THE SMART GRID IN 2010: MARKET SEGMENTS, APPLICATIONS AND INDUSTRY PLAYERS

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EXECUTIVE SUMMARY

The electric power industry is in the early stages of a sea change. From the growing addition of intermittent, often distributed, renewable energy sources to new and efficient ways that residential, commercial and industrial users are consuming electricity, the underpinning grid infrastructure is transforming on an epic scale. The relatively static, slow-changing power transmission and distribution market is finding itself at the confluence of energy, telecommunications and information technology (IT) markets, driving necessary change and innovation in support of a 21st century intelligent utility network. A “Smart Grid.”

The Smart Grid “market” has many moving parts. There are hundreds of vendors, large and small, providing software, hardware and solutions at every layer of the market, from the physical power infrastructure layer to the communications layer, up to the applications and services layer. Countless technologies are being developed, evaluated and deployed. Competing and complimentary system- and network-level standards are being defined. Power providers are planning and implementing varying systems architectures. Government policies are shaping the landscape at state and federal levels. Investments, private and public, are driving innovation at a scale large enough to match that of the problem itself. Consumer adoption for a new wave of energy services is unknown. Definitions as seemingly simple as what a Smart Grid is or should be are inconsistent and often debated. In a nutshell, it’s overwhelming and often confusing.

This report serves to provide clarification of what the Smart Grid is, from end-to-end, and where it’s going as the infrastructure is built out and the applications are ultimately defined and delivered. It does so by providing a graphical taxonomy of the market; explaining the market drivers, benefits and challenges; walking through the many market segments and technologies; laying out the current and future applications; looking at some of North America’s largest deployments to date; detailing venture capital investment in the space from 2005 through 2009; and identifying the major vendors, large and small, along with their products and services, throughout the Smart Grid supply chain.

GTM Research has interviewed over 50 vendors, utilities, industry alliances, R&D organizations and independent industry experts in constructing this report. The goal is to provide our own critical analysis of the market while at the same time incorporating a balanced view of the market, based on input from a wide-range of industry experts, all of who are working to solve specific problems throughout the emerging, end-to-end Smart Grid.

When large, established markets such as the electric power industry face transformation on such a massive and sweeping scale, a tremendous amount of challenges and opportunities are presented. The Smart Grid’s allure, from financing to technology innovation to infrastructure deployment and ultimately customer demand, is driven by the timing of this transformation and the perfect storm of variables coming together to make it possible. With that said and although many industry zealots paint a picture of an electric power panacea, the reality is that the Smart Grid represents a very lengthy, methodical, evolutionary transformation and not a revolutionary change that will be realized overnight.

It’s important to provide an understanding of the Smart Grid, from end-to-end, such that insight can be gained of the ultimate vision and end goals. Beyond that, it’s critical to understand that there are many inter-related submarkets, technologies and applications, all of which will evolve at different paces based on market demand and technology availability.

KEY FINDINGS

The key findings of this report, in no particular order, are listed below.

1. A Smart Grid transforms the way power is delivered, consumed and accounted for. Adding intelligence throughout the newly networked grid increases reliability and power quality; improves responsiveness; increases efficiency; handles current and future demand; potentially reduces costs for the provider and consumer; and provides the communication platform for new applications.
2. There are 11 primary Smart Grid market drivers, ranging from growing energy demand to technology advancements to policy and more. Details of each of these market drivers are contained within the report.
3. The three biggest challenges facing Smart Grid are: interoperability standards, utility business models that promote energy efficiency, and proper development of systems architecture that can support enterprise-wide current and future applications. Details of each of these challenges, and more, are contained within the report.
4. Roughly $1.3 billion in venture capital was invested in the Smart Grid sector between 2005 and 2009 (through June 2009). Just over $105 million of that total went into the space through the first two quarters of 2009.
5. The most funded Smart Grid startup companies to date are those competing in the communications space (solving the end-to-end communication challenge). As this market matures in the next two to five years, and industry giants, such as Cisco, grow their presence in this market sector, we expect the application space to be the next frontier of Smart Grid startup capital.
6. The revolution in information technologies that has transformed other high-tech industries (such as desktop computing, enterprise networking, wireless and wireline telecommunications) has yet to transform the electric power business, arguably one of the farthest-reaching and most extensive "networks" in existence. The Smart Grid, in large part, sits at the intersection of energy, IT and telecommunications markets.
7. The Smart Grid is comprised of three high-level layers, from an architectural perspective: the physical power layer (transmission and distribution), the data transport and control layer (communications and control), and the applications layer (applications and services). Each of these high-level layers breaks down further into sub layers and more detailed market segments, all of which are detailed in the report.
8. The predominant Smart Grid market segments and applications include advanced metering infrastructure (AMI), demand response, grid optimization, distributed generation, energy storage, PHEVs (including smart charging and V2G), advanced utility control systems, and smart homes/networks.
9. This missing link in grid communications – the intelligent field area network (FAN) – is now for the first time being built-out, as a result of wide-scale AMI deployments that replace legacy mechanical meters with advanced digital meters, or "smart meters." The FAN will bridge the communications gap between the utility and the consumer. AMI can best be seen as a transformative application since the AMI/FAN communication network necessary to run advanced metering applications can also be used to transport data for all kinds of other emerging Smart Grid applications. The state of today's Smart Grid market is largely defined by AMI.

10. The Electric Power Research Institute (EPRI) has estimated the cost of building a Smart Grid at $165 billion over the next two decades – which comes to approximately $8 billion per year.

11. Without a Smart Grid infrastructure, renewable energy technologies – lacking the ability to scale significantly – will remain niche. The promise of renewable energy making a significant energy and environmental contribution is a non-starter without a Smart Grid that can facilitate and integrate these variable generation sources. Increasingly, Smart Grid will be about moving "new" technologies and applications – renewable energy technologies as a prominent example – from the land of novelty to the everyday norm.

12. Smart Grid deployments may represent the largest single information technology investment that can be made to reduce CO_2 emissions, as electricity generation is the number one source of greenhouse gases (GHG).

13. Over the next decade, the number of PHEVs is expected to grow materially as consumers realize the associated cost and carbon footprint benefits. It is also expected to grow as performance increases. As such, we expect the popularity of these vehicles to escalate quickly, which presents enormous challenges for utilities that will need the infrastructure and systems in place to smooth the charging schedules of millions of vehicles.

14. Beyond optimizing energy delivery and consumption, the Smart Grid also represents a potentially significant economic growth engine. According to KEMA ("The U.S. Smart Grid Revolution," December, 2008), roughly 280,000 new jobs will be created in the U.S., as a result of Smart Grid projects, over the next four years. Significant opportunity for tech-savvy engineers, marketers, etc., will present itself, as the utility industry is lacking technology expertise that has shaped other industries. In addition, an aging utility workforce will also lend itself to potential job creation in the space.

15. Based on initial research, roughly 70 percent of executives at Smart Grid startups have backgrounds in wireless communications and/or IT hardware/software. A significant sign that many of the "smarts" in the Smart Grid are transitioning from different industries.

16. There are hundreds of companies, large and small, competing for a share of revenue in the growing Smart Grid infrastructure and services market. This report profiles 32 such vendors that GTM Research sees as primary players throughout the end-to-end Smart Grid.

17. End-to-end Smart Grid intelligence and services is a long-term panacea but the market will grow in realistic phases over time, with AMI being the first and largest phase of significance.

18. The top 15 North American AMI deployments represent roughly 41.1 million smart meters scheduled to be deployed by 2015.

19. Many of the advanced applications of Smart Grid are expected to develop in an evolutionary manner based on current technologies available and the needs of the market. For example with PHEVs, it is likely that we will see a simpler associated application (i.e., smart charging) before the market matures to support a more complex form of the application (V2G).

20. Demand response is a viable application today but has virtually no intelligence beyond the business model itself opening up opportunity for technology advancement, venture capital and competitive new products to deliver demand response services for utilities. The "fine tuning" of demand response services will not only provide utilities with virtual peak power (serving as a "fifth fuel" to the four traditional fuels: coal, natural gas, nuclear and renewables) but will also attract more customers, as these energy adjustments/reductions will increasingly be conducted in precise, non-intrusive ways.
21. The network communications layer for FANs will be an exciting area to watch in the coming years as next-generation networks (such as WiMax), and Public Wireless Networks providers (such as AT&T and T-Mobile) intend to challenge the current leading solution in North America, which are radio frequency (RF) mesh networks. Further, internet networking giant Cisco has recently won its first utility scale deployment in this space, meaning that this market will face both new technologies and heavy competition from all angles.
22. The most crucial regulatory reform needed to encourage utilities to foster conservation and energy efficiency will be establishing new pricing regimens for how utilities are to be compensated; ones which create incentives for utilities to earn revenue in ways that aren't entirely linked to additional sales. Otherwise, asking utilities (many of which are investor-backed) to sell less power is analogous to asking Starbucks to sell less coffee.
23. The most crucial regulatory reform needed to encourage consumer involvement in Smart Grid will be eliminating the single, fixed retail rate for most electricity consumption. Until time-of-use (TOU) rates are implemented, smart meters and home energy management systems will have little effect in altering/reducing consumer use, as customers will still continue to be charged the same old flat rates. Customers need information on how prices vary over hours, days, and seasons. With this information they can then decide how and when to consume electricity, according to their own best interests.
24. The often-current mindset (by some utilities) of Smart Grid as a type of "one-off" project is wrong-headed, and fails to understand the integrated and scalable nature of Smart Grid applications and solutions. A top down, enterprise-wide, systems architecture must be developed and employed from the start in order to change the paradigm away from these costly, time consuming, silo'd application deployments.
25. Energy storage (and new battery technologies) could assist in making small-scale distributed generation a viable alternative to large centralized power stations. Energy storage is often considered the "missing link" for renewable energy. As such, energy storage is rightly viewed as critical component of any next-generation power grid; however, despite increased levels of funding in recent quarters, viable cost-competitive storage remains one of the holy grails of the energy world.
26. We are still in the early days of developing home area networks (HAN); it is likely that a hybrid approach – using both wireless and wired technologies – will be used to connect the multitude of devices that will eventually connect to the home network. While ZigBee has emerged as the leading wireless standard thus far, a number of options are competing for market share and driving product innovation, including WiFi, ZWave, 6lowpan and HomePlug. Each are further explained in this report.

1 TAXONOMY OF A SMARTER GRID

1.1 Market Definition and Detailed Taxonomy Diagrams

The GTM Research Smart Grid Taxonomy explains Smart Grid as the convergence of three industries/sectors:

» Electric Power (Energy)

» Telecommunications Infrastructure

» IT (Information Technology)

Each industry's expertise is needed to provide one of three high-level layers of a complete and end-to-end Smart Grid and/or Intelligent Utility Network:

» The Physical Power Layer (transmission and distribution)

» The Data Transport and Control Layer (communications and control)

» The Application Layer (applications and services)

In order to have what is known as a true end-to-end Smart Grid, that is able to run applications back and forth from the utility to the consumer, an end-to-end communication network is needed. While utilities have for years had their own local area networks (LAN) and wide area networks (WAN) to transport data both within the utility's headquarters and to and from the substation, the missing link in communications has been the network that could bridge the utility to the end-user, and vice versa.

The emergence and continued development of an end-to-end communications layer is responsible for advancing the Smart Grid revolution, as new applications will both improve and optimize the generation, delivery and consumption of electricity. Further, on a true Smart Grid, it is not only data that will move in two directions, but power itself, as a more intelligent grid greatly facilitates the introduction of distributed power sources (such as photovoltaic solar panels, micro-wind turbines and stationary fuel cells) at mass scale.

This missing link in communications – an intelligent field area Network (FAN) – is now for the first time being built-out, as a result of wide-scale advanced metering infrastructure (AMI) deployments that replace old fashioned mechanical meters with advanced digital meters, or "smart meters." Smart meters – physical meters that allow for two-way communication – necessitate a communications infrastructure to transport the data, which they generate. In the U.S., the new administration has called for the deployment of 40 million smart meters, and many other developed and developing countries now have equally, if not more, ambitious smart meter rollout projects underway.

It is helpful to think of AMI as having two layers:

1. The transport layer (the communications network that sends data back and forth in between the smart meter and the WAN, via the intelligent FAN).
2. The application layer (running any metering-specific "app" that a utility deems worthwhile).

Effectively the AMI transport layer/communication network provides the missing link in the end-to-end communication network infrastructure, and as such is synonymous with the familiar terms FAN or “last mile” (from the telecom industry) as the final leg delivering connectivity from a utility to a customer. This end-to-end connectivity is certain to bring about huge change in an industry that has lagged behind virtually every other industry in the adoption of communications and information technologies, and will open the door for a wide range of new advanced applications and technologies.

Further, the AMI/FAN not only forms the bridge back to the utility’s operations and control center, but also to the network inside the home or building, referred to as the home area network (HAN). So ultimately, end-to-end communication will extend from the power plant/utility end of the grid all the way to specific appliances inside buildings (lighting systems, refrigerators, dishwashers, HVACs, etc.), giving both utilities and consumers much more granular insight and control over energy generation and consumption decisions. This is especially important, as this further connectivity, allows for applications such as demand response (where utility operators can turn down end-user appliances to curb peak power demands) to perform with much greater precision and reliability.

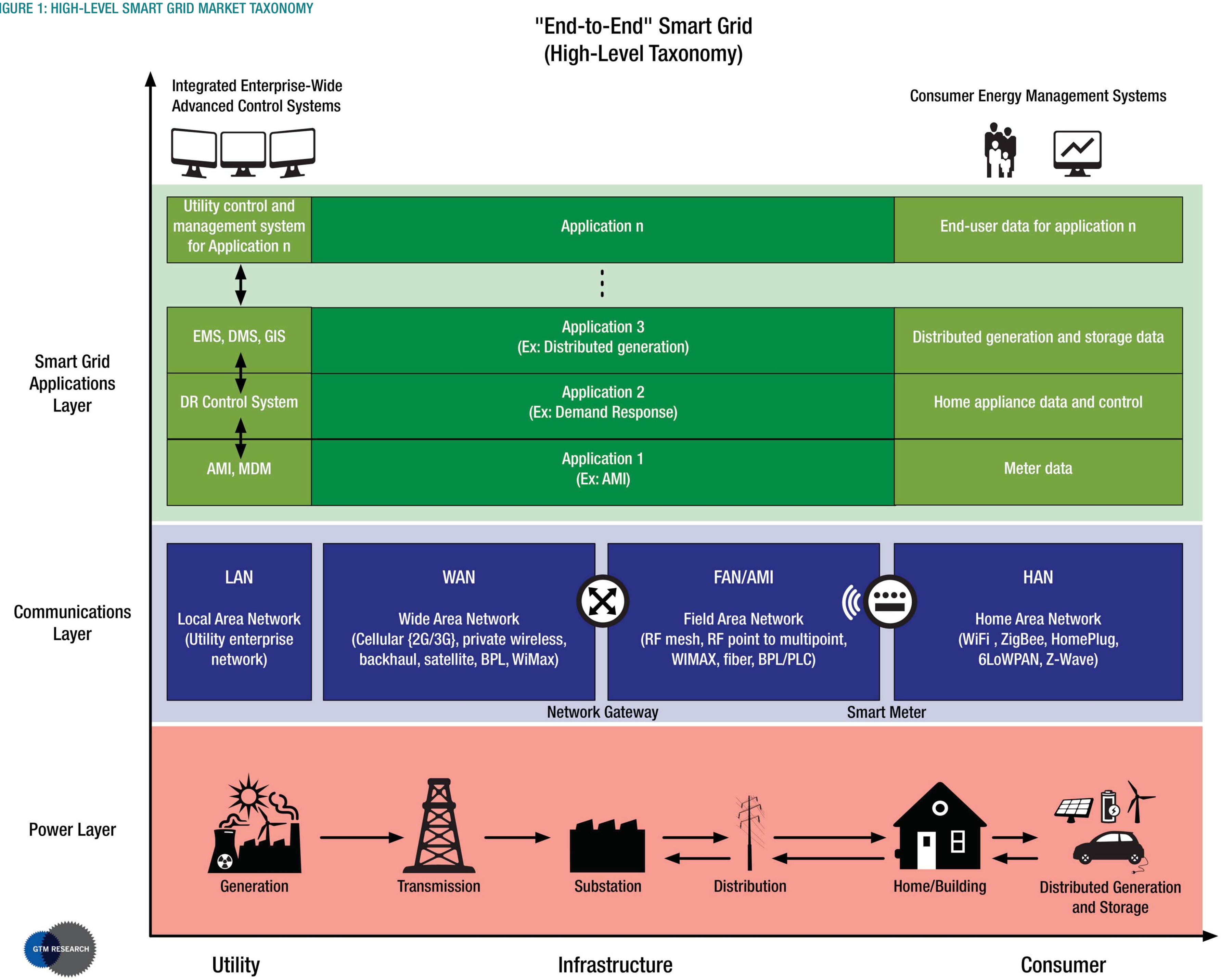
One of the most repeated questions in Smart Grid in 2009 is: “What is, or what will become, ‘the killer app’ of Smart Grid?” GTM Research takes a different approach. Our research concludes that each of the applications highlighted in this report are ground-breaking in their own respect, as each presents new ways to improve either the generation, distribution and/or consumption of electricity (or some combination of all three) and each is worthy of the title “killer app.” As proof of this assertion, new industries are already popping up around each of the applications listed in The GTM Research Smart Grid Taxonomy. (See Figures 1-3)

The more time one spends examining emerging applications and market sectors, such as demand respond and grid optimization, the more one discovers not only the great societal benefits that are enabled as a result of end-to-end communications, but also the business opportunities lying in wait. Similar to creating applications for the Apple iPhone – what you can do on top of this new technology/platform is the exciting area where opportunities exist.

In the realm of communications, we’ve learned to naturally expect the network to improve with each passing year. Even though these improvements are necessary, they stop being a cause for celebration. Ultimately it is the application space that carries the “game changing” potential and pushes innovation forward. What remains to be seen is how long it will take for these new applications to gain a foothold and achieve a wider market penetration. One could argue that the killer app of the years 2006 to 2010 is AMI – as it is responsible for putting the full communication network in place. But, while AMI’s historical significance will not be lost as an enabling technology, AMI is not likely to be the killer app of 2015, as other market segments and applications hold the potential to contribute greater advances in the way that end-users consume and generate electricity.

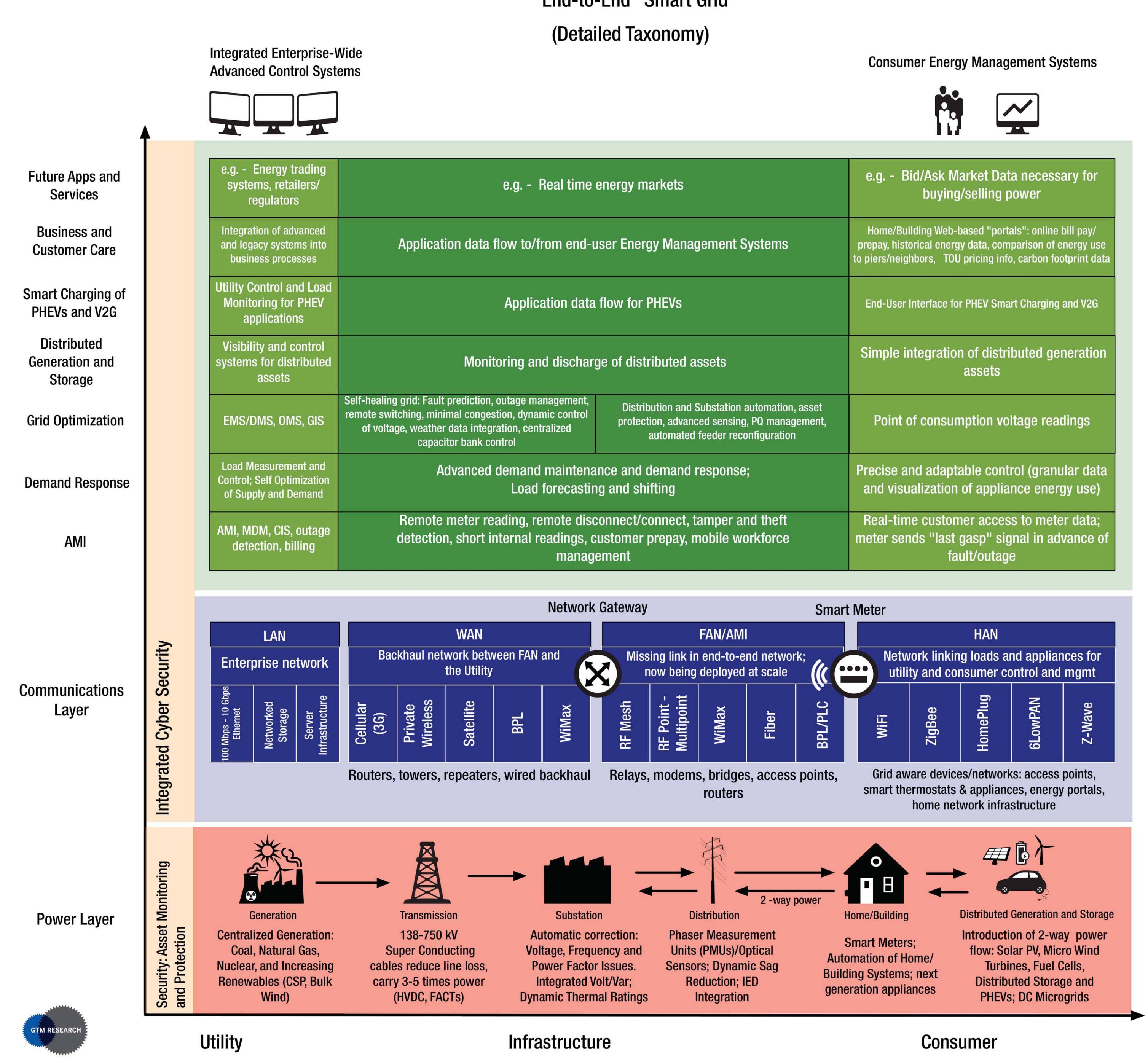
AMI deployments are currently setting off a firestorm of activity from generation to consumption, as both startups and industry giants are anticipating market needs and driving these new technologies and applications forward. On the utility end of the power grid, advanced control systems that not only add new systems and capabilities, but also properly integrate all business systems across the enterprise, will provide a giant leap in an industry accustomed to have siloed systems unable to communicate with and/or leverage one another. On the other end of the grid, home area networks promise to change the way in which consumers relate to their energy usage. In between, there will many applications and technologies stacked on top of each other that will collectively push towards the true vision of a Smart Grid. Once these three layers – power, communications and applications – properly converge, the grid will never be the same.

FIGURE 1: HIGH-LEVEL SMART GRID MARKET TAXONOMY



Source: GTM Research

FIGURE 2: DETAILED SMART GRID MARKET TAXONOMY



Source: GTM Research

1.1.1 Highlights of Smart Grid Market Segments and Applications

Below, the leading Smart Grid market sectors and applications from the taxonomy are highlighted. Refer to Section 2 of this report for more information on these applications.

AMI: The Foundation of the Smart Grid

Advanced metering infrastructure (AMI) can best be seen as a transformative application since the AMI/FAN communication network necessary to run advanced metering applications can also be used to transport data for all kinds of other emerging Smart Grid applications. Grid Optimization is one example of a non-metering market segment that is enormously enhanced by having end-to-end communications, as the utility now gains instantaneous information about grid performance and events such as outages and faults (as opposed to having to wait for a phone call from upset customers informing them of a specific concern).

Demand response (DR) and the integration of distributed generation sources are other examples of applications that can “ramp up” more quickly once the communication network is in place. While AMI applications themselves are metering specific, concerned with making the meter data collection process less labor intensive, and less costly (as utilities will no longer have send out field workers to physically read the meters), these utility-scale AMI deployments, which are now underway across the globe, are truly transformative as a great number of additional benefits and market segments will continue be discovered and deployed in an effort to not only improve system-wide reliability, asset utilization and protection, but also to reduce fossil-based electric generation requirements and their related carbon emissions.

Demand Response: A Market Primed to Perform

Demand response is a relatively simple concept to understand. Utilities incentivize electricity customers to reduce their consumption at critical, “peak” times on demand. Contracts, made in advance, specifically determine both how and when the utility (or an acting third-party intermediary) can reduce an end user’s load. The utility benefits by not having to resort to more expensive (and less environmentally friendly) peaking power plants, and consumers benefit by earning income – making demand response a win-win solution.

To date, most demand response efforts in North America have been coordinated with the larger users of energy – commercial and industrial users. Historically, rudimentary communications – often a phone call – are how operators notified participating customers to turn down the power. Smart Grid communication networks improve the way operators reach consumers. Further, residential users (that have smart meters installed) will increasingly have the option to enroll in DR programs, giving demand response “reach” to a substantial portion of the overall system.

We expect demand response to be the first application of Smart Grid to capture a critical mass of market penetration. The demand response market is now being referred to as a gold mine and industry analysts have called for this market to quadruple over the next five years. Some might, in fact, argue that demand response, not AMI, is the first killer app of Smart Grid; actually, FERC Commissioner John Wellinghoff has done just that, explaining, “demand response is clearly the ‘killer application’ for the Smart Grid.” As DR directly reduces overall demand, and smart meters (in and of themselves) do not, a strong case can be made to support this claim.

Supporting this argument is the fact that demand response is a cheaper, faster, cleaner and more reliable solution than natural-gas-fired peaking plants (the leading response to peak power generation needs). Further, the fact that the two leading solution providers, Comverge and EnerNoc, have both successfully gone public suggests that this is the most mature market segment in Smart Grid. Having said that, the demand response market is still in its infancy; the introduction of millions of smart meters (which can serve as a gateway in between large appliances and the utility control center) will open the floodgates for demand response to reach millions of residential customers for the first time. Also, as a result of the current global economic downturn, it’s a safe bet that more businesses and consumers will enroll in programs where they earn additional income by turning down their power in non-intrusive ways. For these reasons, we expect this market to perform very well in the coming years.

Grid Optimization: Adding Real Intelligence to the Existing Power Grid

Grid optimization entails a wide array of potential advances that will give utilities and grid operators digital control of the power delivery network. The addition of sensor technology, communications infrastructure and IT will help optimize the performance of grid in real-time, improving reliability, efficiency and security. Grid operators will gain improved situational awareness as fundamental system-wide visibility and analytics will now be in place. While AMI deployments lay the foundation for utilities having control of millions of end user devices, real-time command and control of higher level grid devices is of equal, if not greater, value in the current push for overall grid efficiency.

As large-scale utility “upgrades” continue to accelerate in North America and Europe, grid optimization supporters and vendors rightly point out that the resulting efficiency gains are not contingent upon changing consumer behavior, and as such the resulting returns can be seen as more predictable. While the concerns and desires of each utility will vary greatly (with variables such as existing rate recovery structure and the current state of physical grid assets paramount) the predictability of the ROI will make continued investment in grid optimization projects very attractive.

Distributed Generation: Taking Renewable Energy From Novelty to Norm

The whole promise of renewables making a significant energy and environmental contribution is a complete non-starter without a Smart Grid that can facilitate and integrate these variable generation sources. Increasingly, Smart Grid will be about moving “new” technologies and applications – renewable energy technologies as a prominent example – from the land of novelty to the everyday norm.

While PV solar panels and wind turbines are now ubiquitous in marketing campaigns, and research reports, Smart Grid promises to make these green technologies ubiquitous in our actual lives. In truth, many of the solutions that are presently in vogue, as we collectively try to comes to grips with global warming and our dependence on somebody else’s hydrocarbons, have actually been around for decades – if not considerably longer. Solar panels were invented in the 1950s; electric cars pre-date the introduction of gasoline automobiles and were first conceived in the late 19th century. The first electricity-generating wind turbines were invented about that same time, and the more modern wind turbines have their roots in the 1970s. While great technological advances have occurred – improved conversion efficiency, scalability, cost reductions and so forth – the issue is no longer whether these technologies are battle ready, but rather do modern societies have the infrastructures in place capable of supporting the introduction of renewable energy technologies at mass scale. The Smart Grid aims to tackle this scale-management problem.

The intersection of the solar PV industry and Smart Grid is particularly interesting, as solar costs continue to drop and move closer to “grid parity” (the point at which photovoltaic electricity is equal to or cheaper than fossil based fuels, particularly natural gas). We can reasonably forecast far greater PV penetration in the coming decade, especially in areas with abundant sunlight and higher costs of electricity; Smart Grid technologies will be responsible for solving the scale-management problem that arises when you add thousands, if not millions, of new devices to a system.

While distributed generation technologies may not be price competitive in all markets in the near term, we expect them to be competitive in enough areas that Smart Grid technologies related to distributed generation integration will continue to be developed and perfected. The companies that gain market leadership positions in integrating distributed generation sources can expect a growing demand for their products and services, as Smart Grids will continue to become the norm and as a the price of fossil based fuels – in a resource-limited world – continues to rise over the long term.

Energy Storage: The Missing Link

Energy storage is increasingly perceived as both a viable and necessary component of any future, intelligent electric grid. The leading visions of how a Smart Grid should operate usually focus on distributed storage options, rather than bulk storage. While both forms of storage will be welcomed on a grid that historically has had effectively zero storage, distributed energy storage assets – located near the consumption end of the grid – will provide localized power where it is most needed, decreasing the need to build new power plants and transmission lines. The most discussed benefit of energy storage is that it helps solve the intermittency problem associated with renewable energy, and as such, will help these “green” sources of energy scale faster and reach a wider market penetration. While it's true that energy storage will give a huge boost to the potential of renewable energy – and has rightly been labeled the missing link for renewables – significant storage capacity solves an even bigger issue, and that is capturing the massive amounts of capacity generated that otherwise typically goes unused.

As Smart Grid growth continues, this market segment has moved from the shadows into the national spotlight. We expect to see continued and increased funding in this sector in the next five years. Unlike other sectors that will continue to grow step by step; a breakthrough in storage is still needed. While the associated R&D expenses needed to arrive at a storage breakthrough may limit the competition to the very well funded, software solutions that can charge and discharge stored power in a timely and effective manner will also be necessary, and as such we expect to see more IT/ software companies enter into this market in the near term.

The Sacramento Municipal Utility District (SMUD) claimed in its 2008 annual report, "New battery technologies could assist in making small-scale generation a viable alternative to large power stations".

Plug-In Hybrid Electric Vehicles (PHEVs): Smart Charging and Vehicle to Grid (V2G)

One of the most discussed and anticipated "applications" of Smart Grid is the introduction of the plug-in hybrid electric vehicle (PHEV). A PHEV's larger battery will allow for both the possibility of storing electricity, which might otherwise go unused (ideally from renewable, intermittent sources), and of feeding stored energy back into the electric grid, in periods of high demand, serving as a back-up source of power for the electric grid. While the market fundamentals to support what will be a revolutionary advancement in both the automobile and energy industries are not fully in place as of 2010, PHEVs are about to be marketed and sold by virtually every major automobile manufacturer in world in the next two to five years, and as such utilities are now scrambling to ready themselves for what could be a truly disruptive technology. The two leading challenges will be (1) smart charging – how to smooth the charging of millions of PHEVs in order to prevent accidental peaks and (2) how to draw power from these batteries in a way that doesn't alter the expected life of the battery or leave the vehicles undercharged when their drivers turn them on. The concept of vehicle to grid (V2G) – pulling power from car batteries to feed peak demand- properly fits into the energy storage market, and, as such, new systems and analytics will be needed to help this market grow.

Advanced Utility Controls Systems: The Future of Energy Monitoring and Control

An Advanced Utility Controls System refers to the upgrade and continued integration of various mission-critical systems, applications and back-end technology infrastructure necessary to support a utility's monitoring, control and optimization of the grid. In order to leverage the full potential of AMI deployments (and the end-to-end communication networks now in place), utilities will need to develop enterprise wide systems, capable of sharing data across applications and systems. While historically utilities' systems have been far from integrated, the realization of a Smart Grid will depend on a utility-wide integration of systems (and business processes) which allow for real time visibility and decision support. For example, at the system load level before a utility decides to draw power from distributed storage assets to mitigate peak energy demand, that utility would do well to consider if would makes more financial (and environmental) sense to issue a demand response call instead (or for that matter, weigh the cost/benefits of calling upon any and all grid connected generation sources, for a particular scenario). Other cases will be far more specific. For example, the decision on whether it makes greater sense to charge a family's electric car with electricity originating from their next door neighbor's rooftop solar panels (a concept called peer-to-peer) or electricity coming from a centralized power plant. Utilities will increasingly have to face millions upon millions of these types of decisions, and as such advanced utility control systems will be necessary, as the volume and complexity of these types of decisions will surpass the capabilities of human operators, as well as the silo'd utility systems of yesteryear.

Smart Homes and Networks

By adding intelligence and networking capabilities to appliances (such as thermostats, heating, lighting and A/C systems) located inside buildings and residences, both the utility and consumer stand to benefit. Homeowners will be able to monitor their energy consumption and reduce their utility bills with very little effort, as well as financially gain from incentives provided by the utility for energy conservation. Meanwhile, utilities that now have an extension of Smart Grid into the house, can better manage peak demand, beyond simple demand response initiatives. The extension of smart metering intelligence into the home/building itself, connecting the meters to "load centers" is radical advancement for the power grid. While, today certain utilities manage peak load demand by directly capping these load centers' usage, a home area network (HAN) and home energy management system would allow the homeowner to indicate a mix of consumption and efficiency across a range of appliances and devices, changing forever the way the consumer participates in the energy consumption.

