

EESAT 2005 Draws Record Number

Technologies begin to mature; commercialization and integration highlighted

Note: a summary of the following article can be found in the January 2006 issue of the ESA Newsletter.

EESAT 2005 achieved a record of 163 registered participants from 14 countries, indicating growing interest in the role of electricity storage in the future stability and security of the electricity delivery infrastructure. The conference, held in San Francisco on October 17-19, began with welcoming remarks by two of the conference chairs – Imre Gyuk of the US Department of Energy and ESA’s former chair, Bill Hassenzahl.

Kevin Kolevar, Director of the US Department of Energy’s Office of Electricity Delivery and Energy Reliability (OE), provided the keynote address. He outlined the responsibilities of OE, for which the mission statement is ‘to lead national efforts to modernize the electric grid; enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to energy supply.’ The Electric Power Systems Research and Development Division under Bill Parks includes Gyuk’s Energy Storage Systems Program. In outlining future plans for OE, Director Kolevar emphasized the importance of energy storage.

The papers fell into two categories: progress reports on DOE- and state-funded storage demonstrations and studies, submitted for peer review; and a variety of independent storage-related papers.

Economics and Policy Session demonstrates differing views on storage cost and value

The Economics and Policy session kicked off with

an interesting paper from Thomas Jenkin of NREL. Having established the relationship between electricity demand and price, Jenkin showed that releasing a block of stored energy as part of an arbitrage program, if the power level were high enough, would actually reduce the prevailing cost of electricity and hence the arbitrage benefit. However – and this is where it gets interesting – in a fully deregulated market all consumers would benefit from the reduced price level, so the use of storage in this way would benefit society as a whole, even though the owner of the storage system would see a reduced return.

Jenkin also showed that increasing fuel prices don’t necessarily translate to increased arbitrage benefits. While arbitrage may not generate sufficient value to justify today’s prices for storage systems, this was indeed a thought-provoking paper.

The session continued with a paper from Jim McDowall of Saft on combining short-duration storage with generation for cost-effective storage systems in the



Imre Gyuk of the Department of Energy welcomes attendees to the meeting.

short to medium term. McDowall used the Golden Valley BESS in Fairbanks, Alaska and other examples to illustrate this point. Larry Dickerman from American Electric Power discussed the integration of distributed generation into the grid and the use of energy storage to optimize the utilization of generation, transmission and distribution assets. He then went on to discuss the recently announced 1.2-MW, 7.2-MWh NAS system from NGK and S&C Electric that will be installed in one of AEP's West Virginia substations to defer a system upgrade for 6-7 years. AEP plans to relocate the system twice in its operating life to maximize its value. The

James Eyer of Distributed Utility Associates discussed risk-adjusted cost of T&D distributed resources aimed at meeting peak demand. Interestingly enough, the “do nothing” option was found to provide a notable competition for deployment of distributed resources unless their costs become less than \$100/kW per year.

Susan Schoenung of Longitude 122 West presented her study on the cost & benefits of energy storage for three different scenarios; T&D deferral with PQ, T&D deferral with arbitrage and customer bill optimization. For each of these scenarios, her studies yielded cost targets below which the benefit to cost ratios would exceed unity.

Growing support and incentives for renewable generation enhancement

The first presentation in the Renewable and Distributed Energy session came from Germany's Werner Leonhard, a longtime observer and sometime critic of energy policy in his country. Professor Leonhard described the difficulties facing Germany as it attempts to create a sustainable energy system, and painted a possible scenario where storage plays a key role in tying together a system based primarily on nuclear and wind generation, and with limited carbon emissions. This was followed by another visionary for the future of storage, Denis Smedley of the Australia Greenhouse Office (AGO), who described a recently enacted 5-year, \$20.4 million Advanced Electricity Storage Technology program that will provide a boost for technically and commercially proven storage systems for deployment in Australia. Interestingly, the US Department of Energy has linked up with the AGO to ensure that programs in the US and Australia can share experience and avoid duplication of efforts.

Steve Eckroad spoke about the ongoing work at EPRI to quantify the value of storage in wind-coupled, grid-connected applications. His presentation indicated the types of storage technologies most likely to succeed in this application, and noted that early commercial feasibility will likely



Attendees enjoy a mixer sponsored by the ESA in the historic Sir Francis Drake hotel.

last paper in this session was from Régine Clavreul of Electricité de France, who compared the cost of energy storage systems to standby generators for emergency functions. When emergency generators are used for fewer than 1000 hours per year, the increased cost per delivered megawatt-hour provides opportunities for low-cost storage systems.

