Overview

The smart grid is often touted as a relatively bright spot within what is commonly referred to as ‘clean-tech investing’, which the CIO of CALPERS recently described as "a noble way to lose money." Fervent entrepreneurship, a handful of successful IPOs, and a steady M&A appetite from industrial conglomerates, with big balance sheets and low capital costs, have all introduced dynamism into an otherwise stodgy segment of the economy, namely, the electric utility industry. This report details the investment dynamics in this sector, specific as-yet untapped opportunities, and the relevant activities of a range of interesting companies to watch in this space.

Reliability at the heart of profitability

The electricity grid in the United States is surprisingly unreliable relative to those in other developed countries. In industry vernacular, the system average interruption duration index (SAIDI), i.e. minutes of interruption per year, is more than double that of most developed countries (Figure 1). The Electric Power Research Institute estimates that US utilities directly lose $26bn per year due to outages in the distribution network. The economic losses associated with these outages tally to over $100bn per year. Heavy industry tends to be hit the hardest by minor grid outages. The following anecdote is illustrative of this point: A robotic manufacturing facility owned by Toshiba experienced a 0.4 second outage, which caused each robot to become asynchronous with the grid; thus short-circuiting innumerable chips and circuits. The company spent the next 3 months reprogramming each robot, leading to an estimated economic loss of $500m. Clearly, energy surety can be more highly valued than the price of electricity would suggest - particularly in mission critical operations such as data centers, military campuses, hospitals, prisons, high-value manufacturing and R&D labs. In addition to actual outages, minor fluctuations in power quality (i.e. voltage, and power factor) can also wreak economic havoc. For instance, power quality issues typically lead to bubbles and heterogeneous material concentrations in plastic manufacturing and metallurgy, which can ruin entire product batches, valued in the tens of millions of dollars. As a result, commercial and industrial (C&I) sites, which represent 63% of electricity demand in the US, are often willing to pay for their own custom energy solution. In the past, uninterruptible local generators have made up the bulk of these custom solutions. In the future, self-sustaining microgrids that automatically 'island' from the macro-grid will likely become the solution of choice.

Figure 1: International electricity grid reliability

Source: The Brattle Group, Galvin Power Institute, Council of European Energy Regulators, China Southern Power Grid
To be clear, an average of 244 outage minutes each year implies an uptime of more than 99.95% for the US electricity grid. While this is an impressive feat for a complex system, that covers much of the continent and requires nearly ubiquitous real-time management, this can and should be improved through the widespread incorporation of newly developed information communication technology (ICT) throughout the grid. Furthermore, public utility commissions directly incentivize electric utility distributors to improve reliability metrics through bonus pools or penalty payments. As such, companies providing ICT solutions to utilities through embedded edge-of-network sensor technology, industrial solid-state power electronics and, in the future, microgrids are well aligned with the profit motive of a utility company. The suite of technologies in the electricity sector ICT toolbox is often referred to as the ‘smart grid’ or ‘the internet of things’. However it bears mention that ‘dumb grid’ measures remain particularly effective in much of the world. For instance, the superior reliability metrics observed in Western Europe and Japan (Figure 1) are primarily attributable to the prevalence of underground wire networks in these regions - a practice that obviates storm related outages. Digging up concrete to lay cable typically increases the capital expenditure of a distribution line project by a factor of ten. The economics only work in sufficiently dense electricity consumption centers, i.e. Western Europe, Japan and major metropolitan cities around the world.

Siphoning electrons

In addition to reliability problems, theft remains quite prevalent in the electricity industry, particularly in developing countries such as India and Brazil. However developed economies are not wholly immune to this illegal syphoning of electricity. The FBI estimates the cost of electricity theft at up to $6bn each year in the United States – equivalent to 1.6% of annual electric utility revenue. “Technical losses,” industry jargon describing physics-based inefficiencies throughout the transmission and distribution (T&D) network, cost an additional $20bn per annum in the US. The annual aggregate cost of losses is $26bn in the US, which is equivalent to a 7% loss rate. Annual aggregate losses in the US are trumped only by Brazil, where a 19% loss rate leads to $27bn in annual losses.

Figure 2: The cost of international grid losses

Source: World Bank databank, 2010

Embedding sensors into various segments of the grid provides much needed data to isolate technical and non-technical losses on individual distribution lines, potentially leading to billions of dollars in aggregate cost savings and millions of dollars in savings for any one utility. As the old adage states, business is all about making someone money, or saving someone money. One interesting start-up to watch in this space is Awesense, which sells easily deployable electromagnetic line sensors and a software as a service ("SaaS") solution to triangulate losses in distribution lines for utility clients. Most business models attempting to reduce technical and non-technical losses sell stationary distribution automation kits that require significant utility capital expenditure. Awesense offers a cheaper and more flexible solution that can be moved around the distribution network by utility line-workers.