FIGURE 3: SMART GRID APPLICATIONS & MARKET SECTOR TIMELINE

APPLICATION/MARKET SEGMENT	2010	2015	2020
AMI	The first large-scale deployments underway	Substantial and growing market penetration and network Infrastructure build-out	Significant and wide-ranging Implementation
Demand Response	Limited reach (mainly commercial and industrial customers)	Substantial market penetration for residential, commercial and Industrial	Commonplace with a wide variety of end-user service programs
Grid Optimization	A handful of utilities beginning distribution/ substation automation projects	Sensor technology embedded on the distribution network; automation becoming routine	Dynamic Sensing everywhere; Grid becomes an Intelligent Utility Network
Distributed Generation Integration	Nascent	Maturing, but still a small % of power generation	Approaching Mainstream More substantial presence;
Energy Storage	A few pilots among progressive utilities	Expected technology advancements and increased Distributed Generation penetration will boost storage's role	Vital role in supporting Distributed Generation
PHEV	N/A	Smart Charging	V2G (vehicle-to-grid)
Consumer Energy Management Systems	Successful pilots continue to highlight consumer demand	Gaining traction as "set-it-and-forget" technologies make energy management simple to use and cost-effective	Routine, Web-based

Source: GTM Research

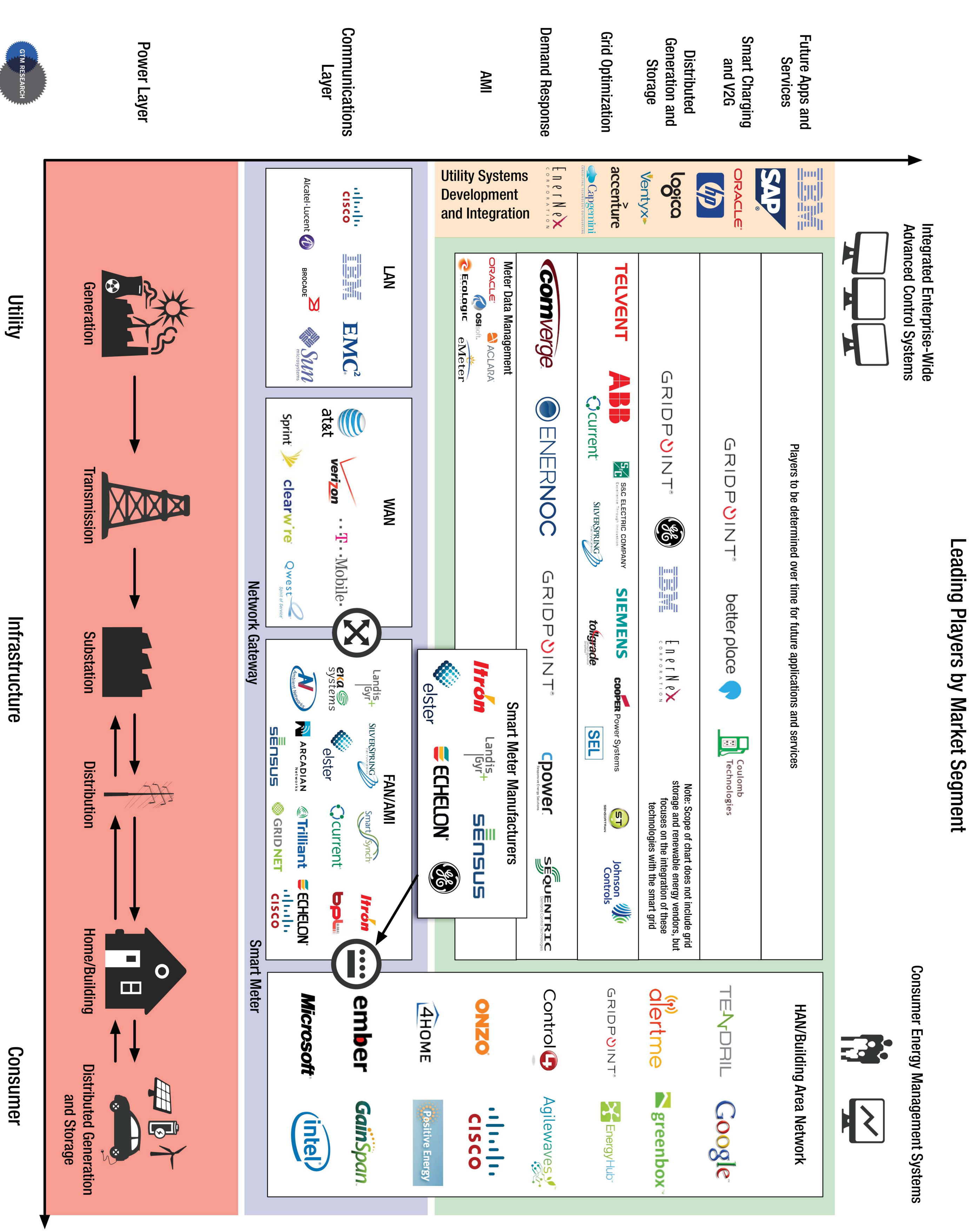
1.1.2 Mapping the Smart Grid Taxonomy to Industry Players

The term Smart Grid is a broad one that encompasses all the market sectors, applications and technologies directed at upgrading and optimizing the generation, delivery and consumption of energy. While admittedly this term has a certain appeal – and has likely proved useful in helping many a startup raise financing and/or in helping utilities appear to be "on the case" in addressing concerns such as outage management and greenhouse gas (GHG) emission – the downside is that the term is too broad, and does not provide insight into what various Smart Grid players actually do and/or how they may compare to one another.

The GTM Research Smart Grid Taxonomy by Industry Player is a useful tool in helping to visually position various Smart Grid players in order to gain more clarity as to where these specific companies compete and how they fit into the larger picture. While, at the time of this writing, it is still a trend for companies to market themselves as "end-to-end" Smart Grid companies, increasingly these solutions and markets will be viewed as modular, and companies will start to brand themselves accordingly. As heavier competition continues to move into each of these sectors – for example the first six months of 2009 saw the formal market entrance of Cisco, Oracle, Google and Microsoft – being perceived as a Smart Grid "jack of all trades" (and "master of none") might not exactly be a winning formula.

Note: The taxonomy does not intend to position each company in every market segment in which they compete; but rather, intends to call to attention what we believe are particular strengths or areas of expertise. While some of the larger players do, in fact, have both the resources and the ambition to compete from end-to-end, we feel that it is more helpful to the reader to discover which companies are leading the way in each sector. For example, General Electric is only included in the AMI/smart metering segment but GE will likely compete in others segments, such as Grid Optimization. Further, this taxonomy is more concerned with the integration of new technologies from related fields (notably renewable energy, storage and electric vehicles) than those actual technologies/companies themselves; as such, you will not find companies such as First Solar, A123 Systems, Tesla Motors or others included here.

FIGURE 4: SMART GRID TAXONOMY BY INDUSTRY PLAYER



Source: GTM Research

FAN/AMI Vendors

At first glance of the taxonomy, it is interesting to examine which segments have attracted the most venture capital, as this tells (at least part of) the story of Smart Grid's evolution. It has become a Smart Grid truism that the communication network – the missing link between the end-user and the utility – is the first solution that must be deployed, and as such the field area network (FAN) and advanced metering infrastructure (AMI) networking companies have received the lion's share of venture capital to date.

Silver Spring Networks, a company that has raised over $165 million, has emerged as the market leader in AMI networking solutions, having won several utility scale deployment contracts including a deal with Pacific Gas & Electric (PG&E) to connect over five million meters (the largest AMI deployment in the U.S.). Actually, with more than 40 million smart meters now scheduled for deployment in the U.S. alone in the next five years, the AMI/FAN sector can now be seen as a maturing market. We expect to see fewer startups entering this space.

In May 2009, Cisco announced a business partnership with Duke Energy, signaling that utilities may increasingly turn to trusted name brand players to solve their communications requirements. Many questions remain, including what is the most appropriate networking technology to support a wide range of future applications; this will continue to be one of the most exciting market segments to follow in the next five years.

Note: Watch for AMI companies that partner with wireless telecom carriers (Smart Synch and AT&T) and/or next generation networks like WiMax (GE/GridNet), as these alternatives may challenge the current dominant solution, which is RF mesh networks (provided by Silver Spring, Trilliant, Itron, Landis+Gyr and others).

Software and Application Vendors

Apart from communications, the other two sectors that have attracted sizable amounts of venture capital are the Applications/Software space and the home area networks (HAN)/home energy management sectors.

As distributed renewable energy, PHEVs and advanced storage solutions continue to be developed and reach greater market penetration, their integration into the grid will be essential; this is primarily a software challenge. It's worth pointing out that the most funded Smart Grid startup, GridPoint (which raised over $220 million), offers software solutions for most of the applications of Smart Grid, including distributed generation, storage and PHEV integration, as well as home energy management systems.

Only time will tell if this multi-tiered approach will prove successful for GridPoint; the applications space is precisely where we expect to find the competition heating up in the next three to five years (as more startups and big name players are likely to jump on board). Recent Smart Grid entrant Oracle is an obvious example of a company to watch for in this space, but a "company" exploring the "two-guys-in-a-garage-with-a-good-idea" methodologies still not out of the question for the applications sector.

Home Area Networks (HAN) and Energy Management Systems Vendors

The Home Energy Management System space has also attracted a good amount of venture capital; however the recent announcements that both Google and Microsoft intend to develop Home Energy Management Systems (and give them away for free) may now make it difficult for new entrants to attract financing.

Startups Tendril and Greenbox are some of the early “leaders” (for lack of a better word) in the Home Energy Management space; however this market is still in the early phases of development (as generally speaking you first need to have a smart meter and network in place to generate and transport the end-user data upon which these that these systems rely). While home energy “portals” are still in the pilot stages; just one large-scale deployment by a major utility would be something of a tipping point for this market, and could happen as early as 2010.

As for the HAN sector – the actual network inside the home which appliances will “talk” over – two chip (semiconductor) companies, Ember and Gainspan have both raised substantial funding, based on competing wireless technologies of ZigBee and WiFi. To date, the ZigBee standard has emerged as the clear favorite, but as more big name companies that have “earned their keep” using IP (Internet Protocol) enter the market, WiFi could gain traction.

Demand Response (DR) Vendors

The demand response (DR) market segment is dominated by a small number of players. Two to be exact: Comverge and EnerNoc. There are others, but these two have the market cornered, at least for now. Comverge has made more headway in the largely un-tapped residential market (approximately 25 percent of Comverge’s demand response portfolio is in residential deployments), which is noteworthy in an industry that largely concentrates on industrial and commercial clients.

Demand response providers play the role of third-party intermediaries between the utility and the end-user; Comverge and EnerNoc are both benefiting from being early entrants into this market, and both are public companies listed on the Nasdaq. While these companies provide software, hardware and communications solutions, the barriers to entry in this market are not so much technological, but have more to do gaining the trust of the risk-averse (and heavily regulated) utility industry. It’s worth noting that as utilities improve their communications networks and control systems, they will have a greater ability to offer these services themselves.

Smart Meters, Advanced Control Systems and Grid Optimization Vendors

The other market segments of Smart Grid are evolving more directly out of the traditional utility vendor community. All of the leading smart metering companies (Itron, GE, Landis+Gyr, Elster, Sensus and Echelon) developed directly out of the traditional metering industry. As these were already well-established companies, venture capital played little, if any role, in the development of these advanced meters.

While Advanced Control Systems and Grid Optimization are both market sectors that are evolving primarily with help of traditional utility product/service providers, there are a lot of “cracks” that could be filled by more flexible and innovative firms. Solutions range from middleware systems that can connect siloed utility control systems to companies that market and sell new technologies (such a sensor technology that can be embedded into the distribution network). Startup, Current Group, is an example of a firm that will compete with traditional T&D vendors in delivering sensor hardware and supporting software systems.

Meter Data Management (MDM) Vendors

While not prominently featured in this report, meter data management (MDM) is a terrific example of a market segment (or sub-segment) where young companies are gaining a real foothold. Being that smart meters are a relatively new technology, there are not that many companies that have experience handling the incredible amount of data that these smart meters generate.

While smart metering companies aim to offer these solutions as part of their overall (advanced metering infrastructure) package, data management historically has not one of their core competencies. eMeter and Ecologic Analytics are two examples of relatively new companies that have already won large utility scale contracts providing back office meter data management solutions.

Further, the fact that Ecologic Analytics, a company who at the time had less than 15 employees, was able to convince PG&E to be its MDM provider (for what is, and will likely remain, the largest AMI deployment in North America) should encourage other startups to focus their efforts on a particular solution and aim to be better than everyone else. In an emerging market these types of scenarios are still well within the realm of possibility.

For a full profile on each of the companies featured in this taxonomy, refer to the company profiles section of this report.

FIGURE 5: SMART GRID AS DEFINED BY LEADING PLAYERS

SMART GRID AS DEFINED BY LEADING PLAYERS
Duke Energy
Duke Energy's long-term vision is to transform the operation of its electric power grid by creating a reliable and scalable networked infrastructure capable of delivering and receiving information from intelligent devices distributed across its power systems, automating components of the distribution systems and leveraging the linked networks for improved operational efficiencies and customer satisfaction.
Xcel Energy
Xcel Energy's vision of a Smart Grid includes a fully network-connected system that identifies all aspects of the power grid and communicates its status and the impact of consumption decisions (including economic, environmental and reliability impacts) to automated decision-making systems on that network. This vision leverages the multitude of vertical system solutions currently available and deploys a horizontal integration of these systems into a real-time, automated "neural network" that will manage all of the variables involved in delivering energy to the consumer. We believe this vision of an advanced decision-making system will allow Xcel Energy to more efficiently deliver energy while providing consumers with valuable information for better decisions on when, where and how to consume energy. The impact will be a greatly improved delivery system that optimizes the impact on the environment, ensures the most efficient delivery, and maximizes reliability.
The GridWise Alliance
The GridWise Alliance sees an electric system that integrates the infrastructure, processes, devices, information and market structure so that energy can be generated, distributed and consumed more efficiently and cost effectively, thereby achieving a more resilient, secure and reliable energy system.

1.2 Smart Grid Market Drivers

At the end of 2008, Greentech Media and GTM Research anticipated that 2009 would be "The Year of Smart Grid." A confluence of concerns including meeting the growing global energy demand, reducing the harmful impact of greenhouse gasses and ensuring the necessary infrastructure upgrades to both integrate renewable energy and protect the grid from interruption led many analysts to announce that the time to invest in a smarter grid was upon us. Not only were the challenges clear, but also the technologies necessary to solve these problems, born out of the internet revolution, had been gaining traction among venture capitalists, and were being successfully piloted by leading utilities in both Europe and North America.

In February of 2009, President Obama put the presidential stamp of approval on the idea of a smarter grid when he signed into law the American Recovery and Reinvestment Act of 2009 ("The Stimulus Plan") which largely focused on three core areas: energy, infrastructure Improvements and healthcare. Smart Grid applications and technologies play at the intersection of the first two: Energy and Infrastructure. Upon signing the Stimulus Plan into law, which directs an impressive $4.5 billion towards Smart Grid projects and initiatives, President Barack Obama declared:

> *"Today, the electricity we use is carried along a grid of lines and wires that dates back to Thomas Edison – a grid that can't support the demands of clean energy. This means we're using 19th and 20th century technologies to battle 21st century*

problems like climate change and energy security. It also means that places like North Dakota can produce a lot of wind energy, but can't deliver it to communities that want it, leading to a gap between how much clean energy we are using and how much we could be using. The investment we are making today will create a newer, smarter electric grid that will allow for the broader use of alternative energy."

New York Times columnist Thomas Friedman inadvertently touched on the primary drivers of the Smart Grid when he wrote, "The country with the most powerful clean-technology industry in the 21st century will have the most energy security, national security, economic security, healthy environment, innovative companies and global respect."

The drivers of the emerging Smart Grid market are many; the primary drivers are listed and outlined in the table below, and further expanded upon in the following sub-sections.

FIGURE 6: SMART GRID MARKET DRIVERS

Growing Energy Demand
» Increasing demand for energy (including more data centers, consumer appliances, and the introduction of electric cars) and specifically an increasing demand for expensive Peak Energy
» A dire need for energy efficiency/conservation to counteract the pace of global energy demand
Energy Independence and Security
» National Security (decreasing fuel supplies and on-going dependence on volatile nations)
» Rising/volatile fuel costs
GHG Reduction
» Increasing awareness of environmental issues, including global warming (electric generation is the largest source of greenhouse gas emissions in the world)
» Social pressures (notably in Europe and the U.S. where the concept of carbon footprints is increasingly understood)
» Optimized distribution and control of power results in overall system efficiencies and reduced GHG emissions
Economic Growth
» Job creation/business opportunities (the renewal and re-invention of the electric power infrastructure is one of the largest business opportunities of this new century)
» Blackouts/brownouts hurt GDP considerably (estimated $150 billion annual in the U.S.)
» Rising asset costs (costs of capital, raw materials, and labor have all spiked)
» Aging infrastructure (average grid hardware 40 years) and aging workforce (e.g., 25 percent of Xcel Energy retires in the next 10 years)
Policy and Regulation
» Regulatory pressures – RPS Fulfillment (many states now aim for "20 by 20" or a similar goal, with California leading the charge, expecting 20 percent renewable energy by 2010)
» The U.S. Congress recognized in both the Energy Independence Act of 2007 and the American Recovery and Reinvestment Act of 2009 (ARRA) that the addition of Smart Grid technologies to the current grid is a key component of reducing carbon emissions
» The new U.S. administration has made energy policy a leading priority and has directed approximately $4 billion in Stimulus funds towards Smart Grid projects

Technology Advancement
» Smart Grid can be seen as the convergence of IT, Telecom and Energy markets
» Rapid innovations in technology over the past decade allow a range of new products and solutions
» Significant amounts of venture capital investment in Smart Grid technologies and solutions
Increased Efficiency Through Grid Optimization
» Multiple integration points for intelligent grid hardware and software from transmission to consumption
» Embedded sensors and monitoring capabilities
» Deployment of advanced two-way communications networks
» Growing Supply of Renewable and Distributed Power Generation and Storage
» Network and systems architecture to support many forms of distributed generation and storage
» Intelligent support for multiple forms of intermittent renewable power sources (centralized and/or distributed)
Advanced Consumer Services
» Robust, simple consumer energy management platforms
» Networked devices within the "smart home"
» New, efficient pricing models for electricity usage
» A more active role in efficient power usage
Infrastructure Reliability and Security
» Networks/systems tolerant of attack or natural disaster
» Ability to anticipate and automatically respond to system disturbances
21st Century Power Quality
» Delivering power that is free of sags, spikes, disturbances and interruptions

Source: GTM Research

1.2.1 Growing Energy Demand

Rising worldwide energy demand coupled with uncertainty about whether future energy supply will adequately meet demand is leading the push towards developing and implementing technologies that can improve the efficiency of energy resources, infrastructure and end-use devices. World marketed energy consumption is projected to increase by 44 percent from 2006 to 2030. *

Smart Grid technologies support both direct and indirect energy efficiency efforts, as they can judiciously determine adequate supply margins (the amount the capacity that is generated in excess of demand to protect against blackouts) in real time, improve the operational efficiency of the distribution network, and allow for a host energy efficient applications (such as demand response) to be introduced at scale.

*Source: http://www.eia.doe.gov/oiaf/ieo.

1.2.2 Energy Independence and Security

Electric vehicles, widely viewed to be a leading solution for reducing dependence on foreign energy, serve as an excellent example of an isolated technology that can not realize its intended promise (and could very well create havoc) without an underlying intelligent grid. For example, a Smart Grid provides the advanced control systems and communication networks needed to charge millions of individual vehicles in a way that doesn't create "accidental peaks."

Only by having algorithms that can determine the safest way to "smooth" the charging schedules of millions of electric cars can we ensure that additional unnecessary stress is not placed on the grid. Without this smarter infrastructure there is simply no way for necessary applications (such as PHEVs, distributed generation and storage) to reach the sort of mass scale penetration needed to create energy independence. Further, it is often the coupling of new applications (i.e., charging electric cars with renewable energy) that provides the ground-breaking solutions that provides real societal benefit.

1.2.3 Greenhouse Gas (GHG) Reduction

Deployment of Smart Grid technologies and services can have a significant impact on CO_2 reduction by intelligently managing the delivery of power to consumers and businesses when and where it's needed.

The growing body of evidence demonstrating the significant negative impact that climate change is having on our natural environment is now understood and recognized by hundreds of millions of people. It is now widely understood that the burning of fossils fuels directly correlates to the problem of global warming. To that point, electric generation is, in fact, the largest contributor of CO2 and greenhouse gases in the world.

These concerns are motivating the growth of whole industries capable of generating energy in cleaner ways. The irony is that many of the renewable energy technologies which hold the greatest promise have been actually been around for decades. What has changed is that the costs associated with renewable energy have dropped significantly as their market penetration continues to rise (solar energy, for example, is now approaching grid parity with "traditional" sources of energy in parts of the United States). Further, the number of governments willing to provide financial incentives to foster renewable energy growth has also increased dramatically over the past decade. Climate change concerns typically have the support of the political left. It is the realization that these technologies only provide a meaningful contribution when they are able to scale (at great volume) that is driving governments to invest in Smart Grid infrastructure and technologies.

James E. Rogers, CEO of Duke Energy believes that energy companies could meet the Obama administration's goal of an 80 percent reduction in 2005 levels of carbon emissions by 2050, if a price on carbon is set, spurring the necessary investment in Smart Grid technologies. Duke Energy happens to be the world's twelfth largest emitter of CO_2 (among companies) and the third largest emitter in the U.S., and Rogers has not only been loud in his advocacy of Smart Grid technologies but also in his advocacy of the need for new utility business models that would put the rate recovery for energy savings (often referred to as "negawatts") on par with energy generation.

1.2.4 Economic Growth

The "upgrade" of the electric power infrastructure is widely considered to be one of the largest business opportunities of the new century. Smart Grid aims to put business intelligence on every critical node of the end-to-end grid, providing a range of new opportunities for established and startup companies. Smart Grid is increasingly viewed as an enabling engine for energy efficiency, renewable energy development, and other necessary energy applications and technologies – not to mention an effective way to defer large scale capital investment projects, which can be difficult to finance in an economic downturn.

The Electric Power Research Institute (EPRI) has estimated the cost of building a Smart Grid in the U.S. at $165 billion over the next two decades – which comes to approximately $8 billion per year. BCC Research estimates that the U.S. market for Smart Grid "enabling technologies" was $17.3 billion in 2008; while Morgan Stanley estimated that the Smart Grid market was worth $20 billion in 2008. In a report called "The U.S. Smart Grid Revolution," (Dec. 2008), KEMA suggests that over the next four-year period roughly 280,000 new jobs will be created in the U.S. as a result of Smart Grid projects. In that same period, KEMA expects that the potential disbursements of $16 billion would catalyze projects totaling nearly $64 billion – a factor of 4X.

FIGURE 7: TOTAL SMART GRID JOBS CREATED AND TRANSITIONED

Category	Deployment Period (2009 to 2012)	Steady State Period (2013 to 2018)	Comments
Direct Utility Smart Grid	48,300	5,800	Direct utility jobs created by Smart Grid programs
Transitioned Utility Jobs	-11,400	-32,000	Utility positions (e.g. meter reading) transitioned to other roles
Contractors	19,000	2,000	External installation and service providers
Direct Utility Suppliers	117,700	90,000	Smart Grid equipment suppliers (e.g., metering)
Indirect Utility Supply Chain	79,300	22,500	Suppliers to Direct Utility Suppliers
New Utility / ESCO Jobs	25,700	51,400	New jobs from new Smart Grid business models
Total Jobs Created	**278,600**	**139,700**	Total new jobs at end of each period

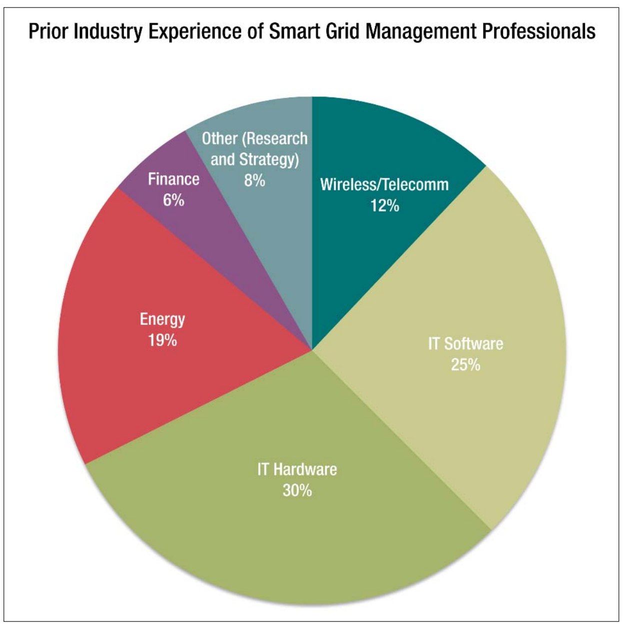
Exhibit 1: Total Smart Grid Jobs Created and Transitioned

Source: KEMA

While it's difficult to reach a consensus on calculations representing global infrastructure build-outs, the key insight is that billions, if not trillions, of dollars will be invested around the globe in the various Smart Grid sectors in the next 20 years. These investments will provide an enabling platform for countless, future applications and industries much in the same way that placing down thousand of miles of broadband fiber-optic cables engendered and accelerated the growth of the internet.

When you consider that the U.S. electric utility sector, with it's annual revenues of roughly $300 billion, is 30 percent larger than the automobile industry and twice as large as the telecommunications industry, and then bring to mind the craze of dotcom investments and telecom M&A which occurred in the mid to late 1990s, a reasonable picture starts to emerge of what can be expected of in terms of Smart Grid investments and M&A in the next five to 10 years. Many of the senior level employees working for privately held companies in Smart Grid, have backgrounds working in either telecom or IT.

FIGURE 8: THE ORIGIN OF SMART GRID'S 'SMARTS'



Source: GTM Research

1.2.5 Policy and Regulation

Regulatory pressures in the U.S. and Europe have been one of the leading drivers of Smart Grid (and Renewable Energy technologies). The new U.S. administration has made energy policy a leading priority and has recently announced funding opportunities of $3.9 billion in ARRA Stimulus funds towards Smart Grid projects. These efforts run parallel to the substantial renewable portfolio standards (RPS) fulfillment requirements that a large number of U.S. states have already committed towards achieving, as well as the increased possibility that a federal cap-and-trade/ climate change law may be put into effect. After a recent meeting with President Obama, German Chancellor Angela Merkel (who has been a proponent of strong curbs on GHG emissions for some time) remarked that in the short time since President George W. Bush had been out of office, the U.S. had undergone a notable "sea change" on climate policies. In the U.S., the combination of significant stimulus funding directed at Smart Grid projects, RPS requirements and the increased likelihood of a price on carbon will all be important drivers in increasing the rate of deployment of Smart Grid technologies and applications.

ARRA Stimulus funds

In June 2009, Smart Grid got another shot in the arm when The Department of Energy (DOE) issued its long-awaited requirements for utilities and vendors wishing to apply for the multi-billion dollar Smart Grid stimulus funding. The funding opportunity announcement sets the exact rules for how to apply for the $3.9 billion in stimulus funds ($3.3 billion of which will provide matching grants at 50 percent cost per share, while the remaining $600 million will be focused on pilot projects). While virtually every vendor has complained that this funding process is taking too long, few have complained about this whopping $4 billion direct investment in Smart Grid – which will actually result in an initial investment of close to $7 to $8 billion, as these grants require the recipient to spend the same amount as given. Further, as it's intended that these investments spur future investment (hence the term "stimulus") the result of American Recovery and Reinvestment Act of 2009 (ARRA) may very well be investments in Smart Grid exceeding $10 billion in the next three-year period (the DOE's stated period of performance for these investments).

The DOE identified six topic areas that it expects Smart Grid projects to fit into. These are:

» Advanced metering infrastructure (AMI)

» Electric distribution systems (Grid Optimization)

» Electric transmission systems

» Integrated and/or crosscutting systems (Advanced Control Systems Integration)

» Equipment manufacturing (Grid Hardware)

» Customer systems (Home Energy Management Systems)

The Climate Bill

As this report goes to press, the U.S. House of Representatives has passed a landmark bill that would establish a federal cap-and-trade program for reducing greenhouse gas emissions. At the center of this legislation is a cap-and-trade system that sets a limit on overall emissions of GHG while allowing utilities, manufacturers and other emitters to trade pollution permits (or “allowances”) amongst themselves. The cap would grow more stringent over the years, increasing the price of emissions and presumably driving the industry to look for cleaner ways of generating and using energy. The climate bill also sets a national standard of 20 percent for the production of renewable electricity by 2020, similar to those already passed by many states (although a third of that could be satisfied with efficiency measures rather than renewable energy sources such as solar and wind power). While this climate bill still needs to pass the U.S. Senate, (and be signed by the President) in order to become law, its effects on the utility industry would be dramatic, to say the least. A price on carbon emissions (or GHG to be more precise) would not only make renewable energy more attractive (as presumably the price of fossil based energy would rise relative to renewables, bringing parity in more and more regions), but would also encourage the growth of all of the leading Smart Grid applications and market segments (each profiled in this report).

1.2.6 Technology Advancement

Smart Grid will move the energy world into the information age. The convergence of IT, telecom and energy will be a giant step forward for the utility industry, as the actual information about energy generation, storage, distribution and consumption will become nearly as important as the actual energy itself. Not only is Smart Grid expected to be the next “boom” industry, but it is directly leveraging all of the technological advances made in the computer, internet and wireless revolutions which preceded. To date, the electric utility industry has lagged behind other industries in taking advantage of the enormous strides that have been made in modern communication and networking technology. The initial upgrade of the electric power industry will be less about the invention and adoption of “new” technologies, and more about implementing existing IT and telecom technologies that have revolutionized other sectors.

That is not to say that there will not be plenty of room for innovation and the introduction of new technologies, and applications – there will be. As we learned with the internet, the keys will be:

- » Finding the most efficient way to move data.
- » Using robust analytics to convert data into actionable intelligence.

Any technology or system capable of delivering real-time business intelligence will further spur innovation and engender even newer applications and solutions. The amount of opportunity for advances in technology on an antiquated grid – that, still resembles the one built by its forefathers more than a century ago – are seemingly endless. From weather prediction data (such as wind, sun and severe weather forecasts) to real-time bid-ask data for energy markets, there is no end in sight for the amount of information that will need to be integrated into both utility and end-user management systems. Most of these technology advances will be in the realm of evolutionary – one generation being slightly better than the next – rather than revolutionary.

One exception is energy storage, which will need revolutionary breakthroughs to foster many of the advances that a true Smart Grid would require. Continued R&D will be needed, and we expect rapid investment in this space, as demand for viable storage options will attract venture capital hoping to develop to the Google of the Energy Age. If the premise of a smarter grid – which is revolutionary – is to go from a centralized generation and distribution model to one that is more distributed and diverse, energy storage will be a necessary component.

1.2.7 Increased Efficiency Through Grid Optimization

The addition of countless sensors and monitors embedded along virtually every node of the energy grid, along with real-time communication networks, is setting the stage for substantial improvements in both the grid's performance and efficiency. Not only can grid operators gain instantaneous data on all relevant major events, but due to the volume of data being collected, most of the necessary actions and adjustments will be automated to optimize the performance of the entire system. Least-cost routing algorithms for the Internet, in terms of automation and cost savings, is a useful comparison in trying to understand the potential of grid optimization. In a similar manner, delivering "least cost power" from the substation to the end user is a readily achievable target once the necessary infrastructure upgrades have been put in place.

The Global Environment Fund reports that a Smart Grid "could send 30 percent to 300 percent more electricity through existing corridors." Steve Fludder, Vice President of GE's Ecomagination division, has recently claimed that by improving the grid's efficiency by 5 percent the U.S. could save 41 GW of power (the equivalent of roughly 25 coal-fired power plants). The expression "low hanging fruit" gets overused these days, but grid optimization is an area that is not only in reach, but that many utilities are already investing in through distribution and substation automation projects.

1.2.8 Growing Supply of Renewable and Distributed Power Generation and Storage

Without a smarter electrical grid renewable power sources will remain niche. While dozens of U.S. states are now racing towards implementing "20 by 20" RPS where states would generate up to 20 percent to 30 percent of their energy from renewable sources by 2020 or some similar deadline, it becomes important to stress the need to have that clean energy properly integrated into the energy supply in a way that is not only advantageous, but also that is not disruptive.

FIGURE 9: U.S. RPS STANDARDS

SUMMARY OF STATE RENEWABLE PORTFOLIO STANDARDS			
State	Amount	Year	Organization Administering RPS
Arizona	15%	2025	Arizona Corporation Commission
California	33%	2030	California Energy Commission
Colorado	20%	2020	Colorado Public Utilities Commission
Connecticut	23%	2020	Department of Public Utility Control
District of Columbia	20%	2020	DC Public Service Commission
Delaware	20%	2019	Delaware Energy Office
Hawaii	20%	2020	Hawaii Strategic Industries Division
Iowa	105 MW		Iowa Utilities Board
Illinois	25%	2025	Illinois Department of Commerce
Massachusetts	15%	2020	Massachusetts Division of Energy Resources
Maryland	20%	2022	Maryland Public Service Commission
Maine	40%	2017	Maine Public Utilities Commission
Michigan	10%	2015	Michigan Public Service Commission
Minnesota	25%	2025	Minnesota Department of Commerce
Missouri	15%	2021	Missouri Public Service Commission
Montana	15%	2015	Montana Public Service Commission
New Hampshire	23.8%	2025	New Hampshire Office of Energy and Planning
New Jersey	22.5%	2021	New Jersey Board of Public Utilities
New Mexico	20%	2020	New Mexico Public Regulation Commission
Nevada	20%	2015	Public Utilities Commission of Nevada
New York	24%	2013	New York Public Service Commission
North Carolina	12.5%	2021	North Carolina Utilities Commission
North Dakota*	10%	2015	North Dakota Public Service Commission
Oregon	25%	2025	Oregon Energy Office
Pennsylvania	8%	2020	Pennsylvania Public Utility Commission
Rhode Island	16%	2019	Rhode Island Public Utilities Commission
South Dakota*	10%	2015	South Dakota Public Utility Commission
Texas	5,880 MW	2015	Public Utility Commission of Texas
Utah*	20%	2025	Utah Department of Environmental Quality
Vermont*	10%	2013	Vermont Department of Public Service
Virginia*	12%	2022	Virginia Department of Mines, Minterals, and Energy
Washington	15%	2020	Washington Secretary of State
Wisconsin	10%	2015	Public Service Commission of Wisconsin

*Five states, North Dakota, South Dakota, Utah, Virginia and Vermont, have set voluntary goals for adopting renewable energy instead of portfolio standards with binding targets.
Source: U.S. Dept. of Energy

A well-known industry example of the difficulties of anticipating and controlling intermittent sources of energy (such as solar and wind) is the "Texas Wind-Out of 2008" where wind energy dropped from 1,700 MW to 300 MW in just three hours. This amount, 1.4 GW, is comparable to losing a large-size conventional power plant and the system operators had to resort to emergency demand response (curtailing power to interruptible customers) in order to avoid a blackout. [Note: While a wind farm is actually an example of centralized generation, and connects at the transmission level in the same way as a traditional power plant, this example highlights the challenge of intermittency, which is a challenge most renewables present.] While this is a dramatic example of a particular challenge, much more prosaic obstacles (such as re-sizing electric lines) lay in wait, as system engineers have to find ways to move power in two directions, on a system that was only designed to go one way.

Also, since the viewpoint that "there is no silver bullet green energy technology" is widely held, it makes sense to ensure that every current and future green technology can reach maximum penetration. This not only includes integrating clean technologies such as solar, wind, wave/tidal and fuel cells but also storing that energy for a time when that electricity is needed.

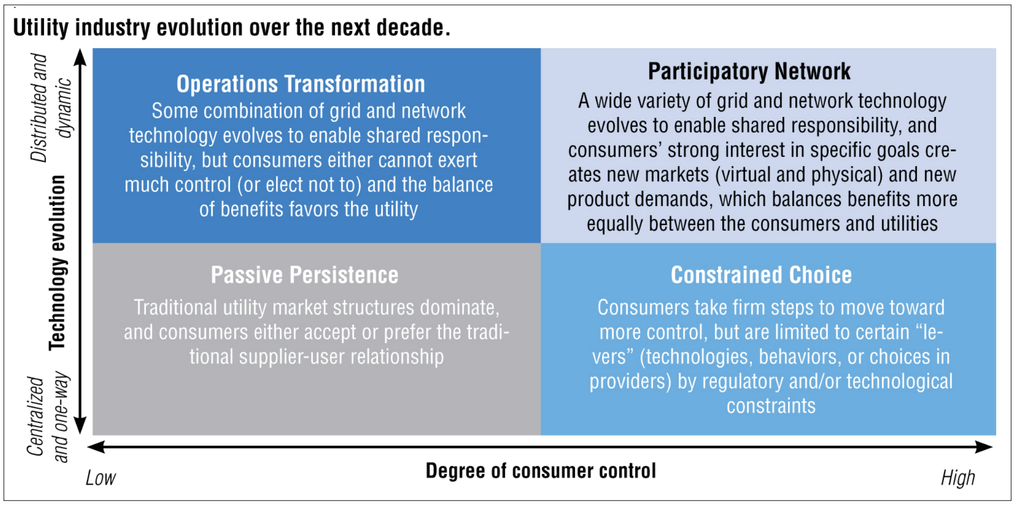
One of the most exciting intersections of clean energy and storage is the plug-in electric vehicle (PHEV), which, if connected to a Smart Grid, could in fact be powered at night via energy generated by the wind. Utility Xcel Energy and software provider GridPoint are currently piloting both wind to battery storage as well as PHEV smart (off-peak) charging solutions. Storage has long been consider the missing link of renewable energy, and having distributed storage, just as having distributed generation sources, will radically change the way in which the grid operates.

1.2.9 Advanced Consumer Services

A major paradigm shift in the way consumers use and understand energy could be rapidly approaching. The true vision of a Smart Grid includes a far more participatory network enabling the consumer the following: an increased choice of energy suppliers, the ability to actively manage their energy use, as well as the possibility to sell any surplus power which they can generate (or have available in storage) on-site. While the voices of European energy consumers have been louder to date – largely in response to environmental concerns – North American consumers are increasingly looking for ways to manage both their energy use and carbon footprints. Equally important, North American utilities will need to find ways to better educate consumers about Smart Grid technologies and applications in order make the business case for their introduction.