Jason Makansi of Pearl Street discussed a few factors for lack of enough attention to energy storage including lack of a consistent public policy and absence of demonstrated ready-to-go concepts. Reaction of the audience, however, indicated that there is no consensus on the reasons and factors for lack of enough attention to energy storage.

be achieved where wind penetration is relatively large or the power system is relatively small, enabling storage to serve a high-value role. On a similar theme, Mindi Farber-DeAnda presented a progress report on the work SAIC, PacifiCorp and VRB Power Systems have done evaluating a specific wind farm in Wyoming and simulating how a storage system similar to PacifiCorp's VRB system in Utah could add value to the wind farm output.

Two presentations spanning the available size of storage systems were those from Gentaro Koshimizu of J-Power in Japan, describing his company's 4-MW/6-MW (pulse) VRB system and Garth Corey, describing Sandia's ACONF advanced hybrid system controller in use with a few kilowatt storage system and photovoltaics to optimize battery life and reduce fuel usage at remote US Coast Guard remote radio repeater sites. The J-Power system has been operational since January 2005 and uses advanced control algorithms to smooth the output from Japan's largest wind farm, thus improving the stability of the Hokkaido island grid system. The ACONF system is also in its first year of testing at Duke Island, and is producing fuel savings of over 30% compared to an identical reference system.

The session ended with a discussion and live demonstration by Srikanth Sridharan from SENTECH of modeling software designed to simplify the task of optimizing the amount of storage to use with solar/hybrid systems. The software, called HybSim, is in the final stages of development before its public release.

Silicon carbide-based converters an upcoming technology in power electronics

The session on Power Electronics was separated into two general areas: existing commercial systems and their performance and advanced power electronics.

Mariesa Crow and Bruce McMillin of the University of Missouri, Rolla, described recent studies of the use of FACTS devices in conjunction with electricity storage. The approach taken at UMR is to develop a computer

model of a portion of a utility and explore its security in the event of a fault or loss of a line. This method allows an assessment of system security both from hardware failure and cyber terrorism. Their laboratory has the ability to test small hardware devices as part of a simulation of real systems.

Larry Rinehart of Rinehart Motion Systems described an ongoing development of a small, 100kVA, converter that has the potential of significantly lowering cost and weight of converters in this power range. Whereas some of the later papers addressed these same potential reductions, this paper described how it might occur by novel use of conventional materials. This device could be coupled to any of several storage devices.

Chong Han of North Carolina State University presented a simple approach for using Emitter-Turn-Off Thyristors with a capacitor based energy storage system.

Three papers addressed the upcoming technology of silicon carbide-based converters. They were the initial view of some SBIR programs that were started in June this year. First comment was that some systems based on this technology are now in use in specialized converters where size and efficiency are of much greater importance than cost. The purpose of the described research programs is to increase the size and reduce the cost of individual components. Independent of cost and efficiency and high power density, SiC can operate at a higher temperature than Si based components. The future will see the replacement of Si devices, much as Si replaced Germanium 50 years ago. One advantage of a component that can operate at a higher temperature is that it is less expensive to remove a given quantity of heat when the temperature difference between source and sink are greater.

Advanced Battery Session highlights system integration

It is perhaps an indication of the advances being made in the field of energy storage, that the vast majority of battery-related EESAT papers dealt with the integration

of batteries in storage applications rather than battery technology itself. The session on advanced batteries therefore comprised just three papers. James Landi of Electro Energy Inc. discussed the progress made on his company's DOE-funded program to develop bipolar nickel-metal hydride batteries. The company has produced a number of high-voltage battery modules in both high-energy and high-power designs.

Showing that you can teach old dogs new tricks, Pat Moseley of the International Lead Zinc Research Organization discussed novel designs for valve-regulated lead-acid batteries used in high-rate partial-state-of-charge cycling applications in various hybrid vehicle designs. By modifying the negative active material and altering the plate geometry and position of the battery terminals it has been possible to demonstrate marked improvements in this type of operation.

Last in the session, Martha Schreiber of EN-o-DE detailed field test results on a 1-kW, 50-kWh vanadium redox flow battery used in a hybrid power system in Austria. This system, used to power a traffic display board, was able to achieve reasonable efficiencies with a daily depth or discharge of 8%.