The ultimate goal of many smart grid companies is increased grid efficiency, which leads to decreased kWh sales for utilities. Oddly, this goal is counter to the profit motive of most utilities around the world. In the US, twenty-six states have implemented regulatory structures that compensate at least one utility in the state for lost revenue accrued in the pursuit of increased efficiency in electricity distribution and use. Such mechanisms are referred to as the ‘decoupling’ of utility revenue and sales. A few Australian utilities, and progressive regulators, have followed suit. European countries have opted for top-down kWh consumption reduction targets. It seems to us that the most promising smart grid business models are those aligned with the profit motive of individual utilities, i.e. improving reliability, eliminating theft, reducing costs, attracting customers and, for most utilities, selling more electrons.

Pushing electrons up a hill

Figure 3: The exponential rise of solar PV

Already burdened by unreliability and theft, the proliferation of distributed energy resources (DERs, see Appendix I for a complete list) at the edges of electricity networks will most likely come to represent the greatest technical challenge ever faced by the modern utility industry. The fundamental architecture of today’s grid, based upon a top down radial transmission and distribution system with unidirectional power flow is simply not built to accommodate significant penetrations of DERs, let alone variable DERs.
European utilities are beginning to face significant reliability problems on the grid due to renewables.

Certain regions within each country will broach PV parity well before the average in each country.

The exponential growth in global photovoltaic capacity is beginning to create reliability issues for electricity grids in Europe. In Germany, the electricity regulator BNA released a report stating that grid congestion caused by renewables integration, at both transmission and distribution tie-ins, forced utilities to call upon interruptible load 197 times in 2011, up from 29 times in 2010. Italy’s largest utility Enel reported that 16% of its medium voltage transformers experienced reverse power flow conditions for more than 1% of the year in 2011. Transformers are simply not designed to handle reverse power flow conditions. At best they will degrade faster under such conditions. At worst they will literally explode.

Bellwether examples like these are forcing utilities and regulators around the world to ‘future-proof’ their own grids before such problems worsen. For context, in the US there is roughly 80GW of combined heat and power (CHP) capacity, 39GW of demand response capacity, 8GW of solar capacity, 100MW of fuel cell capacity and 100MW of battery capacity. Although solar sits in the middle of the DER pack, in terms of installed capacity to date, it is easily the most disruptive due to its exponential growth and unique power quality issues. For nearly forty years module prices have dropped by 24% with every doubling of global production capacity - a cost curve intrinsic to semi-conductor based technologies. It is important to note that while solar module prices have historically declined logarithmically, overall system costs have declined linearly due to stickier installation, ancillary equipment and financing costs. For comparison, wind turbines, fuel cells and batters each decline in price by roughly 14% with every doubling of production capacity. The cost curves for CHP and demand response (more a business model than a specific technology), have effectively flattened. As such, solar is the only distributed energy resource on a steep enough cost curve to give utilities significant cause for concern. The concern is that solar will overwhelm the grid as economic parity is breached in various local markets, presenting a major power systems engineering challenge. Figure 4 illustrates such tipping points by comparing the levelized cost of solar energy as a function of sunshine to the average retail price of electricity in major markets.

Figure 4: Residential PV price parity without subsidy

![Image](image-url)

Source: Saviva Research; EIA, NASA, The United Nations, “Reconsidering the Economics of Solar PV.”

2 Business Council for Sustainable Energy in America 2013 Factbook
ICT to the rescue

Tens of millions of Internet Protocol (IP) addressable ‘smart meters’ have been rolled out around the world and are now being pinged for data on a regular basis. Bloomberg New Energy Finance estimates that global smart grid spending jumped from a trivial amount a decade ago up to $14bn per annum in 2012, and will continue to increase up to $25bn per annum by 2018. Roughly three-fourths of this spending correlates to smart meters. Smart meters have evolved from one-way communication for automated billing applications to two-way communication for consumer analytics and tiered pricing applications. The next phase will be logic-based grid analytics where smart meters interact with other sensors embedded into the electricity network to help diagnose and optimize the utilization of various grid assets. The problem most utilities have is that the first or second generation of smart meters deployed are unsuited for future requirements in communication and controls. Existing proprietary telecommunication infrastructure does not possess the bandwidth or latency characteristics necessary for computationally intensive tasks. Most North American and European utilities decided to build proprietary mesh radiofrequency networks, powerline communication networks and 2G/3G cellular networks on unlicensed airwaves. Increased crowding on unlicensed spectrum is reportedly already causing interference and failed meter reads for utilities. The cost of high-bandwidth, low-latency communication equipment on licensed spectrum, such as 4G LTE or WiMax, or hardwired through fiber-optic cables, is still prohibitively expensive. However 4G LTE is being rapidly deployed around the world. The GSA reported a total of 145 networks deployed in 66 countries by the end of 2012 up from 97 networks one year ago. Consequently, the cost of modems is decreasing, and data-rate costs are decreasing. Economic tipping points for 4G LTE may soon be reached in the utility segment, which would be a boon to the established telecom giants (Verizon, AT&T, Sprint).