The emergence of smart meters and home area networks (HANs) gives consumers the ability to monitor and adjust their power usage in ways like never before. A small-scale pilot test conducted in 2006 by researchers at Pacific Northwest National Laboratory, which provided homeowners with appliances and displays that monitored and transmitted their energy use, successfully demonstrated an average energy savings of 10 percent per customer (and a 15 percent reduction in peak load for the utility). While HAN networks are often still referred to as a “bleeding edge” technology, smart meters which are now currently rolling out at utility scale (notably in California and Texas), allow for time-of-use (TOU) pricing, and could redefine how and when energy is consumed.

FIGURE 10: UTILITY INDUSTRY EVOLUTION OVER THE NEXT DECADE



Source: IBM Institute for Business Analysis

In the coming decades “end-users” will no longer be at the end of the chain, but also the beginning, as they will have far greater possibilities to generate energy, and sell that power on the open market. As prices continue to drop, the economic incentives for the increased adoption of PV and other green technologies will continue to accelerate, thus having the intelligent infrastructure, network automation, analytics and so forth to facilitate that connectivity becomes absolutely imperative.

Chairman of the Colorado Public Utility Commission, Ron Binz, expects to see a “Prius effect” from home energy management platforms or portals, which offer consumers a real-time visualization of electricity usage by allowing consumers to see how much energy they use during a particular time or activity and the possibility of making energy efficiency fun and engaging. (Leading examples include: Greenbox, Tendril and the Google PowerMeter.)

The Galvin Institute has estimated that “wide-spread deployment of technology that allows consumers to easily control their power consumption could add $5 billion to $7 billion back into the U.S. economy by 2015, and $20 billion by 2020.”

1.2.10 Infrastructure Reliability and Security

The promise of a smarter grid, as advocated by groups such as the Department of Energy (DOE), the National Energy Technology Laboratory (NETL) and the Electricity Advisory Committee (EAC), typically includes the following added security benefits:

» Reduced system vulnerability to physical or cyber attack

» Minimal consequences of any disruption, including its duration and economic impact

» Added security-related improvements related to the grid's ability to optimize reliability, communications, computing, self-adjustment and decision-making support

Grid resiliency and security has come into the national spotlight in recent months, largely in response to a story that ran in the Wall Street Journal, regarding cyber grid hackers. While this unsourced story created quite a stir in Smart Grid circles, it did rightly call attention to the security issues involved in bringing two-way high-speed communications and controls to our electric grid, which in many ways is the in the backbone of modern society.

The addition of millions of sensors and smart meters does dramatically increase the number of points that could be targeted and become potentially vulnerable to cyber attack. However, while these concerns should not obstruct the implementation and the deployment of Smart Grid technologies, they do need to be adequately addressed by governments, utilities and companies providing grid hardware and software. Although security will remain a top priority, it should not be blown out of proportion relative to the digital/automated nature of a Smart Grid. Many existing and massively scalable electronic systems have been made secure and there is no reason the Smart Grid will not follow suit.

In terms of general resiliency – and apart from any external threats – having greater situational awareness and visibility allows system operators advanced knowledge of any equipment that is experiencing difficulties and which will need to be replaced or maintained. In the U.S., the average grid equipment is roughly 40 years old. (Note: The typical transformer found at the substation – where power is converted from a higher to lower voltage, or vice versa – is designed to last 40 years. In North America, the average age of these transformers is currently 42 years.) Not to be forgotten is the issue of energy theft. While this is less of an issue in the developed world, one interesting feature of a smarter grid is its ability to detect energy theft, which is a large concern in countries like Brazil, Russia and India.

One of the primary benefits of a high-speed communication network with embedded sensors and automated controls is the ability to anticipate, detect and respond to grid disturbances. A core characteristic of a Smart Grid is its ability to automatically avoid or mitigate power outages, power quality problems and service disruptions. This "self-healing" aspect – the capacity to instantaneously detect a problem and automatically affect a positive outcome – is a major improvement over the grids of yesteryear, which are largely blind to disturbances, threats and actual outages.

One helpful analogy, in trying to imagine a more intelligent grid, is that of human nervous system, where there is distributive intelligence located throughout the body. In a similar way, the introduction of interoperable solutions along the grid, allows for embedded intelligence at virtually every critical node, providing immediate feedback loops. Data sent from a smart meter or an optical sensor inside of a power line can be instantly made into actionable intelligence used to bring the "health" of the grid back into proper balance.

The U.S. economy loses an estimated $150 billion each year due to power outages. Today, the electric grid meets a "3 nines" reliability standard, meaning that power is at 99.97 percent reliability, or that one can reasonably expect to have about three hours of outage time a year. While that might sound like a sufficient measure of acceptability, we live in the age of the internet and e-commerce where most data centers now require "6 nines" or 99.9999 percent reliability, which amounts to about 30 seconds of downtime annually. When one considers the costs associated with one hour of power loss for cell phones networks, brokerage operations or semi-conductor manufacturing, our current reliability standard starts to seem unacceptable.

FIGURE 11: COMPARABLE OUTAGE COSTS BY INDUSTRY

AVERAGE COST FOR ONE HOUR OF POWER INTERRUPTION.	
Industry	Amount (U.S.)
Cellular communications	$41,000
Telephone ticket sales	72,000
Airline reservation system	90,000
Semiconductor manufacturer	2,000,000
Credit card operation	2,580,000
Brokerage operation	6,480,000

Source: U.S. Department of Energy

1.2.11 21st Century Power Quality

As people become increasingly dependent on electricity to drive their lives (both literally and figuratively), it becomes to not only critical to have reliable access to power, but that the quality of the power is sufficient to support modern demands of the digital life.

Today grid operators are primarily focused on power outages rather than power quality (PQ) issues. However, as more "mission critical" appliances are added to the grid, it becomes a paramount concern that they are able to get the proper power quality that they require. Power quality refers to set of boundaries that allow electrical appliances and systems to function in their intended manner without significant loss of performance. Without the proper PQ, an electrical device can malfunction, fail prematurely or not operate at all. If one considers the importance of data centers, cell phones networks, and/or hospital equipment functioning properly, one starts to realize that having reliable power quality is almost as important having power itself. (What may very well happen in the coming years is that consumers will pay various prices for different levels of power quality.)

Further, as renewable energy loads (where the output fluctuates) continue to represent an increasing portion of the total power system load, the power quality delivered by a Smart Grid must be improved to meet the requirements of these sensitive loads.

1.3 Challenges Associated With Smart Grid

In order to realize the comprehensive vision of a Smart Grid advocated by utilities like Austin Energy and Xcel Energy as well as leading industry groups such as the GridWise Alliance, a series of challenges first needs to be addressed. The most cited challenge today is the issue of interoperability standards, as a multitude of actors and technologies will need to "talk" to each other in order to have and an end-to-end intelligent grid. Essentially, you cannot have a "smart" grid if all the major players develop their systems and technologies independently, with the result being incompatible technologies and systems. That is not a vision of a smarter energy future; that is a grid nightmare. Consequently, the issue surrounding interoperability standards is the most discussed challenge of the Smart Grid. With that said, this challenge, although very real, is also somewhat theoretical and idealistic, as complex networks like this often get deployed and evolve/grow prior to industry-defined interoperability standards.

The other principle challenges of arriving at a smarter grid include: future-proofing large-scale utility investments through proper systems architecture, developing regulatory models that incentivize utilities to conserve energy and become more efficient, introducing two-way power flow (from distributed generation sources) onto a grid where power was designed to flow in only one direction, and finally – and perhaps most vital if we are to arrive at a true end-to-end Smart Grid – is engaging the consumer to participate in new programs and change the manner in which they consume energy. These challenges are further defined in the following subsections.

FIGURE 12: PRIMARY SMART GRID CHALLENGES

Primary Smart Grid Challenges:

1. **Interoperability Standards**
2. **Future-Proofing Utility Systems Architecture**
3. **Re-defining Utility Business Models and Incentives**
4. **The Integration of Large Amounts of Renewable Energy**
5. **Consumer Adoption of Smart Grid Services**

1.3.1 Interoperability Standards

The electric grid will lack the real intelligence it needs without a framework for interoperability standards for communications and data flow between physical devices. Drew Clark of IBM Venture Capital Group told Greentech Media in December 2008 that “the missing link is standards. You have to connect the smart meter to the router to the utility and to the energy producers. At each stage there are no standards.” Until the standards are set, there is no way to guarantee that: emerging Smart Grid technologies will be “plug and play” and thus provide modular solutions from one end of the grid to the other; that utilities and vendors won’t be developing expensive, incompatible systems prone to go obsolete prematurely; and that the commercial growth of Smart Grid technologies (and industries) are being accelerated and deployed as needed for the benefit of both consumers and society-at-large. A common set of protocols would make it easier for all players – from utilities to smart meters makers to smart appliance makers to PHEV makers – to confidently research, develop and deploy technologies, applications and systems.

Interoperability standards expert Erich Gunther has stated that the primary issue is not that applicable, mature standards do not exist but rather how to get all the stakeholders focused on quickly prioritizing, adopting and implementing Smart Grid interoperability standards across such a broad and complex technical landscape with many projects already underway. (Mr. Gunther has written that the main problem with the adoption of standards seems to be a lack of awareness of existing battle-tested standards and best practices by individuals involved in designing Smart Grid systems at a high level, and a lack of clear best practices and regulatory guidelines for applying them.)

The potential standards landscape is very large and complex due to how broad in scope the vision of a true Smart Grid actually is. This is why standards adoption has become such an enormous challenge. Energy Secretary Steven Chu has been out-front in his declaration for the need of standards in Smart Grid and many utilities and regulatory groups are collectively trying to address interoperability standards issues through workgroups such as the GridWise Architecture Council and Open Smart Grid (Subcommittee of the Utility Communications Architecture International Users Group) as well as through policy action from NIST (the National Institute of Science and Technology).

The value of a true Smart Grid (gained by both utilities and society) is directly related to the pace of technology implementation that enables a secure, intelligent and fully connected electric grid. There is wide agreement among utilities that the development and adoption of open standards to ensure both interoperability and security are essential for Smart Grid.

1.3.2 Future Proofing Utility Systems Architecture

Utilities must adequately understand and implement the systems architecture and technical requirements necessary to support both present and future applications. Historically, utilities have conducted system upgrades as a series of “one-offs.” The difficulty here is a Smart Grid will not be something that you “do” and then cross it off your list because it’s “done.” The Smart Grid is setting the stage for an evolving energy delivery and management system that will be continually upgraded. Smart Grid is sometimes referred to as “a system of systems” and each of these systems will need to communicate back and forth between each other. For example, a utility’s outage management and advanced metering applications can not be seen as separate, since data from a smart meter (sending a signal from a residence which is about to lose power) can be integral to the success of the utility’s outage manage detection and response systems. Not all systems will be developed and implemented at the same time, so it is imperative that an underlying platform is developed that can support future applications, such that a future system put in place three or 10 years from now, has full compatibility with the systems being deployed today. In this way, the utility doesn’t end up spending a lot of time or money on after-the-fact integration. The myriad of potential overlaps between systems leading to improved decision support and actionable intelligence is one of the most exciting aspects of a Smart Grid, but careful up-front planning and top-down architecture will be need to support these applications.

While Utilities are starting to get the hang of batching applications together in order to market and sell a convincing business case to public utility commissions (PUCs), integrating systems has not been be a particular strong-suit in the past (many utilities to this day lack bus systems architectures). This becomes a critical issue when you start to think about the number of applications that are expected to be deployed as necessary components of a true or comprehensive Smart Grid. “If you assume a rollout period of 36 to 72 months with 60 months, or five years, being the average, and there are 20 new technologies that have been identified that will go into your Smart Grid project, then you are looking at 100 years of technology deployments,” said Eric Dresselhuys, vice president of marketing at Silver Spring Networks. While that might be the extreme case of poor planning, his point is that the paradigm has to be changed to avoid deployment schedules that are both too time consuming and too costly.

Many systems experts have highlighted the urgency of defining standardized interfaces right from the start, and incorporating security, network management, data management and other core capabilities (that will likely interface with any future system or application) into one architecture or “platform” able to support future applications. This “top-down” style integration approach, which allows for unexpected changes, technologies, while reducing costs by leveraging the initial capital investments made on the system architecture, seems to be the most sensible approach. However, re-engineering utilities’ entire systems architecture (in support of applications that may not have yet been invented) is a daunting task, to say the least.

Several Smart Grid networking companies that we have spoken to have, on occasion, complained that the utilities do not have the IT teams in-house to properly understand and implement AMI networking and other advanced applications. Realistically, if utilities are to engineer the best possible architecture to support future Smart Grid applications for a reasonable period (say for the next 15 years), they would do well to leverage the expertise of the world’s most respected IT, networking and telecom companies. This is one of the reasons that industry giants, such as Cisco and IBM, are so enthusiastic about Smart Grid; they realize that the utilities cannot solve these challenges on their own, and further will be extremely cautious to contract startups that may or may not be able to deliver at mass-scale.

From a startup vendor's perspective, one of the major hurdles to deploying solutions and technologies is gaining the confidence of a utility that typically only wants to talk to deeply established companies. One strategy is conducting a series of successful pilot with a utility in order to gain familiarity and trust (this has been the strategy of GridPoint, who has built strong ties to both Duke Energy and Xcel Energy through their pilot initiatives). A second solution is partnering with a more credible brand name. The business strategy of software developer GridNet is based on the belief that in order to succeed in the utility world, a vendor must have strong relationships with utilities, and as such, that company is strategically "piggy-backing" on GE's longtime relationships with utilities.

1.3.3 Re-Defining Utility Business Models and Incentives

In the United States, there is a great need for a new utility regulatory model if we are to expect utilities to genuinely foster and promote energy conservation and efficiency programs. President Obama's stimulus package called national attention to this issue when it authorized the DOE to make energy efficiency funding available to states whose regulators seek to execute "a general policy that ensures that utility financial incentives are aligned with helping their customers use energy more efficiently and that provide timely cost recovery and a timely earnings opportunity for utilities associated with cost-effective measurable and verifiable efficiency savings."

Under the current regulatory model, how can utilities – often publicly traded companies – be reasonably expected to encourage their customers to use less energy, when that proposition would mean earning less money? Could we expect Starbucks to sell less cups of coffee, in the name of a noble cause, without providing some form of compensation to offset the loss of revenue?

A utility's revenue is determined by the kilowatt-hours it sells and a reasonable rate of return on its "rate-base" for capital investment projects (this is usually the un-depreciated value of assets such as power plants, distribution networks, and transmission lines, and is designed to compensate utilities for the risk they take on when they agree to build and finance long-term infrastructure projects). Therefore, if a utility sells fewer kilowatt-hours and/or builds fewer power plants as a result successful energy efficiency programs, their revenue and profit is lower.

Duke Energy has been at the forefront of advocating a new approach to how utilities ought to be compensated, aiming to make energy efficiency a source of profit (rather than being a losing financial proposition for the utility, as it currently stands). However, a recent decision made by the South Carolina Public Service Commission in February of 2009 rejected Duke Energy's widely-publicized Save-a-Watt plan (its energy efficiency program and cost recovery plan) which could be seen as something of a setback; however, more media attention is now being directed toward the need for utilities to be incentivized to achieve energy efficiency/ greater demand side management, and furthermore PUCs and states legislators are recognizing that utilities have the power to initiate wide-scale deployment of demand-side management activities, and would begin, if the regulatory and financial incentives are put into place.

In this example, Duke Energy held that it should receive ratepayer incentives based not on how much it spent on energy efficiency programs, but on how much those programs allowed the utility to avoid spending on traditional supply-side infrastructure. This avoided cost incentive model is a fundamental paradigm shift in the regulatory treatment of utility energy efficiency investments (while consequently allowing Duke to earn a better return than it otherwise would under traditional regulatory models).

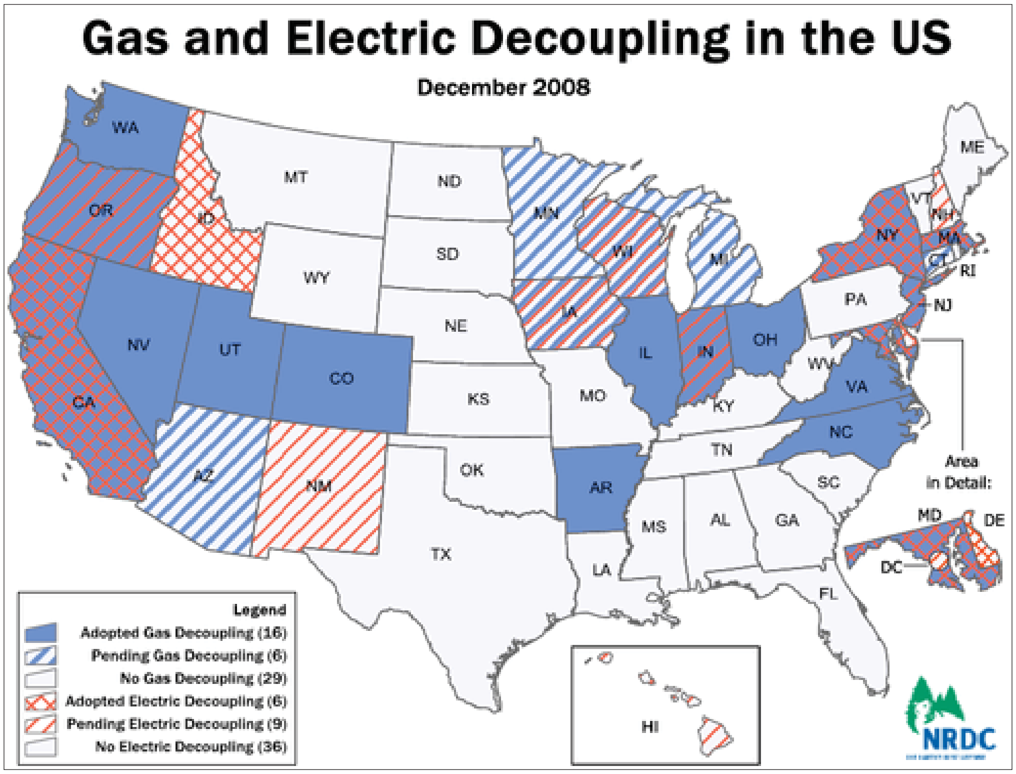
> *"Most state regulatory regimes include inherent disincentives for energy efficiency efforts. Some regulatory innovations, such as decoupling, are aimed at taking away disincentives, rather than creating incentives. We're working to change that paradigm, by encouraging our regulators to allow utilities to earn a return on their investments in saving watts, just as they would for generating watts. This new paradigm would give us an incentive to fully develop all economically sound energy efficiency programs."*
>
> *– Jim Rogers, CEO Duke Energy*

Basically, in order for demand side management (DSM) efforts to work, utilities' profits must be "decoupled" from the volume of energy they produce, allowing companies to prosper even as total energy production drops. Further, utilities argue that they deserve a share of savings they achieve by raising end-use efficiency. The role of regulators under this model would be to monitor performance to make sure that utilities don't profit by reducing investment in needed services.

Expect more states to explore decoupling (which removes the energy disincentive to utilities, but does not address the rate-base issue) as a result of energy efficiency's large inclusion in the stimulus plan. Today only a handful of states have enacted some form of decoupling, including California, Maryland and Massachusetts. If wide-spread decoupling were to happen, energy efficiency (which has often been thought of as the ugly kid sister to the more glamorous renewable energy sector) may become a whole lot more attractive to a variety of actors.

According to Xcel Energy, the current risk in the implementation of Smart Grid is "that these technologies that transform conservation and efficiency efforts can lead to degradation of the regulated return and uncompensated demand destruction. Mitigation of that risk requires efforts of both the utility, as well as the regulators. Utilities will need to focus on the creation of new products and services, transforming from a product model to a service model, and offering customers more options. Regulators will need to be partners in establishing different pricing regimens, ones that create incentives for utilities to earn revenue in ways that aren't entirely linked to additional sales. The focus needs to be on the total customer bill, with an eye toward rewarding both the utility and the customer for conservation."

FIGURE 13: GAS AND ELECTRIC DECOUPLING IN THE U.S. (DECEMBER 2008)



Source: National Resource Defense Council

1.3.4 Integrating Growing Amounts of Renewable and Distributed Energy

First off, there are two separate and distinct challenge areas related to moving/distributing renewable energy: transmission and distribution. The most discussed in the media and in Congress during the first quarter of 2009 is at the high-voltage transmission level; the associated challenge is moving electrons over large distances (for example, moving solar energy from the deserts of the American Southwest to major metropolitan areas such as Los Angeles) such that the energy from renewable energy hot spots can be put to effective use in heavily populated urban areas.

U.S. Senate Majority Leader Harry Reid has been very vocal on this issue, and in March 2009 he introduced a bill that would give the federal government (specifically FERC) the authority to grant permits for new electric-transmission high-voltage lines trumping states jurisdiction on the issue. While building out a national high-voltage electricity super highway is an important issue, it is only loosely related to Smart Grid as the transmission challenge is more about making sure we have the necessary long-distance power lines in place, rather than embedding intelligence onto the grid.

From a Smart Grid perspective, the challenges are primarily at the distribution level and involve:

» Having power flow in two directions on a grid that was only designed to go one-way
» Having the necessary intelligence automated into the system to facilitate the management of intermittent sources of energy

While the addition of substantially more renewable energy must be lauded, this is not easily achievable until the grid has been redesigned to facilitate these new loads.

1.3.5 Consumer Adoption of Smart Grid Services

The last challenge – and perhaps the one with the most uncertainty attached to it – is the work of re-imagining and re-engineering the consumer's relationship with his or her energy use. Changing North American consumption habits, especially those related to energy, which historically has been "dirt cheap," cannot be assumed to be an easy assignment. One of the central tenets of Smart Grid is that by giving the consumer more information they will adjust their energy usage, reacting to real-time signals relaying the price, environmental impacts, and comparative information (i.e., a customer's energy use versus his or her neighbor's) with the result being a win-win for both the consumer and the utility. While this interaction with home and building energy management systems – as well increased participation in generating, storing energy and even selling electricity – is the vision of Smart Grid, it remains to be seen how this level of customer interaction will get off the ground.

The challenge of how to best educate and entice the public to use Smart Grid technologies and applications remains. The first wave of major investment in Smart Grid technologies, the deployment of millions of smart meters, has been focused on real-time measurement of the consumer usage data, but data collection alone does nothing to alter consumers' energy usage. From a technology perspective, the advancement of home energy management systems, home area networks, and new applications (such as electric vehicles, PV and fuel cells) will bring about the deployment of the second wave of components and applications needed for a successful honeymoon and marriage between the utilities and the end-users.

2 SMART GRID APPLICATIONS AND TECHNOLOGIES

2.1 Advanced Metering Infrastructure (AMI)

2.1.1 Introduction

Advanced metering infrastructure (AMI) refers to a system that collects, measures and analyzes energy usage by enabling data to be sent back and forth over a two-way communications network connecting advanced meters ("smart meters") and the utility's control systems. AMI provides utilities unprecedented system management capabilities, allowing for the first time the possibility of having consumers/end-users make informed, real-time choices about their energy usage (acting as a gateway technology to the "smart home"). Millions of smart meters are currently being deployed around the globe. The meme "you can't fix what you can not measure" has allowed smart meters to become the first Smart Grid technology to achieve wide-scale penetration. There are two main components of any AMI system:

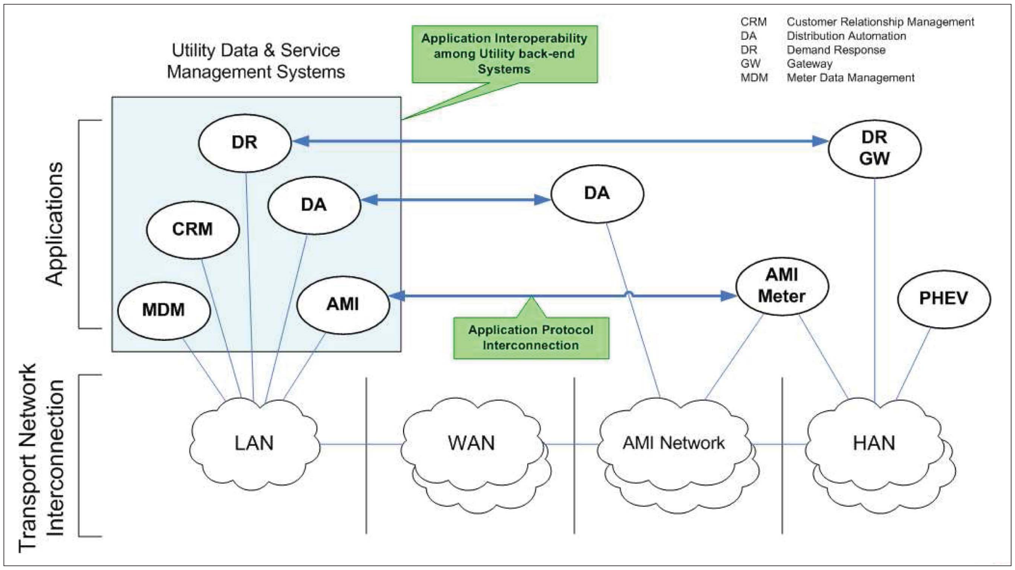
1. The physical smart meter itself, which replaces older mechanical meters unable to communicate
2. The communications network necessary to transport the data that the meter generates

AMI can be explained as having two distinct layers: the application layer and the transport layer.

The application layer is concerned with data collection, monitoring and operational control, related to effectively managing the over-all electric grid. At the application layer, data analysis is also performed; the goal is that information sent from millions of end points is converted into "actionable intelligence" able to help grid operators achieve an efficient and adaptive delivery and utilization of power, as well as ensuring reliability and security.

The transport layer is concerned with moving information back and forth from the utility to the energy user; this is done by moving data across a series of interconnected networks. It should be noted that the reason AMI receives so much attention (apart from smart meters being an easy technology to understand) is because the build-out of the transport layer will allow many other advanced applications to operate, as there will now be a communications network infrastructure in place between the end-user and the utility.

FIGURE 14: AMI COMMUNICATIONS NETWORK SEGMENTS



Source: EKA Systems

An AMI communication infrastructure allows for a multitude of new applications, which can include:

» Remote meter reading for billing
» Remote connect/disconnect capabilities
» Outage detection and management
» Tamper/theft detection
» Short interval energy readings (which serve as the basis for market-based energy rates)
» Distributed generation monitoring and management

One of the most exciting applications that AMI allows for is demand-response, which gives the utilities the ability to turn off/down grid endpoints in real-time (thermostats, HVACs, lighting systems, etc.), based on pre-arranged contractual agreements with customers, in order to curb peak demand.

2.1.2 Challenges/Opportunities

Deploying AMI does not, in and of itself, bring about many of these transformative system improvements. And that is a point that many AMI detractors have made. One often-heard criticism is that smart meters themselves do nothing to reduce consumers' energy use; which is accurate, as smart meters only put that possibly into place. And so, consumers in general and public utility commissions in particular must come to understand that a successful deployment of AMI is one that integrates and allows for -- not only some of the more obvious benefits of AMI (such as a reduction in field personnel, who no longer have to go out and read the meters) but one that establishes a platform for a whole new energy distribution and management system.

In order to achieve the broader benefits of Smart Grid, utilities must leverage AMI as a transformative initiative, and not simply another technology deployment. Unless utilities combine their AMI implementations with a broader operational overhaul, the result will likely be a large-scale missed opportunity with a future need for expensive systems integration and/or replacement upgrades. Leveraging a common network infrastructure significantly lowers both the capital and operational costs of implementing wide-scale DA. The key to taking advantage of AMI's vast opportunities is a structured methodology that first considers every possible current and future need/application/system and then proceeds in designing enterprise-wide business processes.

A basic example would be ensuring that an AMI system could properly communicate with meter data management (MDM), customer care and billing systems (CIS) and outage management systems (OMS). A more interesting example – if AMI is to achieve its potential of redefining the customer experience and transforming the utility operating model – is to consider if an AMI system can:

1. Lay the groundwork for a mass penetration of distributed generation sources.
2. Act as the gateway to Home Area Networks and future applications (such as electric vehicles).
3. Create the possibility for new energy trading markets, allowing end-users to not only buy energy at different prices depending on demand, but also sell energy back to the grid, if they so chose.

2.1.3 Smart Meters: The First Wave of Smart Grid

Smart meters and their corresponding communications networks are the first wave of Smart Grid. To date, smart meters have received the lion's share of the media's attention in stories related to updating the grid. While smart meters alone do not represent the comprehensive vision of Smart Grid, they are an easily understandable technology; they also appear to be the perfect answer to the adage "you can't fix what you can't measure."

Governments and Utilities the world over have recognized the benefits and the need for smart meters. In the U.S., President Obama has called for the deployment of 40 million smart meters. In May 2009 The U.K.'s Department of Energy and Climate Change mandated that advanced energy meters would be fitted in all of that country's 26 million homes over the next 20 years. The U.S. and U.K. are hardly alone in exploring and deploying large-scale AMI deployments. Enel SpA. Italy's largest utility, completed the globe's first large-scale AMI deployment in 2005, installing and connecting more than 30 million smart meters. A glimpse of the morning paper during the next three to 10 years will likely announce hundreds of new large scale AMI deployments (with each project likely costing in the range of $250 million to $2.5 billion, depending on size and location). Australia, Russia, China and Brazil are just a few examples of countries whose utilities are now launching AMI initiatives.

The deployment of millions of smart meters is now pushing Smart Grid forward in a manner analogous to that of email in the mid to late 1990s; email was the application that initially drove the growth of the internet, and Smart Meters will serve the same effect with the Smart Grid.

In fact, this may well prove to be AMI's real historical significance – the role it is playing in driving Smart Grid technologies into wide-scale adoption. While smart meters and AMI networks allow for real-time grid awareness and load control, some industry observers have speculated that the "killer apps" of Smart Grid have not yet been invented.

A recent report by FERC ("2008 Assessment of Demand Response and Advanced Metering") indicated that the ratio of advanced meters to all installed meters has reached 4.7 percent for the U.S., a significant jump from the less than 1 percent in 2006. Prior to President Obama, it was FERC that had first articulated the need for 40 million smart meters in the U.S., an amount that would equate to roughly 20 percent market penetration.

FIGURE 15: FOUR CHARACTERISTICS OF AN INTELLIGENT METER

WHAT MAKES A METER "SMART"? FOUR CHARACTERISTICS OF INTELLIGENT METER:	
1) Interval Measurements » Measuring Both Consumption and Time	2) Interface With Data Monitoring and Discrete Loads
3) Automatic Transmission of Resulting Data » To Energy Provider – No Manual Meter Reading » To Consumer – Load and Usage Control » To Grid Operator – Grid Optimization	4) Two-Way Communications » Data collection » Monitoring » Ancillary Services and Load Control

Source: FERC Commissioner Jon Wellinghoff, Sept. 15, 2008 Energy Intelligence – Road to the Enhancing Energy Productivity

2.1.4 Smart Meter: The Gateway to the Home Area Network

A smart meter can act as a gateway to enable utilities to communicate directly with the customer's home area network (HAN). On a fully realized Smart Grid, customers will rely on home energy management systems (or possibly other in-home control devices) in order to integrate energy data from large appliances, PHEVs, distributed generation/ storage, and smart meters. Correctly establishing this gateway between the customer and the utility is one of the biggest value propositions of the Smart Grid, as it allows the consumer to become an active participant in energy savings and energy markets by: changing their consumption habits, reacting to different price signals at different times of the day, and through providing energy supply through their own distributed storage and generation assets. Further, it allows the utilities the ability to reduce consumers' load (if and when necessary), as well gaining critical information on third-party distributed generation and storage assets located at the consumer's residence.

That smart meters will in fact be the de facto HAN gateway is still not 100 percent assured – though it does increasingly appear that smart meters will be. This is largely because utilities are footing the bill for smart meters, and thus consumers won't have to pay for an alternative solution. Google, who intends to debut its own home energy web-based portal (named PowerMeter) at the end of 2009, has wondered out loud if there is another way to get the data other than using a smart meter (as the majority of population will still be without smart meters in the next five to 10 years, and possibly longer); they have discussed the possibility of "something you will clip onto your fuse box" as a possible alternative. (Despite their expressed concerns over the speed of a utility's AMI deployments, the real issue for Google may well be who owns the data.) The more often-mentioned solution, around the smart meter, would be over a broadband connection. This is far from a moot point, with the 2009 ARRA Stimulus package including $8.2 billion for expanding broadband Internet access throughout the country, and IP heavy weight, Cisco, declaring in May 2009 that they expect to compete in every market segment of the Smart Grid; however many doubt that home users will want to spend the money and make the effort to install their own systems, when the return on that investment is far from clear. (Note: Home automation system maker Control4 and Smart Grid software developer GridPoint have already demonstrated the technical viability of the internet option.)

Commercial and industrial customers have already circumvented the use of the smart meter in many deregulated states; It is possible that residential customers could do this as well, when a suitable technology is more readily available. It is an issue to watch as AMI deployments and customer energy programs increase. The customer will want choice, new services, and simple, set-it-and-forget-it solutions. Like many areas of Smart Grid, the outcome may well be determined not by the best technology, but rather by the best business case. Large-scale utility deployments are ultimately funded by consumers through rate increases, and as such will have to pass the snuff test of state public utility commissions (PUCs).

2.1.5 AMI Networking and Communications

FIGURE 16: CHARACTERISTICS OF VARIOUS AMI COMMUNICATION NETWORKS

	Latency	Reliability	Cost	Maturity	Maintenance	Resiliency	Total
Power line Carrier	4	4	3	1	1	4	17
Broadband over Power line	3	4	4	2	4	3	20
Low Watt ZigBee	3	2	1	1	1	2	10
1 Watt RMS WiFi	2	3	1	1	1	2	10
GRPS/GSM	4	2	4	1	3	2	16
700 Mhz WiMax	2	2	2	3	2	3	14
2/5 Ghz WiMax	2	6	1	4	3	2	18
800 Mhz Trunk Radio	3	3	3	3	4	3	19
900 Mhz Conventional Radio	3	3	3	3	4	3	19
2.6 Ghz MMDS Wireless	2	2	1	3	2	3	13
Satellites	4	3	3	3	4	4	21
Free Space Optical (Laser)	1	3	3	3	3	3	16
Plain Old Telephone	2	2	4	1	2	2	13
Digital Subscriber Line	2	2	2	3	3	2	14
Fiber Optics	1	1	4	1	2	1	10

Setting
E
B
B, C
A
E
A, B, C
B, C, D
A, B, C
A, B, C
C, D
D
A, B, C
E
A, B, C
E

6 = Too New
5 = Not Applicable
4 = Poor
3 = Good
2 = Better
1 = Best

A = Mega Urban
B = Urban
C = Suburban
B = Rural
E = All

Source: Cap Gemini

The AMI network bridges the communications between the smart meter and the Wide Area Network (which goes to the utilities' back haul system), allowing data to flow from a residence or building all the way to utility, and vice versa, in real time speed. Typically, the smart meter communicates to substations and/or other "take out points" (where the utilities' "back haul" networks are located) over a variety of data transmission methods including wire, fiber, phone, radio, and cable. As discussed, one of the major advantages of Smart Grid networks is that the data can move bi-directionally, back and forth between the utility and the end-users. This communications infrastructure is called either the AMI network or the FAN. Since the physical landscapes of different geographical regions are remarkably different – rural, suburban, urban, with the added possibility of extreme weather, different solutions will be appropriate in different field areas. Considerations of a network's latency, reliability, cost, maturity level, maintenance and resiliency are the leading characteristics that need to be weighed.

In deployments around the globe, radio, cellular, broadband-over-powerline, power-line-carrier and fiber have been used. When using radio (the most widely used medium in North America) the decision of which frequency to use is important; lower frequencies work better for rural areas, while a higher frequency is needed for urban/light-urban settings. Since most deployments to date have been done in cities, the 900-MHz range has been most often used. Not only is the communication medium critical to a successful deployment, but also the type of network used (examples included mesh networks, fixed wireless, and/or a combination of the two).

2.1.6 AMI Communication Networks – Competition Heats Up

There is currently on-going debate surrounding what will emerge as the AMI communications standard of choice in the next few years. In order to realize the true vision of a Smart Grid, utilities will want to run as many applications as possible over their field area networks. Issues of reliability, scalability and cost will continue to dominate the conversation, but expect much more attention paid to bandwidth and latency in the coming years, as utilities gear up to attempt advanced applications such as real time demand response (see Section 2.2) to millions of consumer appliances, and will want to ensure that their network is up to the task. Just as with the internet, the more these applications take hold with the general public, the more data is likely to be generated – and will need to be transported. Utilities will need to prepare themselves not just for today's applications, but what can be expected in 10 to 20 years.

