ECCE 2018 Plenary Peers Into Future Of New Energy Sources And Applications

by David G. Morrison, Editor, How2Power.com

When attendees gather this September in Portland, Oregon for the annual IEEE Energy Conversion Congress and Exposition (ECCE 2018), they will not only be discussing the latest developments in electrical and electromechanical energy conversion, they will also be marking the 10th anniversary of the conference. Since its inaugural event in 2009 in San Jose, which drew about 700 attendees, the conference has grown to nearly 1600 participants last year in Cincinnati. Similarly, the conference program has expanded over time with new sessions and activities added. However, this growth has occurred while maintaining the unique character of the conference.

In his message about ECCE 2018, this year's chair Avoki M. Omekanda, describes the elements which continue to set this conference apart:

"We bring together, a multi-disciplinary group of researchers, engineers, and scientists from all over the world to present and exchange break-through ideas relating to the energy conversion systems and technologies. ECCE is unique in our emphasis on integrated systems, presenting the best in applied integrated systems research together with innovations in individual energy conversion components."

These qualities, which will be reflected in this year's conference program as a whole (a preliminary version of which is available here), will also be in evidence in this year's plenary session. As the conference kicks off with this Monday morning session (Sept. 24), speakers representing different segments within the energy conversion field will address topics ranging from fuel cell-powered data centers to silicon carbide and GaN power semiconductors to ocean-powered energy sources and pod-based, high-speed transportation. This article provides a preview of these plenary talks and their presenters.

"Disruptive Facility Architectures With Fuel Cells And Load Side Integration"

Speaker: Sean M James, Director of Energy Research, Datacenter Advanced Development, Microsoft, Redmond, Wash.

Abstract: "*Deploying onsite generation is not a new concept and fuel cells systems are becoming an alternative to conventional power generation equipment. However, simply using fuel cells as an alternative to grid or standby generators does not begin to leverage the disruptive nature of this technology. Microsoft has been researching and testing a new architecture that integrates a simple VDC solid-oxide fuel cell (SOFC) system with a server rack. The benefits include cost savings and high efficiency but more importantly simplicity in design. We will review various architectures that can benefit many industries, not only the data center market."*

The work that James will be discussing at ECCE revolves around the use of fuel cells as the primary source of electrical power—rather than backup power—in a data center. This is a step away from existing centralized power architectures that rely on the power grid, yet must incorporate so much complexity to ensure resilience in the face of possible grid failures.

"The way data centers are built, they're engineered as if the grid is never available," says James who elaborates by saying there are standby generators, which even have their own back up generators and a fuel delivery system that allows refueling the generators while they're operating. "The only reason why data centers don't run off of their own generator plants is because the levelized cost of energy is so high."

However, placing fuel cell power sources at the rack level changes the whole data center power plant design. "We're able to simplify all of that electrical plant and reduce it almost to nothing basically and still get the service, the uptime that we need in terms of keeping the computers up and going."

In the proposed fuel cell-based architecture, the conventional backup power sources go away along with much of the complexity of power distribution and power conversion in the data center. This pays immediate dividends in terms of efficiency. As James notes, with the centralized, grid-based data center architecture, "on average there's about 33% electrical efficiency from the power plant to the point of load. With this [fuel cell] technology you can almost double that, getting above 50, almost 60 percent."

In the experiments done so far by James' group, natural gas is piped into the data center and routed directly to the fuel cells, which are at or near the server racks. The gas line itself is highly reliable (as proven by the already established natural gas infrastructure) and when there is a failure of a given fuel cell, it limits the loss to a single server rack, which is something data centers are already designed to handle.

The SOFC is the fuel cell of choice for this distributed resources approach because it can operate off of natural gas, which is readily available, unlike the PEM fuel cell, for example, which needs to run directly off of hydrogen. However, SOFCs are not strictly limited to natural gas as their fuel source. They could, if it's available, operate directly off hydrogen (rather than generating hydrogen as they do through a fuel reformer) or operate from any hydrocarbon such as diesel, methanol, biogas, waste gas, etc. So there's flexibility in this approach that may be important when it comes to choosing sites for the data centers.

