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State of the Smart Grid Briefing

A Service from Modern Grid Academy

We are very excited to release our seventh quarterly newsletter and our last one for 2014 (a little late this time). We have three articles again. Article 1 is on a very important topic – Internet of Things. Article 2 is on Energy storage and its disruptive capabilities. It is an excerpt from a blog that I regularly contribute to. The third article is about modeling key items such as generation, transmission and distribution in today's every changing world.

Don't miss the last segment which also includes information on our successes and other activities.

Sincerely yours
Mani Vadari, Modern Grid Solutions

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1. Key Highlights

US power sector needs \$2.1 T in investments

The International Energy Agency (IEA) sees need for significant investment in electricity sector. Their report highlighted a number of strategic initiatives that can guide the US economy away from its reliance on fossil fuels and towards greater sustainability. The IEA believes that in many aspects there have been significant improvements and the country is well placed to continue to deliver a reliable, affordable and environmentally sustainable energy system.

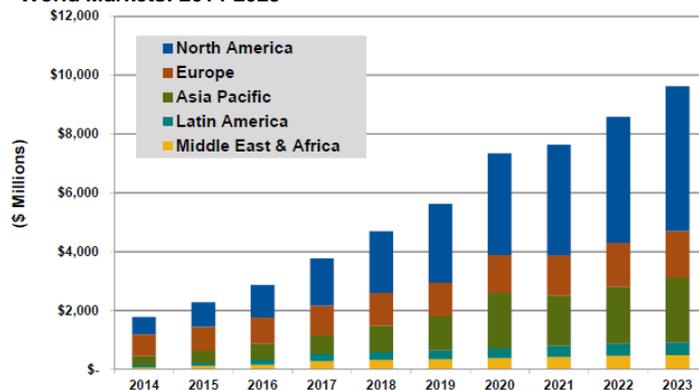
According to the IEA report, the US power sector will require \$2.1 trillion of new investments between 2014 and 2035. This cumulative investment includes 579 GW of new generating capacity, 260,000 km of new transmission lines, 1.3 million km of new distribution lines and extensive refurbishment of both the transmission and distribution networks.

Global Microgrid investment to exceed \$155 B

According to Navigant, microgrids have become a growing phenomenon in the global energy sector in the last few years. This is primarily due to their ability to isolate from the wider electricity grid during power outages, as well as a high capacity to integrate

renewable, distributed energy resources. Demand for the technologies that underlie microgrids is expected to grow rapidly over the next several years. Worldwide investment in microgrid enabling technologies is expected to total more than \$155 billion from 2014 through 2023.

Total Annual Distributed Generation Vendor Revenue by Region, World Markets: 2014-2023



Source: Navigant

CA sub-hourly wholesale market opens

On Nov 1, CAISO began financially binding operations for balancing sub-hourly electricity supply and demand for PacifiCorp's electric service areas in the western US through an energy imbalance market (EIM). By adding its generation resources to the resource pool of the CAISO to meet sub-hourly electricity imbalances, PacifiCorp anticipates enhanced reliability and cost savings, particularly in the face of higher levels of renewable energy generation in the West. This is the first time that CAISO is dispatching electricity for regions lying outside of its footprint. PacifiCorp hopes to see cost savings from the market's usage of lowest-cost generators dispatched more frequently and the market's ability to draw from the much larger pool of generation resources available across the CAISO footprint. PacifiCorp will retain all of its normal grid reliability and transmission service responsibilities after joining the imbalance market.

2. IoT analytics powering an evolving smart energy grid

A growing interconnectedness of the Internet of Things and data analytics is delivering new levels of efficiency, optimization, and services for the smart grid. Recently, Accenture estimated that each smart meter has the potential to generate \$40 to \$70 per meter in

annual savings via IoT-enabled analytics. Multiply that by a utility that has millions of customers and the potential savings are enormous.

From a consumer perspective, if homeowners and businesses were to take advantage of smart grid efficiencies, energy use in the United States could be reduced by 12-22 percent, which equates to tens or hundreds of billions of dollars in savings.

In order to be effective, it is important that utilities and energy service providers have skilled information workers, including data scientists, who understand the IoT and can extract valuable insights in four key areas.