In North America the leading solution to date has been radio frequency (RF) mesh networks (such as those provided by market leader Silver Spring Networks, and fellow competitor Trilliant). Conversely, in Europe, the most common communications solution is actually broadband-over-powerline, which has seen very little action in the U.S. and Canada). In 2009, Public Cell Phone Wireless Carriers (3G Networks) and WiMax (which is being referred to as "4G" and holds the promise of providing long range, high bandwidth and lower latencies) both expressed great interest in competing in the AMI networking sector. Below we will briefly discuss RF mesh networks, as well as the two possible future contenders: 3G and WiMax.

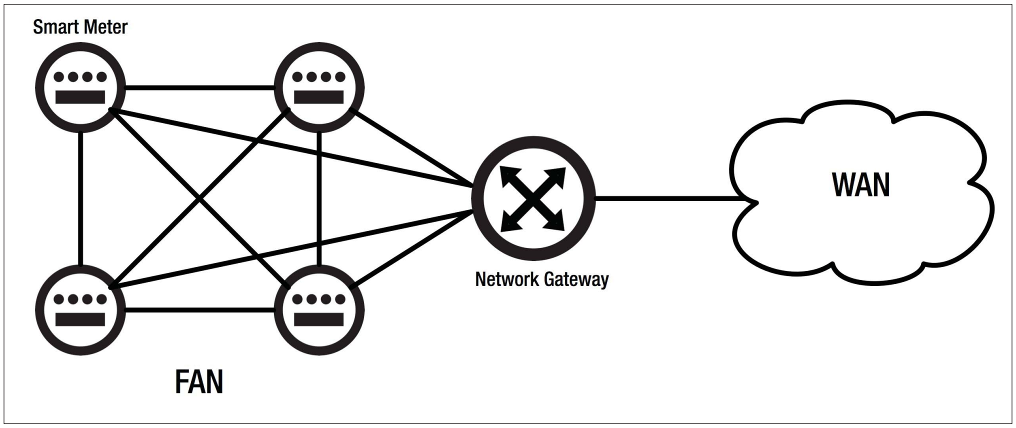
RF Mesh Networks

Radio frequency mesh networks are the leading communications solution in AMI for networks in North America. Multi-hop mesh technology (where each node can communicate with any other node) has proven to be both reliable and redundant. Of equal importance – and why it has been chosen as the solution of choice for the largest deployments in North America (including an approximate five million meter deployment with PG&E) is that it can be easily scaled to include millions of end points (whether that be a smart meters, thermostats, or sensors). Further, these networks can be installed very quickly and the network does not require sophisticated planning and site mapping to achieve reliability. The advantage of a mesh networks over a point-to-point or point-to-multipoint solution (other ways to organize radio network communication) is that scalability is easily achieved.

Further, RF mesh networks are self-configuring, meaning all devices can transmit from their original position, and be automatically recognized by the network. Just as the internet (and other peer-to-peer router-based networks) an RF mesh network offers multiple redundant communications paths throughout the network. If one link happens to fail, for any reason (including the introduction of strong radio frequency interference), the network automatically directs messages through alternate pathways.

Critics of RF mesh contend that while the technology works great in performing AMI specific and related tasks, such as remote meter reading and outage detection (applications that do not generate a substantial amount of data), that this communication technology, due to its higher latencies (vs. other technologies such as fiber or potentially WiMax) may not be sufficient to handle future Smart Grid applications. This is an important point, as these AMI build-outs can go into the billions of dollars range (examples: PG&E $2.2 billion, Southern Cal Edison $1.6 billion), and utilities will be hard pressed to convince PUCs (and their customers) to re-build the network five years down the road.

FIGURE 17: EXAMPLE OF A MESH NETWORK



Source: GTM Research

Q&A WITH PG&E'S ANDREW TANG

Q: Why did PG&E make that switch from PLC to RF Mesh Networks?

A: With PLC [power line carrier] technology, the signal literally travels over the powerline. With RF [radio frequency] mesh technology, the signal travels over the air to some kind of collection point, and the signal can hub from meter to meter [allowing each meter to serve as a relay]. I would call them more mid-band, not narrow-band, not broadband – about 50 to 100 kilobits per second. In an RF mesh network, because each meter is also a relay, they tend to be very, very robust, and if the path back to the collection point is interrupted [by trees or other interfering objects or signals] they can find another path.

Source: Greentech Media (Note: Andrew Tang is senior director of Pacific Gas and Electric Co.'s smart energy web.)

3G Networks

In March 2009, the first major partnership was announced between an AMI networking company (SmartSynch) and a public wireless carrier (AT&T) to connect household electricity meters to utilities via cellular networks. While public wireless utilities had been previously used to carry information over a utility's backhaul system (the WAN), this is the first known example of using wireless public carriers to connect the utility's systems directly with household smart meters. The major advantages of this approach are a reduction of the costs (by not having to build out an entire network) and uncertainty (by leveraging the expertise of the telecom world and the billions of dollars that public wireless carriers continue to invest in these networks). Critics contend that the public carrier networks are not specialized in machine-to-machine area, but others point out that if the telecom giants want to get into this business (and increasingly it looks like they do, as each of the major carriers submitted for stimulus funds for Smart Grid projects) you can expect these giants to do whatever it takes to try to win these large scale, multi-year utility contracts.

WiMax

WiMax promises to introduce a long range, high-bandwidth wireless standard. Unlike the now-popular unlicensed 900-MHz spectrum which is the primary radio communication solution for RF mesh networking players (such as Silver Spring and Trilliant), WiMax runs over licensed wireless spectrum, which is arguably both more secure and reliable. Secondly, a big advantage that WiMax promises to have over RF mesh networks is lower latency. Many industry observers have warned that RF mesh networks may not be sufficiently "future proofed" to allow for future Smart Grid applications due to their higher latencies. They cite trying to run video streaming over a dial-up internet connection as a reasonable analogy (although that example is more to due to speed than latency, both can be reason for concern). For example, if data is needed in order to take a real-time associated action, and the utility does not know whether the latency is 2 seconds or 10 seconds, that could prove very problematic in attempting to run mission-critical applications (such as distributed generation, electric car battery integration or demand response). The primary disadvantage of using a licensed network is that it is more expensive. Further, it's worth pointing out that WiMax has yet to be deployed at scale, so it remains an unproven technology. Not to mention that the cost/benefit analysis, when applied to Smart Grid networks, may not prove out.

2.2 Demand Response/Demand Side Management

2.2.1 Introduction

Demand response (DR) is a relatively simple concept. Utilities incentivize electricity customers to reduce their consumption at critical, "peak" times, on demand. Contracts, made in advance, specifically determine both how and when the utility (or an acting third-party intermediary) can reduce an end user's load. To date, most demand response efforts in North America have been coordinated with the larger users of energy – commercial and industrial users. Now, with the advancement of Smart Grid communications and technology, residential users will increasingly have the option to enroll in DR programs, giving DR "reach" to a substantial portion of the overall system. In fact, many industry observers has expressed that any true vision of a comprehensive Smart Grid is incomplete without demand response included.

We expect demand response to be the first application of Smart Grid to capture a critical mass of market penetration. The demand response market is now being referred to as a gold mine (the New York Times) and industry analysts have called for this market to quadruple over the next five years. It's easy to see why: The on-going deployment of approximately 40 million smart meters in the U.S. will open the door for DR programs to be offered to millions of residential energy users for the first time. These utility scale smart meter deployments will accelerate the pace of DR adoption, as the needed communication backbone between the end users and the utilities will now be in place.

Demand response is a win-win solution for utilities and customers. At times of peak energy demand, DR is a cheaper, faster, cleaner and more reliable solution than adding a peaking power plant. While concerns for the environment are increasing in the U.S. and the EU, the fact that both the utility and the consumer save money will be key driver in the mass adoption of demand response programs.

THE PROBLEM WITH PEAK

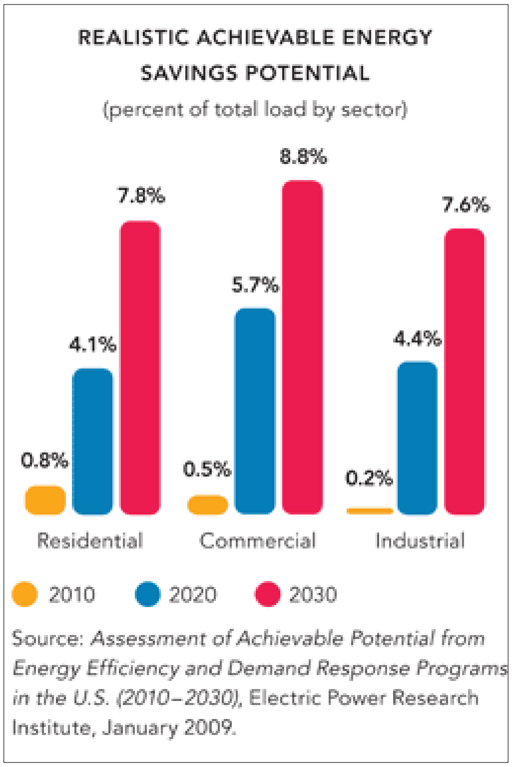
While supply and demand is a bedrock concept in virtually all other industries, it is one that the current grid struggles mightily with because electricity must be consumed the moment it is generated. Without being able to ascertain demand precisely, at a given time, having the "right" supply available to deal with every contingency is problematic at best. This is particularly true during episodes of peak demand.

Imagine that it is a blisteringly hot summer afternoon. With countless commercial and residential air conditioners cycling up to maximum, demand for electricity is being driven substantially higher, to its "peak." Without a greater ability to anticipate, without knowing precisely when demand will peak or how high it will go, grid operators and utilities must bring generation assets called "peaker plants" online to ensure reliability and meet peak demand. Sometimes older and always difficult to site, peakers are expensive to operate – requiring fuel bought on the more volatile "spot" market. But old or not, additional peakers generate additional greenhouse gases, degrading the region's air quality.

Compounding the inefficiency of this scenario is the fact that peaker plants are generation assets that typically sit idle for most of the year without generating revenue but must be paid for nevertheless. In making real-time grid response a reality, a smarter grid makes it possible to reduce the high cost of meeting peak demand. It gives grid operators far greater visibility into the system at a finer "granularity," enabling them to control loads in a way that minimizes the need for traditional peak capacity. In addition to driving down costs, it may even eliminate the need to use existing peaker plants or build new ones – to save everyone money and give our planet a breather.

Source: The DOE Smart Grid – An Introduction

FIGURE 18: DEMAND RESPONSE – ACHIEVABLE ENERGY SAVINGS



Source: Electric Power Research Institute

The Californian utility Pacific Gas & Electric (PG&E), which has one of the most comprehensive DR programs already in place, explains the basic rational behind DR: "It is simple economics – building and maintaining enough power plants to satisfy occasional and temporary peaks in demand would impact rates and the environment. Major capital investment projects with low utilization are not in the best interest of California businesses or our environment. Instead, by temporarily reducing demand when resources reach capacity, we have a more fiscally and environmentally responsible solution to help protect the environment and stabilize energy systems."

The Brattle Group reported in 2007, that even a modest, 5 percent drop in peak demand in the U.S. would yield substantial savings in generation, transmission, and distribution costs – equivalent to eliminating the need for installing and operating approximately 625 infrequently used peaking power plants and associated power delivery infrastructure. This would equate to $3 billion in annual savings, which translates into a present value of $35 billion over the next two decades.

2.2.2 Recent Background

In 2006, the Federal Energy Regulatory Commission (FERC) and the National Association of Regulatory Utility Commissioners (NARUC) began a demand response collaborative effort to coordinate the efforts of the state and federal electric regulators to integrate demand response into retail and wholesale markets and planning. Those efforts have brought DR solutions to the attention of public utility commissions across the U.S. highlighting to the following demand-response trends:

- Increased participation in demand-response programs
- Increased ability of demand resources to participate in RTO/ISO markets
- More attention to the development of a Smart Grid that can facilitate demand response
- More interest in multi-state and state-federal demand-response working groups
- More reliance on demand response in strategic plans and state plans
- Increased activity by third parties to aggregate retail demand response

In a report published in 2007, Thomas Weisel Partners estimated that the U.S. market for demand response "could be as large as $8 billion annually in the next five to 10 years." We estimate that the total U.S. demand response market was already worth $1.5 billion in 2008.

At the end of 2008, FERC Commissioner Jon Wellinghoff (who co-chairs the on-going collaboration with NARUC), noted the link between demand response and Smart Grid technologies, when he explained, "demand response is clearly the 'killer application' for the Smart Grid. By our [recent] FERC report gauging progress and identifying continuing barriers to demand response, we can effectively assess our progress [in terms of] deploying essential Smart Grid technologies." Also According to FERC, 8 percent of energy consumers in the United States are in some kind of demand response program and the potential demand response resource contribution from all such U.S. programs is [now] close to 41,000 MW, or 5.8 percent, of U.S. peak demand.

2.2.3 Demand Response vs. Natural Gas at Peak

Demand response is a cheaper, faster, cleaner and more reliable solution than natural-gas-fired peaking plants. Demand response during periods of peak energy demand is a much cheaper option than natural gas power plants, the most commonly used solution today. The capital cost necessary to build 1 MW of demand response capacity is estimated to be roughly $240,000, compared to the approximate $400,000 it costs to build 1 MW proportion of a natural gas plant. Demand response can be dispatched in a very short time – in under five minutes – whereas natural gas plants (brought on at peak) can take up to 30 minutes to achieve full operational capacity.

Further, demand response, where the "new capacity" is essentially created by a reduction in a share of a population's energy use – and not by burning additional fossils fuels – can be considered a clean alternative to peaking power plants since demand response creates no emissions. Also, since demand response is sourced from a large and diversified cross-section of a population, its capacity can be considered more reliable than a dependence on a limited number of peaking power plants.

2.2.4 Virtual Peak Power: A Growing Market

The need for demand response solutions has created a huge market for intermediate (third party) load aggregators, who can provide "virtual peak power" to the utility by adjusting the participating consumers' thermostats and intelligent grid-aware devices at peak energy hours and aggravating this saved electricity. To date, the two largest capacity aggregation providers in the U.S. are Comverge and EnerNoc. Both companies now manage over 2 GW, and collectively they manage more than 4.5 GW, a very respectable amount of energy, by anyone's account. (Note: At the time of this writing, Comverge and

DEMAND RESPONSE: A TECHNOLOGY EXPLAINED

"Demand response capacity provides an alternative to building conventional supply-side resources, such as natural gas-fired peaking power plants, to meet infrequent periods of peak demand. The Company's software applications analyze the data from individual sites and aggregate data for specific regions. When a demand response event occurs, the Company's NOC (Network Operations Center) automatically processes the notification coming from the grid operator or utility. The NOC operators then begin activating procedures to curtail demand from the grid at the Company's commercial, institutional and industrial customer sites. Its one-click curtailment activation sends signals to all registered sites in the targeted geography where the event occurred. Upon activation of remote demand reduction, its technology, which is receiving data from each site, is able to determine on a real-time basis whether the location is performing as expected."

Source: EnerNoc

EnerNoc's year-to-date stock prices had doubled and tripled, respectively).

2.2.5 Continuing Challenges

There are three primary challenges that could limit opportunities for continued growth in demand response solutions:

4. The limited number of retail customers on time-based rates (which provides the necessary incentive to respond/react to market prices.
5. Limitations on the number of customers that have access to meter data (who lack not only home energy management systems or "portals" to read the data, but in majority of cases the smart meters needed to generate and share that information.
6. The scale of infrastructure investment needed to deploy enabling technologies during an economic downturn.

While there is a bit of a "Big Brother" concern to having utilities control consumer appliances and assets, the transition to real-time pricing (RTP) signals from their utilities along with the advancement of Smart Grid technologies (such as home energy management systems) will set the stage for consumers to dynamically adjust their own energy consumption profiles to minimize costs; this solution will preserve customer autonomy and mitigate privacy issues.

2.3 Grid Optimization/Distribution Automation

Grid optimization entails a wide array of potential advances that will give utilities and grid operators digital control of the power delivery network. The addition of sensor technology, communication infrastructure and IT will help optimize the performance of the grid in real-time, improving the reliability, efficiency and security. Grid operators will gain improved situational awareness as fundamental system-wide visibility and analytics will now be in place. While AMI deployments lay the foundation for utilities having control of millions of end user devices, real-time command and control of higher-level grid devices is of equal, if not greater, value in the current push for overall grid efficiency.

The deployment of wide-spread sensor technologies can be considered analogous to adding a central nervous system to the electric grid. It's worth noting, that in the human body, the brain does not provide all the intelligence; the nervous system gives the body wider, distributive intelligence. A true Smart Grid will have intelligence embedded at virtually every critical node, and just as the human brain can sense and respond to damaged nerves throughout the body, a Smart Grid will immediately react to disturbances throughout the power network. The communication infrastructure is vital to sensing grid activity and issuing control signals for improved grid performance and security. Information technologies will take data generated from millions of end points (such sensors embedded on equipment ranging from capacitor banks to transformers), and convert that into actionable intelligence. Ultimately, the grid will behave much like airplane's autopilot system (with many operational systems operating in the background). A Smart Grid will self-correct, self-optimize, call attention to any pertinent issues, and instruct operators if a manual override is necessary.

Utility Xcel Energy with its SmartGridCity project in Boulder, Colo. (one of the most dynamic pilots attempted to date) has placed a major emphasis on grid optimization activities and they expect "up to a 30 percent reduction in distribution losses from optimal power factor performance and system balancing" – a significant improvement. As large scale utility "upgrades" continue to accelerate in North America and Europe, grid optimization supporters and vendors rightly point out that the resulting efficiency gains are not contingent upon changing consumer behavior, and as such the resulting returns can be seen as more predictable. While the concerns and desires of each utility will vary greatly (with variables such as existing rate recovery structure and the current state of physical grid assets paramount) the predictability of the ROI will make continued investment in grid optimization projects attractive. Grid Optimization serves as an umbrella term that encompasses improvements in three main areas:

1. System Reliability
2. Operational Efficiency
3. Asset Utilization and Protection

Those familiar with Electric Power Systems and Smart Grids may be more familiar with the term "Distribution Automation" which is specific to control and optimization of the distribution network. For the purpose of this report, we are taking an end-to-end view of automation and optimization. The primary benefits of grid optimization include a reduction in the number of outages, better utilization of both fuel sources and grid assets; improved situational awareness and security; and improved forecasting. The following chart highlights some of the major advantages of an optimized power grid.

FIGURE 19: THE CHARACTERISTICS AND BENEFITS OF GRID OPTIMIZATION

1) System Reliability
a) Monitor power flow and grid assets in real-time
b) Decrease the quantity and duration of faults and outages
» Pinpoint failure or faults locations, or predict before occurring
» Remote/automatic switching and restoration (after a fault)
c) Increase in visibility and control
» See exactly where the distribution network is overloaded, underutilized or vulnerable to extreme weather
» Run continuous simulations to anticipate the proper response to any fundamental system event
d) Integrate operations data to make better decisions
e) Re-route power (around disturbances and/or congestion) to maximize efficiency without impacting the end-user's experience
f) Reduce equipment failure
2) Operational Efficiency
a) Optimize Power Delivery and Improve PQ
» Minimize congestion and line losses, achieving "least cost" power
» Dynamic control of voltage regulation
» Reduce feeder losses
» Improved frequency regulation
» Determine if/when renewables can substitute for fossil fuels
b) Decrease in Generation Needs through the mitigation of energy losses
» Substantial Costs savings
» Reduction in carbon emissions
c) Increases/Improvements on System Load Serving Capability
» Efficiency improvements allow more power to run over existing networks
» Improved Load estimates allows for better management and control
» Assess coming weather risks on capacity plans

3) Asset Utilization and Protection
a) Allow utilities to more effectively manage capital in the face of aging infrastructure challenges and a current economic downturn
» Reduce or defer the need for new power plants, power lines, substations and grid hardware
» Capital planning tied to accurate utilization rates
b) Report on the Health and Performance of Critical Grid Assets
» Understand system-wide asset "loading"
» Determine which assets are over/under-utilized
» Asset maintenance based on prediction rather than reaction, allowing the ability to prioritize and properly budget R&M
» Increase asset life

Source: GTM Research

An example of a Grid Optimization solution would be monitoring and correcting the voltage of a transformer. Data collected from a sensor (monitoring the voltage level of the transformer) would be sent at regular intervals from the sensor's gateway over the utility's backhaul network. The system would detect a high or low voltage level reading exceeding the normal threshold, and automatically send a corrective action to adjust that voltage back to normal. The aggregate benefit from having the real-time capability to monitor and "tweak" millions of transformers is a dramatic reduction in both wasted power and improved efficiency.

Although this type of voltage correction might seem mundane, it is actually rather revolutionary in the utility world; historically, utilities have had zero control beyond the substation. North American Utilities, being highly risk averse, have never wanted to admit publicly problems of low voltage (including flicker and excessive voltage drop) that regularly can occur at the end of the feeder. The challenge of having to optimize the energy going to entire distribution network from the substation alone meant that some consumers just had to live with low sub-par voltage. More often the case, however, is the problem of utilities "over-juicing" their residents in order to ensure that the population is adequately supplied. Utilities in the U.S. are required to deliver power to consumers at 120 volts (plus or minus 5 percent, which yields a range of 114 to 126 volts) Since voltage gradually decreases on distribution feeder lines as the cumulative load increases, the voltage must be transmitted at a high enough level so that the very last consumer on the line gets at least the minimum standard of 114 volts during peak load. Not only is the result of this practice higher – and frankly unfair – bills (being that Voltage = Watts/Amps) as consumers are getting power they have not requested but also more greenhouse gas emissions and all the other corresponding problems associated with burning (unnecessary) fossil fuels.

It's interesting to point out that Fred Butler, Chairman of the National Association of Regulatory Utility Commissioners (NARUC), has warned that some utilities might be putting the cart before the horse in their rollout schedules. "Smart meters are not necessarily the best starting point," Butler has cautioned. Butler has suggested that utilities should consider first building out their communications for the distribution system as that could be implemented at lower cost (than the notoriously expensive AMI deployments) and begin creating immediate benefits. (Analyst Note: Several state PUC chairmen that we spoke to for this report expressed similar sentiments.) While the fact is that in many places AMI projects are moving forward full-steam-ahead, the key insight is that the communications networks must be sufficiently designed to support not just metering related applications, but also grid optimization applications and demand response (not to mention, near future considerations such as the integration of distributed generation, storage and electric vehicles).

Companies that will compete in Grid Optimization are the large grid hardware companies such as ABB, SEL, S&C Electric, Areva, GE and Siemens. More than any other sector a few big players have traditionally dominated this sector. What's changed is that the convergence of IT and communications into the utility world will bring a host of new competition into this space. IT giants such as Cisco and Oracle have announced their intentions to throw their hats into the grid optimization ring. Further, leading AMI providers such as Itron and Silver Spring Networks will likely expand their solutions into this space. Start up-companies like Current Group (that markets sensing and monitoring technologies) and MicroPlanet (which offers voltage regulation products) and other complementary technologies and software providers that happen to fall in between the cracks of what larger players are providing will compete here. In fact, we see a lot of room in this market segment for companies that can offer cutting edge devices that can integrate into the larger picture.

XCEL ENERGY'S VIEW OF AN INTELLIGENT, AUTO-BALANCING, SELF-MONITORING POWER GRID

Utilities can expect to enhance and refine their distribution and generation management with the help of real-time system information. As a result, they will be able to respond to peak demand loads more efficiently; identify outages and their related causes more precisely (enabling faster restoration); dispatch a more cost-effective mix of fuel sources (while minimizing environment impacts); and automatically re-route energy as needed to meet consumer demands and avoid unnecessary strain on the power grid.

Perceived Advances:

- Up to 30 percent reduction in distribution losses from optimal power factor performance and system balancing
- Expected deferral of capital spends for distribution and transmission projects based on improved load estimates and reduction in peak load from enhanced demand management
- Potential carbon footprint reduction as a result of lowered residential peak demand and energy consumption, improved distribution losses and increased conservation options
- Possible reductions in the number of customer minutes out as a result of improved abilities to predict and/or prevent potential outages, and more effective responses to outages and restoration
- Potential utility cost savings from remote and automated disconnects and reconnects, elimination of unneeded field trips

It's worth noting here that a true Smart Grid calls for the addition of millions of new distributed generation and storage assets, it is particularly the distribution network (as opposed to the transmission) that needs greater automation, intelligence and optimization. In fact, discussions of Smart Grid in general are primarily focused on the distribution side of the grid, typically from the substation to the consumer. (The challenges at the transmission level are less about adding intelligence, and more about ensuring that there are adequate amounts of transmission to move bulk power to where it is most needed.)

2.4 Integration of Renewable Energy and Distributed Generation Sources

The integration of renewable energy and distributed generation sources at mass scale is one of the most revolutionary aspects of a smarter grid. While many of the renewable energy solutions – such as wind and solar – have been around for decades, what has been lacking is the proper infrastructure to support their introduction in an impactful way. Smart Grid technologies will change this, as smarter grids attempt to fix the scale-management problem. The continued development of true "plug and play" interoperability will promote the same wide-spread deployment in renewables and distributed generation that occurred with personal computers and cell phones, bringing a profound transformation to electric generation in the coming decade.

The terms "renewable energy" and "distributed generation," which are sometimes used interchangeably, are not the same. Distributed generation refers to smaller-scale energy generation or storage assets, and includes both renewable and traditional (fossil-based) generation sources at or near where energy is consumed. Renewable energy can be either large-scale centralized facilities (such as a wind farm or Concentrating Solar Thermal plant) or smaller-scale, distributed generation assets (such as rooftop solar panels or "small wind" deployments).

The intersection of renewable and distributed generation is the next frontier in electric generation; the promise of generating energy virtually anywhere and feeding that supply into the grid will eventually turn the existing energy world on its head. While this transition may take decades, we are already beginning to see very real seeds of change; on percentage basis grid-connected PV (distributed solar energy) is now the fastest growing power generation source in the world, with a global growth rate close to 70 percent in 2008. *

Part of the reason large-scale, centralized renewable projects, such as concentrated solar thermal (CST) plants and wind farms are being deployed ahead of distributed assets is that it is much easier to hook energy generation sources in at the transmission level (as this is where traditional electric generation sources – notably-coal and gas fired power plants – have historically attached to the grid) allowing the electricity to move "downstream" from the plant to the consumer. Also the manufacturing jobs associated with development of low-tech wind turbines, which represents close to half of global renewable energy supply, is currently a favorite cause among many countries' politicians.

*http://www.ren21.net/globalstatusreport/g2009.asp

While these large-scale projects are needed and are already contributing hundreds of gigawatts of capacity around the globe the future potential contribution of distributed generating assets dwarfs the concentrated renewable sources, as they can be located virtually anywhere. It's also important to note – that although residential properties are often first thought of in terms of where to add distributed generation – the potential commercial and industrial distributed generation market is not only massive, but seems to make more sense in terms of the first wave of mass deployment. Those users typically have more space to situate distributed generation assets, and can more easily justify investments that payoff over a longer periods (as they are accustomed to financing initial up front costs for future business returns).

In the same way that cell phones were able to quickly reach mass penetration in developing countries, as a result of wireless networks eliminating the need for expensive infrastructure projects (wires, poles, labor, etc.), distributive generation has the potential to bring power directly to the people (which will serve a huge global demand in many developing and developed countries). In fact, much attention is now being paid to distributed generation's ability to create "microgrids" – independent self-reliant, small-scale grids that generate and store all the power that their users require. While this hot topic gets into a broad range of issues, it's important to note that in the event of a power outage, grid-connected users who have established their own micro-grids would have the ability to "island" – continuing to meet their electric requirements independent of the primary electric grid.

While a conversation about Smart Grid is more interested in bringing distributed generation sources *onto* the grid, we are living in a period where the emergence of distributed generation, advances in electric storage and distributed intelligence is now making a range a new possibilities available. And as a result of these convergences, we can expect a continued global boom in distributed generation technologies.

While it's fascinating to consider how distributed generation and storage will change the power landscape in underdeveloped countries, it is perhaps even more interesting to consider how it will affect the landscape of the developed world, as distributed generation has the potential to reinvent end-users' relationship with energy. Drivers such as concern for the environment, and government subsidies are adding to the momentum, but the real driver here is cost. The emergence of Smart Grid technologies is entering the world's stage at a time when distributed generation costs continue to reach historic lows, notably solar PV. In 2008, many leading analysts announced that solar costs had reached "grid parity" in different parts of the world for the first time, meaning that the costs associated with solar energy were competitive with traditional fossil-based fuels. While each region's grid will, of course, have it's own parity level (as the cost of electricity could be anywhere between 5 cents per kilowatt-hour for China and India to a whopping 25 cents per kilowatt-hour for Italy) many major demand centers which have high retail electricity – such as Italy, Spain, Holland, Great Britain and California – can now turn to solar PV as a cheaper alternative. As such, end-users' relationship with energy will change as selling power to the grid becomes the norm, and customers become more accustomed to both the financial and environmental benefits of green energy.

The two leading challenges associated with the advancement of renewable, distribution generation assets are:

1. Intermittency
2. Two-way power flow integration to and from millions of distributed points

The intermittency challenge results from the source of the renewable power being available only at certain times. There are two ways to solve the intermittency challenge. The first is to use a variety of renewables in combination. An obvious example would be that if a storm kicks up preventing the generation of solar energy, wind turbines could capture the resulting wind energy from the storm. The second and most-discussed possibility is to rely on energy storage. In fact, energy storage is often referred to as the missing link in renewable energy, and electric car batteries are now considered one viable solution in terms of capturing energy that would otherwise be wasted, and putting it to good use (and offsetting the need for fuels that emit CO2). This need is now widely understood, not just by the utility and renewable energy worlds, but also by the financial community; VC interest in storage technology is at an all-time high as of the time of this writing, with storage being one of the most funded sectors in cleantech in the first quarter of 2009.

The second challenge of successfully adding renewables is achieving two-way power flow on a distribution network that was primarily designed for electricity to move in only one direction. Hooking up generation sources in at the distribution level brings with it a whole new complexity of concerns, absolutely necessitating true end-to-end intelligence, as grid operators will need to measure and aggregate how much capacity is being produced from millions of energy producers in real-time, in order to properly route and direct that energy as efficiently as possible. One of the great advantages of distributed energy is that you do not have to move it over long distances as it is generated in close proximity to consumption (minimizing transmission and distribution losses); but as utilities begin to have distributed energy at their ready, they will need to understand the best way to distribute and make use of it.

Grid operators historically have never really had to “think” beyond the substation. Distributed renewables will be a disruptive technology particularly at the utility systems level. They will need to update/reinvent their systems, furthering their visibility, control and intelligence. A continued concern over the next decade will be that communication networks will still not reach to the majority of consumers; in order for grid operators to properly dispatch these distributed generation sources, communication systems are needed in order to send energy price signals and commands. Smart meters, with their capability of measuring energy output – in addition to energy consumption – serve as key enabler of distributed generation. Large-scale AMI deployments are solving this communication challenge for millions of European and U.S. citizens, but the majority of consumers will remain under-served in the near-term.

Apart from IT and communications concerns, many engineering challenges exist in upgrading the actual grid assets themselves. One example is that distribution power lines were designed to handle a certain amount of power. If you now attempt to push 30 percent more power over those lines, you may, in some cases, be crossing the threshold of what those lines can safely carry, and as such, those lines would need to be "re-sized." The same challenges could be expected of transformers and other distribution hardware. Further, protecting the entire system takes on a new complexity once you start moving power in two directions. Consequently protective device coordination will be a major concern. Utilities will need to, in some cases, re-engineer how the system is designed to operate, as issues such as the need for bigger circuit breakers (fuses) will have to be addressed. These are pressing challenges as more than 25 U.S. states have now agreed to meet renewable portfolio standards (RPS) in the next five to 20 years, with other mandates and incentives (such as renewable energy credits or RECs) quickly coming into place.

Apart from overcoming the intermittency and power flow challenges, a third challenge is the resiliency and security of these generation assets. Utilities will need to have 100 percent confidence in the availability of distributed renewable energy, if renewable energy's contribution is to extend beyond niche. Not only will advanced measurement, control technologies and systems need to be installed, but consumer performance standards and metrics must also be developed. Once a distributed asset is added to the grid, utilities will need to ascertain that the owner continues to meet his obligations to keep that unit operating properly. Government regulatory groups will need to perform periodic audits and enforce compliance rules, such that these resources can be trusted. An example of a resiliency issue would be ensuring that each asset follows dispatch instructions within the acceptable tolerance limits, such that grid operators know when they send out a specific signal for energy, they can be certain that they will get the intended, proper response.

Another often-advertised benefit of distributive generation technologies is that they can eliminate or defer large capital investments in centralized generating plants, substations, transmission and distribution lines. Pacific Northwest National Laboratory expects these savings to be in the order of reducing overall costs by "tens of billions of dollars over a 20-year period." To be fair, it should be noted that this argument gets attached to every application and technology in Smart Grid and renewable energy. As we currently are still in the early adopter phase of distributed generation, and expect the first real push to come in the next five to 10 years, it remains a challenge to assess what market penetration will look like, and how much traditional power will be offset. What we might expect, as the current strong public opposition to the construction of new coal and natural gas power plants continues, is for utilities – whose business models are largely based on finding appropriate large scale capital investment projects and "locking-in" at a certain fixed rate of return – to move into the investment of large scale distributed generation projects. In this situation, the utility will already control the power rather than the end-user who could conceivably sell power back to the grid from his home or business. What remains to be determined is whether the utility will lease real estate – notably roof space – or use a revenue sharing model, this is are just one example of the many exciting business challenges that will need to be worked out.

Renewables, historically, have been less than 3 percent of the total amount of energy produced and used. Their positive contributions are often, and perhaps correctly, viewed as negligible. In this discussion, rather than listing and detailing the different renewable technologies – from solar PV to concentrating thermal solar to wave to wind – as is often done, and surmising that due largely to the intermittent nature of the energy source that there is no magic bullet answer among these technologies to respond to our global challenges; instead, we would like to take a different approach and suggest that the magic bullet may in fact be the Smart Grid itself, which will enable all generation and storage options to be integrated and aggregated. Considering that in 2008 the website YouTube required as much bandwidth as the entire internet in 2000, one can acquire an appreciation for just how rapidly newer and better applications can be installed and utilized, when the underlying architecture is sound.

Smart Grid has the potential to unleash the power of renewable energy, providing a uniform platform for distributed generation assets to "plug and play." The primary reasons why distributed renewables have historically had a minor contribution to the energy supply is that (1) they have been relatively expensive (compared to fossil fuels) and (2) they haven't been able to properly scale. The dynamics of both of these factors are rapidly changing. Costs of renewable assets are and will continue to drop, and the scale-management problem is a business and technological challenge that many of the world's most respected and innovative companies – such as IBM, GE, Siemens Cisco, Oracle and Google – are all now racing to address.

While there is wide agreement among scientists that decreasing overall energy consumption is the most important variable in meeting future global energy demand, learning how to scale distributed renewable energy technologies will be a critical step in transitioning from an oil-based civilization to an electricity-based civilization (arguably the second important variable in reversing global warming and meeting future energy demand). We expect the global market for both Smart Grid and renewable energy technologies to continue to expand rapidly and be very competitive in the next five to 10 years, as companies begin to jockey in earnest for the competitive advantage associated with being a market leader. While "Google" and "Cisco" have both officially "thrown their hats in the ring," it remains to be seen who will be the Google and Cisco of Smart Grid Age. This will be a very exciting market to watch in the coming years.

THE DOE'S DEFINITION OF DISTRIBUTED ENERGY

Distributed energy consists of a range of smaller-scale and modular devices designed to provide electricity, and sometimes also thermal energy, in locations close to consumers. They include fossil and renewable energy technologies (e.g., photovoltaic arrays, wind turbines, microturbines, reciprocating engines, fuel cells, combustion turbines, and steam turbines); energy storage devices (e.g., batteries and flywheels); and combined heat and power systems. Distributed energy offers solutions to many of the nation's most pressing energy and electric power problems, including blackouts and brownouts, energy security concerns, power quality issues, tighter emissions standards, transmission bottlenecks, and the desire for greater control over energy costs.

