MEMORANDUM

TO: Docket Control Center

FROM: Steven M. Olea
Director
Utilities Division

DATE: December 19, 2014

RE: STAFF REPORT - IN THE MATTER OF THE COMMISSION'S INQUIRY INTO POTENTIAL IMPACTS TO THE CURRENT UTILITY MODEL RESULTING FROM INNOVATION AND TECHNOLOGICAL DEVELOPEMENTS IN GENERATION AND DELIVERY OF ENERGY (DOCKET NO. E-00000J-13-0375)

Attached is the Staff Report for the Innovation and Technological Development Docket. Staff believes there is an ongoing need to stay abreast of new technology. Staff recommends the Commission identify a venue, such as the Commission's Integrated Resource Planning process, where the Commission can be apprised of emerging technology.

SMO:EAH:vsc

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Docket No. E-00000J-13-0375

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STAFF REPORT
UTILITIES DIVISION
ARIZONA CORPORATION COMMISSION

INNOVATION AND TECHNOLOGICAL DEVELOPMENT
DOCKET NO. E-00000J-13-0375

IN THE MATTER OF THE COMMISSION'S INQUIRY INTO POTENTIAL IMPACTS TO THE CURRENT UTILITY MODEL RESULTING FROM INNOVATION AND TECHNOLOGICAL DEVELOPEMENTS IN GENERATION AND DELIVERY OF ENERGY.

DECEMBER 19, 2014

STAFF ACKNOWLEDGMENT

The Staff Report for Innovation and Technological Development, Docket No.E-00000J-13-0375, was the responsibility of the Staff member listed below. Eric Hill was responsible for preparing this report.

Eric A. Hill, Esq.
Executive Consultant

EXECUTIVE SUMMARY
INNOVATION AND TECHNOLOGICAL DEVELOPMENT
DOCKET NO. E-00000J-13-0375

In November of 2013, the Arizona Corporation Commission ("ACC" or "Commission") opened its Innovation and Technological Development docket. This docket was opened to provide a forum for discussing the impacts emerging technologies will have on the electric utility industry, and to help the Commission recognize regulatory issues that will arise as technology evolves. Technological developments that could potentially disrupt the traditional utility business model were of particular interest. The ACC conducted six workshops, and invited a broad range of industry experts and professionals to speak about six key topics.

Speakers provided detailed information on each of those topics and shared different perspectives, both on how technological development will occur, and how the regulatory environment might change to accommodate new developments. Summaries of each presentation made during the workshop series are attached to this report as Appendix A. During these workshops the Commission identified several common issues that it believes will need to be addressed in the future. This report details those issues, and includes possible regulatory actions.

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APPENDIX

I. INTERCONNECTION RULES

Distributed generation ("DG") was discussed at length during the workshop series, and most of these technologies require a grid connection. Presenters who discussed microgrids, battery storage, residential solar, and Combined Heat and Power ("CHP") systems all expressed concerns about the rules associated with grid interconnection. Presenters believed that interconnection rules should be consistent between all utilities, and that the rules should ease the adoption of DG. Presenters also suggested this issue will become more critical as DG growth continues.

The Arizona Corporation Commission ("ACC" or "Commission") has previously taken steps to establish statewide interconnection rules. In 2007, the ACC began the rulemaking process to create interconnection rules, although the rules were never finalized. The Commission held multiple workshops on the topic of DG interconnection, and workshop participants developed an Interconnection Document. The Interconnection Document includes proposed processes and procedures for standardizing the interconnection of DG facilities of 10 MW or less.

Commission Staff ("Staff") filed a Staff Report on Interconnection that included its proposed version of the Interconnection Document in Docket No. E-00000A-99-0431. There were portions of the document where the participants could not achieve consensus. In those instances, the Staff Report adopted a recommendation from among the competing positions and made other changes as described in the Staff Report. The Staff Report also included descriptions of each section in the Interconnection Document as well as respective participant positions on controversial issues. The Interconnection Document was included in Decision No. 69674.

Today, the Interconnection Document serves as a guideline for interconnection requirements, and it is as far as the Commission has progressed toward developing statewide rules. The Interconnection Document could be converted into rules. It will likely need to be updated prior to conversion to reflect changes and updates to safety standards, technical protocols, and technological advancements that have occurred subsequent to 2007. This update would need to include interconnection policies for not only traditional DG, but microgrids and battery storage systems as well. Alternatively, in its August 8, 2014 letter, the Southwest Energy Efficiency Project ("SWEEP") suggested that the Commission consider adoption of the model interconnection standards developed by the Interstate Renewable Energy Council ("IREC").

II. MICROGRID GROWTH

The term microgrid is sometimes used to label the grid connection infrastructure surrounding a DG or combined heat and power ("CHP") system, but a true microgrid, as defined by the US Department of Energy, is "a group of interconnected loads and distributed energy sources with clearly defined electrical boundaries that act as a single controllable entity with respect to the grid and can connect and disconnect from the grid and enable it to operate in both grid connected or island mode."

Typically these systems are expensive, and consumers are willing to pay a premium for the insurance they provide when operating in "island" mode. Currently, this ability to connect and

disconnect from the grid, thereby ensuring a customer's operational continuity, is the primary reason for establishing a microgrid. Arizona is not currently a top-tier microgrid market today because the major drivers for microgrid growth, such as supply shortages and weather-related disruptions, are not common in the state.

In the future, microgrids could see faster growth in Arizona. Transmission and distribution savings are a reason for utilities to utilize microgrids. One presenter from Navigant Consulting reported that distributed renewables integration and premium reliability for key utility customers are the primary drivers for microgrids in Arizona. The International District Energy Association ("IDEA"), (a trade association representing microgrid developers) believes that this growth can be accelerated with improved regulatory policy. Specifically, IDEA would like to see microgrids and their services accurately defined by state regulators, and have the benefits of microgrids incorporated into reliability planning.

To accomplish this, the Commission could include microgrid development reporting in its Integrated Resource Planning ("IRP") process. In addition, it is likely microgrids will require either unique interconnection rules, or the existing Interconnection Document will need to be updated to include microgrid requirements prior to final rule conversion. Alternatively, the Commission could adopt model interconnection rules which include microgrid requirements.

III. AMI DATA EXPANSION

AMI, or Advanced Metering Infrastructure, permits two-way communication between the utility and the meter. Two-way communication enables advanced capabilities that are essential for the development of the smart grid. These capabilities include time-based rates, remote connection and disconnection, demand response ("DR"), and home automation. AMI meters also provide tamper detection and outage notification to the utility. It is a technology that can be upgraded and is expected to be viable over a twenty year lifetime.

In Arizona, Arizona Public Service Company ("APS") is the largest utility deploying AMI. Nationally, smart meter deployment is growing and is anticipated to have 70% market penetration by 2020. AMI is a mature technology and is now widely adopted by both public and investor-owned utilities. Remote meter reading and demand response created the business case for smart meters initially, but more recently, advanced applications such as voltage and outage management and distribution automation have driven smart meter growth. For consumers, AMI enables behavioral demand response, dynamic pricing, and informed rate design.

Today, many behavioral DR programs rely on multiple channels to communicate with customers around peak times. AMI permits customer engagement with communication based on devices in the customer's home. Typically, the thermostat is that device. Should the customer opt in to a DR program, the thermostat can interface with the utility and signal the consumer to reduce load. Thermostats with fully automated DR capability have recently come to market. AMI also permits dynamic pricing, which is similar to DR. Customers who opt in to a dynamic pricing plan are periodically sent price signals to encourage them to reduce consumption during peak hours when demand is highest and electricity is most expensive.

The continued growth of AMI and the wide range of functions and programs it enables are expected to create a massive influx of data for utilities. Data analytics, management, and security are serious concerns that utilities will need to address. Industry surveys suggest that firms capable of handling AMI data are growing in a fragmented fashion, and that market consolidation among these firms is likely to happen in the near future.

It would be helpful for the Commission to have a more complete understanding of how AMI data are currently managed, and how Arizona utilities plan to manage it in the future. The AMI analytics market is still early in its development, so these plans will understandably change in the future. Data security may be a particular concern, especially considering present consumer attitudes regarding the AMI and AMR meter devices themselves.

The Commission is currently considering data privacy rules that pertain to AMI technologies in Docket No. RU-00000A-14-0014. These rules will address privacy and customer confidentiality issues, but AMI data management appears likely to undergo major changes in coming years. Therefore, AMI applications and data management reporting could be included in the IRP process.