- **Meter Data**—moving from one reading per customer, per month, to multiple readings per set of customers, every 15 minutes or more.
- **Operations Data**—sending substation and field automation data to the central location every 2 seconds; with Phasor Measurement Unit data coming in 30-60 times a second.
- **Asset Data**—Between asset maintenance reports, newer asset health monitors, and the increased focus on online condition monitoring, increased data is being brought into the utility on the health of the assets.
- **Customer Data**—In addition to meter data, numerous utilities are working on energy efficiency and demand response programs, time-of-use rates, and other customer related programs. All of this is bringing in new forms of data.

As the smart grid quickly takes shape, it's becoming very clear that new data sources, stemming from the emergence of the IoT, offer new opportunities for energy service professionals within utilities and beyond.

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Storage soln. enhances rooftop PV in Australia

The Australian Renewable Energy Agency (ARENA) announced \$445,000 funding for Reposit Power to trial an on-grid solar photovoltaic (PV) energy storage and trading system. According to ARENA CEO Ivor Frischknecht, the new technology would allow consumers to gain more value from their rooftop solar PV installations. One in five Australian households now uses solar power. Reposit's GridCredits system can control and store solar energy. This gives consumers access to their own power overnight and at peak times, reducing their demand on the grid. It also allows energy to be sold back into the grid by placing bids into the market, turning residential properties into micro power plants. The \$930,000 project is scheduled for completion in July 2015.

Flow batteries to create \$190 MM market

Large-scale stationary energy is key to a smarter power grid and integration of intermittent renewables. Redox flow batteries are touted as an emerging option, but have been too expensive. According to Lux Research, falling costs are expected to carve out a 360 MWh market in 2020, worth \$190M. Within the stationary energy storage market, four flow-battery chemistries, led by vanadium-based systems, are gaining commercial traction. The vanadium redox flow battery (VRFB) is the most mature technology, and accounts for 75 MWh of deployed systems.

3. Mergers & Acquisitions

Sierra Wireless acquires Maingate

Sierra Wireless has entered into an agreement to acquire Maingate for \$90 million in cash. Sierra Wireless will acquire all the outstanding shares of Maingate, and retain the company's M2M business which includes wireless connectivity services for M2M. Maingate's current shareholders will retain the Enterprise Solutions business, which provides real-time data management tailored for energy services. The acquisition of Maingate is a strong strategic fit for Sierra Wireless, helping to accelerate its device-to-cloud mission with the addition of leading-edge wireless M2M connectivity and managed services.

EnerNOC acquires Pulse Energy

EnerNOC Inc., has acquired Pulse Energy to help utilities better engage all of their commercial and industrial customers, from small businesses to the largest enterprises. Pulse Energy's software enables utilities to deliver targeted energy saving recommendations in a branded environment, catered to each customer's unique profile, including business type, location, and energy use. The integration of EnerNOC and Pulse gives utilities a single platform to deliver unparalleled value to their entire commercial and industrial customer base.

A123 sells battery manufacturing assets

A123 Systems completed the sale of its facilities for the production of certain battery materials to Johnson Matthey, a world-class manufacturer of specialty chemicals. The facilities in Changzhou, China produce lithium iron phosphate (LFP), the cathode material that A123 has historically used across its product portfolio and the companies have entered into a long term supply agreement where Johnson Matthey will supply all of A123's LFP requirements. The deal strengthens Johnson Matthey's position in the battery technologies sector through the production and commercialization of advanced battery materials. It will also support Johnson Matthey's product development programs, working with A123 and other materials customers to provide the next generations of materials.

4. Energy storage help or hurt utilities?

Energy storage is that disruptive technology that many of us power system engineers have been waiting for our entire professional lives. It comes in many different forms with electro-chemical being one of the most common ones. It has the ability to be both a consumer and a generator.

- It is a consumer when it takes on electricity to charge up
- It is a generator when it discharges electricity back into the grid.

There is no other device with a capability such as this in the power system arena.

Why is this important?