Supercapacitors - from soup to nuts

The session on supercapacitors covered a full span of development activities, from proof-of-principle systems to production manufacturing. It also covered a range of technologies; in addition to supercapacitors, the session included lead acid batteries, and hybrid systems with hydraulic/pneumatic CAES. Tom Hund presented the latest life cycle testing data from a VRLA "Cyclon" battery at Sandia. We heard about system simulation of batteries and ultracapacitors in wind energy systems (VTT Processes), and the latest on the expansion of Power Systems Co. (formerly Okamura Laboratories) manufacturing facilities in Japan.

Some innovative concepts were presented by Sylvain Lemoufouet, a doctoral candidate at EPFL in Switzerland. Lemoufouet described two hybrid system

concepts with micro-CAES (pneumatic and hydraulic systems) coupled with supercapacitors and flywheels.

Alternative thinking generates storage possibilities

The Alternative Concepts session included three papers sharing 'out-of-the box' thinking. The jury is still out on whether these ideas will move off the drawing board, but the papers provided some mind-stretching possibilities.

John Halloran of Worcester, MA, described the Potential Energy Storage System, a concept in which energy would be stored in the weight and height of a residential or commercial building. The weight of the building would be supported by hydraulic cylinders, into which fluid could be pumped using off-peak power, raising the entire building. During peak periods, the weight of the building would push the fluid through turbines to generate power.

Dale Van Cor, Wichester, NH, explained the principals of operation behind the Delta Tandem Kinetic Battery, a proposed flywheel storage system that would allow a direct AC charge and discharge process at a fixed frequency. The concept consists of two flywheels with rotation rates kept at a fixed difference, each connected to planetary gear systems which are in turn dynamically connected to each other.

Paul Lieberman, Torrance, CA, talked about Lieberman Research Associates' experience in testing a Transportable Compressed Air Energy Storage (T-CAES) system, a system that stores energy as compressed air, and can convert it back into electricity without combustion.

Flywheels starting to take off

The session on flywheels provided more evidence that flywheel technology is maturing and approaching widespread commercialization. John Herbst from the University of Texas described the progress of demonstrating their 2-MW/130-kWh composite flywheel for locomotive propulsion applications, presenting the

status of testing and analysis. He expects the full scale test in early 2006. Octavio Solis from Vycon presented their plans for introducing a low cost steel flywheel for UPS ride-through and local power quality applications. They showed examples how their technology could help power requirements in light rail applications using regenerative braking and short term energy storage with flywheels.

Shuhei Kato from the Tokyo Institute of Technology showed an example of using a very low cost and simple flywheel based device to ride through very short (sub-second) power disturbances that resulted in high economic losses in Japan. Frank DeLattre reported on a Pentadyne's joint project with Liebert Corp where eight composite flywheels were ganged for a 750-kVA UPS for a hospital application. Performance data was shown that highlighted an impressive operating characteristic that the UPS continued to provide its support even when several flywheels were removed to simulate failure.

Phil Johnson reported on the status of the Boeing 5-kWh / 100-kW composite flywheel with their unique High Temperature Superconductive (HTS) passive bearing technology. The data showed the primary benefit of a very low loss bearing system

This session was very well attended and generated many spirited questions.

CAES shows it's not just hot (or cold) air

The Compressed Air Energy Storage (CAES) session provided highlights of this maturing technology with a focus on application and commercialization, utilizing off-the-shelf equipment and industry-accepted economic models.

Jeffery Greenblatt of Princeton University detailed extensive work on comparing CAES/wind farm integration economics with those of using conventional combustion turbines to stabilize wind farm generation capacity, as well as the use of combustion turbines alone. Results established specific ranges of natural gas pricing where each of these systems is commercially compelling, and

detailed the complementary value of CAES.

Michael Nakhamkin of Energy Systems and Power Consultants described maximizing the benefits of wind



Attendees gather outside the Beacon Power Smart Energy Matrix during the EESAT tour.

farms while increasing the capacity and flexibility of the power generation system by integrating three mature technologies. The elegant combination of an off-the-shelf compressor with underground air storage to augment a conventional gas turbine with air injection enables significant production cost reductions. This captures numerous benefits including the ability to dispatch wind power, independent of the immediate availability of the wind resource.

John Sears of Active Power presented a modular 90-kW hybrid system using exclusively commercially proven energy storage subsystems. These included compressed air and thermal storage for bulk energy dispatch and a flywheel for instantaneous power. The market for this system is lead-acid battery replacements for severe applications. Field test units began shipping in December 2004, and a pilot manufacturing line is scheduled for limited production in late 2005. Full production is scheduled for Q1, 2006.