IV. DISTRIBUTION VOLTAGE OPTIMIZATION

According to the U.S. Department of Energy, about 90% of homes and businesses in the United States receive more voltage than they need, which wastes energy. In the past, utilities have used high voltage due to a lack of voltage measurement capability at the meter, and to avoid customer complaints about low voltages. Today, AMI provides voltage measurement data, and is a less expensive communication link with the utility than was available in the past.

Waste associated with high voltage can be addressed with Conservation Voltage Reduction ("CVR"). National studies suggest a 1% energy reduction may be created by reducing voltage by 1%. CVR is achieved by monitoring feeder voltages and using capacitor banks and load tap changers to adaptively reduce voltages on each feeder at a substation. Traditional CVR involves manually lowered voltages at substations, but adaptive, dynamic CVR allows voltages on every feeder to be changed with load, resulting in greater energy savings. Pacific Northwest National Laboratory estimates that if CVR were to be implemented on every feeder in the United States, annual energy consumption would be reduced by 3.04%.

Several presenters emphasized the importance of updating the distribution grid, and voltage optimization is a key part of that process. Tucson Electric Power ("TEP") is currently evaluating distribution voltage optimization as part of its Volt/Var pilot project. As AMI deployment continues and distribution grids are upgraded with automation technology, increased use of CVR in the state should be considered. To understand potential applications for CVR, as well as the results of pilot projects like the one currently being undertaken by TEP, it would be helpful if utilities reported their utilization of distribution voltage optimization to the Commission.

V. COMPREHENSIVE ENERGY EFFICIENCY

Several presenters discussed the benefits of approaching energy efficiency ("EE") from a comprehensive, complete building approach rather than on an individual measure basis. By evaluating a building as a complete system that can be optimized for efficiency, EE savings can be compounded. This approach to EE is made possible through the use of meter data, which permits energy services companies to scale EE projects and target the most effective measures.

This whole building approach to EE results in significantly higher savings than the traditional individual measure approach. One presenter estimated that EE driven by analytics could be considered a new source of savings by itself, as without it nearly half of potential savings opportunities may be ignored. Comprehensive EE projects based on analytics should be encouraged in Arizona due to the high energy savings these projects yield.

The ACC could encourage comprehensive EE methods by approving demand-side management plans that include programs which feature these projects. The combination of high savings yield and the verifiable nature of savings associated with analytics-based EE could be an effective method for utilities to reach EE targets.

VI. ENERGY IMBALANCE MARKETS

Several presenters discussed the possibility of Arizona utilities joining an Energy Imbalance Market ("EIM"). EIMs permit generators to balance the supply of electricity with demand over a large area, and can lead to increased efficiency and provide benefits for integrating more variable energy resources. In particular, the California ISO's ("CAISO") EIM was discussed as a potential market for Arizona utility participation.

APS is currently evaluating EIM and its potential impacts. On August 26, Commissioner Susan Bitter Smith filed a letter in the docket asking APS to "provide a short description of the anticipated evaluation process of EIM referenced by Mr. [Brad] Albert [with APS] and a current timeline regarding the stages of this process." In this letter, Commissioner Bitter Smith also requested TEP "provide a short description of and any comments regarding the status of their efforts, if any, to evaluate the potential advantages and disadvantages of participation in an EIM."

In its response filed on September 15, APS explained that while it is considering joining CAISO's EIM, it is concerned about that particular EIM's operation because it includes participants both inside and outside of CAISO's balancing area, which make its market rules uniquely complex. In its analysis, APS is evaluating and monitoring three primary issues. First are market economics, and APS is "reviewing production cost modeling studies and comparing operating costs within EIM against a business as usual case." Second are internal costs, so APS is working to "identify and estimate the cost (both start up and on-going) of implementing EIM." Finally, APS is "seeking to understand the extensive list of market rules, charges, workflows, timelines, and their effects on traders, transmission operators, and scheduling coordinators." APS expects its analysis to be completed by spring of 2015. APS also plans to monitor PacifiCorp's experience with CAISO's EIM, as it is one of the largest utilities in the West and it joined on October 1, 2014.

TEP filed its response on September 16, 2014. In its response, TEP cites its membership in the Southwest Variable Energy Resource Integration ("SVERI") group, which is comprised of several large southwest utilities, including APS and TEP. SVERI's purpose is to evaluate ways increased renewable generation can be handled across the group's combined service territories. TEP states, "As a relatively small utility, TEP is not prepared to assume a leadership position in embracing EIMs ahead of our larger regional peers. We will continue to work with SVERI and others to address the impact of intermittent renewable resources while evaluating NV Energy's [a Nevada electric utility] and PacifiCorp's upcoming experience with the California Independent System Operator's extension of an EIM for the region."

EIMs could offer significant benefits to both Arizona utilities and ratepayers. Utilities in the state are evaluating different options for renewables integration, and the Commission should be included in that discussion.

VII. RATE DESIGN IMPACTS

Speakers during the workshop series also discussed the benefits of alternative rate design. Properly designed time-of-use rates can incent energy efficiency and behavioral demand response, and also facilitate the use of advanced technologies. For example, higher time-of-use rates during peak times may incent consumers to adopt technologies like residential battery storage systems, geothermal heat pumps, or thermostat automation devices while helping utilities reduce peak load at critical times.

Bill savings through time-of-use rates are not limited to consumers adopting advanced technology. Salt River Project ("SRP") presented the results of its pilot recruitment program for its EZ-3 price plan. EZ-3 is a time-of-use billing plan that rewards customers for reducing on-peak usage between 3 p.m. and 6 p.m. during weekdays. This pilot program was open to participants with a household income not exceeding 200% of federal poverty guidelines, who had twelve months of billing history. Participants had to reside in a single family home with one central air conditioner and no programmable thermostat.

At the conclusion of the program, SRP made three observations. First, limited income customers can save money by correctly implementing the EZ-3 price plan. Second, pairing a programmable thermostat with proper implementation of the EZ-3 price plan further reduced the customer's bill and SRP's peak demand. Finally, most usage shifting and bill savings occurred during the summer months.

Well-designed time-of-use rates incentivize energy efficient and demand response technology while simultaneously permitting low-income consumers to save on utility bills. Time-of-use rates also most accurately reflect the value of energy delivered to the customer. In the future, the Commission may want to consider increased time-of-use options during utility rate cases, because this type of rate design offers significant benefits to both consumers and utilities.

VIII. INTEGRATED RESOURCE PLANNING

The Innovation and Technological Development docket and workshop series made it clear that technology is progressing quickly in the energy industry and much of that advancement is difficult to predict. The Commission must be ready to address a changing regulatory environment in the face of emerging technologies. In the long term, the electric utility business model may change completely. Presenters discussed entirely new business models, such as a transactive energy mechanism that includes a high level of multi-directional power flow on the grid and enables significantly higher customer participation in both generation and grid operation than possible today.

Due to the significance of ongoing changes to the industry in both the near and long-term, it may be beneficial for the Commission to know how and when new technologies are being used by Arizona utilities. The workshop series has provided an informative forum for understanding emerging technology today, but the ACC may want to utilize its integrated resource planning ("IRP") process to stay apprised of changing technology.

The IRP process is intended to keep the Commission apprised of how utilities will fulfill the energy needs of their customers over a 15-year timeframe, as well as how they plan to satisfy demand response, energy efficiency, and renewable energy requirements, so IRP would be an appropriate venue for discussing how emerging technologies fit into those plans.

New topics to be discussed in IRP would not only include the topics outlined in this report, i.e. microgrid development, AMI data management and security, voltage optimization and distribution automation, and renewables integration strategies including EIMs, but a description of any new technologies the utility is evaluating, the range of impacts on the system, cost projections, and anticipated viability.

If the Commission is concerned that including descriptions of "any new technologies utilities are evaluating" is too broad and too far removed from the core inquiry of an IRP, the Commission may want to identify an alternative venue for staying apprised of changing technology.

Appendix A

Summary of Emerging Technologies Workshop Presentations

Workshop #1, March 20, 2014

I. *The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources*

Clark Gellings, Fellow
Electric Power Research Institute

Mr. Gelling's presentation focused on EPRI's analysis surrounding the value of the centralized electric grid. EPRI's research focused on the changing value of the grid as distributed generation becomes more prevalent, and how distributed resources can be best adopted. The organization notes that photovoltaic, fuel cell, micro-generation, storage, and plug-in electric vehicle resources are all currently seeing significant advancements in both cost and performance, although it is difficult to anticipate how quickly such resources will see widespread adoption.