Consumption of electricity follows a profile during the day with a couple of peaks and valleys. This type of consumption pattern forces utilities across the world to commit their generating units based on a cost/location profile. To support this, some generators deliver power for only a few hours a day leading to a very inefficient use of their capacity. As a result, the overall cost of power supply goes up to cover the fixed and operating costs of these peaking plants.

Where is the value in energy storage?

Energy storage can deliver value in several different ways:

- Consume energy when prices are low and then deliver energy when prices are high or there is congestion in the grid.
- Can be placed in locations close to consumption and also support either at transmission and/or distribution level.

The value, as a result, comes from the ability of the storage device to smooth out the load profile, thereby allowing (1) better use of the full capacity from all forms of generators and (2) being able to make a fuller use of supply from renewable sources of energy by allowing them to deliver generation when they are capable.

What is holding us back?

The main aspect holding us back from going all out with energy storage is cost. As costs come down, it is reasonable to expect that storage will play a major role in utility grid design and also allow the utility grid to accept more supply from renewable sources.

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ONEnergy Inc. acquires AVACOS

ONEnergy Inc. continues expansion into energy efficiency services, through the acquisition of assets of AVACOS Clean Energy for \$1.73 million. Through this acquisition, ONEnergy expands Sunwave's ability to offer customers a suite of clean energy products and services; and secures additional product supply agreements

SGCC to spend \$65 B on grid modernization

State Grid Corp. of China will spend about 400 billion yuan (\$65 billion) this year on its electricity networks as the nation, seeks to curtail fossil fuels, cope with an unprecedented influx of clean energy and higher demand. The spending throws a spotlight on China's challenge to get electricity from where it's generated to where it's needed. The International Energy Agency estimates China will need to spend more than \$4 trillion from now until 2040 to overhaul the way it transmits and distributes electricity. China's annual energy consumption surged 51 percent from 2008 to 2013 and is expected to peak between 2035 and 2040. China is expected to see a larger scale of clean energy development between 2020 and 2030 as the proportion of coal power in its electricity mix falls and energy demand grows.

5. The World has changed

Modeling Investment in Generation and the Grid Post 2015

Utilities have modeled their asset investments for decades, but the model complexity necessary to accurately evaluate alternatives today has exploded. If the investments is in generation, transmission, or even distribution, the factors requiring consideration range from predicting future fuel prices to penetration and impact of distributed energy resources, all of which increase the volatility of modeling investment alternatives. How will the industry consider these new variables in the comparison of increasing generation or managing peak load and the coupled grid enhancements requirements?

The answer lies in employing expanded domain knowledge, both breadth and depth, in the model design. The model must reflect realistic impacts from foreseen trends, such as electric vehicles, rooftop solar, and microgrids, but also modeling of the

uncertainties, such as storage. Another expansion of modelling scope is consideration of wholesale and retail market evolution and their impact on potential energy supply, delivery, and revenue.

Even with robust models that embracing future complexity, environments that solve the models reliably and rapidly remain challenging. Increases in variables and uncertainties expands the requirements of traditional Integrated Resource Planning software to increase the number of "draws" or iterations to be statistically valid. Further, as the model complexity grows, these software applications, which already require days to execute, will run for weeks. Each application run must be set up perfectly at launch or that days of execution are lost. More innovative hybrid solutions focused on mathematical optimization but utilizing stochastic capabilities may offer a mechanism deliver evaluations sooner and better. Our industry needs to compare alternatives to achieve the best, low cost, and most sustainable, deliver of electricity to support our digital society.

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6. Smart Grid venture capital funding

VC funding for smart grid companies came in at \$142 million in 26 deals in Q3 2014. Twelve Smart Grid Communication technology companies raised \$104 M and two Data Analytics companies raised \$12 M. One Security company raised \$10 million, while three Smart Charging (for PHEV) and Vehicle to Grid (V2G) companies raised \$8 million. Three Demand Response companies raised \$6 million and three Distributed Generation and Integration companies brought in \$2 million.

