becoming increasingly connected, thus increasing the demand for energy information over the internet and mobile devices. Further, the connected economy will leverage new platforms, such as the cloud computing, to deliver new and cost effective energy applications to utilities and their customers.

Driver/ Metric	Value	Unit	Source
Global Smart Grid Projects Underway (204 in the U.S.)	267	# of projects	Smart Grid Information Clearinghouse, 2012
Number of Countries who Have Initiated Smart Grid Projects	31	# of countries	Smart Grid Information Clearinghouse, 2012
World Total Electricity Losses (9% of world generation)	1.7	Trillion kWh	IEA, 2009
World population without access to electricity (about 20% of the population)	1.3	billion people	IEA, 2009
World Increase in Net Renewable Generation, 2012 – 2022 (48% increase from 2012)	2,152	billion kWh	U.S. EIA, 2011
World Increase in Net Generation Capacity, 2012 – 2022 (27% increase from 2012)	5,676	billion kWh	U.S. EIA, 2011
World Government Smart Grid Investments/Incentives, 2009 - 2020	123	billion USD	Announced government plans/targets
World Government Plans for Smart Meter Deployments, 2009 - 2020	685	million	Announced government plans/targets
World Government Target EV Stock by 2020	20	million EVs	Announced government plans/targets
Number of Countries With Renewable Energy Targets	66	# of countries	Announced government plans/targets
Smart Grid Venture Capital Value (2007 and 2011 over 159 deals)	2.2	billion USD	Mercom Capital, 2012
Smart Grid M&A Value (2010 and 2011 over 70 deals)	6.0	billion USD	Mercom Capital, 2012
Net Increase in CO2 Emissions from 2000 to 2010 (38% increase)	9	billion tons	2011 JRC EC Global Emissions Report
World Total Mobile Phone Users (87% of world population)	5.9	billion	ITU
World Internet Users (33% pop of world population)	2.3	billion	ITU

Table 2 - Source: Zpryme

Smart Grid Challenges

Smart grid technology, Smart Grid systems, and Smart Grid deployments can all mean very different things across the key stakeholder groups, and across world governments. That said, several industry challenges must be met head on by the key stakeholders if the Smart Grid is to play a key role in realizing the Energy 2.0 vision. Addressing the eight key challenges summarized below will increase the overall progression of Smart Grid technology across the utility value chain. Additionally, an increase in the Smart Grid technology adoption rate will decrease the amount of time it will take for electricity customers to yield the maximum benefits from Smart Grid technology.

1. **Lack-luster Global Economic and Political Climate:** With the exception of emerging markets, the global economy has showed moderate signs of growth. Overall the U.S. and EU are still haunted by the financial crisis that started in 2007. Although the U.S., Latin America, EU, and Asia largely view clean technologies and the Smart Grid as a net job creator for their nations, they are facing larger economic structure problems such as high unemployment, rising fuel prices, increasing debt levels, and poor performing housing markets. These economic pressures increase the political anxiety in these nations as voters and politicians cry out for regime change at the highest levels. During election years, the Smart Grid stakeholders are left to ponder the political implications a new president or prime minister will have on the industry in their respective nations.

At a micro level, utilities that are not controlled or owned by the government, as in the U.S., are faced with the daunting challenge of modernizing their electrical systems on very limited budgets (if any).

2. **Global Consensus on Smart Grid Goals and Benefits:** Although developing global consensus may be a daunting task in the short-term, reaching such a consensus over a 10 year time period is a more realistic milestone. Similar to the global consensus on renewable energy generation, such a consensus would be critical to ushering in the development and deployment of next generation Smart Grid technologies over the next 30 years. Of course, every nation could chart their own course to full Smart Grid deployment, but none the less they would all be on the same course (generally speaking).

3. **Interoperability and Standards:** Much attention has been paid to this challenge over the past three years. Although progress has been slow, the development of these standards and guidelines will ensure next-generation utility systems and solutions offered by vendors and entrepreneurs can meet the strict reliability utilities and electricity customers demand. However, stakeholders should be cognizant of the fact that the industry could thwart innovation by not quickly developing standards.

4. **Value Proposition – Financial Constraints:** This challenge is present across utilities and across the Smart Grid technology spectrum. Although many Smart Grid technologies have proved positive returns in controlled environments or labs, the fact remains that full system testing or validation has not been conducted across entire utility systems for a prolonged period of time. However, critical deployments and demonstration in North America will seek to validate these technologies over the next five years. These tests, along with the massive amount of investments into Smart Grid technologies, will drive down the costs Smart Grid technologies. As costs decrease, the value proposition of Smart Grid

technologies will increase, thus leading to an increase in deployment activity for utilities and technology vendors.

5. **Consumer Awareness, Education and Engagement:** Consumer engagement just may be the 'killer app' the Smart Grid has been missing over the past three years. Although many utilities have indicated their commitment to consumer engagement and education, the fact remains that the majority of Smart Grid designs or plans do not contain a strategic consumer engagement plan. To mitigate this problem, every utility should make electricity customers the focal point of their Smart Grid design plan. This will entail including consumer education, outreach, and education as a key component of their Smart Grid design plan. When consumers become the technology champions for Smart Grid technology, every stakeholder wins.

6. **Integration:** Integrating many different types of technologies, systems, equipment and software on a large scale, and at a pace that has not been done before gives rise to complex integration issues for utilities and technology vendors. Even when the standards and interoperability issues are addressed, integration will still be a challenge. Every industry in transition faces integration problems; however, utilities can mitigate these issues through stakeholder collaboration, documenting best practices and integration pitfalls, and by developing case studies from large scale deployments.

7. **Cyber Security:** As we enter an era where hackers, political extremists, cyber and identity thieves, and terrorists all seek to build their network of followers via infamous hacking acts, Smart Grid stakeholders should take note of the target they are placing on their back. The network, information, data and communication traits of the Smart Grid is a playground of sorts for those that seek to disrupt the status quo for the sake of their distinct view of the world. These groups always seem to stay one step ahead of the authorities, but as always innovation and profits will surely lead to an industry solution that can fend off even the brightest hackers. In other words, Smart Grid stakeholders should recruit the brightest and most intelligent minds to address this problem.

8. **Developing Industry Talent:** As millions of baby boomers begin to retire from the utility industry and from technology vendors, the Smart Grid technology industry will be pressed to develop world class business and engineering minds to solve the grid's current and future problems. To solve this problem, government, academia, utilities and technology vendors should develop a Smart Grid oriented degree, discipline or certification that integrates business, engineering, and ICT coursework. Such a degree or area of study could be developed at both the undergraduate or graduate level.

Smart Grid Roadmap

Smart Grid Roadmap, 2012 – 2022

Major Milestones by Stakeholder

	2012 - 2017	2017 - 2022
Government	• Global and National consensus on smart grid standards and benefits • Effective incentives for smart grid investments	• Constructive collaboration among all stakeholders and across world governments • Provide effective oversight to utility industry and Smart Grid technology implementation
Technology Vendors	• Adapting ICT solutions for Smart Grid applications • Establish Smart Grid standards across stakeholders	• Full interoperability to support Energy 2.0 • Deploy best practices to support the next wave: Energy 3.0
Entrepreneurs and Investors	• Collaborate on large scale Smart Grid deployments • Achieve greater interoperability across all vendors	• IPO of several pure play Smart Grid start-ups • Obtain record levels of venture capital
Energy Suppliers	• Document, verify, and validate Smart Grid technology • Develop implementation guide for lessons learned	• Begin deployment of advanced Smart Grid technologies • Become a customer-centric utility industry
Energy Demand	• Development of energy efficiency standards • Adjust load using storage and on-site renewable energy	• Use of EVs technology to shift peak demand • Deployment of building automation systems
Customers	• Obtain high-level of Smart Grid education/awareness • Integrate EVs, DER, and HEMs into their homes	• New homes connect all appliances to the grid • Ability to sell electricity back to the grid