<table>
<thead>
<tr>
<th>Smart grid application</th>
<th>Peak data rate / bandwidth</th>
<th>Latency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart meter 15-minute reads</td>
<td>Low - 5-20 Kbps</td>
<td>Very high - 15 minutes</td>
</tr>
<tr>
<td>Fault and outage management</td>
<td>High - 40 Mbps to 1 Gbps</td>
<td>Very low - 10-30 milliseconds</td>
</tr>
<tr>
<td>Distribution Automation</td>
<td>Low/mid - 100 Kbps to 10 Mbps</td>
<td>Low /mid - 10 ms to 1-5 min</td>
</tr>
<tr>
<td>SCADA</td>
<td>High - 1 Mbps to 50 Mbps</td>
<td>Low - 100-200 milliseconds</td>
</tr>
<tr>
<td>Distributed energy resource management software (DERMS)</td>
<td>High - 50 Mbps to 1 Gbps</td>
<td>Very Low - 10-30 milliseconds</td>
</tr>
</tbody>
</table>

EPB Chattanooga of Tennessee was one of the few utilities that chose to future-proof their smart meter investment by installing a complete fiber-optic network along with 1,200 automated low-voltage powerflow switches throughout their distribution network. The utility serves 170,000 customers, and in July 2012, lost power for 10,000 customers during a storm. The automated switches reflexively changed the direction of power flow to customers in the affected area, completely restoring power in minutes. The utility estimates that without the automated switches, and the fiber-optic nervous system, it would have taken up to 10 hours to restore power and they would have lost $1.4m in the process. Despite years of development, and billions of dollars in smart meter roll-outs, concrete cost-saving examples from mature smart grid projects like this are still few and far between, in part because of the limitations in associated communication infrastructure.
Big data meets big energy

Smart meter rollouts, however, may be just the proverbial tip of the iceberg in terms of value creation. The real prize lies in integrated end-to-end ICT applications such as distributed energy resource controls, power quality optimization, theft protection and isolation, peak load management, outage restoration, and predictive asset failure analytics. Given the existing telecommunication infrastructure installed, much of the computationally intensive (high bandwidth) analytics and control applications will be embedded into the network, with computers built into actual devices and then remotely managed as a cloud-based SaaS service. Traditionally reluctant to allow critical data streams outside of internal servers, utilities will likely only export the analytics of data-sets to external servers, as opposed to the actual raw-data-feed, instead relying upon portions of mirrored datasets for particular software applications. Significant opportunity exists for providers of such cloud-based analytics services to large utilities through a SaaS subscription. Additionally, an opportunity exists to provide software system integration services to small and medium sized utilities that purchase a wide range of off-the-shelf software products from different providers. Mature software product offerings include:

1. Supervisory control and data acquisition (SCADA)
2. Outage management systems (OMS)
3. Work force management systems (WFMS)
4. Distribution management systems (DMS)
5. Customer information systems (CIS)
6. Meter data management systems (MDMS)
7. Geographic information systems (GIS)
8. Energy management systems (EMS)

These disparate software components are currently not visually centralized for control centers, nor are they translatable across various utility departments. Additionally, many of these systems use a mix of simple database architectures such as excel, SQL, or Java. Integrating these legacy systems into the
kind of big data architecture used by Facebook, Amazon or Twitter [i.e. Hadoop, Hive and Pig] requires considerable expertise. The vast majority of the 3,000+ utilities in the US lack in-house software development teams or data architecture teams. Thus, there is a wide open opportunity both for startups and IT giants.

The ICT-transformation of the utility industry will likely happen relatively quickly, and may represent the only segment of the smart grid industry with return profiles that match the criteria of traditional venture investors: less capital intensive; leverage in the model from IP ownership and low COGS; and 3-5 year exit opportunities, mostly via acquisition. Greentech Media projects a $10bn opportunity in this ‘soft grid’ by 2020. However, as a caveat emptor, the pace of change in the utility industry is famously glacial. A long sales cycle for big contract wins is the name of the game. To date, the sophistication of grid-related SaaS supply has generally outstripped utility demand for new IT services. Consequently, there is a lot of white noise in this investment space; few clear leaders exist, and many if not most will fail, unable to penetrate this difficult utility customer market.