This leads to another aspect of why a fuel-cell based approach is potentially disruptive. It has the capability to greatly simplify and speed up data center construction, while also making it possible to locate them in areas with limited electrical infrastructure. James notes that it's difficult to quantify some of these benefits because the fuel cell powered data center is "still too new. Nothing's been built at scale. But a significant portion of the construction schedule in a data center is associated with electrical. Even before the building gets built, there's a huge phase of preparing all of the underground utilities for electricity."

He adds that some areas where data centers are needed simply don't have the electrical capacity to support, for example, a 100+MW data center, and to make that possible with conventional data center architectures would require significant investment on the part of the local municipality. But with fuel cells "perhaps data centers could come and bring their own capacity. And just the way data centers are built there's always going to be excess capacity as well. So perhaps the datacenter could be providing... additional electrical capacity to the surrounding community. There are a lot of possibilities."

Note: The IEEE Industrial Applications Society recently started a Data Center subcommittee. This subcommittee will meet at 6:00 pm on Monday, Sept. 24 at ECCE as part of the co-located IAS Annual Meeting. For more on this meeting, contact please contact the subcommittee co-chairs Tom Johnson and Daleep Mohla.

Sean James runs Microsoft's data center research and development program within the Microsoft Cloud Infrastructure and Operations group. MCIO provides the foundational cloud infrastructure for over 1,000,000,000 customers, 20,000,000 businesses, 200+ Microsoft online services, in 90 markets. Sean drives new data center technology for Microsoft's next generation data centers including the evaluation, development, and testing.

Sean joined Microsoft in 2006 to manage one of Microsoft's data centers. Later, he joined the construction team and oversaw the design and building of new Microsoft data centers. Prior to joining Microsoft, Sean worked in data center management overseeing the day-to-day maintenance and repair operations for both IT hardware and critical infrastructure, such as electrical infrastructure and cooling equipment. Prior to that, Sean served in the U.S. Navy Submarine Fleet as an electrician.

Sean holds many patents related to data centers and energy, a computer science degree, and is a certified Project Management Professional from the Project Management Institute. He enjoys spending time with his family, guitar, and technology.

"SiC Power Device High Impact Applications And Path To Commercialization"

Speaker: Victor Veliadis, Deputy Executive Director and CTO, Power America, Raleigh, N.C.

Abstract: *In an increasingly electrified, technology driven world, power electronics is central to the entire manufacturing economy. Silicon (Si) power devices have dominated power electronics due to their low cost volume production, excellent starting material quality, ease of processing, and proven reliability. Although Si power devices continue to make significant progress, they are approaching their operational limits primarily due to their relatively low bandgap and critical electric field, which result in high conduction and switching losses, and poor high temperature performance.*

In this presentation, the favorable material properties of silicon carbide (SiC), which allow for highly efficient power devices with reduced form factor and relaxed cooling requirements, will be highlighted. Foundry considerations and cost reduction strategies will be outlined elucidating the path to the projected $1B SiC device market by 2022. SiC MOSFETs, which are currently being inserted in the majority of SiC-based power electronic systems, will be introduced from a power electronics user perspective.

Emphasis will be placed on high impact application opportunities, in which SiC devices are expected to displace their incumbent Si counterparts. These include variable frequency drives for efficient high-power electric motors at reduced overall system cost; automotive power electronics with reduced losses and relaxed cooling requirements; novel data center topologies with reduced cooling loads and higher efficiencies; "more electric aerospace" with weight, volume, and cooling system reductions contributing to energy savings; and more efficient, flexible, and reliable grid applications with reduced system footprint. The efforts of the PowerAmerica manufacturing Institute to bridge gaps in wide-bandgap power technology to enable manufacturing job creation and energy savings will also be discussed.

Veliadis adds that he will also highlight some of the successes for SiC in Power America applications.

Victor Veliadis is deputy executive director and CTO of Power America, which is a U.S Department of Energy wide-bandgap power electronics public-private Manufacturing Institute. Veliadis manages a five-year budget in excess of $140 million, distributed annually to over 35 industrial, university, and national-laboratory projects, to enable U.S. leadership in WBG power electronics manufacturing, work force development, job creation, and energy savings.