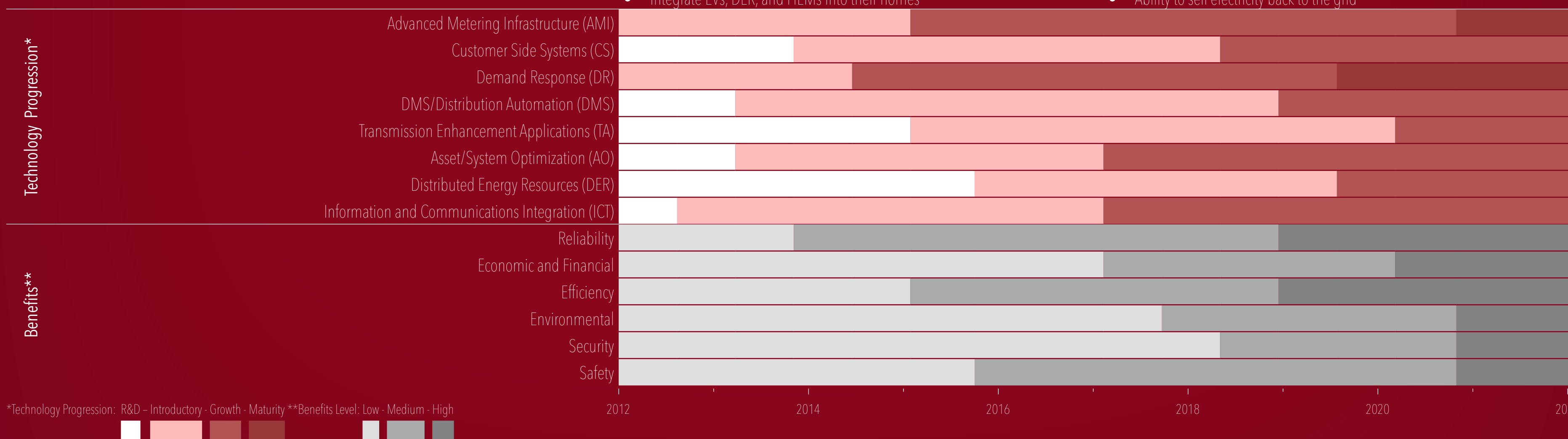


Table 3 - Source: Zpryme

Although multiple Smart Grid pilots, demonstrations and national deployments are currently underway in the U.S. and across the globe, Smart Grid technology is still in a relatively introductory phase. The next 10 years of Smart Grid deployment will build off of the pilots, demonstrations and pilots that have been initiated across the world. Overall, the next 10 years see the grid move from a validation and verification phase to an optimization and advanced technology integration phase. The major phases of Smart Grid technology deployment are described below.

- **2007 – 2012:** With the exception of a handful of utilities, this phase of Smart Grid technology implementation can be characterized as a period of Planning, Pilots, Design, Research and Installation. Even though billions of dollars have been poured into Smart Grid technology to date, the majority of these efforts are just now moving past an installation phase.
- **2012 – 2017:** The next five years will define the future of the Smart Grid. This phase can be characterized as one of Testing, Installation, Validation and Verification. The next five years will be make-or-break years for entrepreneurs and technology vendors as their equipment, solutions, software and systems will be expected to yield positive returns to utilities.
- **2017 – 2022:** If all goes according to plan, this phase can be characterized as Grid Optimization and Advanced Technology integration. During this phase, utility systems and customers will start to truly reap the benefits of Smart Grid technology. An optimized grid will allow utilities to maximize asset utilization, control, and monitor and manage their entire electric system, and allow their customers to embrace advanced energy control and monitoring technologies.

Technology Progression

Please reference the Methodology section of this report for technology definitions, and for guidance regarding the technology progression and benefits rating criteria. Achieving economies of scale will be a critical to the success of the Smart Grid. Economies of scale will enable costs to drop significantly among technologies move from an introductory to a growth phase. The decrease in technology costs will amplify the adoption rate of these technologies as late mover utilities and utilities in the developing world will be better able to justify their ROI for Smart Grid technologies.

- **AMI:** Over the next 10 years, AMI will transition from an introductory phase to a maturity phase. However, the majority of this period will be one of high growth for AMI.
- **CS:** Over the next 10 years, CS will transition from an R&D phase to a growth phase. CS should move into a growth phase a few years after 2017.
- **DR:** Over the next 10 years, DR will transition from an introductory phase to a maturity phase. Among the major Smart Grid technologies to be deployed over the next 10 years, DR will reach a maturity phase the fastest.
- **DMS/DA:** DMS and DA technologies will transition from an R&D phase to a growth phase over the next 10 years.
- **TA:** TA technologies will transition from an R&D phase to a growth phase over the next 10 years. However, TA will spend about the next four years in an R&D phase before moving into an introductory phase.
- **AO:** Similar to TA technologies, AO technologies will transition from an R&D phase to a growth phase over the next 10 years. However, AO technologies are further along in their testing and development than TA technologies, thus they will enter an introductory phase in about two years.

- **DER/DG/Energy Storage:** Although much attention and R&D has been committed to DER, DG, and Energy Storage, these technologies will take the longest to reach an introductory phase. Much of this can be attributed to the high costs of integrating these technologies. However, once a winning technology emerges as superior relative to competing technologies, the adoption of DER, DG, and Energy storage will progress rapidly.
- **ICTs:** Although progressive utilities around the globe are well ahead of the curve in implementing ICTs, especially in North American and the EU. However, ICT penetration is relatively low from a global Smart Grid landscape perspective. That said, ICTs will transition from an R&D phase to a growth phase by 2017. This will also be one of most highly contested markets over the next 10 year. There is plenty of room for growth in this market as ICTs must be deployed across the utility value chain to maximize grid reliability and optimization.

Benefits

Over the next 10 years, society and the key stakeholders will achieve the highest benefit from grid reliability and efficiency. Economic and financial benefits come in third. Environmental, security and safety benefits are expected to deliver the least amount of benefits over the next 10 years.

Emerging Smart Grid Technologies and Applications

Across the utility and stakeholder spectrum, several Smart Grid technologies and applications are expected to yield strong revenue gains and overall grid reliability and efficiency benefits to the industry. Seven of these emerging technologies and applications are described below.

Demand Response and Peak Demand Reduction

The increased amounts of data gathered from a Smart Grid can show where operational efficiency can be improved and increased automation can improve control of various parts of the system, enabling fast response to changes in demand. Reducing peak demand is likely to be the first priority because demand at a system level is relatively predictable and ramps up and down slowly compared with variable generation. As demand response technology develops and human interactions are better understood, the availability, volume and response time of the demand-side resource will provide the flexibility necessary to respond to both peak demand and variable generation needs.

Renewable Energy Integration

The introduction of regional energy resources, including the variable generation sources of solar, wind, small-scale hydro, and combined heat and power, as well as dispatchable generation such as biomass, reservoir-based hydropower and concentrating solar power systems, will increase the amount of generation capability on the system. Smart Grids enable improved, lower-cost integration of these and other variable technologies that may require different electricity system operation protocols.

Energy Storage

Another keystone technology for the Smart Grid and alternative energy is storage. Good energy storage does more than anything else to reduce the strain on the grid and the dependence on central resources. Thermal storage, particularly storing cold in summer, has already taken off as a

Smart Grid technology. But almost any energy storage, whether based on thermal, chemical, or potential energy, can be configured to provide the demand responsiveness that the grid needs today.

EVs, PHEVs, Charging Infrastructure and V2G

The deployment of EV/PHEV technology can also have a significant positive impact on peak demand. If charging is performed in a controlled fashion, either by way of a scheduling process or interactively with signals from utilities, the impact on peak demand could be significantly minimized. The electricity storage in EVs/PHEVs could also be used to reduce the impact of peak demand by providing electricity at or near end-user demand (V2G). Future generations of EVs will have the ability to deliver power from the battery into the grid when needed.

Distributed Energy Resources

Of equal importance going forward is distributed generation (DER), also called on-site generation, wherein electricity is generated from many small energy sources. These DER systems are small-scale power generation technologies, usually in the range of 3 kW to 10,000 kW, and are used to provide an alternative to, or an enhancement of, the traditional electric power system. Distributed generation reduces the amount of energy lost in transmitting electricity because the electricity is generated very near to where it is used, perhaps even in the same building. DER systems may include in the following devices or technology: Combined heat power (CHP), fuel cells, micro-combined heat and power (Micro CHP), microturbines, photovoltaic systems, reciprocating engines, small wind power systems, and stirling engines. In addition, solid oxide fuel cells using natural gas, such as the Bloom Energy Server, have recently become a distributed energy resource.

Distributed cogeneration sources use natural gas-fired microturbines or reciprocating engines to turn generators. The hot exhaust is then used for space or water heating, or to drive an absorptive chiller for air conditioning. Some larger installations utilize combined cycle generation. Usually this consists of a gas turbine whose exhaust boils water for a steam turbine in a Rankine cycle. The condenser of the steam cycle provides the heat for space heating or an absorptive chiller. Combined cycle plants with cogeneration have the highest known thermal efficiencies, often exceeding 85%.

An electric vehicle network may also be an important distributed energy resource some time to come in the future.

Microgrids

Microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operate when connected to a traditional centralized grid (macrogrid). This single point of common coupling with the macrogrid can be disconnected and the microgrid can then function autonomously. Generation and loads in a microgrid are usually interconnected at low voltage, and from the point of view of the grid operator, a connected microgrid can be controlled as if it was one entity. Microgrid generation resources can include fuel cells, wind, solar, or other energy sources. The multiple dispersed generation sources and the ability to isolate the microgrid from a larger network would provide highly reliable electric power.

Smart Cities and Smart Communities

Several concepts are emerging that extend the reach of the Smart Grids from electricity systems to broader energy contexts. One of these is the Smart Community or Smart City. A Smart Community integrates several energy supply and use systems within a given region in an attempt to optimize operation and allow for maximum integration of renewable energy resources, from large-scale wind farm deployments to micro-scale rooftop photovoltaics. The concept includes existing infrastructure systems, such as electricity, water, transportation, gas, waste and heat, as well as future systems like hydrogen and electric vehicle charging. Smart Communities are likely to ultimately evolve to other infrastructure systems such as commercial and industrial Smart Buildings.