The term is DERMS

Distributed energy resource management software (DERMS) is notably absent from the list of mature software products. Ample opportunity remains for providers of innovative monitoring and control software solutions to the DERMS problem. To date, generalist distributed energy resource management software does not exist. Instead software solutions have been developed, and code has been written, with a deep and narrow focus on a particular market segment with a specific technology or service in mind. For instance, Akuacom’s AutoADR protocol, which forms the backbone of Honeywell’s automated demand response SaaS offering, allows CSI loads to remotely bid into price-based demand response markets. A start-up named Geli, on the other hand, has developed a platform to manage lithium-ion storage assets integrated into microgrids and buildings. Similarly, Xtreme Power can monitor and control utility-scale storage assets that bid into ancillary service markets. Numerous companies, such as Energate and EnergyHub, can do the same for smart thermostats. Adura Technologies has addressed a niche in the smart lighting space. Electric vehicles have even been thrown into the mix with Nuvee’s fleet charging and vehicle-to-grid regulation bidding software. Although many DERMS or DERMS-like solutions exist, each is proprietary, and tailored to the physical parameters of a particular technology, as well as the economic relationships of that technology application within a specific marketplace.

Critically, there is no unified middleware code that would allow disparate DERMS systems to be re-written into an interoperable format.

The open-source code enabling communications and data acquisition across financial markets may be the closest comparison of what is needed, but currently missing in the electric grid. A company named Red Hat created a business model to help others integrate legacy code and systems into the open-source system architecture that now underpins the financial sector. Red Hat charges customers subscription fees for unlimited access to support, training and integration services, and on that basis, became the first open-source IT company to reach $1bn in annual revenue at the end of 2012. Green Energy Corp is attempting to be the equivalent of Red Hat in smart grid, but has largely failed to date for lack of a community of users. In order to achieve relevance and eventually, profitability and scale, open-source code requires a sizeable community of active consumers and contributors that create a virtuous network effect around the product. The smart grid community has had neither. Very few coders are also familiar with smart building communication protocols like BACnet, smart home communication protocols like Zigbee and SEP 2.0, demand response protocols such as AutoADR, two-way smart meter communication protocols like ANSI C12.18 or power generation communication protocols like IEC 61850. Making matters worse, inexorable standards bodies at both the national and international level have ossified the collective decision-making around the interoperability of smart grid technologies.
Instead, companies attempting to provide turnkey interoperable product suites have been forced to develop their own proprietary solutions. The end-result is a weak value-proposition for consumers.

**Legos for the grid**

Microgrids provide an elegant technological solution to many of the problems previously listed in this report. A microgrid, at its most fundamental, is an electric distribution system containing loads and distributed energy resources downstream of a substation that can be operated while connected to the main power network, or while islanding. From the perspective of a potential buyer, like a commercial campus or the military, the whole purpose of a microgrid is to control one’s energy fate by eliminating utility grid reliability concerns. For instance, the increased frequency of hurricanes on the east coast in the past few years has driven many businesses to seek microgrid-provided, uninterruptible power supply. For grid operators, microgrids enable a ‘building block’ approach to balancing supply and demand. Dispatch algorithms can be developed to coordinate economic relationships between micro and macro grids, thus simplifying control over distributed energy resources. Figure 6 illustrates the highly integrated ICT nature of a modern microgrid while Table 1 details the relevant technologies.

**Figure 6: Illustration of a microgrid**

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Microgrids represent a fully realized ICT transformation of the legacy electricity grid.
Table 1: Microgrid technologies

<table>
<thead>
<tr>
<th>Technology category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispatchable generation</td>
<td>CHP, fuel cells, microturbines with heat exchangers, diesel gensets,</td>
</tr>
<tr>
<td>technologies</td>
<td>utility grid energy purchases</td>
</tr>
<tr>
<td>Intermittent/limited</td>
<td>Wind, solar (PV and thermal), biogas/biomass, hydropower, heat</td>
</tr>
<tr>
<td>generation technologies</td>
<td>pumps (air/ground)</td>
</tr>
<tr>
<td>Demand side technologies</td>
<td>Absorption chillers, absorption refrigeration, natural gas chillers and</td>
</tr>
<tr>
<td></td>
<td>boilers, lighting and office loads, other HVAC loads</td>
</tr>
<tr>
<td>Storage technologies</td>
<td>Batteries, flywheels, super-capacitors, thermal (precooling/preheating</td>
</tr>
<tr>
<td></td>
<td>buildings)</td>
</tr>
<tr>
<td>Control technologies</td>
<td>Demand response, discrete load management, islanding switches,</td>
</tr>
<tr>
<td></td>
<td>smart meters, solid-state power electronics, capacitor banks,</td>
</tr>
<tr>
<td></td>
<td>Volt/VAR injection devices, storage technologies</td>
</tr>
</tbody>
</table>