The grid is critical to the development of these resources. It provides a transactional value in that it enables consumers to sell the power they generate, and it provides an alternative to energy storage, which is not quite cost-effective. The grid also serves as a backup when distributed resources are not generating, which is significant because it makes those resources viable. The grid is also very reliable. On average, it is 99.97% reliable nationally. It also provides benefits surrounding start-up power and it reduces harmonic distortion, which are both potential problems created by distributed generation.

To address the growth of distributed resources, the "integrated grid" needs to be realized. EPRI suggests that this requires several steps. First, the grid needs to be modernized. Second, there needs to be a communications overlay on top of existing infrastructure and interconnection rules must be updated. Finally, integrated planning and operations, in addition to more informed regulation, comprise the foundation of the integrated grid.

II. *Strategies and Tactics for Dealing with Changing Consumer Consumption*

Dr. Ahmad Faruqui, Principal
The Brattle Group

Normal load growth has not resumed four years after the Great Recession has ended, and although declining growth has been the norm since 1950, usually growth rebounds within five months after the end of a recession. There are three factors driving this change. First, consumer psychology has changed as a new generation of consumers is pushing for more energy efficient products, and those consumers are also faced with continuing economic uncertainty. Utilities are increasingly utilizing energy efficiency, prompted by energy efficiency standards and new legislation. Finally, state and federal governments are pushing more aggressive codes and efficiency standards. In addition to these three factors, two other forces are impacting growth – distributed generation (which the Brattle Group believes can alone eliminate load growth), and fuel switching as shale oil and gas push fuel prices lower.

To address these factors, there are essentially four strategies and three tactics that may be employed. The first strategy would be to do nothing, which the Brattle Group contends would be dangerous, as firms ignore a changing marketplace at their peril. The second strategy is electrification. That is, conducting research, development, and demonstrating new industrial processes that are electric intensive. It is risky to believe that this alone will address growth because it will probably not pay off

anytime soon. The third strategy is a "safe haven," which is to let utilities become wires companies. This is risky because there are already many wires companies, and wires companies run the risk of not being able to collect sufficient revenue since the bulk of distribution charges are tied to sales, and as sales growth slows down they may not be able to cover their fixed costs. The fourth strategy is to go on the offensive and start competing with mainstream solar companies by creating non-regulated affiliates. This doesn't fit with the utilities' core competencies and is also high risk.

The three tactics that are recommended are to 1) rethink rate design 2) rethink forecasting and 3) rethink load and market research. The slowdown in growth is not an aberration, and it is in line with a trend that has been occurring over the previous six decades. Today, however, the driving forces are unique and three have already manifested while two more are on the horizon. Now is the time to determine how best to meet these challenges.

III. *Bloom Energy: Reliable, Efficient, Distributed Energy Generation*
Josh Richman, Vice President of Business Development
Bloom Energy

Bloom Energy markets on-site fuel cell generation units. They convert fuel to electricity through a direct electrochemical reaction that requires no combustion. The company claims it is the most efficient way to convert fuel to deliver electricity that is commercially available. The units do not require the use of water, and they are typically installed at the point of consumption so there are no transmission costs. The technology is reliable and scalable. It is not a disruptive technology because it produces power at base-load level.

Mr. Richman provided several examples of commercial applications for Bloom's products. Life Technologies, a biotech company in California uses Bloom units to provide refrigeration for its inventory because during a grid outage the company's existing diesel generators were not able to get fuel, as that fuel was rationed for hospital back-up generation. Walmart has installed Bloom units to contribute to lower power costs and provide power to stores during grid outages. The Company also provided an example of a Bloom project that was directly passed over by Hurricane Sandy. The units continued to function without incident even under the extreme weather conditions.

IV. *Utility-Scale Battery Energy Storage*
Jeff Gates, Managing Director of Business Development
Duke Energy

There is no single type of battery that is best for energy storage because there is no single type of energy storage. Every battery is defined by certain parameters and specifications. Primarily, these consist of safety, cycle life, capacity, C-rate (how fast a battery can be charged and discharged), price, and energy density. Battery performance is evaluated by two metrics, which are power output and the length of that output. Generally, batteries excel at one or the other of these metrics – very few do both well.

The objective of storage is to optimize resources on the grid. Storage is resilient and reliable, and it has transmission benefits because storage can increase transmission capacity. Mr. Gates suggested that blackouts could be avoided because storage could act as a buffer and give the transmission system time to react to a problem. EIA data suggests that we will need about 40 gigawatts of peak generation over the next 15 years. Battery storage offers advantages over gas peaking generation in

that it has zero emissions and very low standby costs. In places like Arizona, where there is a great deal of solar on the grid, it can be used to absorb load with PV, which is another advantage over conventional generation.

V. *Renewable Energy and Energy Efficiency*
Ken Baker, Senior Manager of Sustainable Regulation and Legislation
Walmart

In 1995, Walmart's then-CEO Lee Scott made a commitment for the company to be supplied by 100 percent renewable energy (an aspirational goal,) to create zero waste, and to sell sustainable products. During Walmart's last shareholder meeting, the company set goals to drive production or procurement of 7 billion kWh of renewable energy globally by December 31st, 2020. In addition, it also set a goal to reduce the kWh per square foot of energy intensity required to power its buildings globally by 20 percent from 2010 by the same date.

Walmart is working toward its renewable target by purchasing renewable power through power purchase agreements on-site or off-site, and with its own renewable generation. Currently, it has 256 existing on-site renewable projects in operation, and 67 that will be installed during this fiscal year. To date, the company has reached 32% of its 2020 renewable target. Walmart's portfolio of on-site generation includes wind, solar, and fuel-cell projects.

Walmart is pursuing a wide range of energy efficiency measures for its stores and distribution centers. One example is the use of daylight systems, which include skylights and computer-controlled electronic dimming ballasts. These systems control interior lighting based on the exterior light conditions, and have resulted in a 20 percent annual savings in lighting energy. Other measures include T8 fluorescent lamps, LED lighting, white membrane roofs, high-efficiency HVAC systems, and hot water reclamation systems. Walmart also started a program to retrofit refrigeration cases with doors, which alone saved 50 million kWh, as well as opening a store in Ohio entirely lit with LEDs, which consumes 34 percent less energy than a conventional Walmart. Currently, the company has achieved 7% of its 20% savings goal by 2020.

VI. *Distributed Energy Storage*
Meghan Nutting, Director of Policy and Electricity Markets
SolarCity

SolarCity is pursuing deployment of battery storage systems for use in conjunction with its photovoltaic (PV) systems. The company believes that combining PV and storage capabilities will reduce the costs associated with producing renewable energy. The value of storage is improved when it is located adjacent to both the generator and the load. SolarCity also believes that storage can further enable adoption of PV, and that storage systems can contribute to decentralized grid stability.

The batteries SolarCity uses for its current systems are essentially the same as those used in Tesla electric vehicles. Currently, these storage systems are used only as backup power for critical loads. In the future, SolarCity would like such systems to be used to help avoid time-of-use rates and to interact with rooftop PV systems. The company has had success using combined PV and battery storage systems to reduce customers' peak demand. The savings associated with such reductions are

greater than the costs of charging and discharging the batteries, particularly if the battery can be charged by PV should the customer have excess production.

SolarCity suggests changes need to be made before such systems may be widely deployed. First, interconnection costs need to reflect the true cost of interconnection, as those costs are very high today. Second, permitting processes need to be streamlined to match the PV installation process. Third, storage needs to be harmonized with renewable generator tariffs that allow for bi-directional energy flows. Finally, policy needs to align customer benefits with grid operation and wholesale market value.

VII. *Grid Integration Challenges and the Role of CSP with Thermal Energy Storage*
Kate Maracas, Vice President of Development, Southwest Region
Abengoa Solar, Inc.

Ms. Maracas' presentation focused on current utility-scale "CSP" (Concentrated Solar Power) generation technologies and thermal storage. She also discussed challenges surrounding the CALISO "duck chart." This chart, which is similar to those created by APS, is a projection of a hypothetical high-load day in 2020, and reflects the need for generation with very high ramp rates. Abengoa believes that this problem demonstrates the need for flexible capacity resources like CSP combined with storage.

Ms. Maracas explained several CSP technologies marketed by Abengoa. Parabolic trough technology involves using parabolic mirrors to track the sun and concentrate sunlight onto receiver tubes. This heats a transfer fluid that is circulated in the tubes, which is then pumped through heat exchangers to generate steam. The steam is used to generate electricity in a conventional steam turbine.