Government

Smart Grid Roadmap, 2012 – 2022: Government Stakeholder

Description: The Government stakeholder is comprised of national, state, local, and provincial entities that regulate and develop policy for the utility and energy sector.

Examples: U.S. DOE, U.S. FERC,

Role: Facilitate national and global communication and collaboration on Smart Grid standards, pilots, and deployments across stakeholders. Provide support, in the form of financial incentives, policy goals, and renewable energy targets are creating a thriving environment for utilities, entrepreneurs, and technology vendors to innovate and implement Smart Grid technology.

		2012 - 2017	2017 - 2022
Major Milestones	Milestones	• Global and National consensus on Smart Grid standards and benefits • Effective incentives for Smart Grid investments • Constructive collaboration among all stakeholders • Private sector endorsement of Smart Grid goals • Facilitate competitive environment for Smart Grid product manufacturers	• R&D and financial support for burgeoning technologies that support Smart Grid effectiveness • Renewable energy and greenhouse gas reduction targets achieved • Constructive collaboration among all stakeholders and across world governments • Provide effective oversight to utility industry and Smart Grid technology implementation
Policy, R&D Support, and Benefits	Major Laws, Regulations, and or Policy Targets	• Require adoption of Smart Grid standards by utilities • Support tax incentives/credits for utility/consumer utilization of Smart Grid technologies	• Incentivize states to provide tax incentives/credits for Smart Grid technologies • Require new homes to have Smart Grid demand response technologies
	Level of R&D and Financial Support for Smart Grid and Electrical Infrastructure	High	Low - Medium
	Major Benefits to Industry and Society	Reliability, Efficiency, Economic	Reliability, Efficiency, Economic, Environmental, Security, Safety

Table 4 - Source: Zpryme

Overview

The Government stakeholder is comprised of national, state, local, and provincial entities that regulate and develop policy for the utility and energy sector. Major governmental stakeholders are mostly oriented around offices of the Department of Energy, although other independent research organizations and national associations of vested parties are also involved. The list also includes standards and policy oriented non-profit organizations that collaborate with regulators to develop Smart Grid policies and standards.

- U.S. Department of Energy (Office of Energy Efficiency and Renewable Energy)
- U.S. Federal Energy Regulatory Commission
- U.S. National Institute of Standards and Technology
- Ministry of Economy, Trade, and Industry (Japan)
- Agency for Natural Resources and Energy (Japan)
- Department of Resource Conservation and Environmental Protection (China)
- National Energy Administration (China)
- Ministry of Power (India)
- Ministry of New and Renewable Energy (India)
- The Ministry of Energy (Russian Federation)
- Ministry of Knowledge Economy (South Korea)
- Korea Smart Grid Institute (South Korea)
- Minister of Natural Resources (Canada)
- National Energy Board (Canada)
- Secretary of Energy (Mexico)
- Department of Resources, Energy and Tourism (Australia)
- EU Energy Commission (all 27 EU nations)
- Brazil Electricity Regulatory Agency (ANEEL)
- United Nations Climate Change and Energy Programs
- European Telecommunications Standards Institute
- International Energy Agency
- National Association of Regulatory Commissioners
- GridWise Alliance
- Electric Power Research Institute
- IEEE
- IEC

Role

The government stakeholder's role is to facilitate national and global communication and collaboration on Smart Grid standards, pilots, and deployments across stakeholders. Government support, in the form of financial incentives, policy goals, and renewable energy targets are creating a thriving environment for utilities, entrepreneurs, and technology vendors to innovate and implement Smart Grid technology. The government's role in developing the Smart Grid is to support the sustainability of an energy supply. A further role in creating Energy 2.0 is to expand the available information about energy through an open, government-initiated distribution of data.

Significant World Government Initiatives

Major world governments, led by the EU, China, and U.S., have laid out detailed Smart Grid plans for their respective countries. These contributions will build the foundation for the future growth and development of the Smart Grid over the next 10 years. The goals and targets of major government are summarized below.

- Australia
  - By 2020, the majority of households and businesses will have access to Smart Grid technology.
  - Goal of 20% electricity from renewables by 2020.
- Brazil
  - Deploy 65 million smart meters by 2020.
  - Goal to have 16% of electricity from renewables by 2020.
- China
  - Install 300 million smart meters by 2015.
  - Goal of 15% electricity from renewables by 2020.
- European Union (EU)
  - European Union mandate calls for 100% customer smart meter rollouts by 2022.
  - This equates to about 240 million households with smart meters by 2022.
  - Goal of 20% electricity from renewables by 2020.
- United States
  - Goal of 40 million smart meters by 2015.
  - 29 states, Washington D.C., and Puerto Rico have Renewable Portfolio Standard Polices to be met between 2015 and 2035.
- Japan
  - Build the world's most advanced next-generation interactive grid network as early as possible in the 2020s.
  - Install 17 million smart meters by 2019.
  - Goal of 20% electricity from renewables by 2020.
- South Korea
  - Goal to install 18 million smart meters by 2020.
  - Bring Smart Grid into metropolitan areas by 2020.
  - Build a nationwide, intelligent power grid by 2030.
  - Goal of 6.1% electricity from renewables by 2020.

The Path Forward

Over the next 10 years, the role of government should shift from one that provides funding, collaboration, and R&D support to one that mainly provides oversight, regulation, and collaboration support. Such a transition should facilitate a transparent market environment that easily enables utilities, entrepreneurs, technology vendors, and electricity customers to implement Smart Grid technologies. Additionally, this role will foster an innovative environment that ushers in a new generation of advanced Smart Grid technologies. Below are three high priority items governments across the world should consider as they seek to implement Smart Grid technologies.

- In their pursuit of next-generation energy solutions, the government should actively engage utilities, technology vendors, industry, and electricity customers.
- By 2022, customers should be driving demand for Smart Grid technology.
- With respect to electricity customers, the government should take the lead in championing Smart Grid education and awareness.

Technology Vendors

Smart Grid Roadmap, 2012 – 2022 – Technology Vendors

Description: The Technology stakeholder is comprised of small, medium, and large for-profit firms and multi-national corporations in the technology, software, networking, telecom, and energy equipment and systems business serving the entire Smart Grid sector, from generation, transmission, distribution, and consumption.

Examples: GE, Siemens, ABB, Cisco, Oracle, SAP, IBM, Alstom, Itron, Elster, Echelon, Telvent, eMeter, Alcara, Sensus, Silver Spring Networks and Toshiba.

Role: Work with policy makers and standards development entities to create large scale solutions that can effectively be deployed by utilities. Develop a deep understanding of the emerging needs and pain points across the full spectrum of the energy business. Foster innovative solutions for the Smart Grid industry through R&D, and by purchasing or investing in start-ups.

		2012 - 2017	2017 - 2022
Major Milestones	Milestones	• Continue adapting solutions for the communications market for Smart Grid applications • Establish Smart Grid standards across all stakeholder groups • Achieve greater interoperability across all vendors serving Smart Grid • Advocate for energy policies and regulatory reform that supports the Energy 2.0 vision • Continue R&D and support of entrepreneurs solely focused on Smart Grid	• Among utilities who have started deployment by 2017, full Smart Grid technology deployment on the supply side • Advanced deployments on the demand side – commercial/ industrial and residential • Full interoperability across Smart Grid ecosystem to support Energy 2.0 • Evolution of an infrastructure to support mainstream adoption of EVs • Deploying best practices gained from global initiatives to support the next wave - Energy 3.0
Innovation Support	R&D Investment Level	High	High
	Support, Investment, and/or Acquisition of Start-Ups	High	High
Area of Solution Need Opportunity Level	Generation	Low	Medium
	Transmission	Medium-High	High
	Distribution	High	High
	Customers (Commercial, Industrial and Residential)	Low	Medium-High

Table 5 - Source: Zpryme

Overview

Creating Energy 2.0 – abundant, affordable, clean energy – is a noble but complex vision, and is very much a work in progress. At the most basic level, each stakeholder group has distinct objectives and is progressing at different rates. Unlike communications, the energy market remains highly regulated, and the prime players – utilities – tend to move slowly. With limited competitive options, this creates a bottleneck for entrepreneurs, who are innovating faster than utilities are able to deploy.

Technology vendors are stuck in the middle of this spectrum, and despite their ability to help utilities successfully deploy Smart Grid, they are constrained by both market-based and structural forces. End consumers are starting to create bottom-up demand for Energy 2.0, driven by concerns around high gas prices, global warming, conservation, sustainability, reducing our carbon footprint, energy independence, etc. Utilities are trying to address this with AMI deployments, demand response, renewable energy projects, etc., but efforts have been piecemeal, and the economics of most initiatives are not yet viable.

This makes for a long sales cycle, which is further compounded by slow progress on developing Smart Grid standards and achieving interoperability among the various stakeholders. At the beginning point of the value chain – entrepreneurs – Smart Grid innovation can only continue so long as utilities are deploying. When rollout programs stall, and/or government subsidies dry up, only the strongest startups can survive, and long term smart innovation will be hindered.