Source: DOE (http://www.oe.energy.gov/de.htm)

2.5 Energy Storage

The advancement of storage technologies holds the promise of revolutionizing our power delivery system. The electricity grid has historically contained a negligible amount of electricity and energy storage. The chief problem has been that storing electricity is incredibly expensive. While this remains a challenge – and there presently remains no single ideal storage technology – the possibility of storage breakthroughs in the next few years is high, as there is more attention now being given to storage as a necessary, viable and as potentially very profitable technology.

A variety of prominent actors – national politicians, Fortune 500s, startup technology companies and financial investors – are now asserting that the commercialization of storage technology is one of our most pressing challenges, and favorable policies and increased investment will continue to propel this sector in ways never seen before. Energy storage has rightly been called "the missing link" for renewable energy; however it hasn't been funded as such. This is changing in 2009, as the race is to become the Google of energy storage is underway. Smart Grid technologies –notably software and analytics – will enable both bulk and distributed storage solutions to come online and serve as a real-time solution. In summary, a Smart Grid without energy storage is analogous to a computer without a hard drive – severely hindered in what it can do. Energy storage assets can:

» Harness the power of renewable energy, capturing energy that is generated when there is little demand – notably wind energy – which would otherwise go unused

» Serve as an alternative to fossil based generation (helping to mitigate increases in demand)

» Act as a back-up power source, protect against costly and disruptive brownouts and blackouts

» Ensure the over-all reliability of the grid (one critical example is by helping to regulate the power frequency)

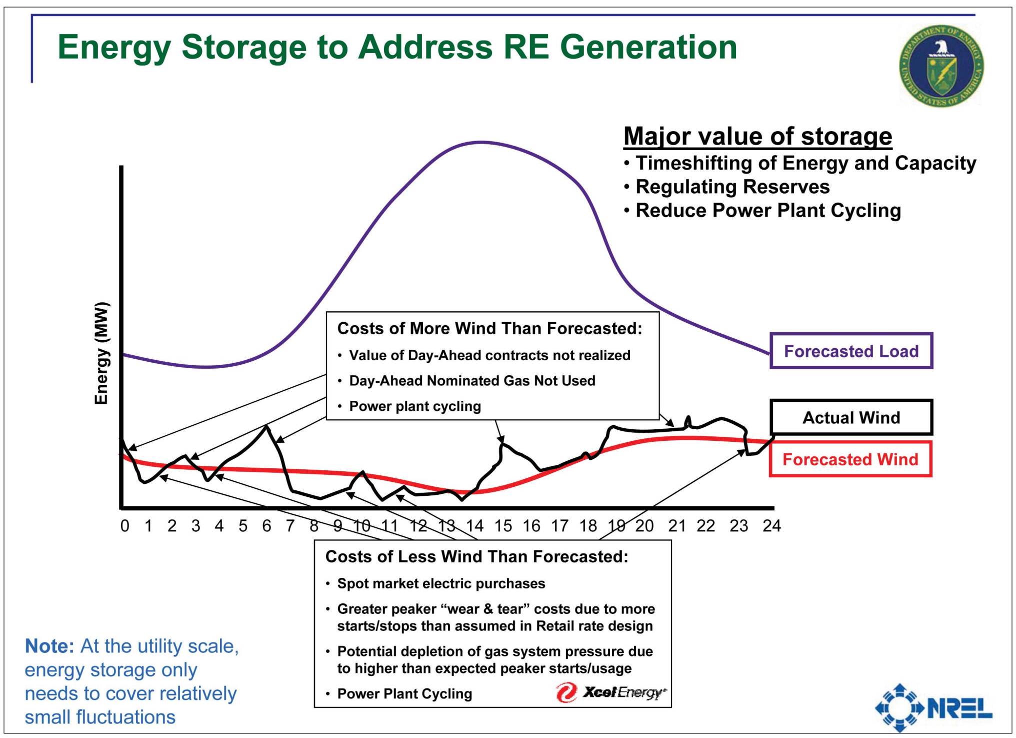
Energy storage has rightly been labeled "the missing link" for renewable energy. Storage not only captures energy that might otherwise go unused, it solves the challenge of relying on energy sources where the output fluctuates. Being that the amount of energy being produced by leading renewables – such as wind and solar – is in constant flux, distributed energy storage assets can capture this energy and discharge it a smoother manner.

Energy storage is increasingly perceived as both a viable and necessary component of any future, intelligent electric grid. The leading visions of what a Smart Grid should look like usually focus on distributed storage (and generation) options, rather than bulk storage. Distributed energy storage devices located across the grid will provide localized power where it is most needed, decreasing the need to build new power plants and transmission lines. The most discussed benefit of energy storage – in Smart Grid circles – is that it helps solve the intermittency problem associated with renewable energy, and as such, will help these "green" sources of energy scale faster and reach a wider market penetration. While it's true that energy storage will give a huge boost to the potential of renewable energy, significant storage solves in even bigger issue, and that is capturing the massive amounts of capacity generated that otherwise typically go unused.

Presently, leading storage solutions include pumped storage (both hydro and compressed air), flywheels, sodium-sulfur batteries, supercapacitors and flow batteries. While electricity storage remains very expensive, energy storage (such as hydro and compressed air) is a far cheaper alternative. These technologies are each now being both piloted and deployed. While each solution presents challenges and limitations in terms of where they can be deployed, costs, scalability, life-expectancies, etc, these options continue to look more viable. (Today, compressed air seems to be the most economical option among those listed; however, geographically conditions will limit where this solution is deployed.)

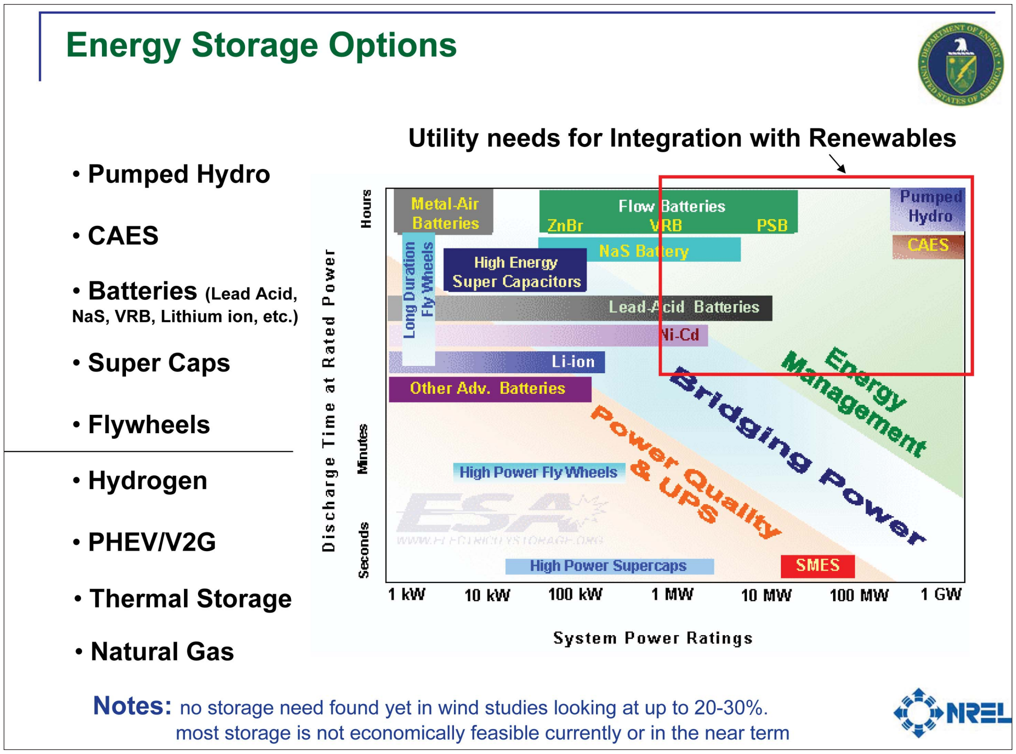
Smart Grid can provide the necessary infrastructure and software solutions to connect the high-performance storage to the grid, and managing the charging and discharging of these distributed storage assets.

FIGURE 20: ENERGY STORAGE TO ADDRESS RENEWABLE ENERGY GENERATION



Source: NREL

FIGURE 21: UTILITY NEEDS FOR INTEGRATION WITH RENEWABLES



Source: NREL

In May 2009, General Electric signaled the importance of storage, announcing a $100 million investment into a sodium-sulfur battery factory, with an expected production capability of nearly 1 GW of storage cells per year, which is almost the size of a conventional power plant. (GE is one of the word's leaders in manufacturing power plants.) Sodium-sulfur batteries store power efficiently but require very high temperatures to operate. A 1-MW Sodium-sulfur battery is being used in a pilot project between Xcel Energy and startup GridPoint for a wind power battery storage project in Luverne, Minn. Wind energy, due to the variability and unpredictability of wind, requires backup, or "firming" power that today usually is provided by peaking natural gas-fired power plants. Energy storage has the potential to eliminate the need for that firming resource, serving as a cleaner option. Other leading utilities such as Pacific Gas and Electric (PG&E), American Electric Power (AEP) and Tokyo Electric Power Co. each already have roughly 5 MW to 20 MW of wind storage in place using sodium-sulfur batteries.

Also in May, U.S. Senator Ron Wyden highlighted the growing importance that energy storage will play in renewable energy development as well as achieving greater energy independence from foreign sources in a new bill brought before the Congress. (See the following box: *Storage Technology of Renewable and Green Energy*).

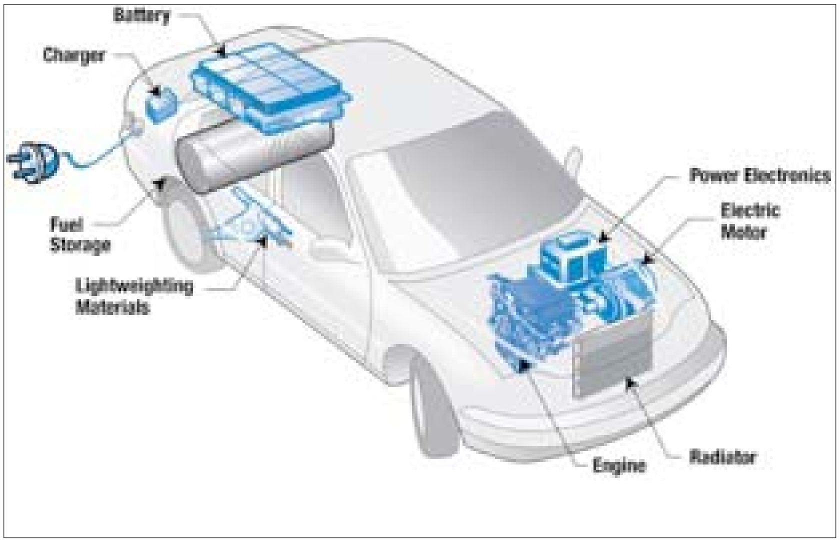
STORAGE TECHNOLOGY OF RENEWABLE AND GREEN ENERGY ACT OF 2009 (STORAGE)
In an effort to increase infrastructure supporting renewable fuels, the STORAGE Act provides investment tax credits for energy storage facilities and equipment that temporarily store energy for delivery or use at a later time. Currently tax incentives are only available for the generation of renewable energy, but output from wind, solar, and wave and tidal energy projects literally rises and falls with natural conditions. Storage technologies can help harness the output of renewable energy sources and allow them to be used when they are most needed. The bill encourages innovation by providing tax credits for a broad range of storage technologies, from water reservoirs to flywheels to hydrogen production to batteries when connected to the nation's electricity transmission and distribution system and when installed in homes, businesses, and factories. If signed into law, the STORAGE bill would provide a 20 percent tax credit for investments in storage systems "that require similar innovations and incentives as other energy technologies." The bill would give also 30 percent investment tax credit for on-site use in individual homes, businesses and factories.

Energy storage, the once the ignored bridesmaid of the greentech world, is starting to receive the attention of plenty of suitors. The potential for energy storage to help integrate renewable energy and act as a substitute to new generation has resulted in a strong boost in investment activity. Energy storage received $121.5 million in venture capital investment in the first quarter of 2009, making it the second most funded technology sector of cleantech (behind only solar energy) for that quarter.

2.6 PHEV Smart Charging and V2G

One of the most discussed and anticipated "applications" of Smart Grid is the introduction of the plug-in hybrid electric vehicle (PHEV). PHEV's larger battery, relative to the previous generation (plug-less) hybrids, will allow for both the possibility of storing electricity, which might otherwise go unused (ideally from renewable, intermittent sources), and of feeding stored energy back into the electric grid, in periods of high demand, serving as a back-up source of power for the electric grid. While the market fundamentals to support what will be a revolutionary advancement in both the automobile and energy industries are not fully in place as 2010, PHEVs are about to be marketed and sold by virtually every major automobile manufacturer in world in the next two to five years, and as such utilities are now scrambling to ready themselves for what could be a truly disruptive technology.

FIGURE 22: A DIAGRAM OF A PLUG-IN HYBRID ELECTRIC VEHICLE



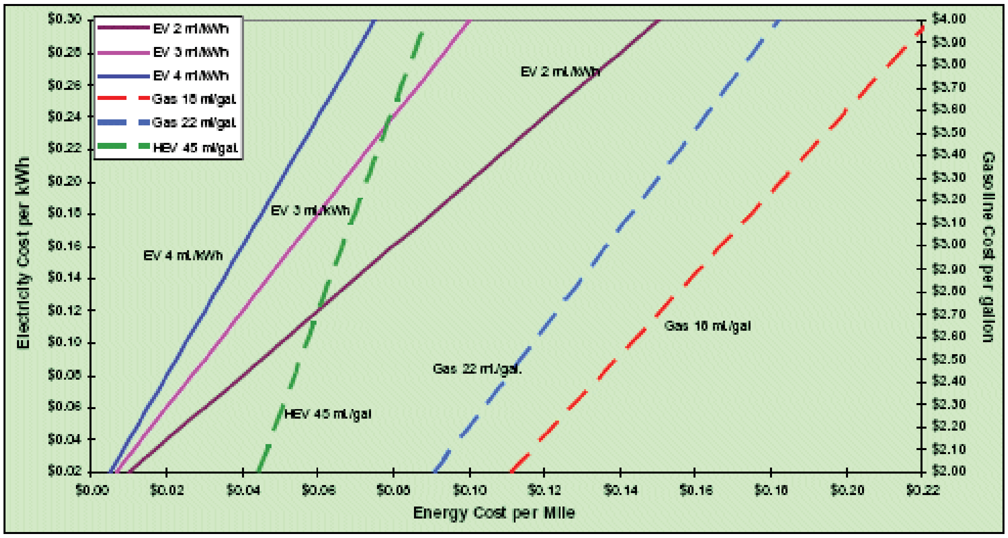
Source: Dept. of Energy, Argonne National Laboratory

Politicians on both sides of the aisle support electric vehicles, as they are both environmentally friendly (a concern of the left) and reduce the need for foreign sources of oil (a concern of the right). The Stimulus Package announced by the Obama administration in early 2009 gives citizens a $7,500 U.S. federal tax credit on battery-powered cars, effectively bridging the price gap between these more expensive vehicles and the traditional cars. In our view, in general there are two remaining barriers to mass PHEV penetration: cheaper and better performing batteries (and hence, cheaper cars) and an electric grid that can support their introduction at scale – a Smart Grid. As PHEVs ramp up, there will be two very interesting challenges/opportunities they will present:

1. Smart charging
2. Vehicle to grid (V2G)

Independent research continues to affirm that PHEVs will be both cheaper to operate, as the cost of electricity is substantially less than petroleum, and "greener" as these vehicles emit at least 30-40 percent lower GHG emissions even when fueled by coal, the dirtiest possible fuel choice, than that of traditional cars. The following chart from the DOE's Vehicle Technology Program shows that fuel costs to operate a PHEV are roughly one third that of traditional cars; electric vehicles cost approximately 4 cents/mile (at 10 cents/kWh) compared with 11 cents/mile (at $2.50/gallon) for the average (gasoline) car.

FIGURE 23: A COMPARISON OF FUEL COSTS FOR PHEVS VS. TRADITIONAL CARS

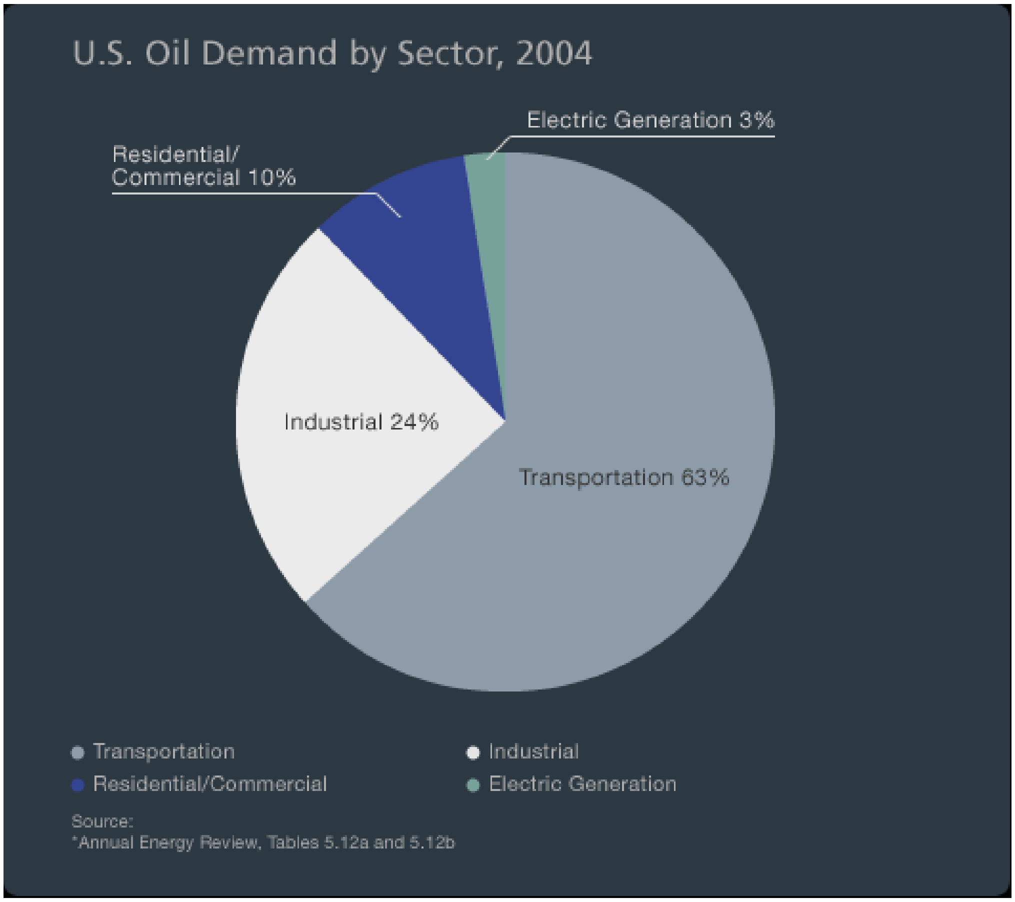


Source: U.S. Department of Energy – Vehicle Technology Program

In terms of emissions improvements, no matter which fuel source is used (which is to say, even if the electricity comes from coal-fired plant) there are significant reductions in CO2 emissions from PHEVs. According to MIT's Technology Review, conventional gasoline cars produce 452 grams of CO2 per mile, whereas a plug-in hybrid using electricity exclusively from conventional coal-fired power plants only produces 326 – a nearly 30 percent drop in emissions. When you consider that just over half of the U.S.'s electricity is derived from sources that are cleaner than coal, the corresponding GHG emission reductions begin to look all the more impressive. (For example, if nuclear electricity or renewable energy is used, that figure would drops to 152 grams of CO2 per mile – essentially just the CO2 produced by the small amount of gasoline occasionally used – equating to a near 70 percent reduction in emissions.)

Another future-oriented study conducted by EPRI and the National Resources Defense Council found that the wide-spread adoption of PHEVs can reduce greenhouse gas emissions from vehicles by more than 450 million metric tons annually in the year 2050 – equivalent to removing 82.5 million passenger cars from the road. Further, because the primary fuel source of PHEVs, electricity, is likely to be originated domestically, this technology indirectly serves to reduce nations' dependencies on foreign sources of oil.

FIGURE 24: U.S. OIL DEMAND PER SECTOR (2004)



Source: Tesla Motors

PHEVs combine operational aspects of both battery-only electric vehicles (BEVs) and hybrid electric vehicles (HEVs), such as the Toyota Prius. A PHEV, like a BEV, can be recharged from the electric grid, store electricity in its battery and use the energy while depleting the battery during daily driving. Unlike a BEV, the advantage of a PHEV is that it can use its internal combustion engine for additional propulsion in highway driving or when the battery is depleted. Due to this versatility, a PHEV can serve as a direct replacement for a conventional internal combustion engine vehicle or HEV. In fact, as the R&D of PHEVs continues at wartime speed and their associated “sticker prices” decline, we expect that the Toyota Prius and other HEVs to become competitively obsolete. HEVs – which lack the ability to plug into grid – will be historically viewed in a favorable light as an important bridge technology, which served to demonstrate the benefits of battery-propelled transportation.

In relation to Smart Grid, there are two major challenges associated with the introduction of the PHEV.

1. The first challenge is that adding millions of new and very large "appliances" to the grid in a way that doesn't cause accidental peaks, or worse, system interruptions. What are needed will be "smart charging" solutions, which directly leverage Smart Grid communication infrastructure and systems to smooth the charging schedules of millions of vehicles.
2. The second challenge is finding a way to take advantage of these millions of new sources of distributed storage (the power stored in these cars' batteries), such that grid operators can now draw upon this new "supply" when needed – i.e., vehicle to grid.

It is estimated that if 25 percent of the automobiles in the United States were to switch over to electric vehicles, the aggregated energy that could be stored is in the neighborhood of 750 GW, which is more energy than the U.S.'s existing grid currently delivers. While it may take decades to reach this level of penetration, just as with distributed renewables, the PHEV highlights the need to have a smarter grid to tackle scale-management issues in order that (1) the vehicles can charge in a way that is not disruptive to the safety and reliability of the grid and (2) the promise of a vast source of distributed energy storage can be realized.

Smart Charging

The key to the success of plug-in hybrids as an environmentally friendly solution and one that doesn't crash the grid is how and when they re-charge. The ideal would be for them to do so in the evening hours, when utilities' inexpensive base-load generators must keep turning and consequently there is a lot of spare, cheap capacity available. The worst impact would be if huge numbers of vehicles attempted to recharge during peak hours, such that costly and dirty peaking power plants would have to come on-line to meet the additional demand. While it is impossible to expect humans, lacking information about price and grid congestion, to properly respond the needs of the grid, Smart Grid solutions will allow PHEVs to automatically charge in a way that is advantageous to both consumers and the overall electric power system. Consequently, the introduction of PHEVs at mass scale presents a scale-management problem (and business opportunity), much like that of the introduction of distributed generation sources.

A study conducted by Oak Ridge National Laboratory in 2008 concluded that the expected increase in ownership in hybrid electric cars and trucks could require major new power generation resources or none at all – depending on when people re-charge their vehicles. Since people cannot be reasonably expected to walk to their cars and plug them in after 10 p.m. (or some other hour when energy supply is high and rates are low) software and systems will need to be developed in order to handle this automatically on behalf of the owner. As an example, the owner might plug in their vehicle when they return home at 5pm, but communications between the grid and the vehicle may determine that it's more advantageous both the owner and the grid to delay the bulk of that particular car's charging for the later, cheaper hours. The Oak Ridge study estimated that the United States would have to build 160 new power plants to handle plug-in vehicles by 2020 if no measures were taken to integrate them into the grid; however if Smart Grid technologies were put in effect to match the charging schedules of millions of PHEVs and BEVs with off-peak energy, the additional power resource needed would be reduced to a range of zero to 8 new power plants.

NREL reached a similar conclusion when it investigated four separate methods of charging electric vehicles: uncontrolled, continuous, delayed and off-peak. NREL concluded that, "the uncontrolled and continuous charging cases add considerable load coincident with periods of high demand, and add to the peak capacity requirements. Delayed charging dramatically improves the situation by avoiding charging during the peak demands in late afternoon and early evening, while the optimal charging case fills the overnight demand minimum. As a result, delayed or optimal PHEV charging avoids any need for additional generation capacity." So while many observers have wondered out loud about the potential destabilizing effects of adding millions of power hungry vehicles, the Oak Ridge study further highlights that it is really a question of having the right intelligent infrastructure in place.

While the exact methods to best handle smart charging are still being developed, the thought of the utility controlling the charging schedules may cause some individually great concern – similar to concerns about the utility issuing a demand response signals. It can be viewed as either invasive or disruptive to the particular needs of a customer. This concern can be properly addressed and overcome, as it will likely be the customer who decides what kind of charging program they require, and as such the car will re-charge based on customer's usage needs and more importantly their "fuel" cost preferences.

The massive deployments of smart meters will directly serve to address this challenge. Smart meters can serve as an information gateway to relay the current price of energy directly to a vehicle. In order for this model to work, time-of-use (variable rate) pricing must be implemented; this way the grid's real-time energy demand requirements/stresses inform consumer energy purchase/usage decisions. If for example a customer wants to fully charge his vehicle at 5 p.m., she will pay a premium over the price she would pay if she could have waited for the later evening hours. End-to-end grid intelligence and the introduction of distributed generation technologies, will likely allow for a range of charging options.

Utilities are interested in using renewable energy to fuel electric cars. IBM currently has a project underway in Denmark with utility Dong Energy, where they are doing simulations to see how PHEV charging schedules can be matched with wind power. Smart Grid software company GridPoint has smart charging pilots underway with Xcel Energy and Duke Energy, and it is looking to provide solutions at the intersection of renewable energy and PHEV charging. (Further, another component of those pilots is "smart billing" where a vehicle could be charged up at multiple locations at the cost of the vehicle owner and not the property owner. It's an important consideration for large appliances that are mobile.)

Storage

While, we have noted that a PHEV charged by coal-generated electricity would generate more CO2 than one powered by clean technologies (e.g., PV panels or wind), since that coal would be burned anyway – as those base-load generators continue to operate 24 hours/day – PHEVs will actually make the grid more efficient by capturing and putting more of the generated electricity into productive use. Thus, beyond the benefits of cheaper, cleaner vehicles, PHEVs provide the additional benefit of making the grid more efficient.

Since electricity generation is the No. 1 contributor to CO2 and greenhouse gas, the environmental benefits associated with storing energy – which would otherwise go unused – are substantial. On the clean energy side of the equation, presently much of the power generated by wind energy goes unused as that electricity is created in the evenings when most of the population is asleep. The potential to store both unused fossil-based and renewable energy is massive. Since the average vehicle is on the road approximately 4 percent to 5 percent of the time, there is tremendous opportunity to have these cars plugged-in and collecting energy that would otherwise go unused.

V2G

Vehicle-to-grid (V2G) in the next five to 10 years might very well emerge as one of, if not, the most transformative applications of Smart Grid. While we believe that the market fundamentals are not yet in place for the V2G to take-off as (1) PHEVs and BEVs will need to first be introduced at a price point that attracts a large mass of individuals beyond just the early adopters and (2) we still may be one or two generations from having the right battery (which can handle such frequent charging and discharging) – it is worth examining, as this concept has the potential to turn the energy world on its head.

Willett Kempton, leader of the V2G Research Group at the University of Delaware, and a V2G pioneer who began developing the technology more than a decade ago explains that “a car sitting there with a tank of gasoline in it – that’s useless. If it has a battery storing a lot of electricity and a big plug that allows moving power back and forth quickly, then it’s valuable.” That’s a pretty simple and straightforward assessment of the value-add of electric vehicles and V2G. What remains to be seen is how much money consumers could reasonably expect to earn per year, and will that incentive further spur the growth of PHEVs and BEVs.

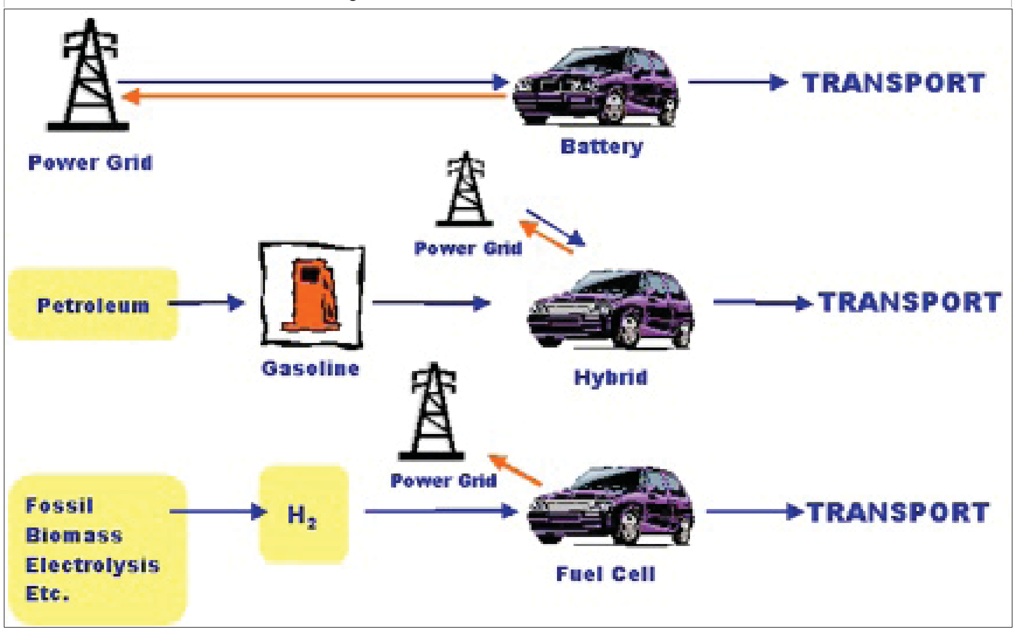
Here is a telling quote from Nancy Gioia, Director, Sustainable Mobility Technologies, Ford Motor Company:

> *“We [at Ford Motor Company] view electrified transportation as a revolution, and when we work with our partners at Southern Cal Edison, the Electric Power Research Institute (EPRI) and many other utilities – they view energy storage as a revolution. So you have two titan industries, combined by this common fuel, called electricity, around a revolutionary element which is energy storage that can change the transportation future.”*

According to the V2G Research Group at the University of Delaware the reason V2G works is that: “Electric-drive vehicles whether powered by batteries, fuel cells, or gasoline hybrids, have within them the energy source and power electronics capable of producing the 60 Hz AC electricity [the same frequency and current that] that powers our homes and offices.” V2G Research Group, the leading research group in the U.S. on this subject, also explains: “Cars pack a lot of power.” One typical electric-drive vehicle can put out over 10 kW, the average draw of 10 houses. The key to realizing economic value from V2G is precise timing of its grid power production to fit within driving requirements while meeting the time-critical power ‘dispatch’ of the electric distribution system.”

FIGURE 25: THE V2G CONCEPT

The V2G Concept: Battery, hybrid and fuel cell vehicles can send power to the electric grid, power that all three already generate internally. For battery and plug-in hybrid vehicles, the power connection is already there. For fuel cell and fuel-only hybrids, an electrical connection must be added. Red arrows indicate electric flow from vehicles to the grid.



Source: V2G Research Group, University of Delaware

2.7 Advanced Utility Controls Systems

Advanced Utility Controls Systems refers to the upgrade and continued integration of various mission-critical systems, applications and back-end technology infrastructure necessary to support a utility's monitoring, control, and optimization of the grid. Advanced Utility Controls Systems primarily include:

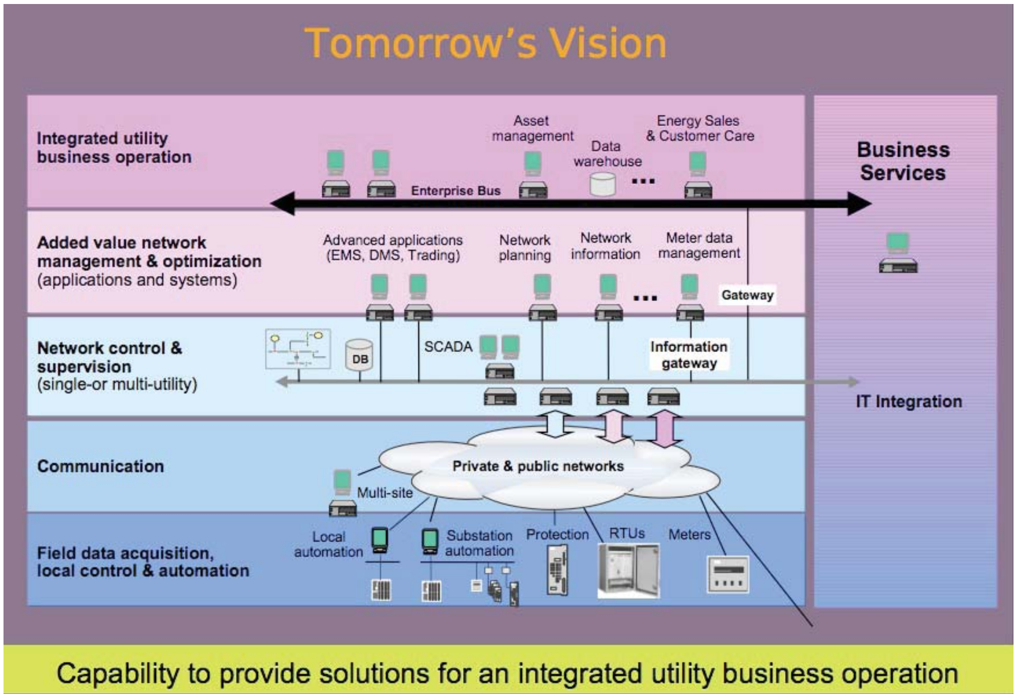
- » Energy management systems (EMS)
- » Supervisory control and data acquisition (SCADA) systems
- » Distribution management systems (DMS)
- » Other advanced applications, such as energy trading and meter data management (MDM)

While historically utilities' systems have been far from integrated, the realization of a Smart Grid will depend on a utility-wide integration of systems (and information), which allows real-time visibility and decision support. These advanced systems will support cross-utility business processes, such as the implementation of demand response, the integration renewable energy, as well as the delivery of information to end consumers (to empower decisions at the consumer level, as well).

The integration of geographic information systems (GIS) onto the distribution network (DMS) is one example of a new capability that will bring tremendous improvements in both visibility and forecasting. The integration of weather forecasting is a second example of an advanced application that could have huge impacts in the performance and protection of the grid. Collectively these new system applications and upgrades provide many of the often-quoted benefits of a Smart Grid, as they improve or provide: grid optimization/increased efficiency, a self-healing grid, 21st century power quality, resiliency, consumer empowerment, and the integration of distributed generation and storage.

Historically, a conversation about a utility's control or operations center operations would be focused primarily on EMS and SCADA, although this is now changing as advances in IT and communications are allowing for a wider range of new systems and applications to be integrated. A utility's energy management system (EMS) is an umbrella term for the system used by grid operators to monitor, control and optimize the performance of the generation and/or transmission system. The monitoring and control functions of EMS are known as supervisory control and data acquisition (SCADA). These terms are often used side-by-side as SCADA/EMS in referring to the utility's main control and operating system. (When named together, EMS more specifically refers to the collective suite of power network applications and generation control, and excludes the monitoring and control functions.)

FIGURE 26: VISION OF INTEGRATED UTILITY SYSTEMS



Source: Reliance Energy

As AMI and grid optimization projects continue to roll-out at mass scale, enormous volumes of real-time data (from millions of end-points) will need to be converted into actionable information, and the usefulness of that data – in many cases – will cut across more than one system. As an example AMI and outage management systems (OMS) will need to be integrated as a smart meter to can send a "last gasp" message to the utility that an outage is about to occur – information that is vital to the continued health and protection of the grid. Conversely, as a result of these large AMI rollouts many legacy applications and systems simply cannot scale to handle the new required levels of data volume and complexity, such that advanced control systems are not only desired, but also necessary.