Power tower technology involves a circular array of tracking mirrors called heliostats, which are used to concentrate sunlight to a central receiver system mounted on the top of a tower. The concentrated solar energy is used to generate steam that turns a turbine.

Integrated solar combined cycle generation, or solar hybridization of fossil fuel plants, is another generation technology Abengoa markets. Essentially, it is the combination of a conventional plant and a solar field. During the day, the solar field provides the steam for a certain percentage of the energy needed, which serves as a fuel substitute. The plant functions as it normally would during the night.

Abengoa also employs thermal energy storage at its plants. Heat transfer fluid is kept in insulated tanks that can maintain heat for days with minimal losses. This stored heat can be readily converted to steam at any time, and responds quickly to changes in demand.

VIII. *Geothermal Heat Pumps/Ground Source Systems*
Glenn Meyers
Verde Sol-Air Services

Ground source heat pumps are a fairly new technology in Arizona, although they've been in use in other parts of the country for several decades. Verde Sol-Air installed its first system in the state in 2001. There are three main components of a ground source system, which are ductwork inside the home, a "GeoExchange" unit, such as a compressor or pump, and a group loop which is filled with

a heat transfer fluid. Ground loops can be placed in several different configurations, including some systems that loop through water sources, including swimming pools.

These systems are beneficial to homeowners because they can cut energy costs by 50-70% compared with conventional HVAC systems. In addition, geothermal systems, particularly the ground loop portion, are very durable and have double the life expectancy of conventional systems. They also require about 50% less maintenance that comparable systems. Utilities see a benefit in that geothermal systems level out peaks in demand as more customers install them in their homes, and that peak reduction includes a corresponding reduction in transmission costs.

IX. *Electrical Load Shifting for Residential and Commercial Buildings Using Thermal Storage*
Dr. Benjamin Ruddell, Assistant Professor, Department of Engineering, College of Technology and Innovation/Senior Sustainability Scientist, Global Institute of Sustainability
Arizona State University

Dr. Ruddell's presentation focused on thermal energy storage for air conditioning applications. He pointed out that in Arizona, the bulk of energy demand is driven by building air conditioning consumption. Ice Energy manufacturers a thermal storage product that utilizes this technology, which is a storage capacity air conditioner. Essentially, it is a five ton air conditioner with an ice tank attached to it. The unit makes ice with a compressor during off-peak hours, and during on-peak hours the compressor is shut down and the ice is used to chill instead of the compressor loop.

Currently, this is an expensive technology, although Dr. Ruddell anticipates that simpler, lower-cost products similar to those sold by Ice Energy will be available for residential and commercial applications within the next five to ten years. He expects that demand will be high for these products because they have the potential to reduce a customer's air conditioning power bill by half, and the incremental cost will be between $500 and $1000, so payoff will happen in a short time frame.

Dr. Ruddell has forecast the impact widespread deployment of these devices would have on electrical demand of the City of Phoenix and the metro area of Maricopa County. He found that with a deployment of approximately 500,000 units, which would be a large fraction of retail commercial and residential buildings in the area, it would be possible to reduce peak loads by 23 percent. He expects that it will likely take 10 to 20 years before this scenario is possible, but emphasizes that a 23% reduction of investment in capital in the power grid within that time frame would be very significant.

Summary of Emerging Technologies Workshop Presentations

Workshop #2, April 25, 2014

I. *Combined Heat and Power (CHP): A Strong Distributed Energy Partner*

Tom Harris, Solar Developer and Financial Broker
PV Advanced Concepts

Combined heat and power involves the use of natural gas fed to an electrical generator. The power generated is for local use, although that power may be put back onto the grid. The value of CHP comes from the capture of hot water and exhaust gases used in the combustion process. For example, a typical CHP unit uses a conventional engine as a generator that works in conjunction with an absorption chiller. Absorption chillers output chilled water, which adds 1 to 3 cents of value per kWh generated by a CHP unit.

CHP units are a dispatchable distributed energy source. They can ramp from 0 to 100% capacity in minutes, and are efficient between a 50 and 100% load. These systems perform well in conjunction with renewable resources like solar. CHPs are programmable and scalable, and often multiple units are used which can be transitioned on and off as needed.

II. *Waste to Energy (WtE) Technologies: Deriving Renewable Energy from Landfills, Treatment Plants and Agricultural Waste*

Mike McClure, Account Executive
Energy Systems Group

WtE technologies generate renewable energy, both as renewable gas and electricity, in addition to aiding in cleaning landfills. These technologies may use several different waste inputs as fuel, including landfill waste, waste water, livestock waste, and food industry and restaurant waste. The resulting output is reliable, non-intermittent renewable energy. Biogas created by WtE may be used in CHP applications (as described above), as pipeline quality renewable natural gas, or as a vehicle fuel.

Mr. McClure believes WtE electricity generation could be on par with grid-supplied generation. Gas supplied through WtE projects carries a premium over traditional natural gas sources, although that could be offset with renewable energy credits. Environmental benefits associated with WtE include eliminating major air and ground pollutants from landfills and agricultural operations, eliminating waste gas flaring, and the potential to eliminate up to 70% of landfill waste.

III. *System Adequacy in a Depleted Inertia Future*

Jerry Smith, Owner
P&R Consulting

Mr. Smith's presentation focused on future system adequacy concerns. These include changing operational needs due to the increasing prevalence of non-dispatchable renewable generation, as well as the retirement of existing coal and nuclear units. He is concerned that this trend reduces the inertia needed for frequency and voltage control, in addition to reducing the ability to manage system disturbances.

Mr. Smith believes Pump Storage Hydro (PSH) technology is the best technology to address these problems, because it provides significant sources of inertia. By its nature, PSH provides storage and is dispatchable, and therefore can be firming for other non-dispatchable renewable resources. Variable spread PSH units provide fast response for voltage and frequency regulation in both generation or pump modes.

IV. *Battery Storage and Forecasting for Improved Grid Integration*
Ted Burhans, Senior Program Manager of Renewables
Tucson Electric Power

(TEP's presentation was in made in conjunction with its research partners in battery storage and renewable forecasting.)

Daniel Cormode, Energy Storage Specialist
SOLON

TEP has partnered with the University of Arizona and SOLON to work on battery storage and deployment at the Energy SMRT (Storage Management Research and Testing) site. The SMRT site features a megawatt scale battery storage and photovoltaic integration project that has been operating since October of 2012. The project integrates a 1.6 MW PV plant with a 500kW inverter and lithium ion battery storage system.

The project was constructed to quantify the value of energy storage, to learn what is involved in the design and execution of storage projects, and learn how to evaluate storage systems. To date, the SMRT site has created value in several ways. It increases the value of power from an installed PV system by smoothing variability. It also provides frequency response, and is remotely dispatchable.

William Holmgren, Post-Doctorate of Physics
University of Arizona

TEP anticipates that integrating variable resources like solar and wind generation will become more difficult as these resources become more prevalent. The University of Arizona (UA) and TEP have developed forecasts to address this problem. Accurate forecasts can help utilities make better predictions for generation and load requirements, schedule more efficient generators, reduce costs associated with generator starts, and optimize the use of battery storage.

The UA is using three methods of forecasting to accomplish these goals. First, the UA uses three day ahead forecasts of solar and wind production using numerical weather models. Second, it uses two hour ahead forecasts of solar production using satellite imagery. Finally, the UA uses one hour ahead forecasts of solar production using a network of irradiance sensors.

V. *Changing Customer Energy Use Patterns: An Arizona Focus*
Jeff Schlegel, Arizona Representative
Southwest Energy Efficiency Project

The Southwest Energy Efficiency Project (SWEEP) offered a responsive presentation to Dr. Ahmad Faruqui's presentation during the first Emerging Technologies workshop held in March.

Arizona is experiencing slow growth rates, which is similar to national trends. Low growth rates can be problematic for the utilities, but can be positive for customers. This is because with slow growth, there is less pressure to develop new resources, less exposure to risk, and increased energy efficiency can help reduce customer bills.

APS is currently forecasting moderate growth in sales, even with the impacts of energy efficiency and distributed generation included. Although Dr. Faruqui suggested that EE and DG could threaten the traditional utility business model in the future, SWEEP believes that is not an immediate concern in Arizona, and this outlook is confirmed by APS data. SWEEP research also indicates current Arizona electricity sales and customer bills would be much higher without existing energy efficiency programs.