Veliadis is an IEEE Fellow, an IEEE EDS Distinguished Lecturer, and has 24 issued patents, three book chapters, and 108 peer-reviewed technical publications to his credit. He is also a professor in electrical and computer engineering at North Carolina State University. Veliadis earned the Ph.D. degree in electrical engineering from Johns Hopkins University in 1995. Prior to being named deputy director and CTO of Power America, Veliadis spent 21 years in the semiconductor industry where his work included design, fabrication, and testing of SiC SITs, JFETs, MOSFETs, thyristors, and JBS, Schottky, and PiN diodes.

"Power Semiconductors: Enabling A Powerful Decade Of Changes"

Speaker: Stephanie Watts Butler, Technology Innovation Architect, Texas Instruments, Dallas, Texas

Abstract: *The decade of ECCE has coincided with an unprecedented shift in technology for power generation, delivery, and conversion. This shift, coupled with the advent of smart phones and IOT, has enabled an explosive growth in electronification in industrial, consumer, and automotive markets. According to IC Insights, power management ICs ship in greater quantity than any other type of IC device. The resulting broad application corresponds with an impressive expansion in the features and capabilities of power semiconductors to address the vast scope of end equipment needs.*

This presentation will examine the changes in power management semiconductors over the past decade. Integration, system in package, voltage levels, and process technologies will be discussed. How different features are more necessary for different markets and applications will be considered. Finally, predictions for changes coming in the next decade will be provided.

According to Butler, the development of power management semiconductors has not simply followed historical trends in recent years. Instead, this field has "experienced disruptive change". As an example, she cites the improvements in power density, efficiency and form factor, which are being enabled in new ways, including the development of GaN power semiconductors.

"If changes were due to historical trends only, the traditional focus on decreasing dollars per watt ($/W) would have led to power density increases only enabled by historical scaling effects. However, entirely new end equipments, such as EV/HEV and factory automation, are driving radically higher performance requirements that only GaN can achieve. Synergistically, because a power IC like GaN exists, new levels of power density, efficiency, and form factor can be assumed to enable new markets," says Butler.

While her plenary talk will discuss broader trends in power management ICs, Butler will also discuss certain trends in energy conversion that are influencing their development and vice versa. For examples, trends toward electrification and what Butler calls "electronification" in electrical machines are "both a driver of power management ICs, as well as being enabled by power management ICs. "

Stephanie Watts Butler, Ph.D., P.E., is the technology innovation architect in High Voltage Power at Texas Instruments (TI), driving new high voltage and isolation technology innovations from concept to revenue by leading partnerships with TI's technology organizations, manufacturing sites, universities, and product development teams. She has produced innovations in the areas of control, process and package development, R&D management, and new product development. The result is power semiconductors that enable TI's customers to make smaller, lighter, and more energy efficient products.

Butler has authored more than 40 papers and 17 U.S. patents. She is the chair of JEDEC's JC-70 Wide Bandgap Committee, co-founder of GaNSPEC, and a fellow of the AVS. SWE honored Butler with their 2016 Lifetime Achievement Award and Business Insider named Butler to their most powerful female engineers list of 2017. Butler also serves on the TxGCP Champion Board and UT Austin Department of Chemical Engineering Advisory Council.

"Ocean Energy"

Speaker: Jason Busch, Executive Director, Pacific Ocean Energy Trust

Abstract: *The maritime sector consists of several well established markets, such as transportation, fishing, ocean observation/science, and conventional energy. Renewable energy has emerged as an important new sector that is not only a part of the "blue economy," it also undergirds many of the sectors that make up the blue economy. From energy utilities to aquaculture, port electrification to desalination, clean energy is a key component of economic growth, as well as decarbonizing existing industries.*

The Pacific Ocean Energy Trust (POET) and its previous iterations have been engaged in various aspects of marine renewable energy for over a decade. With a mission to promote the responsible development of marine renewable energy, POET has worked to advance marine renewable energy technologies toward commercialization. With over $14 million of funding from the state of Oregon, POET has funded technology R&D, environmental studies, stakeholder outreach, education, and policy development.