Top 5 VC Deals in Q3 2014

Company	\$M	Investors
Savant	90	Kohlberg Kravis Roberts
ThetaRay	10	General Electric, Jerusalem Venture Partners, Poalim Capital Markets
Verdigris	7.7	Undisclosed
Origami Energy	5.7	Octopus Investments, Cambridge Innovation Capital
Chargemaster	5.1	Beringea

Source: Mercom Capital Group, LLC

GridWise Alliance - 2014 grid modernization index

The GridWise® Alliance and the Smart Grid Policy Center, released the 2014 Grid Modernization Index (GMI). The GMI evaluates and ranks states based on their progress in modernizing their electric systems with smart grid technologies. The GMI applies a clearly defined set of criteria to evaluate the progress of state grid modernization efforts in three key areas: policy, customer engagement and grid operations. California and Texas tied for the highest overall score, with Illinois, Pennsylvania, Maryland, Delaware, Nevada, the District of Columbia, Arizona, and Virginia rounding out the top ten. Some key findings include:

- States that received federal Smart Grid Investment Grants have higher GMI scores, with the impacts reflected most substantially in the Grid Operations component.
- States with 50 percent or higher penetration of Advanced Metering Infrastructure (AMI) demonstrate higher average

scores in all three scoring categories.

- States with Mandatory RPS Goals have strong positive statistical correlations in the three component scores. States with voluntary or no RPS Goals do not show this same correlation.

Industry's vision of US electric grid in 2030

DOE's Office of Electricity Delivery and Energy Reliability (OE) and GridWise Alliance (GWA) partnered to facilitate a series of multi-stakeholder regional workshops and a National Summit entitled "Future of the Grid: Evolving to Meet America's Needs". A report released with the findings offers key recommendations for the industry. Some of the key elements of the vision include:

- Utility business models will continue to evolve. Consumers and third parties will play an increasingly significant role. Transmission and distribution utilities, in many instances, may

shift from being only commodity providers to being customized consumer services providers.

- Regulatory models will evolve. As non-regulated distributed generation and other Distributed Energy Resources (DERs) become more prevalent, the process for planning for regulated assets (i.e., central generation and transmission and distribution infrastructure) will become more challenging.
- Microgrids will play a role in the future grid and will either operate in parallel or in island mode as needed.
- Distributed grid intelligence will expand.
- Advanced analytics that leverage exponential growth in data will play a critical role.
- There will be a retail market for services.

7. News from Modern Grid Solutions

Electric System Operations – Evolving to the Modern Grid

Dr. Vadari's book "[Electric System Operations – Evolving to the Modern Grid](#)" continues to be received well in the industry. Buy them soon at Amazon.com and other leading retailers. In addition – it is now being used at several universities as course materials

- SUNY Buffalo – Regular course – combined of undergraduate and graduate course
- University of Wisconsin-Madison. Summer course
- Lehigh University, Pennsylvania
- Other universities are actively looking at it for future courses.

Training news

- More online 1-hr courses now available. For a full list, check out <http://www.moderngridsolutions.com/smart-grid-training/smart-grid-online-training-courses.html>.
- [Modern Grid Solutions](#) in collaboration with [The Glarus Group](#) delivered an extensive 3-day course on Power System Fundamentals and Modeling under the auspices of [Clarion Training](#).

Events and News

- Dr. Vadari presented at the IEEE 2014 International Test Conference in Seattle held in October. The topic of his presentation was "Dynamic Microgrids – A Potential Solution for Enhanced Resiliency in Distribution Systems"
- Dr. Vadari presented at the Next Generation Grid Data Architecture and Control a conference hosted by the CURENT center at the University of Tennessee in November. The topic of his presentation was "Managing DER as a Portfolio"
- Dr. Vadari is now a regular contributor to the IdeaXchange blogs managed by Transmission & Distribution World. Check out the latest one at the [T&D World](#) site.
- Dr. Vadari is now a regular contributor to the Intel energy series blog also. Check out the latest one at the [Intel site](#).
- Dr. Vadari will be at Distributech 2014 in the first quarter of 2015. We hope to see you all there.

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At Modern Grid Solutions, *Smart Grids are Business as Usual*

We deliver differentiated services to utilities and their vendors focusing on Smart Grid and System Operations. Our team brings deep expertise in all aspects covering technology and management consulting.