Summary of Emerging Technologies Workshop Presentations

Workshop #3, May 28, 2014

I. a. *Thermostat Innovation*
Kevin Lauckner, Director of Business Development
Honeywell

Fifty percent of Honeywell's products are in some way linked to energy efficiency, and Honeywell is a manufacturer of control systems. In Arizona, a quarter of energy consumed by homes is air conditioning load, which is more than four times the national average. Residential air conditioning also has high coincidence with peak demand, and studies have shown that controlling HVAC load can deliver above a 1 kW reduction per participant. Honeywell believes 1 kW is a low estimate of potential savings when considering anticipated advances in technology.

Honeywell markets a Wi-Fi thermostat system to manage residential load. These systems interface with smartphones, computers, and tablets, and permit remote control of a home's HVAC system, in addition to improving the ease and programing capabilities of the thermostat(s). The systems are also capable of serving a demand response ("DR") function as they are capable of interfacing with the utility should the customer opt-in to a DR program. Similar automated energy management systems are also being used in hotel rooms for the hospitality industry.

I. b. *Resiliency through Microgrids*
Dave Robinson, Senior Sales Support Consultant
Honeywell

Microgrids are not simply a way to brand combined heat and power ("CHP") or distributed generation ("DG") systems. The US Department of Energy defines a microgrid as "a group of interconnected loads and distributed energy sources with clearly defined electrical boundaries that act as a single controllable entity with respect to the grid and can connect and disconnect from the grid and enable it to operate in both grid connected or island mode."

These systems can be expensive, but some customers are willing to pay a premium for the reliability a microgrid can provide. The "island" capability ensures operational continuity for entities that utilize microgrids, and core costs may be mitigated if systems like CHP are integrated. Typical microgrid costs include those for generation and storage facilities, control equipment, interconnection and system configuration.

II. *Distribution Voltage Optimization: Energy Savings for All Customers through Investment in Grid Technology*
Ken Wilson, Owner and Senior Consultant
TransGrid Consulting

According to the US Department of Energy, about 90% of homes and businesses in the US receive more voltage than they need, which wastes energy. Utilities use high voltage because they do not always have voltage measurements at the meter, and to avoid customer complaints about

low voltages. Today, smart meters are able to provide voltage measurement data, and are a less expensive communication link with the utility than was available in the past.

Waste associated with high voltage can be addressed with Conservation Voltage Reduction ("CVR"). National studies suggest a 1% energy reduction may be created by reducing voltage by 1%. CVR is achieved by monitoring feeder voltages and using capacitor banks and load tap changers to adaptively reduce voltages on each feeder at a substation. Traditional CVR involves manually lowered voltages at substations, but adaptive, dynamic CVR allows voltages on every feeder to be changed with load, resulting in greater energy savings. Pacific Northwest National Laboratory estimates that if CVR were to be implemented on every feeder in the US, annual energy consumption would be reduced by 3.04%.

III. *An Overview of Strategic Energy Management*
Mark Hamilton, Principal
Triple Point Energy

The Consortium for Energy Efficiency defines Strategic Energy Management ("SEM") as "a continuous improvement approach to reducing energy intensity over time, characterized by demonstrated customer commitment, planning and implementation, and systematic measurement." Triple Point uses continuous improvement principles often applied to quality control, like ISO or Six Sigma, and applies them to energy efficiency. To implement SEM, Triple Point advises its clients on how to reach energy efficiency goals by using a "Plan-Do-Check-Act" cycle.

Strategic energy management addresses business processes first, which in turn drives operations and maintenance savings, and ultimately capital projects. SEM is delivered over an extended period of time, in some cases over just a few weeks, but usually over a year. Triple Point works with 8-12 customers over a 1 year period by providing workshops, one-on-one coaching, and technical assistance. Utility involvement typically includes working with key account managers who will assist in program structure and facilitation, in addition to providing overall savings management.

IV. *Using Meter Data Analytics to Transform Energy Efficiency*
Sam Krasnow, Vice President of Regulatory Affairs and Market Development
First Fuel

First Fuel is an energy information services company that uses its customers' meter data to "accelerate and scale" commercial energy efficiency projects. First Fuel's building analysis consists of three steps, beginning with compiling meter data and comparing it to weather data, permit and tax filings, etc. to create an "information profile" of a building and its energy use. Next, First Fuel breaks down that information to determine how the buildings' total energy consumption is allocated to different end uses, such as lighting, heating, cooling, plug load, etc. This audit of the building leads to the final step, which is recommending targeted energy efficiency measures based on that data.

First Fuel's research indicates that in a sample portfolio of one hundred buildings, half of potential energy savings opportunities were possible with the use of retrofitted equipment, and half were available based only on operational changes. First Fuel believes this demonstrates the

value of the in-depth analysis it provides, as without it half of potential savings could be ignored. The company believes its services represent a new source of EE savings.

V. *Intelligent Residential Energy Automation*
John Steinberg, Executive Vice President of Business Development
EcoFactor

EcoFactor provides residential energy management. The company uses deep analytics based on data from a customer's home and weather conditions to enable automated optimization of the home's HVAC use. The home's thermostat is used as a sensor, and HVAC usage is adjusted to improve energy efficiency and reach the homeowner's comfort preferences.

Three key services are provided by an EcoFactor system. It improves energy efficiency, and on average EcoFactor customers save $100 on their utility bills annually. Second, it enables demand response through load shaping. Finally, the system can function as a diagnostic tool that can find hidden problems with the HVAC system.

VI. *Microgrids: Impacts of Planning and Policy in Arizona*
Peter Asmus, Principal Research Analyst
Navigant

Navigant has done extensive research on microgrids, and it is the only entity to create a global database on microgrids. The global market for microgrids is growing due to declining reliability of the incumbent utility grid, demand charges imposed by local distribution utilities, and high penetrations of variable renewable resources. Ancillary services, such as demand response, as well as frequency and voltage regulation, are also contributing to microgrid growth.

Arizona is a not a top-tier microgrid market today. Major drivers of microgrid growth, such as supply shortages, weather-related disruptions, and a market for the ancillary services a microgrid can provide (such as an ISO or RTO) are not present in Arizona. The strongest business case for microgrids in Arizona currently is for grid-tied systems that island only for emergencies. For utilities, transmission and distribution asset deferral is also a possible business case. Navigant believes distributed renewables integration and premium reliability for key utility customers are the primary drivers for microgrids in Arizona.

VII. *Alternative Rate Design: a Large Customer Perspective*
Denis George, Energy Manager
Kroger

Kroger has been investing in energy efficiency since 2000. The company has cut its energy usage by one-third during the last 14 years, which equates to approximately 1.2 billion kWh. In Arizona, Fry's stores have reduced usage by 7% since 2007. Energy efficiency has reduced expenses and improved the customer's shopping experience. For Kroger, high utility prices drive efficiency investments, not rebates and incentives.

Kroger would like to see an alternative rate structure, specifically what it terms "hourly time-of-use generation rates." This rate structure would provide customers with day-ahead notice of prices, and be based on hourly incremental costs. This rate structure would only apply to

generation; transmission and distribution would be billed separately. The idea behind this rate structure is that every commercial and industrial user would pay the same price at all times, and it would better assign actual costs to actual usage. It would also improve price signals for renewables, demand reduction, and EE while helping to avoid construction of additional peak load facilities.

Multi-site or Aggregated Rate Structures are another alternative. This rate structure is based on coincident demand at all of a customer's sites. It eliminates what Kroger terms "geographic discrimination," and is made possible by advanced metering technology.

VIII. *Transforming Your Customers into an Energy Resource*
Josh Lich, Senior Manager of Solutions Marketing
OPower

Behavioral DR is a multi-channel messaging platform that communicates with customers around peak times. Behavioral DR channels may include postcards, automated phone calls, text messages, and emails. The messaging is timed to alert customers to reduce usage prior to a peak day and inform them of how much energy they saved, as well as any corresponding bill savings, after a peak day.

OPower has found that among customers who are enrolled in demand response programs, those who received behavioral DR notifications saved significantly more than those who did not. Baltimore Gas and Electric DR participants saved 5% versus 15% for those who received messaging. OPower reports that these notification programs are very well received by customers.

Opower also provides a utility-branded thermostat management platform. Studies suggest that programmable thermostats do not always create energy savings, and in some cases, may cause increased energy use. OPower's strategy to overcome this problem involves engaging customers with communications based on devices in the customer's home. For example, the customer may receive an email suggesting he or she adjust the thermostat at a particular time to achieve greater energy savings.