Many in the utility and energy management industry believe that microgrids are on the cusp of technological and economic tipping points, hence the hype that surrounds them. However the federal government is subsidizing as much as half of the cost of the most advanced microgrid pilot projects (Figure 7). Also, cost-benefit or project return data are essentially nonexistent. The disparity between hype and reality may come down to definitions. Depending upon whom you ask, microgrids can take on many different flavors. The oldest and simplest form of a ‘microgrid’ is a combined heat and power facility with a grid-tie interconnection agreement as well as local thermal and electrical distribution systems. Such facilities prospered after the Public Utility Regulatory Policies Act (PURPA) was passed by congress in 1978, resulting in generous long-term power-purchase agreement contracts between CHP facilities and utilities. Today, institutional, commercial and industrial microgrids are primarily composed of CHP with battery banks and uninterruptable on-site power generation as back-ups.

The next tier of microgrid sophistication branches out to include a diversity of power generation sources embedded within the network (i.e. DERs). Utility-sponsored microgrids designed to service remote regions (such as islands, or indigenous communities in British Columbia), fit this mold. Diesel generators with high fuel and backup battery costs are the most common technology choice in such situations.

The final and most sophisticated tier is a truly ICT-integrated microgrid with a significant penetration of both supply and demand-side DERs that can island from the grid at any time, using automated switching technologies, voltage and reactive power compensation hardware, solid-state power electronics and predictive asset utilization SaaS software. Most of the hardware used by advanced microgrids is not yet produced in bulk, and, as such, remains prohibitively expensive. For instance, islanding switches, which can disconnect an advanced microgrid from the macrogrid within milliseconds, can cost up to $1m per switch for a medium-sized institutional campus.

The vision of a fully autonomous microgrid is primarily being driven by the military, which has at least two strong incentives. First, cutting back on refueling convoys to military encampments directly reduces risk exposure (to the lives of the soldiers’ and equipment used on those convoys). Secondly, concerns of cyber espionage and attack are forcing domestic military bases to decouple from the macro-grid mainframe, with the added benefit of ensuring the lights will stay on in the event of a critical national security moment. Figure 8 illustrates Pike research’s bullish microgrid growth projections, delineated by end-use. We recommend more tempered expectations.
Figure 7: Advanced microgrid development cost sharing

<table>
<thead>
<tr>
<th>Project</th>
<th>Industry Funding</th>
<th>Federal Funding</th>
<th>Other Funding</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santa Rita Jail - California</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Allegheny Power - West Virginia</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>University of Hawaii</td>
<td>8</td>
<td>7</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>University of Nevada</td>
<td></td>
<td>14</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>San Diego Gas and Electric</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>City of Fort Collins, Colorado</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illinois Institute of Technology</td>
<td>5</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>ConEd - New York</td>
<td>6</td>
<td>7</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>ATK Space Systems - Utah</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Source: DOE, LBNL, International Microgrid Assessment: Governance, Incentives and Experience June 2012

Figure 8: Microgrid capacity and growth

Source: Pike Research, extrapolated data presented at the Microgrid Global Forum
The challenge of control

Advanced microgrid controls are not yet fully demonstrated. The complexity of balancing a wide range of supply and demand-side resources; each with its own physical and temporal energy production characteristics, in a miniaturized physical and electrical footprint, is immense. The large scale of utility grids smooths the percentage variability of demand caused by any single consumer’s behavior, historically allowing grid operators to focus entirely on the control of supply.

Today, grid-connected wind generation along with distribution-connected solar PV has stressed this model by introducing variability at both the supply and demand ends of the grid. Additionally, technology and regulatory development has allowed grid operators to control load (i.e. demand) in non-invasive ways, such as pre-cooling buildings, adjusting variable speed drives within heating ventilating and air conditioning systems, and curtailing non-essential loads. Thus the focus of grid operators has begun to shift from controlling supply to controlling both supply and demand. Advanced microgrids represent much greater complexity because as each individual participant becomes a larger percentage of the total load or generation connected to a grid, operators lose the ability to absorb abrupt individual load or generation changes into a larger aggregate load/generation balance (i.e. the grid as it exists today). Furthermore, most microgrid development is almost never a ‘greenfield’ project and involves the integration of a large number of legacy electrical and mechanical systems. At least in part due to these IT and electrical engineering challenges, microgrid software spending is projected to increase nearly 9x in the next six years (Figure 7). To date, microgrid control software has been highly undervalued, underdeveloped, and overlooked, as the goal has been to prove out the prolonged islanding capability of advanced microgrid systems. We contend that software is the secret sauce of a successful microgrid, and will come to enable tremendous economic opportunities within distributed energy resource management.