Technology vendors – who rely on entrepreneurs for a lot of innovation – are in a similar spot, but generally have other options. They can only push so hard to drive utilities to deploy Smart Grid, and if progress is too slow, they will focus priorities and resources into other lines of business – telecom, cable, Internet, etc. – that are in spending mode and have shorter buying cycles. They will continue to remain committed to Energy 2.0, but ultimately can only move as fast as the utilities can go to market.

In terms of broader market presence, technology vendors are dominated by a handful of global players, as they have the scale needed to support the major utilities that drive the lion's share of Smart Grid spending. These solutions are large, complex and expensive, and will define the most successful applications that embody Energy 2.0. However, as the technology moves from the grid out to the end customers, there is much more latitude for smaller scale, specialized services and solutions. At this end of the market, there is room for far more vendors, both large and small, at least for the time being. Over time, as end market solutions reach critical mass and maturity, the vendor pool will consolidate, and to some extent will revert to the majors serving utilities now.

Major Smart Grid Technology Vendors

The small list below is provided for example purposes only, and is not intended to be an exhaustive list of technology vendors active in the Smart Grid space.

> *Cisco, GE, IBM, Siemens/NSN, ALU, Oracle, SAP, Google (not so sure any more), Microsoft (same), ADTRAN, Alvarion, Redline, Sierra Wireless, Tropos Networks, Aviat Networks, Motorola, Toshiba, Hitachi, Tendril, eMeter, GridPoint, Tantalus, iControl, Control4, Coulomb*

Role

Technology vendors play a key role by taking the innovation from entrepreneurs, and working with the regulatory framework established by policymakers to create large scale solutions that can effectively be deployed by utilities. Each utility will have its own Smart Grid roadmap, but to support the Energy 2.0 vision, technology vendors need to increasingly enable connectivity, control and communications for them.

To fulfill this role, technology vendors must have a deep understanding of the emerging needs and pain points across the full spectrum of the energy business, spanning generation, transmission and distribution. This stakeholder group must also have a firm grasp of end customer needs - both commercial/industrial and residential - not only to address current limitations, but also how new technologies create opportunities that arise from end customers working together with utilities to help realize the potential of Energy 2.0.

As a critical stakeholder in the Energy 2.0 and Smart Grid roadmap, R&D is a secondary focus for technology vendors. Their current success comes from commercializing Internet, IT and networking-based technologies in the communications sector, which has undergone a radical transformation during the past 10 years with the advent of IP – Internet Protocol – and more recently, mobile broadband. The R&D for these technologies has come largely from venture-backed startups, many of which have been acquired by larger technology vendors. While some of these vendors are true innovators, they primarily add value via their long-term customer relationships with communications companies, and competencies to scale and support their solutions.

Their value-add for Smart Grid is identifying technologies that have been successfully deployed in the communications sector, and adapting them for utilities, who are now undergoing a similar transformation, but on an even larger and more daunting scale. To a large extent, the R&D from entrepreneurs focused on communications can be leveraged for Smart Grid, but technology vendors are also working increasingly with newer startups just focused on energy.

The Path Forward

This will vary according to where technology vendors focus along the Smart Grid spectrum. Some address it all – generation, transmission, distribution – while others address one segment or just a sub-set such as SCADA, M2M, smart home or EVs. Regardless of focus, the end result 10 years from now will be the same for Energy 2.0 – connectivity, control and communication.

For technology vendors, connectivity will mean providing utilities with solutions that give them full visibility across their network, replacing manual effort with 24/7 sensors and M2M points of contact. Among end users, AMI is the starting point for total connectivity whereby all devices and appliances dependent on the grid will eventually be networked. Once this connectivity is in place, utilities will have far greater control capabilities, and the associated cost and energy savings should more than offset the investment required with technology vendors.

To keep the market moving forward, technology vendors have another important role to play. If the pace of investment from utilities slows down, these vendors will be in a good position to acquire startups that cannot wait out the long cycles for getting to market. This will be especially important for technology vendors who are not willing/able to invest in their own Smart Grid R&D.

Finally, the goal for communications is to create a foundation with utilities to support new services that will come as Smart Grid matures. The possibilities for two-way, real-time communications are vast, and we are still in early days with mobile Internet, cloud, cybersecurity and Big Data analytics. These technologies will lay the foundation for widespread demand response programs, renewables-based microgrids, more accurate demand forecasting and new revenues from smart energy applications, especially around EVs and storage.

Entrepreneurs and Investors

Smart Grid Roadmap, 2012 – 2022 – Entrepreneurs and Investors

Description: The Entrepreneur and Investor take on risk to develop disruptive Smart Grid technology, applications, equipment, systems and software.

Examples: OPower, GridGlo, Incenergy, Tendril, On-Ramp Wireless, Smart Wire Grid and Vizimax.

Role: Innovate for the industry by identifying existing 'solution gap' within the utility value chain (generation to consumption).

Capture significant sales and profits by achieving a distinct competitive market position, and/or position their company for growth – with IPO or buyout as an exit strategy.

		2012 - 2017	2017 - 2022
Major Milestones	Milestones	• Obtain a significant number of utility customers • Collaborate with utilities, government, and major technology vendors on large scale Smart Grid deployments • Achieve greater interoperability across all vendors serving Smart Grid • Develop international operations and customers • Become highly engaged in the standards and policy development conversation	• IPO of several pure play Smart Grid start-ups • Obtain record levels of venture capital • Emergence of firms providing services for commercial/industrial and residential • Emergence of firms providing 3rd party information management solutions to utilities • Emergence of firms providing services to support mainstream adoption and integration of renewable generation, storage, EVs, and EV charging
Financial Support	Angel, Seed, and Venture Capital	Medium-High	High
	Government and Industry	Medium-High	Low-Medium
Area of Solution Need Opportunity Level	Generation	Low	Low
	Transmission	Low	Low-Medium
	Distribution	Medium	High
	Customers (Commercial, Industrial and Residential)	Medium-High	High

Table 6 - Source: Zpryme

Overview

Entrepreneurs and investors take on risk to develop disruptive Smart Grid technology, applications, equipment, systems and software. Listed below are some of the start-up companies that have thrived in developing world class Smart Grid solutions. Some of the major investors are GE, Hitachi, Khosla Ventures, Tech Coast Angels, BDC Venture Capital, Intel Capital, Physic Ventures, Qualcomm Ventures, Kleiner Perkins Caufield & Byers and Emerald Technology.

OPower, GridGlo, Incenergy, Tendril, On-Ramp Wireless, Smart Wire Grid, Vizimax, Silver Spring Networks, Cpower

Role

Within the context Smart Grid development and Energy 2.0, entrepreneurs and investors innovate for the industry by identifying existing 'solution gaps' within the utility value chain (generation to consumption). This enables them to capture significant sales and profits by achieving a distinct competitive market position, and/or position their company for growth – with an IPO or buyout as an exit strategy. Further, this stakeholder is charged with developing next-generation solutions and technologies for the utility industry as major technology vendors are not designed to develop niche solutions for fast growing industries.

The Path Forward

Over the next 10 years, entrepreneurs and investors will take the lead in developing next-generation Smart Grid solutions and technologies. This will be especially true as government backed funding and investments are scaled back over the next five years. Further, the next 10 years will give rise to a handful of IPOs for companies solely dedicated to providing Smart Grid oriented solutions. However, this transition will leave many start-ups and investors with plenty of 'war wounds' as many companies will not have the financial liquidity to survive the long buying cycles of utilities. Finally, entrepreneurs and investors that develop solutions for utility distribution systems and electricity customers will see significant opportunities in areas such as M2M, V2G, B2G, home area networks, sensors, energy storage and renewable integration systems and software, and mobile energy management applications.

Major Technology Vendor Acquisitions of Niche Smart Grid Firms and Start-Ups

Over the past two years several global technology vendors have acquired Smart Grid focused firms and start-ups. The top acquisitions in 2011 and 2012 (to date) are listed below. This trend is expected to accelerate over the next 10 years.

Company	Acquirer	Value (millions)	Date
Cooper Industries	Eaton Corp.	$11,460	2012
SmartSynch	Itron	$100.0	2012
eMeter	Siemens	$220.0	2012
RuggedCom	Siemens	$382.0	2012
Comverge	H.I.G. Capital	$49.0	2012
Landis+Gyr	Toshiba	$2,300.0	2011
Telvent	Schneider Electric	$2,000.0	2011
Summit Energy	Schneider Electric	$268.0	2011
EnergyConnect	Johnson Controls	$32.3	2011
EnergyResponse	EnerNOC	$29.9	2011

Energy Supply

Smart Grid Roadmap, 2012 – 2022 – Energy Suppliers

Description: Utilities providing generation, transmission and distribution of electricity (any combination).

Examples: Duke Energy, State Grid Corporation of China, TEPCO (Japan), PG&E, SCE, Austin Energy, Xcel Energy, and National Grid.

Role: Provide reliable, sustainable, and affordable power to their customers.