IX. *Decision Making in Micro-grids from Concept to Construction*
Nathan Johnson, Assistant Professor
Arizona State University, Department of Engineering and Computing Systems

The ASU Engineering Department has developed a comprehensive tool for use in the development of microgrids. ASU's approach offers guidance at each stage of the development process, from the initial idea to design, construction, and operation. The tool enables microgrid developers to apply data-driven modeling and analysis, define system boundaries clearly, and synthesize disparate information and modeling tools. It also permits integrated decision support, and features viewing options that are suited to individual stakeholders. Integrating these functions into one application improves the quality of information provided to developers and simplifies decision making.

X. *Emerging Technologies: The Role of Natural Gas*
Joe Varela, Manager of Energy Solutions
Southwest Gas

Natural gas prices have declined and stabilized since 2008, and industry experts expect this trend to continue. Natural gas, when dispatched from well head to burner tip, loses less than 10% of its energy content, which makes it a preferred fuel for microgrid technologies and CHP plants. CHP plants recover waste heat that can displace boiler load, power a steam turbine, or provide heat for an absorption chiller system that results in a combined overall plant efficiency of over 60%. Arizona has several CHP plants currently in operation.

Natural gas use is growing in the transportation industry. Transit buses, refuse trucks, long-haul trucks, and school buses are typical applications for conversion from diesel to natural gas. Natural gas provides three key benefits over diesel. First, it reduces CO2 emissions by 20-30%. Second, it enhances domestic energy security as 98% of the natural gas consumed in the US is produced in North America. Finally, according to the US Department of Energy, it provides a cost savings of over $1.50 per gallon on a retail national average over the diesel fuel equivalent.

XI. *EnerNOC*
Mona Tierney-Lloyd, Senior Director of Western Regulatory Affairs
EnerNOC

EnerNOC is a provider of energy intelligence software ("EIS"), and it offers three EIS products. SupplySMART is software that helps companies procure energy (in competitive markets) and manage utility bills. EfficiencySMART provides visibility and reporting for energy efficiency projects, permits facility optimization with software for meter analytics, and features project management software for energy project tracking. DemandSMART is demand response software that tells customers when to reduce consumption, and includes demand management functions that predict and quantify peak demand charges.

EnerNOC acts as a third party demand response provider to utilities. The company interfaces with both the utility and EnerNOC's portfolio of commercial and industrial customers to reduce consumption when needed. This enables EnerNOC to provide a firm resource to utilities that has the characteristics of a peaking power plant.

Summary of Emerging Technologies Workshop Presentations

Workshop #4, June 25, 2014

I. *Utilities and Microgrids*
Scott Bordenkircher, Director of Technology Innovation and Integration
Arizona Public Service

Microgrids are comprised of dispatchable energy resources, "smart/fast" switches that permit coupling between the utility and the microgrid, and advanced controls. These controls and resources must, in aggregate, have the ability to: 1) manage transitions between grid-connected and island mode, 2) balance loads and resources, and 3) manage microgrid transient reliability and stability.

Major customer segments for microgrids include utilities, universities and campuses, the military, data centers, medical and biotech firms, critical infrastructure, and remote locations. APS currently has several active microgrid efforts, including Carol Spring Mountain, which is a hybrid system that features storage, diesel generation, and PV solar. Carol Spring Mountain is not technically a microgrid because it is not connected to the grid, but it includes all other microgrid components. Aside from providing the energy needs of Carol Spring Mountain, it has also served as a microgrid test bed for APS since 1998.

II. *Software Driving Energy Efficiency Scale and Measurability*
David Wolpa, Director of Client Solutions
Energy Savvy

Energy Savvy is a provider of management software for energy efficiency ("EE") applications. It markets a cloud based system that utilities can use to streamline EE implementation from initial customer engagement to quantifying completed project savings. It also provides secure portals that permit each stakeholder (the utility, customers, trade allies, etc.) to log in and collaborate throughout the EE implementation process. By using a centralized platform like the one Energy Savvy markets, utilities can reach EE objectives, improve customer satisfaction, and reduce program costs.

III. *Meritage Homes: Setting the Standard for Energy-Efficient Homes*
Michael IlesCremieux, Regional Vice President of Land Acquisition

Meritage Homes has been building 100% Energy Star certified homes since 2010, and it was the first national homebuilder to do so. Meritage differentiates itself from other homebuilders by offering highly efficient products, and buyers are willing to pay a premium due to energy cost savings over the life of the home. Meritage Homes also appraise for more than competitive homes due to their efficiency.

Meritage would like Home Energy Rating System ("HERS") scores to be mandated labeling for every new home, similar to fuel mileage ratings on new automobiles, so that consumers will consider energy consumption as part of their home purchase decision. Meritage is also a proponent of energy efficient mortgages. These mortgages take into account a homebuyer's

monthly energy cost savings, and could permit buyers to receive additional consideration for financing.

IV. *Microgrids: Moving into the Mainstream*
Rob Thornton, President and CEO
International District Energy Association

Microgrid growth is currently driven by several factors, including demand for greater grid reliability, expanded deployment of clean energy sources, flexibility to tap local energy supplies, and local infrastructure advantages during extreme weather events. The microgrid industry believes this growth can be accelerated with improved regulatory policy. The International District Energy Association ("IDEA") would like microgrids and their services to be accurately defined by state regulators, and have the benefits of microgrids incorporated into reliability planning.

IDEA has several key objectives for the microgrid industry. First, it would like to ensure equitable access to grid resources and revenue. Second, it would like to foster a new grid paradigm in which there are more owners of distributed resources on the grid, and it wants to ensure a reasonable cost of access for all grid participants. Finally, it would like to see predictable, long-term regulations that eliminate risk from investments and help microgrid developers attract private capital.

V. *Sustainable Energy Use Technology*
Rich Barnes, Vice President and Global Director, Sustainable Energy Use
DNV GL

DNV GL provides planning, implementation, and evaluation services for sustainable energy use programs and works with APS and TEP in Arizona. DNV GL tests, certifies, and promotes five categories of energy management technology. This includes energy efficiency equipment, building shell technology, controls, information and analysis systems, and system and process optimization.

DNV GL believes the greatest potential for improving energy efficiency is derived from analyzing facilities as integrated systems that can be optimized. One example of this kind of optimization is in industrial applications. Industrial facilities can manage energy use in procurement, equipment selection and controls, and in production operations. DNV GL uses variability analysis to determine the maximize efficiency of the facility, and works with operators to make the behavioral changes needed to reach that efficiency.

VI. *Energy Efficiency Achieved with Microturbine Based Combined Heat and Power Systems*
Vito Coletto, Corporate Accounts Director
Horizon Power Systems

Horizon Power Systems is a distributor of Capstone microturbines, which are commonly used for microgrid generation. Combined Heat and Power ("CHP") systems simultaneously produce electricity and heat from a single fuel source. This waste heat may be used for space heating, water heating, process heating, pool heating, and space cooling. CHP systems can be configured

to provide both prime power and back-up power, which are attributes that make them attractive for microgrid applications.

CHP systems are comprised of a prime mover or engine (such as a microturbine), a generator that is integrated with the prime mover, heat recovery equipment (heat exchangers), and equipment that provides electrical and mechanical connections. The result is total system efficiency that can range from 65 to 80 percent when microturbines are used as the prime mover. CHP customer classes include large retailers, hospitals, office buildings, telecommunications facilities, hotels, schools, landfills, and waste water treatment plants.

VII. *The Impact of Geothermal Heat Pumps on Energy Efficiency and Peak Demand*
Morgan Stine, Member and President of Green Earth Energy and Environmental, Inc.
The Geothermal Exchange Organization

Geothermal heat pumps use the ground as a heat sink, producing efficiencies that are about 50 percent greater than conventional HVAC methods. Geothermal heat pumps are both renewable, due to the use of the constant temperature of the earth to provide heating and cooling, and efficient, as they avoid the thermal loads of buildings and reduce energy needs. This is significant because 70 percent of energy consumption in a typical single family home is used to meet thermal loads, and a GHP can reduce that consumption to less than 35 percent.

Western Farmers Electric Cooperative is a case study in how to structure an effective peak demand reduction program. In 2010, the Cooperative funded 1000 heat pumps, both air and ground source units. The results demonstrated a large disparity in performance. The air source units' performance declined in hot conditions, while GHPs were able to consistently perform as expected and deliver peak demand reduction. This consistency during hot weather makes GHPs a good option in Arizona.