Figure 9: Microgrid controls software spending

Source: Pike Research Microgrid Global Forum 2013
Looking forward

A few gigawatts of global microgrid deployment combined with a few hundred million dollars of software spending over the next 5 years is small potatoes for the global electricity industry. The reason that this sector is fundamentally exciting is that somewhere within the smart grid/microgrid miasma lies the key to unlocking one of the most intractable development problems on earth – electrifying the developing economies of the world. A distributed hub-like model for electricity infrastructure development, built around anchor tenants, and providing mobile payment-based electricity access may leapfrog the developed world’s centralized grid architecture. It would not be the first time that intensive military research and development introduced transformative technology, creating entire industries. Our May report will dive into this topic by exploring cellphone tower energy management solutions in developing countries. Critical to this vision, as well as the more immediate needs of utilities in developed economies, is monitoring and control software for a wide range of DER assets. The following profiles represent a brief overview of the companies tackling pieces of this opportunity.
Company Profiles

Nexgrid

Description: Nexgrid, formerly Intelagrid, manufacturers self-managing smart grid monitoring and control communication gateways for utilities as well as commercial, industrial and resident customers. The company has three product offerings: network infrastructure, software and intelligent end points. The company’s EcoNet communication gateways allow large amounts of end-point data to be streamed over a single platform via Zigbee and/or Wifi, and then backhauled through a utility’s RF-mesh network.

Size: 30 employees.

Funds raised: $1m in seed financing to date.

Relationship Highlights:
- The company has integrated its ‘ecoOne’ software into General Electric and Sensus smart meters. EcoOne gives utilities, and consumers, visibility into device usage and allows for firmware upgrades to be pushed to meters at the edge of the network.
- The company holds ten undisclosed utility contracts.

Proximetry

Description: Proximetry provides network management and bandwidth optimization for utility data-backhaul telecommunication infrastructure. To date, the company has primarily focused on the deluge of smart meter data being produced, but in the future it could be well positioned to prioritize and manage the backhaul of datasets associated with distributed energy resources.

Size: 100 Employees.

Funds raised: $12.5m through 5 investments to date.

Relationship Highlights:
- Siemens will integrate Proximetry's Airsync network Management System into its North American electric, gas and water grid projects.
- Proximetry will integrate EDX Wireless’s networking design and planning tools into its AirSync network management solution.
- Cisco Systems is collaborating with Proximetry to integrate their respective GridBlocks and AirSync systems.
- CSC and Proximetry are working together to form a smart grid network management cloud service.
- Arcadian networks broadband communication hardware and software will be integrated with Proximetry's Airsync software.

BPL Global

Description: Better Power Lines Global is principally a distribution automation company that focuses on hardware with embedded sensors and integrated enterprise software in the smart grid industry. The company’s Power SG foundation software platform underlies its substation automation and distributed energy resource management solutions. The system acts as a bridge between grid operators (DMS, EMS, OMS) and back-office enterprise software (GIS, CIS, MDMS) providing enhanced intelligence and control of grid resources. Structured debt financing arrangements along with strategic acquisitions have fueled the company’s growth over the past few years.

Size: 145 Employees.

Funds raised: $103.1m through 9 investments to date.

Relationship Highlights:
- September 2011, BPL partnered with the French utility EDF, Saft and Schneider Electric to deploy a smart grid project on the islands of Corsica, Guadeloupe and La reunion.
- Joined the IBM smart grid consortium in 2008.
Doble

**Description:** Doble, which was acquired by ESCO Technologies under the umbrella of Aclara in 2007, is the gold-standard for asset diagnostics. The cloud-based dobleARMS product provides real-time event notification using a suite of analytics tools to manage, integrate, and analyze data with regard to asset health for high value utility assets. Additionally, the company has collected over 25 million prior utility asset performance tests from over 350,000 electrical devices. Such a database and software suite will be highly relevant to the rise of distributed energy resources.

**Size:** Very large.

**Relationship Highlights:**
- Doble have recently teamed up with San Diego Gas and Electric for a condition-based substation maintenance program. SDG&E is at the forefront of asset management diagnostics in the US, and so this contract could be a stepping stone to significant contract wins elsewhere for Doble.
- OSIsoft and Space-time Insight have also joined the SDG&E partnership.
- S&C Electric is also bringing the DobleARMS product to market as one of S&C’s multiple cloud-based utility offerings.

S&C Electric Company

**Description:** S&C Electric Company has been global leader in grid infrastructure design and implementation for most of the past century. Its specialty is designing and manufacturing switching and protection products for the grid. The company has been particularly active in the microgrid space lately. S&C offers a high-speed fault clearing system and an energy storage management system through its IntelliTeam that is highly regarded in the industry. The company has also been making a push into renewable energy management with its line of distributed static volt/VAR compensators and community energy storage offerings.