Collaborate with vendors, entrepreneurs, government, and customers to deploy technologies that will increase grid stability and energy efficiency, and provide social and financial benefits to their customers.

Energy suppliers are funding, integrating and implementing the lion's share of Smart Grid technology.

Major Milestones

	2012 - 2017	2017 - 2022
Milestones	• Collaborate with other utilities, government, and major technology vendors on large scale Smart Grid deployments, standards creation, and policy guidance • Full AMI deployments among early adopter utilities • Document, verify, and validate Smart Grid technology • Develop national implementation guide for benefits and lessons learned	• Complete DMS/DA and Demand Response deployments among early adopter utilities • Maximize grid optimization and begin deployment of advanced Smart Grid technologies • Become a customer-centric utility industry • Achieve renewable generation and integration targets • Deploy advanced customer facing technologies and dynamic pricing options

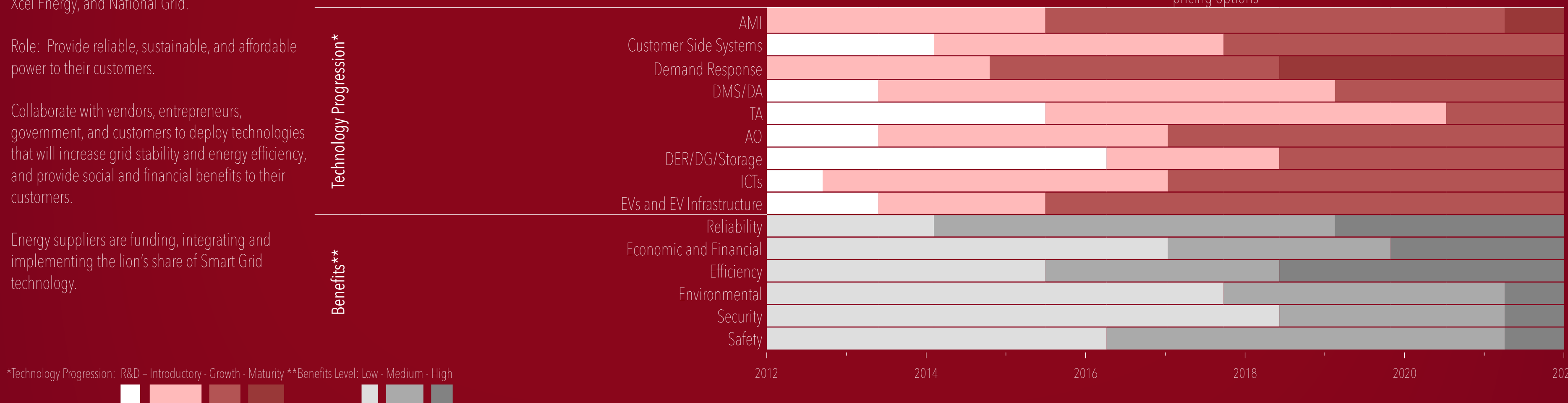


Table 7 - Source: Zpryme

Overview

Energy suppliers are funding, integrating and implementing the lion's share of Smart Grid technology. Additionally, utilities are currently the central focal point of the Smart Grid technology revolution. Progressive utilities that are currently deploying Smart Grid technology include: Duke Energy, State Grid Corporation of China, TEPCO (Japan), KEPCO (South Korea), PG&E, SCE, Austin Energy, Xcel Energy, and National Grid.

Role

Even though there are drastic changes taking place in the utility industry, their overall role remains the same: provide reliable, sustainable, and affordable power to their customers. Within the context of Energy 2.0 and Smart Grid technology implementation, utilities must collaborate with vendors, entrepreneurs, government, and customers to deploy technologies that will increase grid stability and energy efficiency, and provide social and financial benefits to their customers.

Technology Progression

Please reference the Methodology section of this report for technology definitions, and for guidance regarding the technology progression and benefits rating criteria. Given that utilities will account for the majority of Smart Grid investments and technology deployments over the next 10 years, the technology progression for utilities is very similar to the overall 2012 – 2022 Smart Grid Roadmap.

- **AMI:** Over the next 10 years, AMI will transition from an introductory phase to a maturity phase. However, the majority of this period will be one of high growth for AMI.
- **CS:** Over the next 10 years, CS will transition from an R&D phase to a growth phase.
- **DR:** Over the next 10 years, DR will transition from an introductory phase to a maturity phase.
- **DMS/DA:** DMS and DA technologies will transition from an R&D phase to a growth phase over the next 10 years.
- **TA:** TA technologies will transition from an R&D phase to a growth phase over the next 10 years.
- **AO:** Similar to TA technologies, AO technologies will transition from an R&D phase to a growth phase over the next 10 years.
- **DER/DG/Energy Storage:** Although much attention and R&D has been committed to DER, DG, and Energy Storage, these technologies will take the longest to reach an introductory phase. Much of this can be attributed to the high costs of integrating these technologies. However, once a winning technology emerges as superior relative to competing technologies, the adoption of DER, DG, and Energy storage will progress rapidly.
- **ICTs:** Over the next 10 years, ICTs will transition from an R&D phase to a growth phase.
- **EVs and EV Infrastructure:** Over the next 10 years, EVS will transition from an R&D phase to a growth phase. However, the transition from introductory to growth will be relatively short due to the increasing fossil fuel costs in developed countries that are expected to ramp up the demand for EVs, therefore forcing utilities to rapidly deploy the infrastructure to support EVs.

Benefits

Over the next 10 years, utilities will achieve the highest benefit from grid efficiency. The second and third highest benefits will come from reliability and economic and financial benefits. Environmental, security and safety benefits are expected to deliver the least amount of benefits over the next 10 years.

The Path Forward

Overall, utilities can be classified into two categories when it comes to Smart Grid technology implementation: Early Adopters and Late Movers.

- Early Adopters
  - Over the next 10 years, these utilities will shift from a ratepayer-centric business model to a customer-centric business model.
  - 2012 to 2017 will see these utilities invest heavily in AMI, distribution automation technologies, and transmission monitoring technologies.
  - 2017 to 2022 will see these utilities aggressively implement energy storage, distributed generation, V2G and B2G, d customer-level networks, applications, software, equipment, technologies and systems.
- Late Movers
  - 2012 to 2017 will see these utilities closely monitor the progress and results of Early Adopters.
  - 2017 to 2022 will see a portion of Late Movers begin to deploy Smart Grid technology (mainly AMI).

World's Largest Smart Grid Projects by Utility

The top 30 largest announced Smart Grid deployments in the world total $112 billion in committed spending from 2010 to 2020. The U.S. projects are the total project value of U.S. ARRA Smart Grid grant funded projects announced in November of 2009. State Grid of China, KEPCO, and TEPCO amounts are the announced spending on their Smart Grid projects from 2010 to 2020. Clearly, the State Grid of China has set out to become the world's most advanced utility when it comes to Smart Grid technology implementation.

Top 30 Largest Smart Grid Deployments in the World (2010 to 2020)

Company	Acquirer	Value (millions)
State Grid Corp of China	China	$100,000
KEPCO	South Korea	$1,970
TEPCO	Japan	$2,600
Duke Energy Carolinas, LLC	U.S.	$688
CenterPoint Energy	U.S.	$639
Florida Power and Light Company	U.S.	$579
Progress Energy	U.S.	$520
Baltimore Gas and Electric Company	U.S.	$472
PECO	U.S.	$415
Oklahoma Gas and Electric	U.S.	$357
Pacific Gas and Electric Company	U.S.	$356
Southern Company Services, Inc.	U.S.	$330
Sacramento Municipal Utility District	U.S.	$308
NV Energy, Inc.	U.S.	$278
Consolidated Edison Company of New York, Inc.	U.S.	$272
PJM Interconnection, LLC	U.S.	$228
EPB	U.S.	$227
Potomac Electric Power Co	U.S.	$210
Central Maine Power Company	U.S.	$192
Battelle Memorial Institute	U.S.	$178
Detroit Edison Company	U.S.	$169
AEP Ohio	U.S.	$150
Vermont Transco, LLC	U.S.	$138
New York State Electric and Gas	U.S.	$125
Los Angeles Department of Water and Power	U.S.	$121
FirstEnergy	U.S.	$115
Salt River Electric	U.S.	$114
Western Electricity Coordinating Council	U.S.	$108
Idaho Power Company	U.S.	$94
Consolidated Edison Company of New York, Inc.	U.S.	$92
Total		$112,046

Table 8 - Source: Zpryme

Energy Demand

Smart Grid Roadmap, 2012 – 2022 – Energy Demand

Description: This is infrastructure that consumes electricity for industry and society functions. This excludes residential consumers.

