INTRODUCTORY INFORMATION

Welcome

The IEEE Power & Energy Society (PES) is proud to be holding its 2017 General Meeting in Chicago, IL USA. The technical program theme of ***"Energizing a More Secure, Resilient & Adaptable Grid "*** will provide a platform to offer new insights, innovative ideas and answers to some of the most intriguing and important questions facing the power industry today.

The Local Organizing Committee, PES Technical Committees and the General Meeting Coordinating Committee welcome colleagues and friends from all facets of the industry and corners of the world to a valuable technical program, productive committee meetings and exciting networking opportunities.

Our Thanks

PES gratefully acknowledges the support of the 2017 General Meeting's host utility, ComEd and of all our other generous meeting contributors.

Conference Overview

Below is a brief overview of the conference and meeting schedule and a description of each element of the meeting. The descriptions are in approximately the same order as they occur during the meeting.

Note: Attire for the conference is business casual. No denim jeans or shorts in the technical sessions or committee meetings, please.

CONFERENCE LOCATION

The 2017 General Meeting will be held at the Sheraton Grand Chicago Hotel, Chicago, IL USA.

CONFERENCE SCHEDULE AT A GLANCE: A quick overview of the meeting in chronological order. Detailed description of the events listed can be found elsewhere in the program.

Note: A limited number of sessions and events (in particular, some committee meeting) may fall outside this schedule.

Tutorials, Technical and Leisure/Companion Tours and Evening Events, Student, Industry and Faculty Luncheon, and Awards Dinner are optional activities with limited capacities; they require an additional fee and tickets for admittance. Plain Talk courses are co-located with the General Meeting, and require a separate registration rather than General Meeting registration. See the General Meeting Registration page for more information about the Plain Talk courses http://www.pes-gm.org/2017/

Day	Time	Event/Sessions
Sunday	All Day	Registration/Information
		Committee Meetings, Tutorials*
	PM	Companion Tour*
	PM	New Attendees Orientation *(3:00 PM)*
	4:00 PM	IEEE PES Scholarship Plus Reception
	Evening	Welcome Reception
Monday	All Day	Registration/Information
		Companion Lounge for registered companions and registered children
	AM	Attendee and Presenter Breakfasts; Companion Breakfast
		PES Members Meeting *(8:00-9:00AM)*
		Plenary Session *(9:00-11:00AM)*
		Companion Tour*
	11 AM	Committee Meetings start
	PM	Committee Meetings, Technical Sessions, Technical Tours*, Companion Tour* Tutorials*
	Evening	Committee Poster Sessions, Fellows Reception, Candidates Meet-and-Greet (all co-located) *(5:00-8:00 PM)*
Tuesday	All Day	Registration/Information
		Super Sessions, Committee Meetings, Technical Sessions
		Plain Talk Course *(co-located event, separate registration required)*
		Companion Lounge Program for registered companions and registered children
	AM	Student Poster Contest and Attendee Breakfast *(co-located with the Student Poster Contest)*; Presenter Breakfast; Companion Breakfast, Companion Tour*
	PM	Technical Tour*, Companion Tour*
	Evening	Awards Dinner and Ceremony *(7:00-9:30PM)*
Wednesday	All Day	Registration/Information
		Committee Meetings, Tutorials*, Technical Sessions
		Plain Talk Course (co-located event, separate registration required)
		Companion Lounge Program for registered companions and registered children
	AM	Attendee and Presenter Breakfasts; Companion Breakfast
		Companion Tours*
	Noon	Student / Industry / Faculty Luncheon – *Ticket required*
	1:30 PM	Student / Industry / Faculty Job Fair
	PM	Technical Tour*
	Evening	IEEE PES Women in Power Networking Reception; Young Professionals Seminar and Networking Reception
Thursday	All Day	Registration/Information (until 12pm)
		Committee Meetings, Technical Sessions, Tutorials*
		Plain Talk Course (co-located event, separate registration required)
	AM	Attendee and Presenter Breakfasts; Companion Breakfast

		Companion Lounge Program for registered companions and registered children (until 12pm)
Friday	All Day	Committee Meeting

*Indicates an additional registration feel is required for this event / session.