**Size:** 1,900 employees.

**Relationship Highlights:**
- Recently teamed up with Doble to provide cutting edge transformer monitoring and predictive asset failure software solutions.
- Recently won a contract with Southern California Edison contract for a 1MW smart grid SMS storage system.
- AEP also awarded S&C with its smart grid community energy storage gridSMART Ohio project.
- Won the largest automated switching contract to date with EPB of Chattanooga.

Alstom

**Description:** Alstom Grid, an offshoot of the French Alstom Group, provides integrated products across the smart grid value chain. Of interest to this report is the company’s DERMS pilot project with Duke Energy, a smart grid demonstration project with Maui Electric, and a second DERMs pilot project with EDF in Nice, France. These projects are incorporating large quantities of distributed energy resources, and as such, provide Alstom with unique test beds to be a global leader in DERMS. The acquisition of UISOL and Psymetrix in 2011 provided the company with a world-class wide area measurement system and demand response management system platform that may both be relevant for future microgrid projects.

**Size:** 20,000 employees.

**Relationship Highlights:**
- Purchased UISOL and Psymetric in 2011.
- Won multiple DOE smart grid demonstration project awards to lead Maui Electric and Duke Energy’s smart grid pilots.
- Recently announced an MOU with Toshiba for technology transfer and international project development.
Tollgrade Communications

**Description**: Tollgrade Communications Inc provides asset monitoring hardware and software products for the utility and telecommunication industries in North America and in International Markets. The company’s LightHouse Sensor Management software provides a cloud-based visualization, analytics and management platform that is open for integration with utility SCADA, OMS and DMS systems. Founded in 1988, the company has drifted financially over the last decade. After five years of significant negative net income, the company was turned around into profitability by the private equity firm **Golden Gate Capital**.

**Size**: 100 Employees.

**Funds raised**: Golden Gate Capital acquired Tollgrade for $127m in February 2011.

**Relationship Highlights**:
- Formed a partnership with Sprint in May 2012 to offer hardware, communication and data transmission packages.
- Has held a strong partnership with **Ambient Corporation** as an integrator of smart grid platforms since March 2010.
- Tollgrade claims to have 12 utility clients in North America, plus contract wins in Europe and South America.

Toshiba

**Description**: Toshiba has made big moves into the smart grid/smart home space over the past few years. The multi-billion dollar acquisitions of **Landis+Gyr** and **Ecologic Analytics** put the company in good standing as a global smart meter and meter data management provider. However it is the company’s leadership position within the 600 member Japan Smart Community Alliance along with the recent $33m rollout of EV charging stations, PVs, storage, building energy management systems, home area networks and community battery management systems that most strongly points toward a vertical integration strategy. Of particular interest to this report is Toshiba’s microgrid software that integrates solar and lithium ion battery technologies into building energy management systems.

**Size**: 210,000 employees.

**Relationship Highlights**:
- Leads the 600 member Japan Smart Grid Community Alliance.
- Recently signed an MOU with **Alstom Grid** that will likely lead to greater international cooperation between the two smart grid industrial goliaths.

Varentec

**Description**: Varentec is developing solid-state power electronics for industrial applications. Solid state transformers allow the manipulation of electrical waveforms, harmonics, transients, voltage and reactive power – which may be necessary for the ultimate success of microgrids. Additionally Varentec’s grid router (ENGO-W) is being designed to route fractional amounts of power on transmission and distribution grids, which would enable bi-directional power flows with variable power sources in microgrid applications. Fundamentally, however, the most direct route to market for Varentec is to sell volt/VAR support kit to utilities.

**Size**: 30 Employees.

**Funds raised**: $7.7m Series A led by Khosla ventures.

**Relationship Highlights**:
- Recipient of $5m ARPA-E grant.
- Varentec’s ENGO-V10 volt/VAR compensator is being piloted in the field with multiple undisclosed utility clients.
## Power Analytics

**Description:** Power Analytics has developed a smart grid software platform that monitors and manages onsite power generation. The technology has primarily been used by data centers, manufacturing plants, nuclear power plants and oil platforms. The software suite, called Paladin SmartGrid, aims to optimize energy consumption among multiple sources, including utility power and renewable on-site generation. Optimization parameters can be toggled according to a user’s preferences, focusing on minimizing cost, carbon footprint, utility generated power or other parameters. The platform monitors the power quality and capacity of the microgrid in real time to evaluate the possibility of feeding excess energy into the smart grid. It also monitors all transactions between the public and microgrid infrastructures, and maintains the rate and pricing information for management of private-public exchange.