Worldwide, marine renewables are quickly tracking toward commercial viability. The question is not whether machines can be built to reliably extract energy from the ocean's winds, waves, and currents; the question is whether the levelized cost of energy (LCOE) of those machines are competitive with other sources of energy. Additionally, these technologies provide benefits not reflected in the LCOE, including resilience, environmental, and coastal economic development, as well as grid benefits.

The technologies themselves vary across sources and markets. Floating wind energy marries established wind technologies with oil and gas technologies, and is most promising for large utility projects. Tidal technologies reflect well established turbine technologies, as well as variations of helical and Archimedes screws. Predictable and backed by established OEMs, these technologies are already coming to market. Wave energy, perhaps the most promising in its flexibility and potential, is the last to converge and commercialize.

Jason Busch is executive director of POET, an organization that supports the responsible development of marine energy on the West Coast. He is also a co-chair of the Marine Energy Council, the national trade group for the marine hydrokinetic energy sector.

Busch is actively involved in both business and community organizations. He is on the Energy Trust of Oregon's Renewable Energy Advisory Committee, Oregon Department of Land Conservation and Development Territorial Sea Plan Rulemaking Project Committee, the Northwest National Marine Renewable Energy Center Advisory Council, and the Department of State Lands Rulemaking Advisory

Committee. He has multiple publications, including most recently a chapter in Climate Change Impacts on Ocean and Coastal Law, published by Oxford University Press.

Prior to joining Oregon Wave Energy Trust, Busch was principal at Sustainable Legal Solutions LLC, where he provided legal services specializing in renewable energy company start-ups and project development. Previously, he was an attorney for Ater Wynne and Stoel Rives in Portland, Oregon.

Busch holds a B.A. in political science from Texas A&M University and an M.A. in philosophy from the University of Southern Mississippi. He received a doctor of jurisprudence degree in 2006 from the University of Oregon School of Law, graduating with honors and admitted to the Order of the Coif.

"Hyperloop—Creating The Future Of Transportation"

Speaker: Jiaqi Liang, Director of Power Electronics, Virgin Hyperloop One, Los Angeles, Calif.

Abstract: *High speed transportation is one of the most exciting areas of research and development. Its advancement has and will continue to profoundly impact everyone's life on this planet. With speeds two to three times faster than high-speed rail, hyperloop can reduce a 300-km (180-mile) commute to under 20 minutes, smashing today's traditional commuting boundaries. Hyperloop can extend the range of autonomous urban mobility, providing an on-demand physical and digital backbone for connected vehicles.*

This talk will share Virgin Hyperloop One's vision and journey in engineering the first new mode of transport in 100 years, making high-speed transportation effortless and affordable. Advanced electromagnetic and electrical energy conversion systems are some of the key enabling components for hyperloop. We leveraged the latest computational and optimization tools to predict our system performance, iterate our designs with less time, and develop prototypes at much lower cost. Our full-scale DevLoop testing facility in Nevada is the only one of its kind in the world, allowing us to test and validate our prototypes at scale, and integrate various complex components and subsystems—all in the controlled environment of the tube. We will share some of our latest design and results from the DevLoop systems.

Jiaqi Liang is the director of power electronics at Los Angeles–based Virgin Hyperloop One. He is responsible for engineering hyperloop's power electronics and energy systems. He was part of the technical core team to deliver the first multi-megawatt linear propulsion subsystem test in early 2016 and the full-scale integrated hyperloop system test in 2017 at VHO's Nevada test site.

Prior to joining Hyperloop One, Jiaqi worked at ABB as a power electronics scientist and R&D project leader. He coinvented more than 10 patents, and coauthored more than 30 technical papers. Jiaqi obtained his bachelor's degree in electrical engineering from Tsinghua University in Beijing, China, and the M.S. and Ph.D. degrees in electrical engineering from Georgia Institute of Technology in Atlanta, Georgia.

For more information on the ECCE conference, see How2Power.com's special ECCE section and see the ECCE 2018 conference website.