VIII. *Hybrid Lighting Solutions by EASCOR*
Wes Moyer, President and CTO
EASCOR Hybrid Lighting Systems

EASCOR manufactures lighting systems that can reduce its customer's cost of electricity for lighting up to 100 percent. Each system is self-contained, and uses natural light and a daylight spectrum as an alternative to conventional interior lighting. These systems use fiber optics and LEDs in combination with solar power. Daylight is captured from rooftops, and compressed through fiber optic cable to each fixture. Light from LEDs (typically powered by solar panels attached to each fixture and lithium ion storage batteries) blends with light from the fiber optics to ensure light output remains constant even when clouds obstruct sunlight outside.

Fiber optics provide higher quality light than traditional fluorescent lamps, as they emit natural sunlight. EASCOR lighting can be attached to the grid or can function independently as a standalone system. EASCOR estimates that an average installation will earn a return on investment within 3.5 years, not including any utility rebates or credits.

Summary of Emerging Technologies Workshop Presentations

Workshop #5, July 28, 2014

I. *TEP's Distribution Automation Strategy*
Jim Taylor, Senior Director of Engineering & Operations Technology
Tucson Electric Power

TEP's strategy for distribution automation will allow it to operate its distribution system in a similar manner to its transmission system, making it responsive to changes in load. To implement these changes, TEP will modernize distribution feeders, continue AMR meter deployment, and implement automation technologies similar to its Volt/Var pilot project.

The company is going to modernize distribution line switching by adding switches that can be controlled remotely. It also has a pilot project called Green Advisor which tracks distribution feeder information and provides real time indication of outages, faults or other events. TEP is also planning to update its distribution control and operations with its new Distribution Management System.

II. a. *Wholesale Market Evolution and the Energy Imbalance Market*
Brad Albert, General Manager, Resource Management
Arizona Public Service

APS currently conducts transactions on the wholesale power market in block increments that can be no smaller than a single hour. An Energy Imbalance Market ("EIM") allows transactions to occur in five minute intervals. The EIM system permits generators to balance the supply of electricity with demand over a large area, and can lead to increased efficiency and provide benefits for integrating more variable energy resources. APS is currently evaluating EIM and its potential impacts. On August 26, Commissioner Bitter Smith filed a letter in the docket asking APS to "provide a short description of the anticipated evaluation process of EIM referenced by Mr. Albert and a current timeline regarding the stages of this process." In this letter, Commissioner Bitter Smith also requested Tucson Electric Power "provide a short description of and any comments regarding the status of their efforts, if any, to evaluate the potential advantages and disadvantages of participation in an EIM."

In its response filed on September 15, APS explained that while it is interested in joining CAISO's EIM, it is concerned about that particular EIM's operation because it includes participants both inside and outside of CAISO's balancing area, which make its market rules uniquely complex. In its analysis APS is evaluating and monitoring three primary issues. First are market economics, and APS is "reviewing production cost modeling studies and comparing operating costs within EIM against a business as usual case." Second are internal costs, so APS is working to "identify and estimate the cost (both start up and on-going) of implementing EIM." Finally, APS is "seeking to understand the extensive list of market rules, charges, workflows, timelines, and their effects on traders, transmission operators, and scheduling coordinators." The company expects its analysis to be completed by spring of 2015. PacifiCorp is joining CAISO's EIM on October 1st, 2014, and APS will be closely monitoring its performance.

Tucson Electric Power filed its response on September 16, 2014. In its response, TEP cites its membership in the Southwest Variable Energy Resource Integration ("SVERI") group, which is comprised of several large southwest utilities, including APS and TEP. SVERI's purpose is to evaluate ways increased renewable generation can be handled across the group's combined service territories. TEP states, "As a relatively small utility, TEP is not prepared to assume a leadership position in embracing EIMs ahead of our larger regional peers. We will continue to work with SVERI and others to address the impact of intermittent renewable resources while evaluating NV Energy's and PacifiCorp's upcoming experience with the California Independent System Operator's extension of an EIM for the region."

II. b. *Technologies for a Flexible Grid*
Scott Bordenkircher, Director, Technology Innovation and Integration
Arizona Public Service

APS is working to transition to a flexible grid. This transition enables better use of distributed generation resources by managing two-way power flow, dynamic voltage variability, and load and generation mismatches. A flexible grid is capable of accommodating the variability associated with many distributed resources, and will be sized to include additional distributed generation.

The flexible grid is comprehensive in that it includes components involving generation, transmission, distribution, and the individual customer. During the next five years, APS is working on three "foundational blocks" of the flexible grid. The first block is its Energy Management System ("EMS") and Advanced Distribution Management System ("ADMS"), which are highly advanced operational platforms. The second block is increased usage of communication devices that improve situational awareness of the grid system, such as sensors that detect when faults occur. The last block is automated switching, which permits remote operation of approximately half of the distribution system.

III. *The Role of Utilities in Connected Cities*
Gerard Warrens, CEO
Stealth Software

Stealth Software believes that at its core, the smart grid is a system of two-way communication between the end user and the utility. Millions of new intelligent devices are being installed along the grid, and 40 million smart meters are expected to be deployed in the US by 2015. The energy sector is now collecting a great deal of new data as a result of advanced metering technology, and this data will require secure storage and management.

Seventy-five percent of energy produced is consumed by cities, and Stealth Software is involved in the CityNext initiative, which includes energy management and analytics for cities. Stealth is developing a comprehensive, secure IT platform that can combine functions associated with CityNext and manage the influx of data utilities will be receiving in coming years.

IV. *Alternative Energy Integration with the Grid*
Dr. Sayfe Kiaei
Professor of Electrical, Computer & Energy Engineering
Director, Connection One NSF Center
Arizona State University

Dr. Kiaei emphasized the need for an energy system that is smart and sustainable. This means that it is able to sense demand down to the individual meter, and transmit that data back to different types of substations. Those substations could be a nearby microgrid, a local substation, or the centralized power grid. In turn, that data can be used to more efficiently match generation with demand.

Smart grid development requires sensors that can monitor demand and communications infrastructure to transmit that data. Dr. Kiaei believes that "Moore's Law" is applicable to power electronics and the grid system. Moore's Law states that the number of transistors possible in an integrated circuit doubles every year, resulting in consistently smaller, more advanced electronic equipment. This trend suggests that smart grid development and integrated electronics development will become easier and more prevalent in the near future.

Summary of Emerging Technologies Workshop Presentations

Workshop #6, August 18, 2014

I. *Energy Systems Integration*
Dr. Bryan Hannegan, Associate Laboratory Director of Energy Systems Integration
National Renewable Energy Laboratory

Energy systems integration and modernization of the electric grid is needed to prevent security disruptions, respond to extreme weather events, allow for increased use of renewable resources, and permit new uses like electric vehicles. The grid will need to accommodate two-way power flow from distributed generation, and be accessible to new technologies. The US Department of Energy has directed NREL and other laboratories to research these issues through its Grid Modernization Initiative.

NREL analyzes grid development in five layers, which include the device layer, the local control layer, the communication and computation layer, system control layer, and market layer. NREL operates the Energy Systems Integration Facility in Colorado. The facility combines fifteen laboratories into a single megawatt-scale grid distribution system. It can be controlled by a high performance computer that allows for modeling and simulation of future grids and energy systems.

II. *Transactive Energy: A Sustainable Business and Regulatory Model for Electricity*
Ed Cazalet, Co-Chair and CEO
OASIS Energy Market Information Exchange Technical Committee and TelMix Inc.

The Transactive Energy ("TE") business model creates two types of energy transactions, forward and spot. Consumers can purchase power at a fixed rate with a forward transaction, or buy it at the current spot price. There are two products, electric energy (which is produced at a certain place and time, such as that delivered through a transmission connected substation) and transport (electric energy delivered at a different place and the same time.)

This is an example of how TE works for the average consumer: The consumer purchases a fixed quantity of energy for a fixed subscription payment. If the consumer uses less than the subscribed amount of energy, he or she is paid for the difference at the hourly spot price. Or, if the consumer uses more than the subscribed amount of energy, they pay for that difference at the hourly spot price. If the consumer's needs change, at any time the consumer can automatically buy or sell a quantity of energy at the current spot price.

III. *Transactive Energy: A Blend of Value and Control*
Doug Houseman, Member
GridWise Architecture Council

Mr. Houseman predicts that the grid will remain important for the foreseeable future and that policy changes will be needed. He expects that almost all growth in generation and demand response will occur in the distribution grid. In the future, the grid must better accommodate multi-directional power flow at scale, shortened decision time frames (such as 5 min intervals

instead of 1 hour), and enable customer participation in market and grid operational services. The grid also must be able to maintain power quality and address phase imbalance issues.