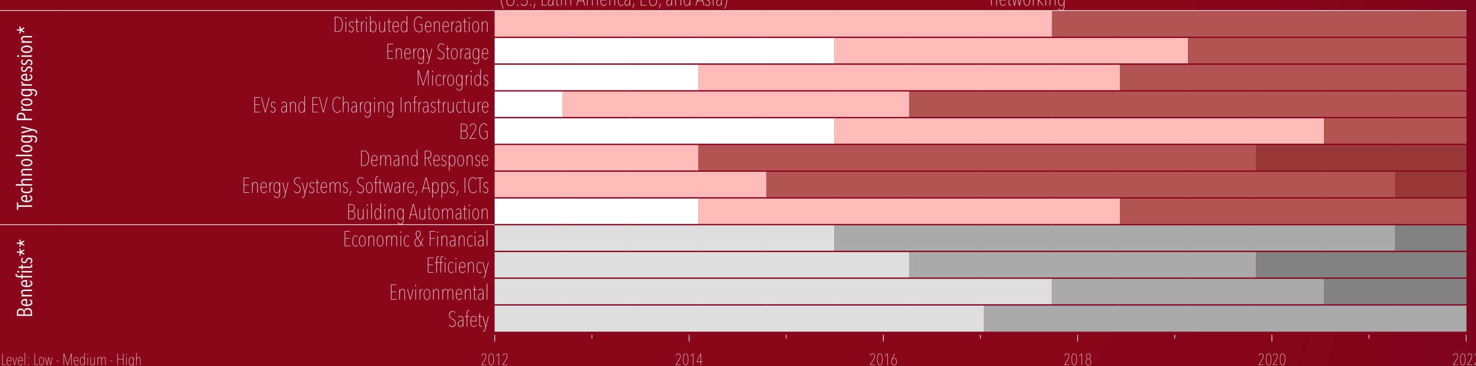
Examples: Commercial and Industrial buildings, offices, and transportation and city infrastructure.

Role: Provide reliable, sustainable, and affordable services, products, and or goods to their customers, and provide a safe and environmentally friendly place to work.

Collaborate with utilities and vendors to evaluate Smart Grid technologies that enable the Energy Demand stakeholder to decrease their energy costs, decrease their impact on the environment, integrate renewables, and create channels to participate in electricity market operations.

Major Milestones

	2012 - 2017	2017 - 2022
Milestones	• The development of energy efficiency standards, ratings and disclosures leading to the retrofit of existing buildings • Advances in internet technologies and the inclusion of the commercial, industrial and institutional buildings into the Smart Grid as a virtual energy source • Shift load off-peak using storage and on-site renewable energy sources leading to being off the grid altogether • Two-way interoperable communication between supply and demand to achieve action and reaction in real time • Deploy several national Smart Building and Smart City Projects (U.S., Latin America, EU, and Asia)	• Real-time pricing and automated demand requests • Ability to produce and sell small amounts of electricity back to the grid • The deployment of EV/PHEV technology to provide positive impact on peak demand • Deployment of building automation systems and energy storage systems • Self-powered wireless devices to integrate smart building technologies into existing buildings • Wireless Mesh technology for next-generation wireless networking



*Technology Progression: R&D – Introductory - Growth - Maturity **Benefits Level: Low - Medium - High

Table 9 - Source: Zpryme

Overview

Energy 2.0 has been formulated because of skyrocketing energy costs, a lack of clean energy supply, and an increasingly information-rich society. Meeting energy demand for homes, buildings, transportation, and infrastructure is certainly critical to building a fully optimized Smart Grid.

Commercial, industrial and institutional buildings account for approximately 40% of the world's energy consumption and 20% of total CO2 emissions. The U.S. Energy Information Administration (EIA) is expecting demand for electricity in the commercial sector to grow to 42% by 2035. In 2008, overall emissions came from buildings (40%), transportation (33%), industrial (27%), residential (21%) and commercial (19%). For commercial and industrial consumers, energy bills comprise a large percentage of operating expenditures, particularly demand-related charges which represent an average 30-70% of the total electric bill. Therefore, the intersection of the Smart Grid and the Smart Building will open the way for significant opportunities for building owners, utilities, technology vendors, and entrepreneurs.

Role

The BAS (Building Automation Systems) industry is going through a very significant change with advances in internet technologies and the inclusion of the commercial, industrial and institutional buildings into the Smart Grid as a virtual energy source. The goal of net zero buildings is to shift load off-peak using thermal storage and on-site renewable energy sources leading to being off the grid altogether. Within this context, the energy internet is an important solution since the distribution grid can no longer grow substantially in major cities. The energy internet will allow rapid interaction with the supply grid to enable supply and demand to talk and cooperate with one another to achieve action and reaction in real time without manual intervention. When this is coupled with real-time pricing and automated demand requests, great changes can be made within the existing electrical infrastructures.

What started as EMS Energy Management back in the 1970's has evolved into a myriad of services including base control systems, integrated building information systems, facility management, and increasingly more inclusive of IT infrastructures found in today's large buildings. There is currently a return to the basics of energy management with a completely new set of technologies, tools, and players. Building automation systems monitor and control a building's lighting and mechanical systems and are operating in roughly half of all buildings over 100,000 square feet in the United States. In addition, commercial and industrial consumers are becoming "prosumers", a group that can be defined as electricity consumers who produce small amounts of electricity at or near the point of consumption. They actively engage themselves via demand response, distributed energy production, co-generation, and more.

The latest trend of importance is the connection of buildings to the Smart Grid (B2G) by way of critical enablers such as demand response (load shifting). Demand response is a method of exercising greater control over an entire electrical grid system by using a facility's individual ability to reduce usage when the grid is overly stressed.

Today, most problems preventing buildings from contributing to energy efficiency and peak demand reduction are political, not technical. The

Federal Government shies away from efforts that are based on such a large and robust endeavor even though the Energy Star program for commercial and industrial building has achieved significant market share on a voluntary basis. Nonetheless, individual states of the union have become very interested in building energy rating and disclosure as a tool to help the marketplace value energy efficiency, encourage building energy retrofits and reduce energy consumption and greenhouse gas emissions. The absence of a federal policy has allowed states and jurisdictions to experiment with different strategies. In fact, 25 states have energy efficiency standards or targets in place. These mandates are primarily aimed at existing buildings, which comprise the vast majority of the building stock and present the largest opportunity for reductions in energy and greenhouse gas emissions.

The U. S. marketplace is already factoring energy efficiency into its real estate decision-making and this will be a huge driver in pushing the Smart Building and Smart Automation technologies into a state similar to a snow ball rolling downhill and becoming larger and larger as it rolls. Energy-efficient properties have greater occupancy levels and higher lease rates and sales prices than comparable but less-efficient buildings. These trends will likely accelerate as more buildings are rated and more ratings are disclosed. If consumers show deference to energy-efficient properties, the owners of less efficient buildings will be forced to make building energy efficiency improvements to remain viable in the market.

Linking commercial and industrial buildings to the grid is heating up and, at the end of the rainbow, lies a pot of gold. All types of companies, including conglomerates and start-ups are going it on their own or are partnering and acquiring others. Companies with huge global footprints, such as Siemens, GE, IBM, Schneider Electric, Johnson Controls, Honeywell, Echelon, EnerNOC, SAP, and Oracle that have no direct experience are snatching up young technology innovators to jump on the bandwagon. These heavy weights are throwing their weight (and cash) around by covering upfront costs in return for later sharing in revenues from the energy savings.

Johnson Controls recently completed an acquisition of EnergyConnect Group, a leading demand response provider. Johnson has traditionally been in the market helping building operators manage how much energy they consume. With this acquisition, JC can now help them manage when energy is consumed. With help from EnergyConnect, commercial users no longer have to turn things off manually in answer to a demand response event. The system can trigger a pre-programmed, set-and-forget response. Or it can give the building operator a choice from several pre-programmed strategies. JC hopes to get a jump on their competitors by aggressively pushing into more advanced DR applications. The company also believes it will be able to increase peak reductions by using buildings and water heaters for thermal storage.

But Johnson Controls and others running to the market might experience a little trip. Because here comes GE with self-powered wireless devices to integrate smart building technologies into existing buildings. The cost of re-wiring and retrofitting existing buildings makes automation too costly for most existing buildings, particularly those of a historic nature. GE has partnered with German self-powered wireless technology provider EnOcean to offer more than 50 products to make it easier and cheaper to integrate building technologies where installing wires or batteries is impractical. The variety of new Smart Building solutions will be based on a combination of GE's HabiTEQ which operates a building's subsystems such as lighting, heating, ventilation, blinds and security from a central control unit or on-line and EnOcean's battery-free wireless technology which has the capability of fitting equipment such as sensors in historic buildings or ultra-thin switches on glass panels. The EnOcean-equipped devices need no maintenance and pull power from ambient heat and light or from a switch being pressed.

GE has also joined the EnOcean Alliance, a consortium of companies dedicated to building and promoting self-powered wireless monitoring and control systems by providing common standards.

Wireless Mesh technology has emerged as a new one for next-generation wireless networking to provide a wide variety of applications that cannot be supported directly by other wireless networks. With the recent emergence of standards, wireless solutions are ready to be deployed in building automation networks. For both new and old structures, wireless networking is expected to improve the existing applications and open up new ones. Wireless Mesh Networks (WMNs) deployed in building automation systems is at an early stage; however, as more and more building functions and applications are controlled electronically and wirelessly, the use of WMNs will offer distinctive advantages in the field of commercial and residential buildings.