**Size:** 34 Employees.

**Funds raised:** Undisclosed.

**Relationship Highlights:**
- ABB, Alstom and Siemens as well as Ontario Hydro, Detroit Edison, New York State Electric and Gas are designed 'select customer's by Power analytics.
- Recipient of $5m ARPA-E grant.
- Varentec’s ENGO-V10 volt/VAR compensator is being piloted in the field with multiple undisclosed utility clients.

## Space Time Insight

**Description:** Space Time Insight provides situational awareness solutions for critical infrastructure, such as utilities, telecommunications and transportation. Using analytics and geospatial software, the company can churn vast quantities of data into actionable visualization tools. The company is currently providing utilities and independent system operators with visualization tools to improve asset utilization, detect grid disturbances, to better manage demand response resources and outages and to detect grid disturbances and outages. The company has not yet focused on distributed energy resources, but it is well-positioned to do just that as a service for utilities or microgrid operators.

**Size:** 125 Employees.

**Funds raised:** $16m total through a series B round.

**Relationship Highlights:**
- Key customers include Florida Power & Light, SDG&E, SCE, California ISO, Cisco Systems.
- Key partnerships include Accenture, Cisco, SAP, Oracle, and IBM.
- Key investors include Enertech Capital and Opus Capital Ventures.

## Green Energy Corp

**Description:** Green Energy Corp provides open-source software engineering services to utilities with the goal of replacing legacy systems with open-source solutions. The company’s flagship product, the open-source GreenBus platform, uses cloud computing to support legacy and greenfield energy system interoperability.

**Size:** 5 Employees.

**Funds raised:** $2m through the state of Colorado.

**Relationship Highlights:**
- The company merged with Magpie TI, a software-engineering service provider in February 2010.
- Duke Energy, Florida Power and light and The Piedmont Electric Membership Corp subscribed to the GreenBus service.
## Appendix I: List of distributed energy resources

<table>
<thead>
<tr>
<th>Supply type</th>
<th>Description</th>
<th>Financial Value</th>
<th>Operational Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninterruptible Power Supply</td>
<td>Intermittent generation to avoid power interruptions associated with grid outages.</td>
<td>Avoid financial losses associated with power interruption.</td>
<td>Significant increase in reliability.</td>
</tr>
<tr>
<td>Combined heat and power (CHP)</td>
<td>Base load generation AND thermal.</td>
<td>Offset electrical use, thermal use and demand charges through more efficient use of fuel’s energy.</td>
<td>Significant increase in reliability.</td>
</tr>
<tr>
<td>Fuel cells</td>
<td>Base load generation.</td>
<td>Offset electrical use, thermal use and demand charges.</td>
<td>Significant increase in reliability.</td>
</tr>
<tr>
<td>Solar</td>
<td>Intermittent Generation (during daytime).</td>
<td>Offset demand charges during the day and electrical use, SRECs.</td>
<td>Decreases system reliability and introduces power quality issues.</td>
</tr>
<tr>
<td>Batteries</td>
<td>Firm generation, can be stationary or mobile (electric vehicles).</td>
<td>Reduce demand charges, subsidies.</td>
<td>Significant increase in reliability.</td>
</tr>
<tr>
<td>Geothermal or biomass</td>
<td>Base load electricity generation AND thermal applications.</td>
<td>Offset electricity use, thermal power demands and RECs.</td>
<td>Significant increase in reliability.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demand type</th>
<th>Description</th>
<th>Financial Value</th>
<th>Operational Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load shedding: capacity program</td>
<td>Offerings in reduction in capacity when called.</td>
<td>Payment based on capacity qualified: represent the bulk of demand response markets to date.</td>
<td>Must reduce capacity when called.</td>
</tr>
<tr>
<td>Load shedding: Emergency Interruptible programs (EI)</td>
<td>Offering to reduce load during grid emergencies.</td>
<td>Payment based on capacity and energy reduced.</td>
<td>Limited since only called when there is a grid emergency.</td>
</tr>
<tr>
<td>Ancillary service markets</td>
<td>Offering energy and capacity into the ancillary service markets.</td>
<td>Significantly higher than capacity or EI programs per unit of curtailment.</td>
<td>Requires near real time bidding and curtailments.</td>
</tr>
<tr>
<td>Load shifting (e.g. precooling)</td>
<td>Precooling or the ability to shift the load to a non-peak time.</td>
<td>Reduced demand charge, and no fixed price program.</td>
<td>Infringing upon the comfort of building tenants.</td>
</tr>
<tr>
<td>Load into supply market</td>
<td>Offering ‘negawatts’ into wholesale energy market.</td>
<td>Greatest theoretical value, but no enabling regulatory framework yet implemented.</td>
<td>Lack of appropriate DERMS solutions.</td>
</tr>
</tbody>
</table>
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