Wholesale and retail electric markets will need to be connected as generation becomes increasingly prevalent in the distribution grid, and economic and physical control mechanisms need to be in place to manage this connection. Transactive energy is that economic mechanism. Physical controls will need to be coordinated at the ISO or RTO level, the local market and operation level, and the customer level. Mr. Houseman defined transactive energy as "the ability of customers and others, using value driven control systems, to optimize their use and sale of electric services to markets and grid operators to enhance economic efficiency and reliability."

IV. *Introduction to Southwest Power Pool and the Energy Imbalance Market*
Carl Monroe, Executive Vice President and Chief Operating Officer
Southwest Power Pool

Southwest Power Pool ("SPP") is a pooling organization comprised of eleven member utilities and is a founding member of the North American Electric Reliability Corporation. SPP is also a NERC regional entity. SPP is incorporated as a non-profit corporation in Arkansas, and is a regulated public utility and RTO under FERC. SPP has 370,000 square miles of service territory, 627 generating plants, and 48,930 miles of transmission lines serving more than fifteen million people.

SPP operates in the transmission service market where participants buy and sell use of regional transmission lines that are owned by different parties. It also operates in an integrated marketplace where participants buy and sell wholesale electricity day-ahead and real-time. The day ahead market commits the most-effective and reliable mix of generation for the region. The real-time balancing market economically dispatches generation to balance real-time generation and load, while ensuring system reliability.

V. *Briefing on the Energy Imbalance Market*
a. Mark Rothleder, Vice President of Market Quality and Renewable Integration
California Independent System Operator

The California ISO is a single balancing area that combines the service territories of Southern California Edison, San Diego Gas and Electric, and Pacific Gas and Electric that includes a day-ahead market and a real-time balancing market. CAISO includes 60,703 MW of capacity and serves about thirty million people. California has a renewable portfolio standard requiring 33% renewable resources by 2020, which has brought about the "duck chart" problem. The "duck chart" indicates that over time net load will continue to decrease during the day and creates the possibility of overgeneration, while during the evening there is a high peak load that requires resources that can ramp quickly.

The Energy Imbalance Market ("EIM") can mitigate both overgeneration and ramping challenges. Today, individual balancing areas can only balance loads and resources within their respective borders, but in an EIM the market operator automatically dispatches participating resources across balancing areas to balance energy. The larger region provides increased reliability and economic benefits to all participants. The EIM is scheduled to go live on October 1, 2014.

b. Stacey Crowley, Director of Regional Affairs
California Independent System Operator

There are two phases of governance in the CAISO EIM. The first phase was completed in May 2014. It consists of a transitional committee that is comprised of eleven regional stakeholders who were chosen through a sector-based nomination and ranking process. The committee acts in an advisory capacity to the CAISO Board of Governors on the development of a long-term, independent EIM governance structure.

The second phase of governance will be the implementation of that long-term structure, which will occur after the committee submits its recommendations to the CAISO Board and that structure is adopted. The committee is currently working on those recommendations. The committee will be holding public meetings through the west, and will meet at least as often as the CAISO Board of Governors until its recommendations are finalized.

VI. *Energy Imbalance Market: Customer Savings from a Modernized Grid*
Amanda Ormond, Managing Director
Western Grid Group

Western Grid Group is a proponent of Arizona joining the EIM. The financial savings from joining the EIM for utilities similar to APS are estimated to be approximately 1-1.5% of system production costs. APS has a one billion dollar system, so its estimated savings would be ten to fifteen millions dollars per year. Western Grid Group is concerned that these savings will be lost for Arizona ratepayers until joining.

EIM can also enhance reliability because it can be used as a tool to improve situational awareness. Current EIM member utilities report that the reliability benefits alone are valuable enough to justify joining. The benefits of EIM are expected to grow as more utilities join because members have access to greater resources and more information on regional markets. NV Energy conducted a system study that projected its initial savings from joining EIM would be roughly six to nine million dollars in 2017, but would grow to seven to twelve million in the following five years.

VII. *Emerging Technologies in Arizona: The Projected Economics of an Energy Independent Community*
Lon Huber, Special Project Advisor
Residential Utility Consumer Office

Mr. Huber provided several hypothetical examples of communities in Arizona and how they might adopt various technologies. The discussion included homes with centralized storage, local storage, rooftop solar, natural gas backup, and geothermal heat pumps. Mr. Huber concluded that peak usage and managing costs are the keys to determining how best to utilize these resources, and that energy efficiency and energy management software are needed. He believes that geothermal heat pumps should be more widely considered because of their ability to reduce peak demand.

Mr. Huber also discussed storage and its projected price declines. In his hypotheticals, he estimated battery storage prices will decline seven percent annually, which is slightly below the rate that is expected by several Wall Street industry estimates. This decline is similar to the price

decline that has occurred with solar panels, which follow what is known as the Swanson Effect. The Swanson Effect states that the price of photovoltaic cells decrease by twenty percent every time shipments of the product double. In aggregate, Mr. Huber's assumptions (battery prices decline at seven percent per year, solar prices decline at two percent per year, and grid costs increase at three percent per year) suggest that in roughly sixteen years, solar and battery storage will reach price parity with the grid.

VIII. *AMR vs. AMI and Smart Grid, the Benefits of Each for Arizona Utilities*
Jeff Rowe, Western Region Account Executive
Itron

AMR or Automated Meter Reading involves one-way communication from the meter to a utility data collection device. That device could be a mobile computer or a fixed data collector. It benefits customers and the utility by eliminating the need for the utility to visit the home to read the meter. This technology has been available and in use for over twenty years. AMI or Advanced Metering Infrastructure is more advanced than AMR. AMI permits two-way communications between the utility and meter.

Two-way communications enable advanced capabilities that are essential for the development of the smart grid. These capabilities include time-based rates, remote connection and disconnection, demand response, and home automation. AMI meters also provide tamper detection and outage notification to the utility. It is a technology that can be upgraded and is expected to be viable over a twenty year lifetime.

IX. *Smart Grid Industry Trends and Arizona AMI Update*
George Lucas, Executive Director of Smart Grid
Elster

Smart meter deployment is growing and is anticipated to have 70% market penetration in the US by 2020. AMI is a mature technology and is now widely adopted by both public and investor owned utilities. Remote meter reading and demand response created the business case for smart meters initially, but more recently advanced applications such as voltage and outage management and distribution automation have driven smart meter growth. These advanced applications have made AMI an integral part of utilities' "end to end" management of the distribution grid.

Elster smart meters provide a single, universal end point for smart grid development. Elster markets a universal and modular portfolio of systems that can be adapted to a particular utility's needs. New trends in metering have brought about a communications evolution, and are resulting in an influx of data for utilities. AMI systems must be able to manage this traffic while being synchronized with other critical operational systems, and be able to present this information intelligently to system operators.

X. *Emerging Technologies and Applications for Power Distribution Networks*
Robert Wilhite, Managing Director, Americas Region
DNV GL Energy Advisory

DNV GL Energy Advisory recently conducted a survey of the industry and made several key observations.

- Integrating distributed integration is widely considered the most significant challenge the utility industry is facing over the next five years. Distributed energy technologies include both demand and supply side applications, which have varying degrees of forecasting complexity.
- There are a broad range of options for energy storage that vary based on individual needs. Energy storage technologies underwent a shift in 2013 in developing applications that include longer duration requirements to serve utility needs, such as peak demand reduction.
- Distribution automation presents significant benefits for grid modernization.
- Data analytics firms capable of handling AMI data are growing in a fragmented fashion and market consolidation is likely to happen in the near-term.
- Broad smart grid benefits have already been achieved in a number of US deployments.

XI. *Limited Income Customer EZ-3 Recruitment Pilot*
Aaron Dock, Manager of Load Research
Salt River Project

SRP recently completed a pilot recruitment program for its EZ-3 price plan. EZ-3 is a time of use billing plan that rewards customers for reducing on-peak usage between 3 pm and 6 pm during weekdays. This pilot program was open to participants with a household income not exceeding 200% of federal poverty guidelines, who had twelve months of billing history. Participants had to reside in a single family home with one central air conditioner and no programmable thermostat.

At the conclusion of the program, SRP made three observations. First, limited income customers can save money by correctly implementing the EZ-3 price plan. Second, pairing a programmable thermostat with proper implementation of the EZ-3 price plan further reduced the customer's bill and SRP's peak demand. Finally, most usage shifting and bill savings occurred during the summer months.