Technology Progression

Please reference the Methodology section of this report for technology definitions, and for guidance regarding the technology progression and benefits rating criteria.

- Distributed Generation: DG will have a long transition from an introductory phase to a growth phase.
- Energy Storage: Over the next 10 years, energy storage will transition from an R&D phase to growth phase. However, the next four years will be an R&D phase.
- Microgrids: Similar to Energy Storage technologies, microgrids will transition from an R&D phase to a growth phase over the next 10 years.
- EVs and EV Infrastructure: Over the next 10 years, EVs will transition from an R&D phase to a growth phase.
- B2G: B2G will transition from an R&D phase to a growth phase over the next 10 years. However, the growth phase will not occur until the early 2020s.
- DR: Over the next 10 years, DR will transition from an introductory phase to a maturity phase.
- Energy Systems, Software, Apps, ICTs: Over the next 10 years, ICTs will transition from an introductory phase to a maturity phase.
- Building Automation: Over the next 10 years, building automation ill transition from an R&D phase to a growth phase.

Benefits

Over the next 10 years, the energy demand stakeholder will achieve the highest benefit from energy efficiency. The second and third highest benefits will come from environmental and economic and financial benefits. Safety benefits are expected to deliver the least amount of benefits over the next 10 years.

The Path Forward

Buildings must change the way they use energy through Smart Consumption by dynamically managing energy usage, leveraging onsite generation and storage capacity, and integrating data analytics into building operations. A Smart Building of the future can save energy, and even earn money, by a two-way communication with the power grid and reacting appropriately based on price or other signals to reduce peak demand, as well as to provide system flexibility and enable the deployment of variable generation technologies.

International collaboration will be critical to achieve roadmap milestones by sharing experiences with pilot programs, leveraging national investments in technology development, and developing common Smart Grid technology standards that optimize and accelerate technology development and deployment while reducing costs for all of the stakeholders.

Consumers

Smart Grid Roadmap, 2012 – 2022 – Consumers

Description: Consumers, including demand from homes, that use, manage, monitor and wish to control their electricity usage.

Examples: Residential customers of utilities.

Role: Voice their opinion regarding electricity pricing, renewable energy options, environmental concerns, and their ability to access and manage their energy usage data.

Leverage information technology, demand response programs, wireless communications, mobile devices, and advanced energy systems, apps, and appliances to reduce their energy usage and electricity bills, and decrease their carbon footprint.

Become active participants in the energy markets, driving the demand for new technologies from utilities and technology vendors.

Major Milestones

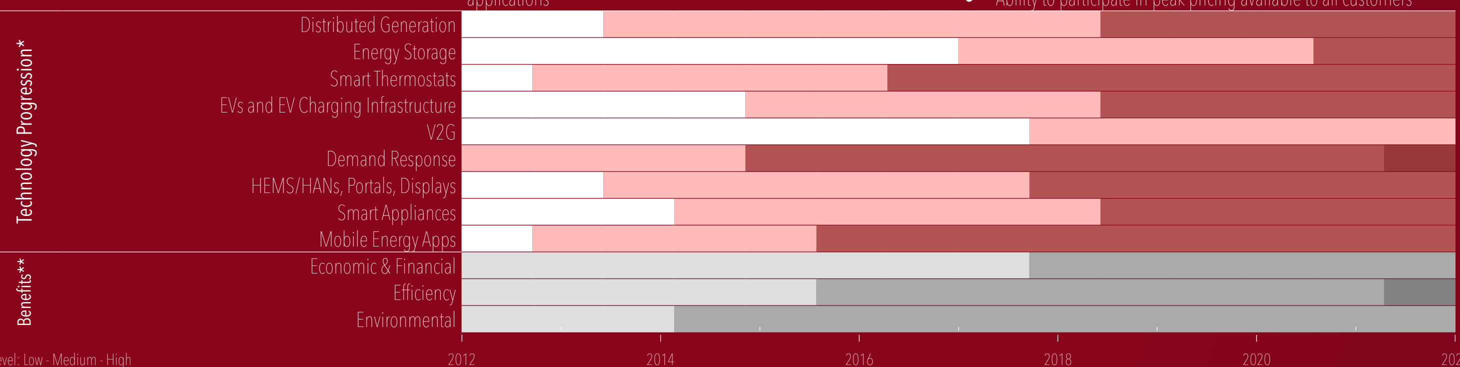
Milestones
Note: milestones pertain to customers located in areas where utilities are deploying Smart Grid technologies

2012 - 2017

- Obtain high-level of education and awareness about the benefits of Smart Grid technologies
- Availability to view and monitor real-time energy data
- Increased security and privacy options developed
- Ability to integrate EVs, DER, storage, smart appliances, and HEMs into their homes
- Ability to download multiple categories of mobile energy applications

2017 - 2022

- New homes connect all appliances to the grid
- Ability to produce and sell small amounts of electricity back to the grid
- The deployment of EV/PHEV technology to provide positive impact on peak demand
- Option to purchase multiple renewable sources of energy to supply electricity
- Ability to participate in peak pricing available to all customers



*Technology Progression: R&D – Introductory - Growth - Maturity **Benefits Level: Low - Medium - High

Table 10 - Source: Zpryme

Overview

Consumers will become a focal point of the Energy 2.0 framework, as the utility industry will experience a shift from a ratepayer centric business model to a consumer-centric business model. After improvements to the current electrical grid are completed, technology will turn to meeting the needs of consumers, moving them from passive recipients of energy to active participants in energy production.

To fulfill this role, consumers will have to be educated about the potential benefits of the increasing technology in the electrical grid, as well as how these benefits can affect them. Currently information is available on the benefits of applying advanced technology in the Smart Grid framework; however it is not in a format that consumer can easily digest. Hence, education is the key to the successful, widespread adoption of the Energy 2.0 vision. Consumers want to know what is in it for them. They want to know exactly how they will benefit from Smart Grid technologies. It is imperative for utility companies to engage consumers during the Smart Grid planning and design rather than just before AMI deployments begin.

Consumers are currently in the early adoption phase. A small, but significant number of early adopters are embracing the move to a more advanced and efficient energy system. These consumers typically work in the energy market, or have background knowledge or other education into the potential benefits of applying advanced technology to the utility industry. These early adopters are extremely important to the field. They are the most likely to pay a premium price for improvements, new products and services, and to improve their own energy efficiency. Early adopters will influence the industry's development over the next 10 years. However, the majority of consumers want proof that Smart Grid technologies can benefit them. Late adopters will look to the early adopters for guidance in this transition. As more people see their energy savings and progress, as well as the new offerings of the field, they will begin to follow and more consumers will become active in the field.

Role

Currently the energy market is utility driven, as the needs of the aging infrastructure and increasing energy needs of the country drive the market. The consumer pays increasing costs for current production, maintenance and improvement costs. Currently, the average consumer does not understand how energy is generated or how billing for electricity services works.

At the present time, consumers are most concerned with the price of utility services and are willing to participate in programs that would lower their monthly bill. However, a growing number of consumers are also concerned with environmental and economic issues in relation to their energy usage. Overall, consumers are interested in receiving instant feedback from data that would allow them to make better choices regarding their energy use. In short, consumers are willing to make changes to their electricity consumption patterns, if they knew what their options are and the best way to implement them

To meet these needs and concerns, some new smart consumer products are widely available, such as smart meters, smart appliances, and smart thermostats. Other products such as solar panels and wind turbines also allow consumers to produce energy for use at home, with excess energy sold back to the utility company. Several programs are also being deployed to increase energy efficiency especially during peak periods and provide consumer focused products. These programs demonstrate the trends in the utility industry towards customer satisfaction and the beginnings of future deployment of the grid.

1. Austin Energy and other companies offer a program where they will install smart thermostats in the home. The consumer then allows the utility to turn off the thermostat during peak periods when energy is scarce and a black out is possible.

2. Some companies, such as Ambit Energy, focus on offering more choices to consumers. Ambit provides two billing packages that are 100% obtained from wind energy, in addition to several utility packages with a traditional mix of energy production.

3. President Obama's administration has announced a Green Button program. This program seeks to create standardization by encouraging utility companies to install a Green Button on their website that allows consumers to obtain instantaneous, personalized usage information.

4. The Department of Energy has announced Apps for Energy Contest that offers $100,000 to software developers from integrating the Green Button framework with customer focused applications. Winning programs can offer information on websites, personal computers, or mobile devices.

Technology Progression

Please reference the Methodology section of this report for technology definitions, and for guidance regarding the technology progression and benefits rating criteria. Overall, Smart Grid technology will progress rather slowly for consumers over the next 10 years. However, once consumers are educated about these technologies, growth will occur rather rapidly. That said, utilities must deploy the appropriate customer side systems before consumers and begin to demand these technologies in high fashion.