New applications such as meter data management (MDM) and advanced analytics, as well as necessary modifications to existing applications such as customer information systems (CIS) and DMS all require a thoughtful top-down systems architecture which can provide increasingly tighter integration across functional domains. Advanced Utility Systems will integrate utility business operations, add value to network management and optimization (through new applications and systems), allow for better network control and supervision, and improve field data acquisition, local control and automation. Utilities need a complete set of integrated systems to transform the exponential growth of data into information that drives utility performance; in a true Smart Grid systems like EMS, SCADA, DMS, OMS, workforce management, renewable energy management and any other pertinent system will all need to share information with each other.

Due to the enterprise-wide nature of these challenges, expect industry giants such as IBM and Oracle to be very active in the advanced utility systems space. While a startup software company may be able to develop a best-of-class solution for one particular critical challenge (e.g., the best load analysis or workforce management software) utilities – who typically lack deep IT experience to begin with – will only want to partner with trusted names in redeveloping and upgrading their systems' architecture.

It's important to note that many utilities still do not even have applications like DMS in place, so the challenge in the next few years will be to both add and integrate systems. As such, a utility may choose a company with deep experience in distribution automation, such as ABB or SEL, to add DMS to its system, and meanwhile choose a big player such as Oracle or IBM to develop the enterprise systems architecture. Increasingly, as the Smart Grid sectors begin to take shape, the solutions will be viewed as modular, and it will become the norm for companies to partner in order to tackle different requirements that a particular utility may have. Further the predominant Smart Grid marketing strategy of the day – where it's fashionable to be an everything-under-the-sun-smart-grid-company will no longer hold appeal, vendors will need to hone their offerings and focus on their core competencies.

2.8 Smart Homes and Home Area Networks

Home area networks (HAN) are the fun part of Smart Grid. A network within the home that enables devices and major appliances to communicate with each other and dynamically respond to price (and carbon) signals sent from the utility, relaying whether or not electricity is currently expensive. Who doesn't want their dishwasher to realize that if it waits three hours to run its cycle, it will save 50 percent for that particular energy transaction? For that matter, who doesn't want a "smart home," outfitted with rooftop panels, micro wind turbines, advanced storage and smart charging capabilities for the electric car in the driveway, where each of these applications is visibly trackable and remotely controllable in real time via a web-based home energy management system? Who doesn't want the capabilities to learn their energy usage and energy generation on their iPhone, and discover that the utility is actually paying them for the excess solar energy which they recently generated, or had available in storage?

Perhaps HAN is so much fun because it doesn't actually exist in any meaningful way (beyond demonstration pilots) – but for the first time ever it's entirely reasonable to expect that it will soon arrive at mass scale. While HAN remains in the realm of great promise, speculation, debate and uncertainty – it is often referred to as a bleeding-edge technology – things that will have changed in the years between 2006 and 2012 are:

3. Tens of millions of smart meters will be deployed, for the first time, enabling a communications gateway in between the consumer and the utility.
4. Agreement on interoperability standards will mature.
5. Consumers will increasingly use home energy management portals, just as they already use online banking and automatic bill pay applications.

6. The expected switch to time-of-use (TOU) pricing plans in many regions will greatly encourage consumers to begin to "program" their energy use.
7. Appliance manufactures will learn to market products based on total cost (appliance cost + associated energy costs), explaining the benefits/savings of smart devises that automatically choose to operate when electricity is off-peak.

By adding intelligence and networking capabilities to appliances, thermostats, heating and A/C systems, both the utility and consumer stand to benefit. Homeowners can monitor their energy consumption and reduce their utility bills with very little effort and also gain from incentives provided by the utility for energy conservation. Meanwhile, utilities that now have an extension of Smart Grid into the house, can better manage peak demand, beyond simple demand response initiatives. The extension of smart metering intelligence into the home/building itself, connecting the meters to "load centers" is radical advancement for the power grid. While, today certain utilities manage peak load demand by directly capping these load centers' usage, a home area network and management system would allow the homeowner to indicate a mix of consumption and efficiency across a range of appliances and devices, changing forever the way the consumer participates in the energy consumption.

REDEFINING ENERGY USE

"We're not talking about traditional demand response where consumers have little or no control. … We're talking about putting the power into the hands of the consumers, who can customize their energy use to save money or maximize comfort." – Rob Pratt, Pacific Northwest National Laboratory

"Smart [Grid] technology will actually extend beyond the grid itself and into the homes and businesses of electricity customers. As that technology is deployed, the light switch and outlet will no longer be the only direct interfaces between the individual customer and the grid." – Karen Antion, Board Chair, New York Independent System Operator (ISO)

Source: U.S. Dept of Energy and NY ISO True Grid Symposium

While the smart home has been an exciting proposition (for early adopters/futurists) for decades, what is different now is that for the first time an infrastructure is being deployed that can support communications between the end-user and the utility. This is the important change. Similar to the way that broadband networks have enabled the emergence of popular web apps such as Facebook, YouTube and Netflix Instant, AMI networks will provide a platform that will encourage the development of a new generation of end-user energy management tools and applications. Modern technology has revolutionized the way we do business and communicate, and we expect it to be no different in the realm of the Home Area Energy Network.

WHAT UTILITIES EXPECT
"What we want to do is increase the amount of information, give them more granular insight, whether it's on an hourly basis or every 15 minutes, some increment where they can see with more clarity what's happening [with their energy usage]," Matt Smith, Duke Energy's Director of technology development said, adding that he would like to see this energy usage data driven down to the device level so customers can see, for instance, what their top five energy-consuming devices are. He also wants to be able to deliver this information in near real time, as opposed to the current method of providing historical information. "Our focus is not just the Smart Grid but how we enable our customers to participate in energy efficiency."

Source: Utility Automation and Engineering T&D

According to PG&E, the North American utility with the largest AMI project, to date, (5.4 electric smart meters at a project cost of spending $2.2 billion) The HAN device market is forecasted to grow at a Compound Annual Growth Rate of 185 percent and represent a $3.3 billion addressable market by 2012. The following chart shows PG&E's assessments of the benefits of HAN:

FIGURE 27: HAN BENEFITS

Customers	» Reduced Energy Spending and Increased Environmental Benefits: The HAN will provide customers with tools to reduce their net energy use and shift demand from peak periods, reducing cost and improving their environmental footprint » Increased Empowerment: Customers will gain greater control, flexibility and choice over their energy usage
Utilities	» Improved Match Between Energy Generation and Consumption: Improved energy efficiency and reduced peak demand will reduce energy supply constraints and reduce the need for investment in growing energy generation » Increased Operational Efficiencies: By enabling automated two-way communications between the utility and the consumer, HANs will enable utilities to improve operational efficiency. » Improvement in delivery of Energy Programs: HAN provides a platform to promote energy efficiency, demand response, and other customer education programs » Differentiated Services: HAN will provide a vehicle to offer differentiated services
Society	» Reduction in CO2 and Greenhouse Gas: Reduced carbon emissions, greenhouse gases and conservation of natural resources will result from reduced net and peak energy demand enabled by HAN » Societal Energy Usage Behavioral Shifts: Information on energy usage made available through HAN will promote macro shifts in societal energy usage behavior

Source: Edison Foundation http://www.edisonfoundation.net/iee/issueBriefs/PG&E_HAN_January_2009.pdf

The HAN market has two main product/service areas:

1. The communications network.
2. The home energy management system (or "portal"), where the consumer gains insight into their consumption habits and can react to utility price signals.

The Communication Network

While we are still in the early days of developing home area networks, it's likely that a hybrid approach, using both wireless and wired technologies, will emerge as the solution to connect devices into the home network. For mobility purposes, many appliances will be embedded with semi-conductor chips and communicate wirelessly. The current leading standard for the wireless home network communications is ZigBee, a low power wireless mesh networking technology. Running a distant second is WiFi. (Concerns of WiFi's power requirements have kept it from gaining substantial traction in the industry.) Other wireless standards include Z-wave, which reduces the likelihood of experiencing radio interference (by running on a sub gigahertz frequency), and 6LoWPAN (an abbreviation for IPv6-based low power wireless personal area network), which is an open network based on Internet Protocol (a direct challenge to ZigBee's more closed network). All of these groups have an alliance or trade group to promote their individual standards. Apart from the technological differences, the major advantage ZigBee currently has over its piers is that both the smart meter community and the remote control community have largely adopted this communications protocol, two (potentially) massive markets. Still, despite ZigBee's emergence as the industry leader it's far too early to call a winner, principally because there is already a massive amount of existing infrastructure, software, standards, developers, and knowledge dedicated to Internet Protocol (TCP/IP).

The alternative to the wireless solution is powerline communications through a home or building's existing electric wires. The HomePlug Power Alliance has been the leading promoter of the wired solution, arguing this option gives greater performance and quality of service than the wireless option.

Actually, HomePlug and ZigBee have formed a joint working group (a marketing effort) to promote themselves as the combined best solution for wired and wireless connectivity. In May 2009, the ZigBee/HomePlug Smart Energy profile was selected by the U.S. Department of Energy and the National Institute of Standards and Technology (NIST) as an initial interoperable standard for HAN devices and communications and information model.

Home Energy Management Systems

The second technology area is the home/building energy management system (also known as the home portal): where the consumer directly interfaces with his or her energy data (consumption choices and preferences, and even the option to sell generated/stored energy back to the grid, if the price is attractive).

While the era of the smart home is still many years in the future, it is closer today than it ever has been. Utilities and other large service providers are the players that will move this market forward, and the key driver/benefit will be energy efficiency. Once the network infrastructure is in place, even if it's only a smart meter talking to a smart thermostat – the most basic connection – we expect that this market to open up, and in a big way. As soon as consumers get accustomed to programmable energy savings and the corresponding monetary benefits, they will want and expect even greater functionality. Once the market is established, more vendors will enter into the space, creating new and more exciting HAN innovations, bringing us closer and closer to a self-configuring wireless network or quite literally “the Internet of Things.”

3 SMART GRID AMI DEPLOYMENTS

3.1 Top 15 North American AMI Deployments

The following table defines the top 15 AMI deployments in North America, highlighting the relevant details underpinning each deployment.

FIGURE 28: TOP 15 NORTH AMERICAN AMI DEPLOYMENTS

TOP 15 AMI DEPLOYMENTS - NORTH AMERICA											
	Utility	Territory	Total Smart Meters	Meters Deployed to Date	Pilot	PUC Approval	Announced	Plan Completion	Meter	Network (com & infrastructure)	Notes
1	PG&E	Northern and Central California	5,400,000	557,000	N	Y	2008	2012	GE/Landis + Gyr	Silver Spring (Smart Synch small role)	$2.2 billion for AMI project which includes 5.4 million electric meters - to date 2.3 million gas & electric have been deployed
2	AEP	Midwest	5,000,000	200,000	N	multiple territories	2007	2015	GE and Landis + Gyr (different territories)		the 5,000,000 meters represents a goal, AEP has been adversely affected due to recession
3	Southern California Edison (SCE)	Southern California	4,800,000	ongoing	N	Y	2007	2012	Itron	Itron	$1.63 billion smart-metering program SCE has signed a $480 million contract to buy 5.3 million (gas and alectric) meters and communication equipment from Itron, which will provide 80 percent of the meters for the program, according to Vanessa McGrady, a spokeswoman for SCE.
4	Southern Company (includes Georgia Power)	South	4,400,000	1,000,000	N	Y	announced Jan 2008	2013	Sensus	Sensus	
5	Florida Power and Light (larger territory)	Florida	4,600,000	100,000	N	Y	2008	N/A	GE	Cisco (networking) & Silver Spring (wireless communications)	$500 million expected cost (doesn't include the $200 million for the Miami smart grid project. In the project, GE will supply smart meters, Silver Spring will provide wireless communications and Cisco will provide networking. Carol Browner, who coordinates energy policy at the White House, was on hand for the announcement along with FPL Group CEO Lewis Hay, GE CEO Jeffrey Immelt, Cisco's John Chambers and Silver Spring Networks CEO Scott Lang.
6	Oncor	Texas	3,000,000	250,000	N	Y	2007	2012	Landis + Gyr	Landis + Gyr	$700 million project cost. IBM, Cap Gemini and Ecologic Analytics are also working on Oncor's smart grid project.
7	DTE	Detroit, MI	2,600,000	30000	Y		announced Aug 2008		Itron	Itron	$350 million program means more accurate meter reading, power outage detection
8	CenterPoint	Houston, Texas	2,400,000	250000	N	Y	announced Feb 2009	2014	Itron	Itron [with eMeter software]	
9	Pepco Holdings (PHI)	Deleware, MD, NJ	1,900,000	expected start 4th Q 2009	N	Partial	announced Mar 09	2013	GE/Landis + Gyr	Silver Spring	both Landis + Gyr and GE will deploy in Deleware "with flexibility to expand usage of the smart meters in other areas of PHI's service territory" as of writing waiting for PUC approvals in MD and NJ. Deleware alone will cost $100 million
10	Duke Energy	Indiana, Ohio	1,500,000	0	Y	Partial	2008	2014	Not announced	Cisco	Duke has received PUC approval for a 700,000 meter deployment in Ohio; Duke is seeking approval for an 800,000 meter project in their Indiana territory. The cost of these two deployments will be $1 billion. Duke has not yet begun the PUC approval for their two largest territories (North Carolina and South Carolina), which will be another 2.4 million smart meters.
11	Sempra/San Diego Gas & Electric	San Diego and southern Orange counties	1,400,000	expected start 2nd Q 2009	N		announced July 2008	2011	Itron	Itron	PUC approved $572 million project
12	Ontario Smart Metering Initiative (13 different utilites)	Ontario, Canada	1,300,000	ongoing			2007	2010	Elster 63%, Ozz/Trilliant 25%, 9% Sensus	Elster/Trilliant/Smart Synch	http://www.metering.com/node/10059
13	Connecticut Light & Power	Connecticut	1,200,000	0	Y	N			-	-	proposed nearly 2 years ago, and was transitioned into a pilot costing roughly $13 million rather than the initial $225 miilion
14	Portland General Electric Co.	Portland, WA	850,000	N/A		Y		2007	Sensus	Sensus	a cost of $130-135m, delivering annual savings of $18m from 2011
15	APS (Arizona Public Services)	Arizona	800,000	100000	N	Y	announced June 2008	2012	Elster	Kore Telematics/AT&T (backhaul)	Currently 100,000 smart meters have been installed around the state and the company is currently replacing 7,000 meters per month. Within five years, APS expects to deploy about 800,000 smart meters.

Source: GTM Research

4 VENTURE CAPITAL INVESTMENTS IN SMART GRID: 2005–2009

In 2004, the term Smart Grid didn't really exist – despite the Demand Response successes of now-public firms like Comverge and EnerNoc.

Fast forward five years and we've seen hundreds of millions of dollars of VC investment flow into a wide range of Smart Grid startups, essentially creating a new market and ecosystem from power generators to home networks. 2009 has gotten off to a slow investment start but that will change in the coming quarters.

Smart Grid technology, investment, and infrastructure must emerge if the states are to meet their ambitious Renewable Portfolio Standards.

But beware. As Stephen Lee, the Senior Technology Executive for Power Delivery and Utilization at the Electric Power Research Institute (EPRI) warns: Smart Grid players must avoid the hype. "We are at the peak of the Smart Grid hype cycle. When Obama and Biden talk about the Smart Grid you know it's being hyped."

FIGURE 29: VC FUNDING IN SMART GRID, 2005–2009

YEAR	VC FUNDING IN SMART GRID FIRMS
2005	$60M
2006	$281M
2007	$419M
2008	$461M
2009 ytd	$37.5M+

Source: GTM Research

4.1 2008 and 2009 Smart Grid M&A

In today's difficult business environment we expect to see more M&A activity and consolidation.

FIGURE 30: RECENT M&A IN THE SMART GRID SECTOR

BPL Global	Acquired Serveron, a provider of technology and services to monitor electric utility assets.	Financial terms were not disclosed. Since 1999, Serveron has raised ~$48M in VC from Perseus, Siemens Venture Capital, El Dorado, Nth Power, Cascadia Pacific Management, et al.
Consumer Powerline	Acquired Xtend Energy, a provider of rapid response services to industrial, commercial, and retail customers, where customers have a brief window in which to supply excess capacity in response to sudden energy events.	Undisclosed
GE Energy	Acquired Mapframe, to expand its Smart Grid portfolio of utility transmission and distribution offerings.	Undisclosed
GridPoint	Acquired V2 Green (PEV integration)	Undisclosed
SmartSynch, a provider of wireless smart metering technology	Acquired Applied Mesh Technologies, a provider of energy monitoring and usage control solutions to utilities and enterprise customers.	Undisclosed

Source: GTM Research

4.2 2008 VC Investment in the Smart Grid

Soaring energy costs, an aging electricity grid, national security concerns and government regulation are creating a boom in smart utility meters and the semiconductors that go into them.

Most Smart Grid investments don't require hundreds of millions of dollars to create a factory. VCs look at the Smart Grid market as a capital efficient alternative to the capital-intensive wave of green investments of late. Additionally the technology of the Smart Grid – wireless communications, mesh networks, semiconductor integration, and software – is a familiar vernacular to the VC community.

Look for big players like Intel, IBM, Cisco and Oracle to begin vying for a larger slice of the Smart Grid pie either through investment or acquisition. What follows is a detailed list of Smart Grid VC investments, by quarter, from the first quarter through the fourth quarter of 2008.

FIGURE 31: 2008 VC INVESTMENT IN SMART GRID

Q1 2008 VC INVESTMENT IN DR AND SMART GRID			
Fat Spaniel	$18M Round B	Ignition Partners led with PCG, Applied Ventures, Element Partners, Chrysalix	Renewable energy monitoring and reporting software and systems
GridPoint	$15M Round D Add-on	Quercus Trust	Managing energy sources and storage for utilities
Tendril Networks	$12M Round B	RRE Ventures led with Vista Ventures, Access Venture Partners, Appian Ventures	Zigbee-based energy management SW and HW for residences
Ambient	$2.5M (Private Placement)	Vicis Capital	“Smart-grid” technologies that use power lines to transmit data
Green Plug	Undisclosed Round A ($1.2M?)	Peninsula Equity Partners	Advanced power strips enable collaboration between electronic devices and their power sources

Q2 2008 VC INVESTMENT IN DR AND SMART GRID			
SmartSynch	$20 M Round E	Credit Suisse led with Battelle Ventures, Beacon Group, Endeavor Capital, GulfSouth Capital, Kinetic Ventures, OPG, Siemens Venture Capital, et al.	Wireless smart metering technology
Silver Spring Networks	$17M Round C	Edison Electric Institute, Foundation Capital	A networking platform that allows utilities to connect energy-generation equipment, energy-storage devices and appliances, and energy-monitoring management and software
eMeter	$13M	Siemens led with DBL Investors, Foundation Capital	Advanced metering and Smart Grid software
Verdiem	$12M	NCD Investors led with KPCB, Catamount Ventures, Phoenix Partners	PC software that reduces energy consumption across computer networks
Onzo	$4M	Scottish & Southern Energy, Sigma Capital Group	Energy management and carbon monitoring
DeepStream Technologies	Undisclosed	3i and Doughty Hanson	Intelligent sensors addressing energy management, protection, and control
Grid Net	Undisclosed	Intel Capital	Smart-grid software developer

Q3 VC INVESTMENT IN DR AND SMART GRID			
BPL Global	$23M Round D	Cross Atlantic Capital Partners, IFA Group, Novitas Capital, El Dorado, and Morgan Stanley	Software and services for electric utilities to build the Smart Grid
Eka Systems	$19M	Flybridge Capital Partners, RockPort Capital, The Westly Group, Metropolitan Investments	Wireless nodes, gateways, software and tools for smart utility networks
EnOcean	$6.6M	Wellington Partners, 3i Group, Emerald Technology Ventures, Siemens Venture Capital, BayTech Venture Capital, et al.	Energy harvesting technology, wireless sensors, and RF communication for building automation, lighting, AMR, and environmental applications
EpiSensor	$1.5M Seed	Enterprise Equity, Enterprise Ireland, et al.	Zigbee-based wireless sensors and controllers for lighting, energy monitoring, building management, etc.
GDCM	Undisclosed	Balderton Capital	Energy efficient data center management
Green Energy Options (UK)	$1.46M	Thames Valley Investment Network, Bank of Scotland, et al.	Smart meters and home energy hubs
GridPoint	$120M Round E	Goldman Sachs Group, Susquehanna Private Equity Investments, The Quercus Trust, Altira Group, Standard Renewable Energy Group	Smart-grid infrastructure
Trilliant	$40M	MissionPoint Capital Partners, Zouk Ventures	Network solutions and software for advanced metering, DR, and Smart Grid management

Q4 2008 VC INVESTMENT IN DR AND SMART GRID			
Silver Spring Networks	$75M	KPCB, Foundation Capital, JVB Properties, Northgate Capital	Communications hardware, software, and services for the smart-power grid
Ice Energy	$33M Round B	Energy Capital Partners, Second Avenue Partners	Managing air-conditioning electricity usage Freezing water in an insulated tank at night and using the ice to cool air during the day
Positive Energy	$14M	NEA	Demand-response and energy efficiency data technology
Ambient (OTC)	$8M	Vicis Capital Master Fund	Software and services for electrical utilities to deliver IP-based services on existing power lines
Eco Power Solutions	$7M	Altira Group	Energy recovery and emission control technology
RLtec (UK)	$960K	Low Carbon Accelerator, et al.	Grid management technology for DR and energy balancing

Source: GTM Research

4.3 Q1 2009 VC Investment in Smart Grid

What follows is a detailed list of Smart Grid VC investments in the first quarter of 2009.

FIGURE 32: Q1 2009 VC INVESTMENT IN SMART GRID

Q1 2009 VC INVESTMENT IN DR AND SMART GRID			
Sentilla	$7.5M Round B	ONSET Ventures, Claremont Creek Ventures	Demand-side energy management software for data centers and commercial and industrial facilities
Silver Spring	$15M Round D add-on	Previous Round D investors include KPCB, Foundation Capital, JVB Properties, Northgate Capital	Up-round? for the wireless smart-grid equipment and software maker
SynapSense	$7M	Robert Bosch Venture Capital, Emerald Technology Ventures, Sequoia Capital, ARV, Nth Power, DFJ Frontier	Wireless energy efficiency solutions for data centers
GridPoint	Undisclosed	Craton Equity Partners	Open software platform for distributed energy

Source: GTM Research

The only way we can reach aggressive Renewable Portfolio Standards and exploit energy storage, distributed generation, PHEVs, demand response and smart meters is through an integrated and intelligent grid.

But the entity we call a Smart Grid is more of a theoretical construct than a true engineering problem. In a perfect world we could build, a self-aware, self-healing, sensor-laden, robust and secure mesh network from scratch that allowed dynamic forward pricing to inform customer and utility energy usage and choices.

But in the real world – we are attempting to overlay intelligence on an antiquated legacy network that has many masters and many flaws. Utilities tend not to move quickly and are slow to innovate. Legislation is slow and imperfect and standards often compete.

Nevertheless, there is momentum in this field and VC-funded startups like Silver Spring and Fortune 500 firms like IBM and Intel are starting to drag the utilities and the grid into the 21st century.

4.4 Q2 2009 VC Investment in the Smart Grid

What follows is a detailed list of Smart Grid VC investments in the second quarter of 2009.

FIGURE 33: Q2 2009 VC INVESTMENT IN SMART GRID

Q2 2009 INVESTMENT IN SMART GRID			
Tendril Networks	$30M Round C	VantagePoint Venture Partners, Good Energies, RRE Ventures, Vista Ventures	Residential Smart Grid software and wireless sensors
Zenergy (AIM)	$13.8M	Arranged by Panmure Gordon & Co and Mirabaud Securities	Suoerconductors as fault current limiters, preventing current surges on the grid. Recently announced contracts with NY's Con Ed. SC Power is the U.S. subsidiary.
AlertMe (UK)	$12.8M Round B	Good Energies, Index Ventures, SET Venture Partners, VantagePoint Venture Partners	ZigBee-based web-enabled home energy management devices add-on to security systems
Ember	$8M	Chevron Technology Ventures, Stata Venture Partners, Polaris Venture Partners, GrandBanks Capital, RRE Ventures, Vulcan Capital, DFJ ePlanet Ventures, New Atlantic Ventures, et al.	The leading maker of ZigBee wireless mesh networking chipsets for communications between devices such as utility meters and thermostats
Powerit Solutions	$6M	Siemens Venture Capital, ArcelorMittal's Clean Technology Fund, @Ventures, Expansion Capital	Intelligent energy management and efficiency systems
Hexaformer (Sweden)	$4.6M Round B	Sustainable Technologies Fund, Innovations Kapital	Electric transformer cores
OutSmart Power Systems	$2M Seed	Bainco International Investors, Clean Energy Venture Group, Manifold Products	Hardware and software systems to monitor and manage energy usage, building occupancy and other activities in commercial buildings
EnergyHub	Undisclosed Round A	.406 Ventures, Physic Ventures	Home energy management solutions

5 COMPANY PROFILES BY SECTOR

This section profiles the leading Smart Grid solution providers across the various market sectors: advanced metering, AMI networking and communications, demand response, grid optimization/distribution automation, software, and home area networks (HAN). Also profiled are a select group of larger companies that have broad interest across various markets segments.

It is important to note that some market segments are more defined than others. With confidence, we can support that the companies In Section 5.1 (the smart meter manufactures list) are the top advanced metering companies in the world. While there may be some dispute if the No. 1 spot belongs to Itron, GE or Landis+Gyr; these are big players of start metering.

On the other end of the spectrum, the HAN space is still taking form. As such, there are a number of vendors that could have been included (and in some cases companies that have raised substantial funding) but were not selected for this report. Having said this, we believe our HAN list is representative of the most competitive and viable energy management portal companies.

5.1 AMI – Advanced Metering and Networking/Communications

5.1.1 Echelon

Echelon Corp. (Nasdaq: ELON) competes as an AMI metering and networking solutions company. Echelon completed the communications infrastructure – using power line networking – for the largest smart meter deployment to date, a project with Italian Utility Enel SPA, where more than 30 million smart meters were successfully networked.

Echelon's smart meter business, called Networked Energy Services (NES) is based on smart meters that communicate data over power lines to concentrators that use IP-based communications networks to get information back to utilities. NES is relatively young (it was started five years ago) though it is now responsible for approximately 50 percent of the company's revenue (the other half coming from its AMI networking solution, Lon Works). The company competes with Itron, Elster, SilverSpring Networks, Trilliant, SmartSynch, Landis+Gyr, GE and other AMI metering and networking providers.

Echelon engages in the development, marketing, and support of hardware and software products and services that enable original equipment manufacturers and systems integrators to design and implement open, interoperable, distributed control networks. The company provides primarily a suite of network infrastructure products, LonWorks Infrastructure product line, which includes transceivers, concentrator products, like its control modules, routers, network interfaces, development tools, and software tools and toolkits to the original equipment manufacturers. It offers a networked energy services system that provides a two-way information and control path between the utility and its customer to the utility industry; and it offers its i.LON internet server family of products to the system integrators serving the street lighting, remote facility monitoring and energy management markets.

The company serves building, industrial, transportation, utility/home, and other automation markets. Echelon sells its products and services through direct sales organizations, third-party electronics representatives, distributors, value-added resellers, and integration partners. It operates principally in the U.S., China, France, Germany, Hong Kong, Italy, Japan, Korea, the Netherlands and the U.K. Echelon was founded in 1988 and is headquartered in San Jose, Calif.

Deployments: Echelon has approximately 1.5 million meters installed in Europe and contracts in the EU to install several million more (Echelon currently has more than 90 pilots underway in Europe). It also provides power line networking to a 30+ million smart meter system for Italian utility Enel SPA.

Echelon's only North American smart meter contract is with Charlotte, N.C.-based Duke Energy for a project in Cincinnati that has seen about 60,000 meters deployed so far. That project will use Echelon's power line networking to bring data to concentrators that will then transmit data using a variety of cellular, wireless and fiber networks – Duke hasn't specified which vendors yet (see Analyst Note below).

Recent News: In late April 2009, Echelon announced that it will install cellular radio modules in its smart meters and use T-Mobile's cell network to carry data to and from utilities. (Note: This was the latest in a series of smart meter-cell phone partnerships announced in 2009 aimed at challenging the dominant RF mesh model of most U.S. utilities. AT&T announced a similar partnership with AMI networking provider, Smart Synch in March 2009.)

Analyst Note: Echelon's system has been less popular in the United States, where most utilities have opted for RF mesh or other wireless communications to connect smart meters, citing the higher costs associated with power line networking. Echelon released an updated versions of its LonWorks platform (version 2.0) in March 2009 with the promise of delivering new products and installing those products by as much as 50 percent less (compared to the old systems).

According to Deutsche Bank Securities analysts, Duke Energy plans to spend $1 billion to bring smart meters to its entire 4 million-household area in the next five years. Echelon will likely be seeking to prove itself in Duke's pilot deployment to get involved in those larger projects.

5.1.2 Elster

Elster is one of the leading providers of advanced metering infrastructure (AMI) and markets both smart meters and the supporting software and networking solutions.

Elster has delivered over two million smart metering devices worldwide to date. Elster competes with Itron, Landis+Gyr, GE, Sensus and Echelon, the other leading players in AMI sector. Elster uses 900-MHz mesh networks for their networking solutions (which is also used by Silver Spring Networks and Trilliant, and is currently the most popular networking solution in North America). Elster's smart meters are named Rex, and its AMI mesh network solution is called EnergyAxis.

Elster Group is focused AMI and integrated metering and utilization solutions to the gas, electricity and water industries. Elster smart metering system solutions provide utilities with energy conservation capabilities via demand response programs, Smart Grid applications, and operational efficiencies resulting in significant value creation across the utility enterprise. Elster's AMI and AMR products, systems, and solutions reflect the experience gained from over 170 years of dedication resources and energy. The group has over 7,500 staff and operations in 38 countries, focused in North and South America, Europe, and Asia. Division Elster

Note: Subsidiary Electricity Elster Electricity LLC (which focuses on advanced electricity metering products, communication solutions and metering automation systems) was formerly ABB Electricity; the company remains close ties to ABB and is currently developing loss detection applications leveraging AMI data to improve network reliability and efficiency.

AMI Product Information

Elster's REX meter is an electronic meter designed for residential metering. With two-way communications, it offers demand, time-of-use (TOU) pricing, load profile recording, bidirectional metering, and critical tier pricing (CTP) capabilities in addition to kWh consumption measurement. The REX meter has on-board two-way radio frequency (RF) communications that permit the meter to respond to requests over an unlicensed 900-MHz local area network (LAN). Of note: the REX meters on the EnergyAxis System act as repeaters and are self-registering.

The capability of the EnergyAxis mesh communications network enables sophisticated billing and systems data collection, automated account management, and provides alerts for different events (such as outages, tamper indicators, and other system anomalies).

Analyst Note: Elster has one large deployment in progress with Arizona Public Services (APS) for 800,000 smart meters. However, it has not landed one of the major North American utility AMI contracts (as has Itron, GE, Sensus and Landis+Gyr) and as such it has fallen out of popular attention with the press, despite being one of the earliest providers of complete AMI solutions.

ELSTER	
Headquarters	Raleigh, NC
Employees	7,500
Ownership	Private
CEO	Jim McGivern
Category	AMI Metering, AMI Networking/Communications

GE
Energy

5.1.3 General Electric

GE/GE Energy is one of the Top 3 advanced metering companies in the world. Unlike its competitors, such as Itron and Landis+Gyr, GE only provides the physical meters and does not provide the network/communication infrastructure. These "smart meters" allow for two-way communication from the utility to the end-user, and vice versa.

GE Energy (www.ge.com/energy) is one of the world's leading suppliers of power generation and energy delivery technologies, with 2008 revenue of $29.3 billion. Based in Atlanta, Georgia, GE Energy works in all areas of the energy industry including coal, oil, natural gas and nuclear energy; renewable resources such as water, wind, solar and biogas; and other alternative fuels. Numerous GE Energy products are certified under Ecomagination, GE's corporate-wide initiative to aggressively bring to market new technologies that will help customers meet pressing environmental challenges.

Advanced Metering: GE has won many of the largest AMI deployments in North America, including: a share of the 5.3 million meter deployment with Pacific Gas and Electric (Landis+Gyr was also selected as a metering provider for the PG&E deal), a 5.0 million meter scheduled deployment with AEP, as well as large deals with Florida Power and Light and Oklahoma Gas & Electric.

Note: GE is profiled in this report as a Metering Company. However, GE is also competing in other Smart Grid sectors such as software and Grid Optimization. GE Energy's Smart Grid software solutions will help enhance power reliability and increase energy productivity. These solutions also: will help manage alternative renewable power sources, like solar; maximize the utilization and life of assets; and pinpoint areas of concern on the grid, similar to online mapping tools that pinpoint traffic congestion on roads and highways.

Deployments: GE has landed several of the largest AMI contracts in North America including deals with: PG&E, AEP, Florida Power & Light and Pepco Holdings.

Competition: In the Advanced Metering Sector, GE competes with Itron, Landis+Gyr, Sensus, Elster and Echelon.

Analyst Note: A deployment that GE is involved in with Texas utility Centerpoint using WiMax is of particular interest, due to the fact that WiMax will allow for communications speed of 1 to 2 megabits per second. This is much faster than 50 to 100 kilobits per second that RF Mesh networks provide for AMI Networking (Mesh networks, used by networking players such as Silver Spring Networks, Trilliant and Eka Systems, have been the predominant choice in AMI networking to date). While this is a bit like comparing apples to oranges, since the RF networks are used to collect meter data, and the WiMax network (in this case) is used for backhaul communications, many have argued that this bandwidth is what is needed to make the split-second automation of the electricity distribution grid a reality and suggest that RF networks may not have enough bandwidth to support future end-user applications, and as such are expecting next-gen networks to quickly move into the AMI networking space.

To that end, GE is rumored by be releasing a WiMax smart meter in the near future. However, it appears to be hedging its bets, as it has recently partnered with Silver Spring Networks to provide smart meters in the Florida Power & Light AMI deployment.

5.1.4 Itron

Itron is one of the top three advanced metering infrastructure (AMI) companies in the world. The company provides both components of an AMI solution: the actual "smart meters" and the supporting communications network and software. The company's main competitors are Landis+Gyr, and GE.

Itron Inc., incorporated in 1977, provides a portfolio of products and services to utilities for the energy (and water) markets throughout the world. The company is a provider of metering, data collection and software. Itron has two business segments: Itron North America and Actaris. Itron North America generates the majority of its revenue in the United States and Canada, and offers electric meters, electric, gas and water automated meter reading (AMR) and advanced metering infrastructure (AMI) systems, software and services. Actaris, which Itron acquired in 2008 for $1.6 billion, generates the majority of its revenue in Europe, Africa, South America and Asia, and offers electricity, gas and water meters, AMR and AMI systems and services. The company competes in 60 countries and roughly two thirds of its revenue is from international contracts. Close to 3,000 Utilities around the globe use Itron products and services.

Metering: Apart from allowing for two-way communication between the end-user and the utility, The Itron smart meter's (named the Centron) functionality is enhanced by embedding Ember's ZigBee Alliance chip to provide a full two-way communications pathway to the home. Thus, it becomes the gateway to the home area network's (HAN) appliances and control systems, and allows for the possibility of demand response and other energy saving applications.

Networking/Communications: Itron North America offers AMI, or smart metering, systems with its OpenWay architecture. OpenWay is a standards-based, open-architecture smart metering solution that helps utilities manage limited energy supplies and provide pertinent information about energy usage to energy consumers. The OpenWay system provides two-way communication for residential and commercial electricity meters, which allows for data collection, and certain command and control functions, including remote connect and disconnect, net metering, integrated clock for critical peak pricing (CPP), time of use and CPP displays on register, interval data storage, alarms and upgradeable firmware.

Deployments: In North America, Itron has won four major utility scale AMI contracts. Those deals are with Southern California Edison (SCE), Sempra Energy's San Diego Gas & Electric, CenterPoint Energy (Houston), and DTE Energy subsidiary Detroit Edison. The Southern California Edison deal is the largest to date, and will deliver 4.8 million meters and the communications infrastructure by 2012. The total value of this contract was for $480 million. (SCE will actually buy 5.3 million meters – includes gas and electric. This contract represented 80 percent of the total meters SCE purchased.)