Meeting includes DUIT tour

On the final day of the conference, EESAT attendees were treated to a private tour of the Distributed Utility Integration Test (DUIT) facility in San Ramon. DUIT is funded by the CEC and is sited within PG&E's Technical and Ecological Services facilities. With dual 230kV transmission feeds and an extensive selection of power equipment and circuits installed, the DUIT facility is the first full-scale, integration test of commercial-grade, utility grid interactive Distributed Energy Resources (DER) in the United States. It is the next step for emerging technologies in assuring safe, reliable, and cost-effective inclusion into the electric system to accelerate market acceptance. DUIT's goal is to advance the state of the art for integration practices and strategies, through a better understanding of the benefits and challenges associated with substantial penetration into the electric distribution system.

During the EESAT tour, the selection of technologies under evaluation included the exciting new Smart Energy Matrix from Beacon Power. This is a 100-kW precursor to the 1-MW array of flywheels integrated in a shipping container, and designed to provide generation and transmission support services. In addition, other systems under evaluation included 34 residential PV inverters from various suppliers, a 300-kVA diesel genset with advanced anti-islanding control algorithms, and two microturbines.

DOE Peer Review 2005

Directly following the three-day EESAT Conference, the Energy Storage Program within the Department of Energy hosted its annual Peer Review Meeting to present a number of key DOE projects not highlighted in the EESAT Conference. Garth Corey of SNL presented the work of Dr. Phil Symons in the highly successful ACONF project, demonstrating significant operational improvement of renewable generation system design in the field. Ben Norris of Norris Energy reviewed the field performance of the production NAS

BESS technology implementation by AEP. Dan Brown of SNL discussed Energy Storage Surety in the context of autonomous power systems for military bases. Ben Craft of West Mead Vaco reviewed the development of Lead Carbon Asymmetric Capacitors, and Dr. Debosmita Das of AEP presented an innovative concept for reducing the associated power electronics costs by utilizing off-the-shelf components for packaging and cooling requirements.

Dallas Marckx of Peregrine Power introduced the important Silicon Carbide development area with a strong emphasis on costs and reliability. He was followed by Kent Holst of Iowa Stored Energy Plant in a discussion of Wind/CAES compatibility in terms of dispatchability and the value of ancillary services. Satish Ranade of New Mexico State University presented her work on Laboratory Scale Transmission Systems modeling with Energy Storage. Yilu Liu of Virginia Tech discussed Distributed Energy Resource interactions between wind and storage systems. The final paper was presented by Jim Fiske of LaunchPoint Technologies, describing the exciting designs and opportunities for 3rd generation flywheels consisting of hub-less spinning rims, and their associated attractive cost projections.

Dr. Imre Gyuk, DOE's Program Manager for Energy Storage, wrapped up the session with his closing remarks, highlighting the bright and immediate prospects for Energy Storage.

Next EESAT meeting likely to move

In addition to the many conference papers there were plenty of opportunities to network with others in the energy storage community, and not just at the breaks. The welcoming reception on the Sunday evening was followed on Monday by an ESA-sponsored reception. The highlight of the social agenda, however, came on Tuesday evening when attendees were able to enjoy spectacular views of the San Francisco skyline and fine cuisine in the Carnelian Room atop the 52-floor Bank of America building. The dinner was complemented by superb Rosenblum wines supplied by ESA's Bill Hassenzahl.

After three successive EESAT conferences at San Francisco's Sir Francis Drake Hotel it is likely that EESAT 2007 will seek a new venue. As always, the ESA will provide support for the conference in its new location and will provide updates as new information emerges. ◀

About the ESA

Our Mission

To promote the development and commercialization of competitive and reliable energy storage delivery systems for use by electricity suppliers and their customers, thereby bringing financial and technical benefits for energy storage operators.

Membership Benefits

- ▶ Gain early knowledge of the latest developments in energy storage technology and field/customer applications of new/innovative storage technologies, and information on how these can be used for member's business advantage
- ▶ Early notification of upcoming business leads in US and abroad
- ▶ Enhanced exposure to potential customers for energy storage products and services
- ▶ Ability to network with users, manufacturers, and researchers in the energy storage field
- ▶ Access to ESA contact list of more than 800 names of industry leaders interested in energy storage
- ▶ Ability to actively interface with key representative from government and industry to receive insights into energy storage markets and strategic directions of key industrial firms

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