- **Distributed Generation:** DG will have a long transition from an R&D phase to a growth phase.
- **Energy Storage:** Over the next 10 years, energy storage will transition from an R&D phase to growth phase. The growth phase is not expected to occur until 2017.
- **Smart Thermostats:** Over the next 10 years, smart thermostats will transition from an R&D phase to growth phase. The majority of this 10 year period will be one of high growth.
- **EVs and EV Infrastructure:** Over the next 10 years, EVs will transition from an R&D phase to a growth phase. The growth phase will not occur until 2018 or 2019.
- **V2G:** V2G will transition from an R&D phase to an introductory phase over the next 10 years.
- **DR:** Over the next 10 years, DR will transition from an introductory phase to a maturity phase. The maturity phase will be reached in between 2020 and 2022. However, the majority of the next 10 years will be one of growth for DR.
- **HEMS/HANs/Portals, Displays:** Over the next 10 years, these devices and technologies will progress from an R&D to a growth phase.

- **Smart Appliances:** Over the next 10 years, smart appliances will transition from an R&D phase to a growth phase.
- **Mobile Energy Apps:** Over the next 10 years, mobile energy apps will transition from an R&D phase to a growth phase. The majority of the next 10 years will be one of high growth for mobile energy apps.

Benefits

Over the next 10 years, the consumers will achieve the highest benefit from energy efficiency. The second and third highest benefits will come from environmental and economic and financial benefits.

The Path Forward

Starting with transparency in their own usage, then transparency in their communities, and finally transparency in their utility company, consumers want information so that they can make the best decisions regarding their energy use. Increasingly, consumers will seek to understand their own energy consumption, when and how they use energy, how much the energy costs at that time, and what they can do to lower their usage and ultimately their bills. Further, the will want to know how they are using energy in comparison with their neighbors and comparable residences. They want to be able to see their progress, both in terms of their bills and in their choices.

Finally, consumers will also want to know where their energy is generated and have some assurance that it is environmentally sound. As people see how Smart Grid technologies such as EVs and home energy management systems can make real improvements to the environment, they will increasingly look to their utility to provide the means to embrace such technology.

Conclusions

1. Although multiple Smart Grid pilots, demonstrations and national deployments are currently underway in the U.S. and across the globe, Smart Grid technology is still in a relatively introductory phase.

- **2007 – 2012:** With the exception of a handful of utilities, this phase of Smart Grid technology implementation can be characterized as a period of Planning, Pilots, Design, Research and Installation. Even though billions of dollars have been poured into Smart Grid technology to date, the majority of these efforts are just now moving past an installation phase.
- **2012 – 2017:** The next five years will define the future of the Smart Grid. This phase can be characterized as one of Testing, Installation, Validation and Verification. The next five years will be make-or-break years for entrepreneurs and technology vendors as their equipment, solutions, software and systems will be expected to yield positive returns to utilities.
- **2017 – 2022:** If all goes according to plan, this phase can be characterized as Grid Optimization and Advanced Technology integration. During this phase, utility systems and customers will start to truly reap the benefits of Smart Grid technology. An optimized grid will allow utilities to maximize asset utilization, control, and monitor and manage their entire electric system, and allow their customers to embrace advanced energy control and monitoring technologies.

2. Smart meter and AMI deployments are the first step in creating an intelligent and advanced Smart Grid.

3. Government support, in the form of financial incentives, policy goals, and renewable energy targets are creating a thriving environment for utilities, entrepreneurs, and technology vendors to innovate and implement Smart Grid technology. For example, the EU, China, and U.S., have laid out detailed Smart Grid plans for their respective countries. These contributions will build the foundation for the future growth and development of the Smart Grid over the next 10 years.

4. Overall, utilities can be classified into two categories when it comes to Smart Grid technology implementation: Early Adopters and Late Movers.

- Early Adopters
  - Over the next 10 years, these utilities will shift from a ratepayer-centric business model to a customer-centric business model.
  - 2012 to 2017 will see these utilities invest heavily in AMI, distribution automation technologies, and transmission monitoring technologies.
  - 2017 to 2022 will see these utilities aggressively implement energy storage, distributed generation, V2G and B2G, d customer-level networks, applications, software, equipment, technologies and systems.
- Late Movers
  - 2012 to 2017 will see these utilities closely monitor the progress and results of Early Adopters.
  - 2017 to 2022 will see a portion of Late Movers begin to deploy Smart Grid technology (mainly AMI).

5. On the Energy Demand side, the next five years will see this stakeholder embrace demand response program participation. Further, they will embrace customer sited renewable energy and energy storage technologies. Between 2012 and 2017, Smart Grid and information and

communication technology (ICT) adoption to control and monitor energy usage will change from a pilot/beta phase to an introductory stage. Such technologies will grow from an introduction to growth stage among Energy Demand stakeholders between 2017 and 2022

6. Over the next 10 years, as end market solutions for utilities reach critical mass and maturity, the technology vendor pool will consolidate.

7. From 2012 to 2017, Smart Grid technology vendors with solutions that enable, support or enhance AMI and distribution automation will see strong revenue gains.

8. Universal standards make innovation faster and cheaper, and make it easier to bring new ideas into the Energy 2.0 vision. Supporting Energy 2.0 requires interoperability across a wide range of sectors – commercial, consumer, energy, electrical, communications, etc.

9. All elements on the supply side must be integrated for utilities to benefit from Smart Grid and deliver Energy 2.0. Key technology milestones at this point will include network support for wide area monitoring, and utility adoption of LTE/WiFi, energy management systems (EMS), and global information systems (GIS).

10. Smart grid innovators will need government and industry support until utilities are better able to invest and deploy at a level that meets market demand.

11. Technology solutions for the demand end of the market will take longer to develop, but at this point, it should be advanced enough to support demand response programs, smart home integration platforms/home area networks (HAN), mobile energy management applications, data privacy/protection solutions, and possibly renewable-based microgrids.

12. As consumers become more educated, they will embrace the changes in the utility framework more readily and will become more willing to invest in its improvement.

13. Private sector support is necessary in the Smart Grid chain (investment–manufacturing–implementation–consumption–public support) as governments incentivize adoption.

Recommendations

1. Develop a well-designed consumer engagement strategy with every new Smart Grid deployment plan or project.

2. World governments should develop a broader vision on energy policy and Smart Grid. Such a vision will get us beyond regional solutions and closer to the goal of a national grid. This can only be accomplished when governments come to table to develop a consensus on Smart Grid goals and benefits.

3. Over the next 10 years, the role of Government should shift from one that provides funding, collaboration, and R&D support to one that mainly provides oversight, regulation, and collaboration support.

4. As renewable resources become a large contributor to energy supply, private sector support and collaboration among all stakeholders must intensify.

5. Utilities should initiate Smart Grid adoption following coordinated standards. Tax credits for utilities and consumers should also be established.

6. States should be incentivized to support Smart Grid implementation. New homes and buildings should be required to have Smart Grid demand response technologies

7. By 2022, interoperability should be resolved to the point where global standards allow vendors from the world over to sell to utilities the world over. This will bring a level of competition and innovation that drives down prices and makes the broader vision of Energy 2.0 achievable.

8. Technology vendors, especially those providing ICTs, should develop consumer based analytics programs that allow homeowners to compare their energy usage across time periods, by time of day, by month or year to determine improvements to energy efficiency, benchmark progress, and show areas for improvement.

9. Comparable Smart Grid or utility metrics programs should be developed across utilities and nations to identify any areas out of the normal range and identify areas where problems may be occurring or need attention. This identifies potential pulls to the total electrical grid, and by correcting them allows for improved efficiency and lowered monthly bills for customers.

Outlook

The 2012 to 2022 Smart Grid Roadmap presented in the report offers a general framework intended to enhance collaboration efforts that can spur the innovative technologies and progress that puts nations around the world on a path toward an abundant, clean and affordable energy.

The Energy 2.0 vision and technology progression represents the possibilities when Smart Grid integrates with other forms of urban infrastructure – water, gas, roads, transit, public safety, waste management, etc. – to help build and run smarter cities. Global urbanization is accelerating rapidly, and all of these elements will need to be more centrally managed to keep pace. This is very much the domain of technology companies, especially those with strength in networking and IT. However, the next five years will define the future of the Smart Grid. The next five years will be make-or-break years for entrepreneurs and technology vendors as their equipment, solutions, software and systems will be expected to yield positive returns to utilities.

For technology vendors and consumers, EVs and EV infrastructure represent the single largest opportunity on the demand side of Smart Grid. By 2022, technology vendors will have created viable solutions to support a nation-wide EV infrastructure, including charging stations, smarter batteries, billing systems, and both V2G and G2V capabilities to fully integrate EVs with Smart Grid. Once the infrastructure is in place, utilities, buildings, homes and communities will demand advanced networks, applications and software to manage their EVs for home and business use.

Emerging applications and technologies such as 'Beyond LET', wireless sensor networks, wireless power transfer (WPT), M2M and cloud based solutions will give utilities the agility and processing power they need rapidly deploy next-generation Smart Grid technologies and systems.

At the end of the day, the Energy 2.0 vision and evolution of the Smart Grid network will radically transform modern day energy, electricity and communications markets. It is imperative that governments, utilities, entrepreneurs and technology vendors understand that renewable energy integration and building an advanced Smart Grid are just the first steps of this transformation process.

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