Competition: In the Advanced Metering Sector, Itron competes with Landis+Gyr, GE, Sensus, Elster and Echelon. In the AMI Communications/Networking Sector, Itron primarily competes with Silver Spring Networks, Eka Systems, Landis+Gyr, Elster and Trilliant.

Analyst Note: In June 2009, Itron announced a partnership with demand response provider Comverge to integrate both companies' technologies in order to use the smart meter as the gateway to demand response solutions. As each of these companies is one of, if not, the biggest name in their respective fields, it will be intersting to see how quickly utilites adopt this combined solution. Hooking up homes with devices that can turn down electricity use when utilities face peak power demands is one of the central promises of a smarter grid; having two of the biggest names in the game working together may be a cause for concern for the competition.

Itron had announced in May 2009 that it was working with Google in a similar capacity in the home energy management space; Google intends to be a leader in home energy management systems and is expected to debut a web application named "PowerMeter" at the end of 2009.

ITRON	
Headquarters	Liberty Lake, WA
Employees	8,700
Ticker	Nasdaq: ITRI
Ownership	Public
CEO	Malcolm Unsworth
Category	AMI Metering, AMI Networking/Communications

5.1.5 Landis+Gyr

Landis+Gyr is one of the Top 3 advanced metering (AMI) companies in the world. The company has installed over 300 million electricity meters (this number includes both AMR and older generation equipment). L+G actively competes with Itron and GE for the title of global smart metering leader. Landis+Gyr provides both "halves" of advanced metering infrastructure: "smart meters" and the necessary networking communications systems to support two-way data flow.

Landis+Gyr is a global provider of commercial, industrial, and residential electric meters, as well as networking communications systems. The company has over 5,000 employees, 600 full-time professionals dedicated to R&D, and operations in 30 countries across five continents – reinforcing the company's commitment to provide utilities with end-to-end, advanced metering solutions that are empowering the next generation of Smart Grid – driving better environmental results for utilities, consumers and society.

Landis+Gyr has further business interest in other Smart Grid sectors including: network management/grid optimization, distribution automation and personal energy management, though primarily the company's marketing efforts are pointed at their bread and butter business, advanced metering solutions.

Deployments: Landis+Gyr has secured four of the major North American utility AMI contracts to date. The first deal is with Texas utility Oncor Energy worth $360 million (three million smart meters and networking communications systems). The second is with Pacific Gas & Electric; that deal is valued at approx. $250 million for an order of roughly 2.5 million meters. The third deal announced in March 2009, is with PHI (of which mid-Atlantic utility Pepco is a subsidiary) and will likely end up being close to one million meters. (The overall territory is estimated at 1.9 million customers; pending PUC approval in several states, and the metering portion of the deal is to be shared with GE, as was the PG&E deal). The fourth deal, announced in June 2009, is with AEP Texas for 700,000 smart meters (the value of this five-year contract was not announced).

Analyst Note: Landis+Gyr has been on a hot streak lately, securing its third major North American utility scale deal in the past 18 months. The PHI deal included several other Smart Grid all-stars, including GE and Silver Spring Networks. Increasingly, as the size of these utility contracts goes from the pilot stage to full scale large deployments, Smart Grid competitors and partners are willing to view these deals as modular, and take whichever piece they can get. To this point, one company insider admitted, "If you only get the metering contract, and the networking part of the deal goes to a competitor, that still a *big* deal, and shouldn't be considered kissing your kid sister."

Competition: In the Advanced Metering Sector, Landis+Gyr competes with Itron, GE, Sensus, Elster and Echelon. In the AMI Communications/Networking Sector, Landis+Gyr primarily competes with Silver Spring Networks, Eka Systems, Itron, Elster and Trilliant.

LANDIS+GYR	
Headquarters	Zug, Switzerland
Employees	5,060
Ownership	Private
CEO	Cameron O'Reilly
Category	AMI Metering, AMI Networking/Communications

5.1.6 Sensus

Sensus, an AMI metering and networking company, uses a different, and simpler, technology than the other large players in the space (such as Itron and Landis+Gyr).

Instead of relying on RF mesh networks, Sensus beams the data from the smart meter to radio towers (ranging in height from 50 to 600 feet) where transmitters collect the data, and then communicate that data to the utility's "back haul" system. Sensus only uses licensed frequencies to transmit meter data, and does not used shared band frequencies as does its competitors (such as Silver Spring or Trilliant).

The Sensus Metering Systems companies are leading global provider of water, gas, heat and electric meters including comprehensive metering communications system solutions that comprise both automatic meter reading (AMR) and advanced metering infrastructure (AMI) systems. Sensus is a time-tested technology and communications company providing data collection and metering solutions for water, gas, electric and heat utilities around the globe.

AMI Solution

The FlexNet AMI solution provides customers with the technology to achieve unmatched results in range, redundancy, resiliency, recovery and reliability. Only FlexNet has primary-use, FCC licensed spectrum, supplying uncluttered transmissions for water, gas and electric utilities in both rural and urban areas, regardless of terrain. FlexNet fits seamlessly into a utility's operational and customer service strategic plan, empowering customers to communicate with a complete range of endpoint devices. FlexNet technology reduces cost, mitigates technology risk, enables pricing flexibility and demand response, and improves operation and maintenance efficiency for forward-thinking utilities. FlexNet offers simple, reliable performance that exceeds industry standards, cross-vendor compatibility, system scalability and future-proof operation. In February 2009, Sensus made open systems upgrades with the addition of IP addressability for all electric, gas, and water Smart Grid endpoints within the FlexNet network.

Deployments: Sensus won the contract to provide 4.3 million Southern Company customers with AMI meters and networking over the next five years. Southern Company subsidiaries will deploy Sensus' FlexNet AMI solution when they launch their new Smart Meter programs to customers across the Southern Company footprint. Notably, this is one of the Top 5 AMI deployments to date in North America (the others being contracted by utilities PG&E, AEP, Florida Power & Light, Southern California Edison). Sensus has also won a respectable 800,000 smart meter project in Portland, Ore. to be completed in 2010,

In December 2008, Sensus also announced a 430,000 smart meter and AMI contract, subject to Hawaii PUC approval, to be deployed between 2009 and 2015. (Note: 19 tower network sites throughout Oahu, Maui and Hawaii Island will provide the advanced, two-way radio frequency network coverage.)

SENSUS	
Headquarters	Raleigh, NC
AMI Solution	FlexNet
Ownership	Private
CEO	Peter Mainz
Category	AMI Metering, AMI Networking/Communications
Employees	3800

5.2 AMI – Networking/Communications

5.2.1 Current Group

The Current Group combines advanced sensing technology with low latency IP based communications networks and software to deliver a range of Smart Grid solutions including: optimized power delivery, improved reliability, integration of renewable/ distributed sources of energy and end-user management solutions. The company, one of the technology partners in Xcel Energy's SmartGridCity, develops and markets: sensing gateways, network infrastructure as well as supporting systems (asset management, power quality measurements, fault analytics and other critical grid activities).

The company provides electric utilities a Smart Grid solution that increases the efficiency and reliability of the electric grid while reducing the environmental impact of electric usage. Current's scalable solution combines advanced sensing technology with low latency IP based communications and enterprise analysis software and related services to provide location-specific, real-time actionable data that is easily integrated into a utility's existing IT infrastructure. The company develops both hardware and software to achieve comprehensive end-to-end Smart Grid solutions.

Current, a private company, was founded in 2000 and has blue chip investors including EnerTech Capital, Google Inc., Goldman, Sachs & Co., and Liberty Associated Partners (an investment partnership between Liberty Media Corporation and the Berkman family) among others. Current's progress has been recognized by several awards including the World Economic Forum 2009 Technology Pioneer for its innovation, impact on business and society, future growth and sustainability, proven concept and visionary leadership; the GoingGreen East 50 Top Greentech Companies; the Dow Jones 2008 Ten Most Innovative Clean Tech Companies in Europe; the 2006 Platts' "Global Energy Commercial Technology of the Year" for its technology in relation to emissions reduction, practicality, reliability and overall commercial success; and Red Herring's 2006 "Top 100 North America."

Note: The Company began as a broadband-over-powerline (BPL) company, but this technology is no longer a part of its business.

Deployments: Xcel Energy is piloting Current's technology in its SmartGridCity project in Boulder, Colo., one of the nation's first fully-integrated Smart Grid communityies Current also has a deployment of more than 100,000 homes and businesses with Oncor Electric Delivery Company in the Dallas-Fort Worth area. Current is also a participant in several European Union-sponsored projects, including one led by Iberdrola, the world's fourth-largest electric utility.

Strategy: Unlike most companies operating in the communications/networking space (who beat the drum for the business case of smart meters), Current notes that smart meters alone do nothing to change consumer energy consumption patterns. Current believes that the primary benefits of having a smarter communications infrastructure (i.e., decreased generation needs, reduction in carbon, reduction in outages, more effective use of capital) comes from the optimization of the grid itself through optimized power delivery and improved distribution management, as such, it has been vocal in the need for lower-latency communications networks.

Analyst Note: The Current networking solution relies on fiber/cellular networks in the expectation of higher future bandwidth needs (and lower latency), and accordingly is considerably more expensive than other networking competitors using higher latency RF mesh technologies (such as Trilliant and Silver Spring Networks). Current argues that if you accept the possibility of PHEVs, increased integration of solar and wind energy and vast improvements being made to the distribution network, than low latency will be absolutely essential – and one cannot get this reliability with RF mesh networks. While this may be true, what remains to be seen is whether PUCs (Public Utility Commissions) will be willing to approve a considerably more expensive network infrastructure in the name of "future proofing." While Current clearly has a more comprehensive vision of Smart Grid than many of its competitors, landing a utility-scale networking contract is the validation that The Current Group presently could use.

5.2.2 Eka Systems

Eka Systems Inc. is an AMI networking solutions company providing both hardware and software to enable mesh networking of smart meters. The company competes against Silver Spring Networks, Trilliant, Current Group, Grid Net, SmartSynch as well as the major smart meter developers that provide their own AMI infrastructure (such as Itron, Elster and Landis+Gyr).

The company provides internet-enabled wireless device networking technology for monitoring, controlling, and integrating utility and energy infrastructure. It offers AMI through EkaNet residential meter nodes that helps to build residential meter networks; EkaNet wireless gateway, which supports multiple meter types on same network; EkaNet network manager for managing mesh network; and EkaNet field tool suite for network deployment.

Eka offers solutions for utility metering that tracks and analyzes usage, implement demand response and load curtailment, and detect outages rapidly and prevent leaks; sub-metering for multifamily, residential, and commercial properties; and substation integration and distribution automation for wireless substation integration and fault isolation, and management in distribution lines. It serves utility companies, original equipment manufacturers, and systems integrators. Eka was founded in 2000 and is based in Germantown, Md.

Eka Systems has reportedly raised around $40 million in funding to date. Its last round, for $18.5 million, which the company announced in July 2008, was led by Flybridge Capital Partners and included the Angeleno Group, RockPort Capital Partners, The Westly Group and Metropolitan Investment.

Strategy: “True mesh networks lead to robust, low-cost, scalable sensor networks,” says the company on its website.

Deployments: Eka has had two had note-worthy pilot deployments to date. The first a deployment of 20,000 electric meters (and 10,000 gas) is located in San Marcos, Texas. (This project was selected as “AMI Project of the Year” by Utility Automation and Engineering T&D Magazine, in February 2009.) The other deployment, in operation since 2005, provided the AMI infrastructure for 30,000 meters in St Petersburg, Russia.

Analyst Note: It’s hard to predict what lies ahead for Eka Systems. It is another example of an AMI networking provider that needs that validation of a large-scale utility contract. At the moment increased competition is coming into the space, from public cell phone carriers on one side and from IT giants like Cisco on the other end. Whether Eka can grow into a Silver Spring remains to be seen. There will be no shortage of smart meters that need to get networked in the next five to 10 years, but gaining the trust of utilities is easier said than done.

5.2.3 Silver Spring Networks

Silver Spring Networks is the leader of AMI networking solutions in North America. The company is involved in large-scale utility AMI projects with PG&E, Florida Power & Light, Pepco Holdings, Oklahoma Gas & Electric and two Australian utilities. Collectively these contracts amount to more than 10 million "smart meters" for which Silver Spring provides the networking solutions. The company competes with other networking AMI players such as Cisco, Trilliant and SmartSynch, as well as advanced metering companies that are able to provide their own network solutions (such as Itron, Landis+Gyr and Elster).

The company is a networking "pure play" focused on providing two-way real time communication between the end-user's smart meter (as well as intelligent devices and sensors) and the utility's control and management ("head end") systems. Silver Spring Networks' Smart Energy Network is based on the Internet Protocol (IP) suite and addresses the challenges of running multiple applications and devices on a common networking infrastructure using multiple transport technologies. (Note: Silver Spring Networks does not manufacture or market smart meters.)

Silver Spring Networks enables utilities to achieve operational efficiencies, reduce carbon emissions and offer their customers new ways to monitor and manage their energy consumption. SSN provides the hardware, software and services that allow utilities to deploy and run advanced applications such as: Smart Metering, Demand Response, Distribution Automation and Distributed Generation, over a single, unified network. Silver Spring's Smart Energy Network is based on open, Internet Protocol (IP) standards, allowing continuous, two-way communication between the utility and every device on the grid. In 2008, the World Economic Forum honored Silver Spring Networks as a Technology Pioneer. Silver Spring Networks also holds patents in the area of utility network optimization.

Investors: To date the company has raised over $150 million in venture funding. In March 2009, Silver Spring announced that it had raised an additional $15 million as part of a Series D round (Note: Google invested an undisclosed amount at this time.) This latest funding was added onto a $75 million Series C round, completed in October 2008, led by Kleiner Perkins Caufield & Byers. Silver Spring has also received prior funding from Foundation Capital, JVB Properties and Northgate Capital.

Business Partners: A review of Silver Spring Networks' business partnerships is in many ways like looking at "The Smart Grid All-Star Team." What is interesting about these Smart Grid projects is that two separate vendors can be competitors in one deal and partners on another, as interoperable technologies allow for modular solutions. While not every major industry player is included, this is a fairly representative list of leading players in each of the Smart Grid Sectors: advanced metering; demand response; distribution automation; home area networks; networking; and software.

Advanced Metering: GE Energy, Itron, Landis+Gyr, PRI, Sensus, Kinects Solutions

Demand/Energy Management: Comverge, EnerNoc

Distribution Automation: ABB, DC Systems, S&C Electric Company

Home Area Networks and Devices: Tendril, Greenbox, Control4, Arch Rock, Onzo, Carrier Corporation, Energate, Exegin, Invensys, Radio Thermostat of America

Networking: Cisco, Digi International

Software: eMeter, GE Energy, GridPoint, Itron, OSIsoft, Oracle

Analyst Note: In 2009, Silver Spring Networks and ABB announced the successful completion of interoperability testing of ABB's substation computer and PCD recloser device with Silver Spring's Smart Energy Network. This testing highlights the importance of the ongoing convergence of Grid Optimization, Advanced Control Systems, and AMI projects. Expect Silver Spring to continue to offer these types of services – beyond simply networking – as utilities will ideally want to leverage many/all of their Smart Grid initiatives over the same communications network.

Further, while we have noted the potential drawbacks of medium bandwidth/higher latency (RF mesh) networks in this report, it is undetermined whether these networks can be augmented over time just as the internet was. Presently, Silver Spring is clearly benefiting from, and gaining momentum, from its position as the market leader.

To Watch For: Cisco's entrance into Smart Grid in 2009 is certain to send a message that bigger guns now have their sights on these AMI networking contracts.

While Silver Spring is working as a partner with Cisco in the Florida Power and Light AMI project, in June, Cisco announced a business partnership with Duke Energy, where Cisco alone might conceivably build out the network infrastructure using its own hardware (the cost of Duke's first two large-scale deployments – Ohio and Indiana – will be $1 billion). Because Cisco is the largest networking company in the world, its emergence as a Smart Grid network player will cause Silver Spring a fair amount of heartache. Still, Silver Spring is currently the dominant AMI networking solution provider in North America (and Australia) and will continue to capitalize on its strong reputation. Many observers expect Silver Spring to be one of the first Smart Grid companies to go public.

PRESS RELEASE EXCERPT (JULY 29, 2008) SILVER SPRING AND PG&E -- ANNOUNCE LARGEST AMI DEPLOYMENT IN NORTH AMERICA
Pacific Gas and Electric Company (PG&E) has selected Silver Spring Networks to provide advanced networking products and services to serve its 5 million electric customers in California. Silver Spring Networks and PG&E have signed a definitive agreement and deployment activity is underway, with full metering deployment expected to be completed by 2012. PG&E will initially focus on using the technology to support advanced metering and home networking applications. In addition, the platform will enable PG&E to realize additional operational and environmental benefits in the future. Under the agreement, Silver Spring Networks will provide network infrastructure, network devices, operating software and a variety of services in long-term support of PG&E's efforts. Although initial deployments are scheduled to be completed within five years, the contract extends to provide continued support and expansion over 20 years. Under the agreement, PG&E will have broad flexibility in managing the timing and scope of its technology deployments. In addition, certain services and products under the agreement are contingent on regulatory approval as part of PG&E's SmartMeter Program Upgrade.

Source: T&D World (http://tdworld.com/info_systems/highlights/pge-silver-springs-0808/)

5.2.4 SmartSynch

SmartSynch is a Smart Grid network infrastructure company utilizing standard IP communications via public wireless networks.

Smart Synch has a remarkably different business model than the other major networking players competing for large-scale AMI deployments. Rather than building out the necessary communications infrastructure (as does Silver Spring and Current, who use RF networks and fiber optics, respectively) SmartSynch has elected to partner with public wireless networks (such AT&T and T-Mobile) to provide the necessary communications backbone in order to provide two-way delivery of real-time energy usage data.

SmartSynch offers end-to-end, IP-based solutions capable of delivering grid intelligence to and from any device. Products and services include SmartMeters and SmartBoxes that immediately IP-enable the grid, software solutions, and network management services for utilities and their customers, as well as clean-tech companies in need of remote communications and control functionality for products ranging from solar panels to plug-in hybrid vehicles.

Founded in 2000, SmartSynch networking solutions originally relied on pager networks; however the company now exclusively leverages existing cellular networks (including both GSM and CDMA technologies). To date, SmartSynch has roughly 75 deployments (including pilots) with North American electric utilities. While many of those projects are not yet at utility scale, SmartSynch has established itself by partnering with many of the largest utilities in North America, including Hydro One, AEP, SoCal Edison, PG&E and Exelon. SmartSynch has approximately 84 employees.

SmartSynch is backed by a reported $80 million from Credit Suisse, Battelle Ventures, Beacon Group, JP Morgan Partners, Nth Power, Siemens Venture Capital and Duke Ventures.

Note: In March 2009, the company announced one of the most interesting partnerships in Smart Grid networking, to date, when they officially partnered with AT&T to connect household electricity meters to utilities via cellular networks. Shortly after, in April, the partnership announced their first utility contract, a pilot project with Texas-New Mexico Power Co. to link up roughly 10,000 homes. (While public wireless utilities had been previously used to carry information over a utility's "backhaul" system, this is the first known example of using wireless public carriers to connect the utility's systems directly with household smart meters.)

Trilliant

5.2.5 Trilliant

Trilliant is an advanced metering infrastructure (AMI) networking solutions company that provides the wireless communications backbone for smart metering and other Smart Grid applications.

The company has one large-scale deployment with Ontario-based utility Hydro One, where they provided the communications network to support more than 750,000 smart meters (making this one of the largest AMI projects to date in North America). The company competes with the other major AMI network providers such as Silver Spring Networks, SmartSynch (who is partnered with AT&T), Eka Systems. The company also competes against smart metering companies that can provide their own AMI networking infrastructure such as Itron, Landis+Gyr, and Elster.

The company's AMI communications network is named SecureMesh, and as the name implies, is based on a wireless, radio frequency mesh network operating system. The company also provides hardware (such as communication chips to enable smart meters, and communications gateways) and software for applications (such as demand response, load control and distribution monitoring). The company has now implemented more than one million full two-way, intelligent communication devices to power Smart Grid applications.

Trilliant has had one round of venture capital led by MissionPoint and Zouk Ventures for a reported $40 million.

Deployments: Trilliant was chosen as the AMI networking company for the Hydro One Smart Grid initiative. To date, the company has connected over 750,000 smart meters.

Analyst Note: The company as of October 2008 had already crossed the $100 million revenue mark, putting it on good financial standing for a startup (technically the company has been around since 1985, but has been re-launched and re-outfitted several times since).

Trilliant's founder and CEO Bill Vogel changed positions in March 2009 to become senior VP of strategic development in order to make room for new CEO Andy White, who had formerly been head of GE Hitachi Nuclear Energy. (This has been a trend in Smart Grid in the first six months of 2009, as companies switch from the startup phase to the operations phase – having senior management with deep ties to the utility world is widely viewed as a big plus.)

5.3 Demand Response

5.3.1 Comverge

Comverge Inc. (Nasdaq: COMV) are a leading provider of demand response solutions. Comverge, as well as competitor EnerNoc, is the most prominent names in the demand response sector. Comverge also provides energy efficiency services, installing technology which aids in cutting energy consumption.

Comverge boasts over 2,600 MW of clean energy capacity under management, providing clean energy solutions that improve grid reliability and supply electric capacity on a more cost effective basis than conventional alternatives by reducing base load and peak load energy consumption. With over 500 U.S. utility clients and five million devices installed, Comverge “smart megawatts” technology is widespread and in use across the nation. Its “pay-for-performance” programs provide capacity that can reduce emissions, eliminate line losses, increase reliability and defer generation and transmission acquisition.

The company was backed by Rockport Capital Partners, Nth Power, EnerTech Capital Partners, NorskHydro Ventures and Ridgewood Capital. Comverge went public in 2007.

Recent Activity: On Jan. 21, 2009, Comverge entered into a five-year agreement with Pepco Holdings Inc. (PHI) to provide services, including demand response hardware and software system and installation and marketing services compatible with PHI’s future AMI network.

In April 2009, Comverge release a new product called Apollo Integrated Demand Response Management System. Apollo is one of the industry’s first integrated Demand Response Management Systems that links in-home demand response devices to electric utility operations and back office utility applications. Apollo is an enterprise class, 100 percent web-based application, designed to provide a platform for advanced demand management applications as well as future energy-related software applications. In June, Comverge announced a technology partnership with Itron, one of the largest meter companies in the world, to link their services through Itron’s smart meter.

Analyst Note: According to CEO Robert Chiste, “Utilities have a tough time getting [demand response clients] below 250 kW,” Small and medium-sized businesses are “a good sweet spot, but it is difficult to get to.”

Note: Comverge is reported to have 25 percent of its demand portfolio from the residential sector. (Most demand response to date has been done with commercial and industrial users.) With its recent partnership with Itron, expect Comverge to expand its lead in this – virtually untapped – market.

5.3.2 EnerNoc

EnerNoc Inc. (Nasdaq: ENOC) is demand response solutions provider focused on the commercial, institutional and industrial market. (Its primary competitor in the demand response sector is Comverge Inc., which also trades on the Nasdaq.)

The company, which was incorporated in June 5, 2003, is a developer and provider of clean and intelligent energy solutions. EnerNoc uses its Network Operations Center (NOC) to remotely manage and reduce electricity consumption across a network of commercial, institutional and industrial customer sites to enable a more information-based and responsive, or intelligent, electric power grid. EnerNoc's customers are electric power grid operators and utilities, as well as commercial, institutional and industrial end users of electricity.

As of Dec. 31, 2008, the company managed approximately 2,050 MW of technology-enabled demand response capacity from approximately 1,650 different commercial, institutional and industrial customers in the demand response network across approximately 4,000 customer sites. In May 5, 2008, EnerNoc acquired South River Consulting LLC (SRC), an energy procurement and risk management services provider.

Recent News: In March 2009, EnerNoc announced it has entered into a contract to deliver 250 MW of power to four utilities in Maryland: Allegheny Power, Baltimore Gas and Electric, Delmarva Power and Light Company, and Potomac Electric Power Company.

Analyst Note: The recent Maryland deal means that the company, which signed seven utility contracts in the first quarter, now has a total amount of demand response capacity of 2.5 GW, putting it neck and neck with Comverge for the claim of demand response industry leader.

5.4 Grid Optimization / Distribution Automation

5.4.1 ABB

ABB is a market leader in power and automation technologies that enable utility and industry customers to optimize their performance. It is very active in integrating distribution management systems into advanced utility control systems. Smart Grid applications that ABB provides include: unbalanced load flow analysis, fault location, restoration and switching, SCADA/EMS/DMS/OMS/AMI (various systems) integration, Volt/VAR optimization and remote/automatic switching and restoration – these solutions are primarily located in between the distribution network and the utility control room.

The ABB Group of companies operates in around 100 countries and employs about 120,000 people. The company's North American operations are headquartered in Cary, North Carolina, and employ about 15,000 people. The company has been in operations for over 100 years, and claims to have invested over $10 billion in R&D in the last decade to develop a more reliable grid infrastructure, with a special interest in energy storage. ABB has one of the broadest portfolios of products and services for the utility industry, offering end-to-end solutions (from the smart meter all the way to the control center). ABB's other main offerings for the upgrade of the power grid include HVDC Light, FACTS and WAMS, solutions primarily for the transmission of power.

The company has been out-spoken on the need for interoperability standards for substation automation and protection projects. All ABB transmission and distribution protection and control devices used in substation and distribution automation devices such as relays, communication gateways and substation controllers, go through a vigorous testing to ensure compliance to the IEC 61850 standard. ABB has the largest installed base of IEC 61850 devices globally, extending to more than 600 electric power systems in 57 countries. As announced by DOE Secretary Chu and Commerce Secretary Locke in May 2009, IEC 61850 will serve as the initial Smart Grid interoperability standard for substation automation and protection.

ABB competes against S&C Electric, Cooper Power Systems, and SEL at the distribution level. ABB also competes against GE and Siemens (the other major players in power systems and delivery), although GE is more focused on generation, while Siemens is more focused on transmission.

Analyst Note: The Company is very concerned with establishing interoperability with Advanced Metering Infrastructure, and is partnered with Silver Spring Networks to provide automated restoration services.

5.4.2 SEL

SEL offers a complete line of products and services for the protection, monitoring, control, automation, and metering of electric power systems. The company is one of the partners in the SmartGridCity project in Boulder, Colo. (SEL introduced the world's first digital relay in 1984. This was a big upgrade for the power protection industry – offering fault locating and other features at a reduced cost of earlier systems.)

SEL provides grid optimization solutions – including recloser controls, protective relays and information processors – that improve distribution reliability as part of a Smart Grid. These solutions rapidly isolate faults, restore power, monitor demand, and maintain and restore stability.

Xcel Energy's SmartGridCity in Boulder, Colo., showcases improved grid performance, power reliability, and conservation that result from applying Smart Grid technologies. Substation control systems do much more than protect or meter the system. SmartGridCity highlights how all those local capabilities can be integrated into an economical, secure system.

Many SEL products in use today already have the communications and control capabilities to make the grid smarter and more secure:

» Transformer protection for exception-based maintenance
» Recloser controls and communications solutions for a self-healing grid
» Fault indicators for complete fault location and reduced fault-finding time
» Distributed intelligence for reliable control of advanced generation technologies
» Smart metering solutions for revenue metering, power quality and control systems that can help reduce energy usage
» Cybersecurity solutions for a more secure grid

Many SEL solutions have additional "smart" features built in:

» Synchrophasors
» Distribution fault locating
» Power quality recording
» Integrated metering
» Advanced security features

Analyst Note: SEL has successfully deployed Smart Grid products and solutions with Progress Energy, AEP, Commonwealth Edison (ComEd), the national utility of Mexico, Comisión Federal de Electricidad (CFE) and many other leading global utilities. The bottom line: SEL will continue to see increased growth in Smart Grid.

5.5 Software, Solutions and Applications

5.5.1 Aclara Software

Aclara, a subsidiary of ESCO Technologies Inc (NYSE:ESE) is a Smart Grid software company that focuses on of meter data management (MDM), network planning, load forecasting, and Customer Information System (Customer Care and Billing Systems) or CIS. The company was founded in 1997 and was acquired by ESCO in 2005. Aclara Software continues to be operated as a stand-alone company.

The company is currently working with over 95 energy companies on a global basis. Several million energy company customers have used Aclara Software's applications. Aclara Software solutions have demonstrated the ability to reduce capital and operating costs. Aclara Software has developed a number of innovative software applications, several of which have been recognized with awards.

Aclara Software has also developed a home energy management system (or "portal"), energyguide.com that provides Aclara Software with a platform for exploring ways to best communicate with consumers. Aclara Software gained new employees, products, and clients through the acquisitions of EcoGroup Inc. in 1998, and ICF Energy Solutions Inc. in 2004. Aclara Software has 90+ employees and works closely with sister companies, DCSI and Hexagram.

Analyst Note: Aclara's MDM solution is being used by the utility Arizona Public Services (APS) for that utility's AMI project (approximately 800,000 meters), as well as Pennsylvania Utility PPL Electric.

5.5.2 Ecologic Analytics

EcoLogic Analytics LLC (formerly known as WACS) provides meter data management (MDM) software solutions and decision management technologies for utilities. It offers a meter data management system (MDMS), a suite of software solutions that include gateway engines, meter data warehouse, meter read manager, meter reading analytic, navigator graphical user interface, automated validation engine, network performance monitor and reporting engine, service order engine, real time outage validation engine, data synchronization engine, calculation engine and residential rate analysis API, and virtual metering aggregation components. The MDMS also integrates with various automated meter reading (AMR – older generation digital meters) and CIS (customer information systems, which namely involves billing) to deliver data to business users in the enterprise.

The company's EcoLogic Analytics solution offers a flexible, configurable and highly scalable architecture, enabling it to receive data from any AMI/AMR system and/or manual source. Its engines and analytics provide utilities with support for critical operational and business processes. Founded in 2000, the company is headquartered in Bloomington, Minn.

In 2005, EcoLogic Analytics was chosen as the vendor to provide the fully integrated MDMS for PG&E's Advanced Metering Infrastructure Project, the biggest AMI deployment in North America – a huge win for the company.

That implementation will see the EcoLogic Analytics MDMS system as the central system managing communications and transmission of data by and between the AMI vendor meter reading systems and PG&E utility back-office systems (such as asset management, customer information, work management, engineering, and outage management systems). MDM is a key component of the larger effort by PG&E to deploy advanced automated meter reading capability and two-way communications to all 9.3 million meters (5.1 million electric and 4.2 million gas) in the PG&E service territory.

EcoLogic competes against eMeter, Aclara Software, SAP, Oracle and any other software or AMI provider that can offer highly scalable MDM solutions.

Analyst Note: In February 2009, the company landed its second major contract with Texas utility Oncor and will now serve as the MDM provider for more than three million electric meters in Oncor's service territory. Landis+Gyr will provide the smart meters and the project is scheduled for completion before 2012. This will be another of the largest AMI deployments in North America. The relationship between EcoLogic Analytics and Landis+Gyr began in 2001 with joint field deployments and was later expanded though Landis+Gyr's strategic investment in the company in 2007. IBM's has independantly certified EcoLogic Analytics' ability to scale its solution up to 10 million meters – that means basically any utility in the world is in play for them.

5.5.3 GridNet

GridNet, is a provider of network management software, and communications product reference designs for "next-gen" smart meters, specifically designed to run on a WiMax "4G" network. In 2008, GridNet licensed its WiMax smart meter reference design to GE Energy, for use in GE's advanced meter product family – rumored to be named the GE WiMax SmartMeter – and based on GridNet's PolicyNet software. (GE has not officially announced the launch of this product.) Grid Net was founded in 2006 by Ray Bell, a former Cisco vet, entrepreneur-in-residence at Foundation Capital, as well as onetime interim CEO of Silver Spring Networks. GridNet is privately held and backed by Intel Capital, GE Energy Financial Services (not to be confused with GE Capital), and Catamount Ventures. GridNet is headquartered in San Francisco, Calif.

While GridNet continues to be in "stealth mode" it has disclosed that it is working on pilot demonstrations with four utilities testing WiMax as an AMI communication solution for the first time. (Officially, the pilot contracts belong to GE, with GridNet providing the network management software.) The business strategy of the company is based on the belief that in order to succeed in the utility world, a vendor must have strong relationships with utilities (a difficult proposition for any startups). As such, the company is strategically "piggy-backing" on GE's longtime relationships with utilities.

Also of note, GE WiMax Smart Meters will use Intel's WiMax chipsets, and Founder Ray Bell has been very vocal in suggesting that these chips will ride a powerful cost curve, quickly making these meters more affordable. (Bell has explained that the chip sets currently cost $36, and expects that they will drop to below $10 in the next 12 to 18 months.)

Unlike the now-popular unlicensed 900-MHz spectrum which is the primary communication solution for mesh networking players such as Silver Spring and Trilliant (two of the leading AMI networking companies), WiMax runs over licensed wireless spectrum, which is arguably both more secure and reliable. Secondly, a great advantage that WiMax has over RF mesh networks is lower latency. Many industry observers have warned that RF mesh networks may not be sufficiently "future proofed" to allow for future Smart Grid applications due to their higher latencies (for example, if data is needed in order to take a "real time" associated action, and the utility does not know whether the latency is two seconds or 10 seconds, that could prove very problematic). The primary disadvantage of using a licensed network is that it is more expensive. Further, it's worth pointing out that WiMax has yet to be deployed at scale.

Analyst Note: The promise of WiMax as a viable, and potentially "game-changing" communication solution for AMI and other Smart Grid applications (such as grid optimization projects), as well as the company's strong financial backers, make GridNet one of the more interesting companies to come along. The company has put all of its chips on the WiMax technology, banking on a successful roll-out; it will be very interesting to see how WiMax is accepted into the market in the next 12 to 24 months, and if, in fact, GridNet has made a sound bet.

eMeter

5.5.4 eMeter

eMeter makes software that manages the enormous volume of data coming from smart meters, providing both MDM and AMI integration for utilities information systems.

eMeter provides software to enable utilities to realize the full benefits of their AMI (advanced metering infrastructure) investments. eMeter's solutions allow for demand response and real-time monitoring of resource usage, resulting in greater energy efficiency and more reliable service, while minimizing the costs of AMI deployment, data management, and operations. The company competes with AMI companies that can provide their own software AMI and MDM software such as Itron and Sensus, as well as other software companies such as Oracle.

eMeter's flagship software, named EnergyIP, is an advanced metering information system (AMIS) that combines MDM with a vendor-neutral integration platform linking AMI systems to utility information systems. The suite of EnergyIP AMI Business Process Management applications includes: commercial and industrial interval-data collection, complex billing, and web presentment of detailed energy usage data.

eMeter can plan, install, and configure the EnergyIP software, as well as provide strategic consulting services related to MDM, AMI and demand response. The company has offices in the United States, Australia and India.

Recent News: eMeter has raised $25 million in the past two years, including a Series A round in April 2007 led by Foundation Capital and DBL Investors and an April 2008 Series B round led by Siemens (NYSE: SI), which in June announced a strategic partnership for global distribution with eMeter. The company is also backed by Foundation Capital and DBL Investors.

Deployments: In February, eMeter announced a deal with CenterPoint Energy (NYSEL CNP) to support the Texas utility's plan to install two million smart meters in its territory. That follows deals with Alliant Energy, Jacksonville Electric Authority and the Canadian province of Ontario, among others. The company claims to have 20 million meters under contract.

Analyst Note: Being that millions of smart meters are being deployed by utilities around the globe, we expect the task of managing that data – MDM – to be a very competitive space. The fact that the company has a reported 20 million meters under contract puts eMeter in good standing. As AMI deployments flourish, utilities will now need to handle approximately 2,000X more data per quarter for each smart meter installed (and that is if hourly reads are done; it would be substantially higher if the meter reads are at shorter intervals). Enterprise software heavyweights such as Oracle, SAP and IBM have been hawking this territory, and utilities may be drawn to opt for the bigger brand names in the future, as they start to offer more robust solutions. It will be interesting to see eMeter's business and marketing strategy going forward in light of this heavy competition. M&A activity is certainly not out of the picture.

5.5.5 GridPoint

GridPoint is a Smart Grid software company that develops modular systems and applications for utilities to improve and implement: energy efficiency, load management, renewable energy management, energy storage management, and electric vehicle management. GridPoint also offers consumers online energy management portals for greater efficiency, reliability and savings. The company provides software solutions across many of the emerging Smart Grid sectors.

GridPoint has been one of the most funded and most discussed startups in Smart Grid. Founded in 2003, GridPoint has raised more than $220 million as it has moved from making products that monitor energy use for residential and commercial clients to creating its trademarked “SmartGrid Platform” (software) aimed at giving utilities the technology to manage the flow and storage of power at a moment’s notice. GridPoint’s headquarters is located in Arlington, Va.; notably, the last two Directors of

FIGURE 34: EXAMPLE SMART HOME WITH CORRESPONDING SMART GRID APPLICATIONS

Source: GridPoint

the CIA sit on the Advisory Board to the Company.

GridPoint is currently working with utilities such as Xcel Energy, Austin Energy and Duke Energy developing the following Smart Grid applications: advanced demand management (load measurement and control), energy storage (providing instant backup power), renewable energy integration (notably wind and solar), PHEV integration (plug-in electric hybrid vehicles), advanced utility control consoles (which supplement existing SCADA/EMS utility control systems with greater performance monitoring and control), and home energy management systems ("portals").

The GridPoint Platform applies information technology to the electric grid to provide utilities with an intelligent network of distributed energy resources that controls load, stores energy and produces power. The software platform features a single interface, located in a utility's control room, for managing a variety of distributed energy assets, including plug-in electric vehicles, solar panels, wind turbines, advanced storage technologies and household devices such as thermostats, electric water heaters, pool pumps, etc. During peak periods, utilities can efficiently balance supply and demand by discharging stored power from distributed generation assets or reducing customers' non-essential loads. GridPoint's platform also offers homeowners benefits including real-time information and control, greater energy efficiency and savings, outage protection, online energy management and renewable energy integration.

Recent News/Funding: GridPoint raised $120 million in September 2008 (its latest round of VC funding) and bought Seattle-based V2Green (for an undisclosed price). V2Green makes technology to allow plug-in vehicles to communicate with and provide power back to utilities. GridPoint previously had raised roughly $102 million before that in four rounds of funding, with investors including Goldman Sachs Group and Susquehanna Private Equity Investments, New Enterprise Associates, Perella Weinberg Partners, Robeco and the Quercus Trust.

Two Pilots of Note:

Storage Pilot With Xcel Energy: Extending GridPoint and Xcel Energy's business relationship, GridPoint was selected as technology partner and now controls the flow of power between an 11-MW wind farm in Luverne, Minn. and a 1-MW, sodium-sulfur battery that is capable of holding 7.2 MW/h of energy. (Note: Lux Research predicted in May 2008 that bulk energy storage for utilities could hit $50 billion if only 10 percent of installed wind power plants adopted it. However, because utilities are slow to adopt new technologies, Lux expected that the market would likely be limited to only $600 million by 2012.)

PHEV Pilot With Duke Energy: GridPoint is also involved in a smart charging pilot with Duke Energy. GridPoint's software allows the PHEVs to be "grid aware" allowing the timing and pace of charging to be adaptively controlled to meet the needs of both drivers and the Grid.

Analyst Note: GridPoint announced in February of 2009 a strategic alliance with enterprise software giant OSIsoft. OSIsoft's PI System is considered the industry standard in enterprise infrastructure for the management of time series (real-time) data and events. The partnership might allow GridPoint to leverage OSIsoft's PI System (which is already deployed with many utilities) with the hopes of scaling up GridPoint's applications and ensuring that these applications properly function at mass scale in real time. (Note: It's one thing to do a pilot with a few thousand customers; handling the data involved with a utility scale deployment is a much bigger challenge.)

While GridPoint has yet to secure a utility scale contract; through pilot initiatives, it has emerged as one of the early contenders in the applications/software market segment. A review of the major applications on The GTM Research Smart Grid Taxonomy will show GridPoint competing for all major applications/submarkets. While increased competition (from companies with names like Oracle) is expected to come into this space, it will be interesting to see if this early bird gets the proverbial worm.

Note: The company recently hired Xcel Energy's Vice President and CIO (Chief Information Officer), continuing a Smart Grid trend of late – bringing utility execs into senior management positions in the hopes luring large scale utility contracts.

5.5.6 OSIsoft

OSIsoft delivers enterprise-wide real-time visibility into operational and business information. OSIsoft PI System software provides the infrastructure for collection and management of time series data required to monitor and implement Smart Grid applications such as AMI. A global base of more than 14,000 installations across energy, utilities, manufacturing, life sciences, data centers and process industries relies upon the OSIsoft PI System for similar data-collection and management functions to manage assets, mitigate risks, improve processes, drive innovation, make business decisions in real time, and identify competitive business and market opportunities.

The OSIsoft PI System collects, manages, analyzes, and presents data from AMI, substation automation, distribution automation, SCADA/EMS, and other data sources so that the information can be leveraged by operators, engineers, maintenance technicians, managers, directors and senior management (Note: OSIsoft specializes in presenting data for non-IT personnel).

OSIsoft has been providing real-time event management, retrieval, and deep archiving of volumes of data for scalable management of relevant variables and events for our utility customers for over 25 years. OSIsoft supplies reliable, highly available and secure software for mission critical processes. A privately held company founded in 1980, OSIsoft Inc. is headquartered in San Leandro, Calif.

Analyst Note: The volume of data that Smart Grids generate will present enormous business opportunities for software companies that can manage large volumes of data in real time. In February, OSIsoft announced a partnership with GridPoint. This particular partnership is interesting, as it marries one of the most funded Smart Grid software developers (GridPoint) with the ability to scale (OSIsoft).

5.5.7 Ventyx

Ventyx is a private software provider to the utility industry, delivering business solutions to maximize operational and financial performance for more than 900 customers around the globe. The company has approximately 1,200 employees, operates in 40 countries and has revenues topping $250 million in 2007. The company provides the following operational solutions for utilities: asset management, workforce management, CIS (billing and rate calculations), energy trading and risk management, energy market operations. The company also delivers energy planning and analytics solutions.

Ventyx software helps clients manage their customers, assets, workforces, spare parts inventories, and other tools necessary for providing effective customer services. It provides software to manage an automate energy trading, energy operations, and energy analytics. Ventyx targets industries with complex, asset-intensive needs, including energy and utilities and communications.

Specific to Smart Grid projects, The Ventyx Smart Grid Operations solution enables support of the commercial and retail utility operations that are required to deliver demand response programs, distributed energy management, and resource optimization.

SmartGridCity Technology Partner

Ventyx's role in SmartGridCity will include providing work management solutions for deploying Smart Grid technologies; MRO management for work and service requests triggered by the Smart Grid; and planning and analytics for price and load forecasts and decision support for connecting customer actions to trading and investment decisions in real time.

Ventyx Is the Culmination of Several Recent Mergers and Acquisitions:

» December 2006 – Indus (a public company) is acquired by private equity firm Vista Equity Partners and merged with existing Vista property, MDSI.

» March 2007 – Indus/MDSI re-branded as Ventyx

» June 2007 – Ventyx acquires Global Energy Decisions

» September 2007 – Ventyx acquires NewEnergy Associates

» February 2008 – Ventyx acquired Tech-Assist Inc.

Analyst Note: With a significant portion of the North American utility workforce set to retire in the next 10 years, a software company that can master workforce management and automation solutions will likely have a stable source of income going forward.

5.6 Home Area Networks and Energy Management Systems

5.6.1 Control4

Founded in 2003, Control4 Corporation has developed a single platform to provide centralized home control and automation for home-theater, multi-room music, lighting, temperature and safety and security. The company's business concerns actually extend beyond energy usage (which they address through lighting and temperature controls) into the full vision of a "smart home." The company markets and sells both hardware and supporting software.

Control4 offers a complete product line of wireless and wired IP-based home automation products that works over a mesh network to integrate the control of lighting, audio, video, landscape and climate into a centralized system. The company's "The Composer" software allows homeowners to manage all aspects of a home automation system including location, device, connection and programming.

Control4 also manufactures various components: including lighting products, such as wireless dimmers, wireless switches, wireless outlet dimmers, and wireless outlet switches; audio/video equipment, including WiFi speaker points, Ethernet speaker points, multi tuners, multi channel amplifiers, audio matrix switches, and disc DVD changers; climate control products, such as wireless thermostats; touch screens, including wireless touch screens, wall mount touch screens, wireless mini touch screens, and Ethernet mini touch screens; keypads, such as wireless keypads and LCD keypads; controllers, including home controllers, media controllers, and home theater controllers; and accessories, such as contact/relay extenders and system remote controls. The company also provides software, such as composer home edition and 4sight Internet services software. In addition, it offers developer tools, including SDK version and card access wireless installation analyzers. Control4 is based in Salt Lake City, Utah.

The company is backed by vSpring Capital, Thomas Weisel Venture Partners, Frazier Technology Ventures, and Foundation Capital and has raised approximately $33 million in venture capital.

Analyst Note: Control, the home entertainment system maker, is coming at the home energy management market from a very different angle from the other companies profiled in this report. While most believe that a web-based application will likely emerge as the tool of choice for consumers in programming their energy needs; until a standard emerges, we are likely to see a wide assortment of approaches.

Note: The company raised and additional $17.3 million in July 2009.

5.6.2 Ember

Ember Corporation develops and markets semiconductors (chips), and software for wireless home networks based on the ZigBee wireless standard. Ember's products enable companies involved in energy technologies to help make buildings and homes smarter, consume less energy, and operate more efficiently. Ember's low-power wireless technology can be embedded into a wide variety of devices to be part of a self-organizing mesh network. Ember is headquartered in Boston and has its radio development center in Cambridge, England. The company is a promoter and Board member of the ZigBee Alliance and its platform is the "Golden Suite" for 802.15.4/ ZigBee interoperability testing.

In June 2009, The company announced its newest generation of chips, the EM300 Series. Ember's next-generation ZigBee chip family claims to pack the industry's highest wireless networking performance and application code space into the lowest power-consuming chip set. The world's first ARM Cortex-M3 based ZigBee system-on-chips (SOCs), the EM300 Series deliver industry leading Performance, Code Density and Power Efficiency. These chips are expected to be priced under $3 (in high volumes), the EM300 Series chips will be available in late the third quarter of 2009.

While this is an emerging sector of Smart Grid, Ember will likely compete against other major chip manufacturers, such as Texas Instruments, Freescale Semiconductor and Atmel Corp.

Analyst Note: Founded in 2001 at M.I.T., Ember is one of the most heavily funded companies in the Home/Building Area network space, having raised a reported $89 million to date. Being that its technology is 100 percent based on the ZigBee wireless network standard, Ember is one of the loudest promoters and supporters of the ZigBee Alliance. As of June 2009, ZigBee has emerged as the leading networking standard for home and building networks, and Ember is the current market leader in ZigBee semiconductors. The downside is that these chips are rapidly becoming a commodity product, with everyone and their mother rushing in to manufacture them.

5.6.3 GainSpain

GainSpan is a WiFi semiconductor company that provides chips for home and building automation. The company is presented in this report to highlight WiFi as a competing technology to ZigBee (which has emerged as the industry standard in home and building automation).

GainSpan provides a low power, single chip WiFi solution for battery-powered or energy-harvesting-based sensor applications (an important point for a technology which has been viewed by many as too power hungry). GainSpan provides a complete WiFi system-on-chip (SOC) that can run sensor devices for an expected period of up to 10 years (on a single AA battery). Leveraging the very large installed base of WiFi access points, GainSpan and its partners aim to reduce energy consumption and carbon footprints as well as the operation and installation costs of residential, commercial, industrial sensor network applications.

GainSpan's continuing mission is to create a broad range of semiconductor solutions (embedding these chips into as many appliances as possible) to continually improve usage capabilities for many new applications worldwide, while leveraging ubiquitous WiFi.

GainSpan, founded in 2006 by a team of executives and engineers from Intel has raised $30 million in venture capital in two rounds. Investors include Intel Capital, New Venture Partners, Opus Capital, OVP Venture Partners, Sigma Partners, and Camp Ventures.

The company competes against leading ZigBee SOC manufactures, such as Ember, as well as other WiFi SOC companies such as G2 Microsystems and ZeroG Wireless.

Analyst Note: Currently GainSpan is in a difficult position. ZigBee continues to win favor with smart metering companies, leading utilities, and remote control manufacturers (for in-home appliances) and has achieved the position of the industry standard; this is largely due to low power requirements, network scalability, and reliability. Gainspan's business case is built largely upon the following points:

3. WiFi power requirements have come down significantly from several years ago.
4. WiFi provides better security (as the WiFi WPA2 protocol has evolved over many years).
5. WiFi allows for IP addressable devices, which ZigBee does not.

5.6.4 Google (PowerMeter)

Google PowerMeter is a web-based home energy management system that receives information from utility smart meters and energy management devices and provides customers with access to their home electricity consumption right on their personal iGoogle homepage. Google PowerMeter is currently testing with eight very different utilities around the globe (including San Diego Gas & Electric, Glasgow EPB, Reliance Energy and TXU Energy). The unifying factors among this group of utilities are (1) that they have installed (or are installing) residential smart meters, and (2) that they have "a desire to serve their customers by providing access to detailed information that helps save energy and money." Google plan to expand the rollout of PowerMeter in late 2009. Google has also announced that it is working with both GE and Itron, two of the largest smart meter manufactures and energy management startup Tendril.

Google notes that, "Studies show that being able to see your electricity use makes it easier to reduce it…. Unfortunately, many of today's smart meters don't display information to the consumer. We consider this unacceptable. We believe that detailed data on your personal energy use belongs to you and should be available in a standard, non-proprietary format. You should control who gets to see it, and you should be free to choose from a wide range of services to help you understand and benefit from it. We're working with federal and state governments to ensure our energy policies encourage consumer information.

"Google PowerMeter takes advantage of our scalable, secure IT architecture and our popular iGoogle platform to show you your detailed energy use (and it's free to both utilities and consumers). We're pleased to be working with a number of utilities to deliver Google PowerMeter to their customers. But when it comes to empowering consumers with better information, we don't believe there is a 'one size fits all' solution – which is why we hope that there will soon be an entire ecosystem of energy information products and services."

In typical Google fashion, PowerMeter looks to be very simple and intuitive to use. Its goals are the detailed in the following diagram.

FIGURE 35: GOOGLE POWERMETER GOALS

	**Analyze**: Get better information about how you use energy and what you can do to be more efficient.
	**Save**: Reduce your energy bills and carbon footprint by making smart decisions about your energy use.
	**Share**: Strike up a little friendly competition to see how your energy consumption compares to your friends and neighbors.

Source: Google

Google has said that it intends to focus on monitoring and providing energy data on the larger household appliances (and as such getting energy use data on every single appliance wasn't that critical a concern for it). Google intends PowerMeter be an open-source platform, which means that third-party developers and device makers will be able to add more specific applications (and compete in areas in which Google has no direct interest). In this way, PowerMeter can be seen to be modeled after the very successful iPhone.

Analyst Note: One of the biggest Smart Grid announcements in 2009 was that Google intended to:

6. Enter the home energy management space.
7. Give its product away to utilities and consumers for free.

Google's entrance into the home area network sector has the potential to radically change the landscape for companies developing hardware and software around the smart meter. While competitors have publicly claimed that Google's entrance is a net-gain, as it brings more attention to the sector, behind closed doors those competitors are likely expressing a different set of feelings.

It is still too early to announce PowerMeter as the future de facto standard for home energy monitoring, however Google's entrance all-but-ensures that the heightened competition in this space will ultimately deliver terrific, easy-to-use, inexpensive (or free) solutions for the consumer.

Note: In late June, Microsoft also entered the home energy management sector, with the product launch of Microsoft Hohm.

5.6.5 Greenbox

Founded by the creators of Flash (the multimedia technology platform), Greenbox Technology provides an interactive energy management solution – a web-based home energy usage dashboard – for utilities and residential energy customers. Greenbox's products enable homeowners to easily track, comprehend, and manage their energy usage, reducing their environmental footprint while potentially saving money. Through leading-edge design and insightful analysis of home resource usage, Greenbox Technology lets people to make informed choices about their utility use that are aligned with their values and priorities. Greenbox presents easy to understand graphs, charts, historical data and community comparisons to help inform consumer energy decisions.

The Greenbox technology plays "downstream" from the smart meter, leveraging AMI deployments and giving the home user real time data, primarily related to the cost of energy. Further, the Greenbox portal would ideally communicate to any intelligent device (smart thermostats, refrigerators, etc.) in the home. Note: For this technology to reach any kind of wide adoption, time-of-use pricing models will almost certainly have to be in place; otherwise what incentive would there be for consumers to change/re-arrange their energy usage, if the price of energy is the same 24 hours/day.

To its credit, and for a startup, Greenbox seems to be one most known home energy management solutions. The Company has a business partnership with Silver Spring Networks, the AMI communications/networking leader in North America, and is currently piloting its technology with Oklahoma Gas & Electric (as well as five other unnamed utilities). The company is focused on capturing both residential customers and light commercial users (i.e., "mom and pop" stores), the highest payers on a kilowatt basis that utilities have. Ultimately the company hopes to deploy their software at "utility scale," by licensing its product.

Analyst Note: It's still a bit early to predict which companies in the home energy portal space will succeed, or even survive. People familiar with the Greenbox product consistently give it high marks, in terms of both its ease of use and its functionality. Its energy usage dashboard, one could say, is very "google-ly." The only problem is that Google has also entered the picture (and will soon release the Google PowerMeter), not to mention Cisco, who in May 2009, announced that they also would compete in the home energy management space. The company also competes against well-funded Smart Grid companies such as Tendril and GridPoint.

In June, Greenbox kept with a current trend among Smart Grid startups, naming a new CEO and signaling a shift from the founding phase to the operations phase. Greenbox picked Ivo Steklac, a 20-year veteran of such metering giants as Elster and Schlumberger, as its new CEO. Expect to see this pattern continue, as startups will need strong energy-world connections to help engage notoriously slow-moving utilities that (1) operate in regulatory-driven marketplace and (2) have a preference for well-tested technologies.

At the time of this announcement Greenbox said it was expanding its partnerships with utilities and the host of companies including: "demand response providers, AMI vendors, meter data management firms, device manufacturers, and system integrators" – basically players from all the markets segments that make up an end-to-end Smart Grid.

FIGURE 36: EXAMPLE OF GREENBOX'S ENERGY MANAGEMENT SYSTEM

Source: Greenbox

5.6.6 Onzo

U.K.-based Onzo offers consumers a way to measure and monitor their energy consumption. Onzo's first product, to be launched in mid-year 2009, includes an energy display and an intelligent web portal that will allow consumers to reduce consumption, lower their bills and cut carbon emissions. Onzo's energy management systems are being designed to convert data transmitted via a Smart Grid communications network into a consumer-friendly context, by providing a range of actionable information.

Analyst Note: Onzo has raised £2 million (approx $3.3 million) from Sigma Capital Group and Scottish and Southern Energy. Southern Energy has already placed an order for £7 million ($11.5 million) devices and services. While there are many companies rushing into the home energy management space, making it hard to predict the winners, getting orders in advance of a product launch is a good sign.

5.6.7 Tendril

Tendril Networks makes hardware and software solutions for applications such as: demand response, energy monitoring, energy management and load control. The Boulder, Colo.-based company is one of the better known Smart Grid startups; it offers a wide variety of products and services, including: a energy management system for both consumers (based on the ZigBee HAN standard) and utilities, smart devices (such as smart thermostats, smart plugs, and in-home displays,) as well as web based and iPhone enabled displays and energy controls. The company also develops applications for utilities such as network management, direct load control, customer load control. Tendril has been competing to be the demand side platform, (called TREE) which would allow third-party software developers to develop applications on top of it.

TREE is an end-to-end residential energy management system. The Tendril Residential Energy Ecosystem (TREE) enables consumers to better understand their energy consumption patterns and empowers them with the ability to make a difference. TREE allows energy suppliers to establish a deeper relationship with their customers and deploy smart energy conservation programs designed to meet the individual needs of their consumer.

From the Company: The TREE Platform is an open, enterprise-class demand side energy management software solution for utilities and energy retailers. Designed to support multiple energy management applications simultaneously, including Energy Efficiency, Demand Response, and Pricing. TREE provides a complete solution that is scalable, unified, and optimized for seamless integration with the utility back-office, a variety of meter networks, and ZigBee enabled devices. The TREE platform is a unified energy management platform with an open, standards-based architecture that can scale to support millions of homes and their smart energy devices. The platform's open set of APIs allows for seamless integration with new user interfaces and existing back-office enterprise systems, including meter management and billing systems, as well as load-monitoring and security applications.

The TREE platform can be accessed by consumers in various ways including, the Vantage consumer portal, mobile devices, an energy management widget, smart thermostats, and smart in-home displays. These devices provide access and information about the other devices in the home area network (HAN) as well as details on their energy consumption and billing information. The Vantage Utility Management Center provides energy retailers with the ability to monitor and manage millions of HANs simultaneously, and communicate directly with their customers regarding service and support in real-time.

According to Greentech Media's Jeff St John: "The Boulder, Colo.-based Tendril Networks makes energy displays, wall outlets and thermostats that talk to one another using the ZigBee communication standard. The startup has deals in place with more than 30 utilities and plans to announce a commercial rollout in 2009 that will involve about 5,000 to 10,000 new homes a month, along with about ten more field trials. Still, it recently had layoffs, and has announced it will license its software to third-party equipment developers."

Analyst Note: In June 2009, the company raised a third round of funding in the amount of $30 million, bringing the total amount that the company has raised to $50 million, making it one of the most funded private companies competing the Home Area Network space. The fact that Tendril was able to raise such a substantial amount – after Google announced its own home monitoring product and in a recessionary period – speaks to how profitable VC's and energy insiders expect the home energy market to become.

FIGURE 37: EXAMPLE OF TENDRIL'S CUSTOMER PORTAL

Source: Tendril

5.7 Other Major Players

5.7.1 Cisco

Cisco Systems Inc. designs, manufactures and sells Internet Protocol (IP)-based networking equipment and other products related to the communications and information technology (IT) industry, and provides services associated with these products and their use. The company provides a line of products for transporting data, voice and video within buildings, across campuses, and around the world. Its products are designed to transform how people connect, communicate and collaborate. Cisco Systems Inc.'s products, which include primarily routers, switches, and products it refers to as its technologies, are installed at enterprises, public institutions, telecommunications companies, commercial businesses and personal residences. The company has over 66,000 employees, was founded in 1984 and is headquartered in San Jose, Calif.

In May 2009, Cisco – which had been pursuing Smart Grid largely in stealth mode – formally announced its Smart Grid market leadership ambitions. Cisco said that they were determined to compete in the following market segments: AMI networking and communications, distribution and transmission automation, data storage and home/building energy management – a substantial portion of the end-to-end Smart Grid.

Cisco had already signaled their interest in Home/Building energy management systems in January 2009 when they announced EnergyWise, a software meant to link commercial buildings' computers, lighting, phones, and other building appliances to an energy management platform. At that time, Cisco also acquired Richards-Zeta Building Intelligence Inc., a software provider for building automation networks.

But the recent May 2009 announcement clearly demonstrated that Cisco is taking the broad approach to Smart Grid, and consequently, every other company competing in Smart Grid now has cause for concern. Marie Hattar, vice president of network systems and security, sized up the "communications infrastructure market … in the realm of about $20 billion per year over the next five years." Hattar continued, "If you think today about how large the routing and switching market is, it's about a $25 to $30 billion market… So if we're looking at $20 billion being the start of the [Smart Grid] rollout, I think it will far eclipse the routing and switching market." While others may dispute Cisco's assessment of the current market size; Cisco made it clear that they see massive opportunities, and that it intends to compete in virtually every area of Smart Grid.

Analyst Note: In April 2009, Florida Power & Light (FPL) announced one of the more interesting Smart Grid deployments, to date, with its $200 million Energy Smart Miami project. In the project, GE will supply smart meters, Silver Spring will provide wireless communications and Cisco – making its very first Smart Grid deployment -- will provide the networking. In a show of how important this announcement was, the ceremony was attended by FPL Group CEO Lewis Hay, GE CEO Jeffrey Immelt, Cisco CEO John Chambers, Silver Spring Networks CEO Scott Lang and Carol Browner (who coordinates energy and climate change policy for President Obama).

In June, Cisco had a bigger announcement, forming a business partnership with Duke Energy in advance of Duke's $1 billion smart meter/AMI roll-out. While Duke has been one of the most ardent supporters of Smart Grid these past five years (and has tested various applications from PHEVs to microgrids) it has taken the go-slow approach in selecting an AMI networking partner, perhaps showing an unwillingness to work with an untested partner. In an industry that has a high aversion to risk, the choice of Cisco will likely be viewed as the safe choice – and you can expect many other utilities to follow suit. Cisco will now will likely compete with Silver Spring Networks, the current AMI networking leader, for all future AMI contracts.

5.7.2 IBM

International Business Machines Corporation (IBM) develops and manufactures information technology products and services worldwide. Its Global Technology Services segment offers IT infrastructure and business process services, such as strategic outsourcing, integrated technology, business transformation outsourcing, and maintenance. The company's Global Business Services segment provides professional services and application outsourcing services, including consulting and systems integration, and application management. Its systems and Technology segment offers computing and storage solutions, including servers, disk and tape storage systems and software, semiconductor technology and products, packaging solutions, engineering and technology services, and retail store solutions.

IBM's Software segment primarily offers middleware and operating systems software comprising WebSphere software for web-enabled applications; information management software for database, content management, information integration and business intelligence; Tivoli software for infrastructure management, including security and storage management; Lotus software for collaboration, messaging, and social networking; and rational software, a process automation tool. The company's Global Financing segment provides commercial financing to dealers and re-marketers of IT products; lease and loan financing to external and internal clients; and sale and lease of used equipment. IBM serves banking, insurance, education, government, healthcare, life sciences, aerospace and defense, automotive, chemical and petroleum, electronics, distribution, telecommunications, media and entertainment, and energy and utilities, as well as small and medium sized business. The company was formerly known as Computing-Tabulating-Recording Co. and changed its name to International Business Machines Corporation in 1924. IBM was founded in 1910 and is based in Armonk, N.Y. The company has more than 400,000 employees.

IBM offers a broad portfolio of capabilities for utilities needing to design and implement utility-scale Smart Grid projects and initiatives. IBM has been one of, if not the, most active companies in driving public policy and awareness concerning Smart Grid issues, detailing the benefits, challenges, technologies, and expected roll-out periods of the different technologies.

IBM competes in both the services and software sectors of Smart Grid. IBM can serve utilities in many ways; providing trusted expertise for PUCs looking to make deployment decisions on behalf of their state's residents; playing the role of essentially of a "marriage counselor" between distribution utilities and IT providers; assessing whether a particular startup/technology is ready for a large-scale deployment order; and tackling many other issues – that an industry which has lagged behind in IT and communications – is likely to encounter.

On the software end, IBM will offer both systems architecture and enterprise applications for the primary market sectors of Smart Grid, AMI demand response, distributed generation and storage, HANs and PHEVs.

IBM has Smart Grid pilot projects underway with leading utilities including Texas utility CenterPoint, Ohio-based AEP (American Electric Power) and Michigan's Consumers Energy as well as a research partnership with French utility EDF. IBM also has a notable project with the island nation of Malta. That five-year contract to "design and deliver a nationwide Smart Grid implementation" was reported to be 70 million. To date, IBM has not announced the majority of its projects and partnerships.

Notes: IBM Global Financing, the lending and leasing business segment of IBM, announced in March of 2009 that they are making up to $2 billion available to finance IT initiatives in key economic stimulus areas, including Smart Grid and energy efficiency projects. IBM claims that "the move will help U.S. organizations move ahead with IT projects that could improve their infrastructure or competitive edge and point them in the direction of economic recovery."

In June 2009, IBM announced the creation of an industry alliance with key leaders in metering, monitoring, automation, data communications, software and analytics to provide smart solutions for energy (as well as water, waste and greenhouse gas management). Charter members of (what is to be called) the Green Sigma Coalition are Johnson Controls, Honeywell Building Solutions, ABB, Eaton, ESS, Cisco, Siemens Building Technologies Division, Schneider Electric and SAP. The coalition members will work with IBM to integrate their products and services with IBM's in-house expertise.

For the past several years, IBM has been working on a "road map" for the Smart Grid. This has been developed with the consultation of more than 40 utilities worldwide. In March 2009, IBM announced that they are donating that tool to the Carnegie Mellon Software Engineering Institute (SEI), who will continue the work, and place it into the public domain. The so-called "Smart Grid Maturity Model" will serve as a strategic framework for utilities, vendors, regulators, and consumers that have a role in Smart Grid transformation – from technological to regulatory to organizational.

Analyst Note: When you consider that many utilities do not even have Bus Systems Architecture, there are will be huge opportunities for IBM to deliver a wide range of products and services (including systems architecture, middleware, advanced applications and a wide variety of consulting work). The company claims to already be actively engaged in many of the largest AMI deployments around the globe. To its credit, IBM has been one of the earliest and loudest proponents of the Smart Grid; the company seems to be well poised to reap the benefits of being a market leader.

5.7.3 Microsoft

As this report went to press, Microsoft announced its entrance into the home energy management market segment, with the launch of MS “Hohm.” Microsoft Hohm will allow consumers to monitor and manage their own energy consumption online. Microsoft Hohm is scheduled for release in July/August 2009. Microsoft’s speedy rollout is a result of the company is focusing on non-smart meter energy data first (and then incorporating smart meter dataas it becomes available). Microsoft has enlisted four utilities – Puget Sound Energy, Seattle City Light, Xcel Energy and the Sacramento Municipal Utility District – to provide customer energy data for the site, and is working on partnerships with about a half-dozen more. Microsoft also has partnerships with smart metering giants Itron and Landis+Gyr to integrate their data.

Analyst Note: Expect Microsoft to challenge Google, Tendril, GridPoint, Greenbox and any other energy management systems, as the company is dedicating substantial resources to compete in this space. One key difference between Google and Microsoft is that Google intends to launch their product through the philanthropic arm of their company, Google.org, while Microsoft is aiming on making Hohm a core part of its business.

FIGURE 38: MICROSOFT’S HOME ENERGY MANAGEMENT SYSTEM

Source: Microsoft

5.7.4 Oracle

Oracle Corporation (Oracle), incorporated in 2005, is an enterprise software company. The company develops, manufactures, markets, distributes and services database and middleware software, as well as applications software that help organizations to manage their businesses. Oracle is organized into two businesses: software and services. These businesses are further divided into five operating segments. Its software business consists of two operating segments, new software licenses, and software license updates and product support. Its services business consists of three operating segments, consulting, On-Demand and education. The company's software business represented 80 percent of its total revenues and its services business represented 20 percent of total revenues for 2008. The company has more than 84,000 employees, was founded in 1977 and is headquartered in Redwood City, Calif.

In the second quarter of 2009, The Company announced the introduction of Oracle's Smart Grid software – an end-to-end software offering including mission-critical applications and back-end technology infrastructure. Oracle promises to offer AMI – Outage management integration, grid optimization, demand response/load analysis, CIS, work and asset management, MDM as well as the integration of renewable energy.

Note: In 2006, Oracle purchased SPL WorldGroup, which makes revenue and operations management software for utilities. In 2007, Oracle bought utility MDM software company Lodestar Corp.

Oracle will be competing against fellow IT and enterprise software giants like IBM, SAP, startups like eMeter and Ecologic Analytics, and smart meter makers like Itron (who provide their own MDM software).

Analyst Note: In May of 2009, Oracle ended the suspense when it announced its ambitions to tackle everything under the Smart Grid sun. Clearly, as a leader in enterprise software, Oracle will have plenty opportunity in an industry that has sorely lagged behind in information technology. As utilities transition their control systems to integrate new applications, Oracle will be seen as a trusted name that can be relied upon to help manage the challenges of systems architecture and integration. Notably, Oracle will be able to provide a variety of middleware solutions, bringing utility legacy systems into the digital age.

While Oracle does maintain business relationships with the majority of the top utilities, IBM currently has a much stronger presence with projects specific to Smart Grid, notably Advanced Metering Infrastructure projects. It will be interesting to see where Oracle begins its attack; while we expect CIS and MDM to be two likely starting points, Oracle is big enough and has the resources to compete wherever it sees fit.

5.8 Additional Industry Players

Here is a list of other companies that are expected to strongly compete in Smart Grid.

COMPANIES:	MARKET SEGMENT:	WEBSITE:
SAP	Advanced Control Systems	http://www.sap.com/
Ambient	AMI Networking	http://www.ambientcorp.com/
Arcadian Networks	AMI Networking	http://www.arcadiannetworks.com/
BPL Global	AMI Networking	http://www.bplglobal.net/eng/index.aspx
CPower	Demand Response	http://www.cpowered.com/
Sequentric	Demand Response	http://www.sequentric.com/
Ziphany	Demand Response	http://www.ziphany.com/
Areva	Grid Optimization	http://www.areva-td.com
Cooper Power Systems	Grid Optimization	http://www.cooperpower.com
Johnson Controls	Grid Optimization	http://www.johnsoncontrols.com/
Microplanet	Grid Optimization	http://www.microplanet.com
Sensortran	Grid Optimization	http://www.sensortran.com
Siemens	Grid Optimization	http://www.siemensenergy.co.uk/
Telvent	Grid Optimization	http://www.telvent.com/sites/telvent/en/
Tollgrade	Grid Optimization	http://www.tollgrade.com/
Agilewaves	HAN	http://www.agilewaves.com/
AlertMe	HAN	http://www.alertme.com/
Energate	HAN	http://www.energateinc.com/
EnergyHub	HAN	http://www.energyhub.net/
4Home	HAN	http://www.4homemedia.com/
Honeywell	HAN	http://www.honeywell.com/
Intel	HAN	http://www.intel.com
Positive Energy	HAN	http://www.positiveenergyusa.com/
Outsmart Power Systems	HAN/Building Area Network	http://outsmartinc.com/
Enernex	System Integration	http://www.enernex.com/
HP	System Integration	http://www.hp.com/
Logica	System Integration	http://www.logica.com/

APPENDIX: ACRONYMS USED IN THIS REPORT

3G: Third-Generation Mobile Phone System

4G: Fourth-Generation Mobile Phone System

AMI: Advanced Metering Infrastructure

AMIS: Advanced Metering Information System

AMR: Automatic Meter Reading

ARRA: American Recovery and Reinvestment Act of 2009

CCP: Critical Peak Pricing

CIS: Customer Information System (Customer Care and Billing Systems)

CTP: Critical Tier Pricing

DMS: Distribution Management Systems

DOE: Department of Energy

DR: Demand Response

DSM: Demand Side Management

EAC: Electricity Advisory Committee

EMS: Energy Management Systems

EPRI: Electric Power Research Institute

FACTS: Flexibile AC Transmission Systems

FAN: Field Area Network

FERC: Federal Regulation and Oversight of Energy

GHG: Greenhouse Gas

GIS: Geographic Information Systems

HEV: Hybrid Electric Vehicle

HAN: Home Area Network

ISO: Independent System Operator

LAN: Local Area Networks

MDM: Meter Data Management

MDMS: Meter Data Management System

NARUC: National Association of Regulatory Utility Commissioners

NETL: National Energy Technology Laboratory

NOC: Network Operations Center

OMS: Outage Management Systems

PHEV: Plug-in Hybrid Electric Vehicles

PLC: Power Line Carrier

PMU: Phasor Measurement Units

PQ: Power Quality

PUCs: Public Utility Commissions

PV: Photovoltaic

RECs: Renewable Energy Credits

RPS: Renewable Portfolio Standards

RF Mesh Networks: Radio Frequency Mesh Networks

RTP: Real-Time Pricing

SCADA: Supervisory Control and Data Acquisition

SOCs: System on Chips

TOU: Time of Use

V2G: Vehicle to Grid

WAN: Wide Area Networks

WiMax: Worlwide Interoperability for Microwave Access