REGISTRATION AND INFORMATION -

Sheraton Grand Hotel – Ballroom Promenade, 4thd Floor

Sunday, 16 July	*10:00AM - 8:00PM*
Monday, 17 July-Tuesday, 18 July	*6:30AM - 7:00PM*
Wednesday, 19 July	*6:30AM - 4:00PM*
Thursday, 01 July	*6:30AM – 12:00PM*

All attendees are required to register for the 2017 General Meeting and pay the appropriate fee in order to participate in any aspect of the meeting.

At the registration counters, you may pick up your advance registration packets, register on-site, purchase tickets for luncheons or companion and evening events (depending on availability), ask questions at both the registration and information counters.

Conference Proceedings: All registrants for the technical program will be able to download a copy of the conference proceedings from a secure web site. Or, if when registering you indicated you wanted a copy of the proceedings on a USB stick, you can pick that up at registration. You must indicate you want the proceedings on USB stick when registering for the conference in order to receive it on USB stick. Information on downloading the proceedings will be sent via the registration when the proceedings are available.

INCLUDED WITH REGISTRATION -

Attendee registration fees include: Continental breakfasts Monday-Thursday, Welcome Reception Sunday evening, full technical session and committee meeting program (including the Poster Session and Reception on Monday evening, and Student Poster Contest on Tuesday morning), the conference proceedings either via download or USB stick, the opportunity to participate in any of the available optional events open exclusively to registrants at the prevailing registrant rate.

Companion and Children registration fees include: Continental breakfasts Monday-Thursday in the Companion Lounge, welcome reception on Sunday evening, Poster Session and Reception/ Fellows Reception on Monday evening, companion lounge Monday-Thursday, the opportunity to participate in companion tours and any of the other available optional events open to registered companions at the prevailing registered companion rate. Companions are not admitted to technical session nor do they receive a copy of the proceedings. *Note: Registered children must be accompanied by a registered companion when in the companion lounge or participating in any conference activities, including tours.*

The Companion Lounge is located in the Sheraton Grand Hotel.

Student registration fees include: Continental breakfasts Monday-Thursday, welcome reception Sunday evening, full technical session and committee meeting program (including the poster session and co-located receptions on Monday evening and the Student Poster Contest

on Tuesday morning), the conference proceedings either via download or USB stick, participation in any program elements designed exclusively for students. If you wish to attend the Student/Industry/Faculty Luncheon on Wednesday, you must purchase a ticket for the luncheon. Plus optional events open to registrants at the prevailing registrant rate.

IN AND AROUND THE REGISTRATION AREA

PES-Related Displays: Tables with literature and with materials about PES and IEEE membership, programs, publications and future meetings.
Information Booth: Staffed by local volunteers, you can obtain information about the meeting, the venue and the Denver area from knowledgeable people.
Message Center: A bulletin board where you can find last-minute changes to the meeting program or room assignments, and leave written messages for other attendees.

NEW ATTENDEES ORIENTATION SESSION

Sunday, 16 July 3:00PM - 4:00PM

A short orientation session will familiarize first-time attendees with PES and the PES General Meeting. Session will provide an understanding of the various types of technical sessions, committee meetings, tutorials, technical tours, and social events. At the end of the session, the newcomer should be able to navigate confidently through the General Meeting and obtain maximum value from the experience. Session will include a question and answer period.

WELCOME RECEPTION

Sunday, 16 July 5:00PM-8:00PM Navy Pier

Take this opportunity to renew old acquaintances and meet more members of the power and energy community. You are invited to enjoy a complimentary hors d'oeuvre buffet and a cash bar. Photo ID will be required to purchase alcoholic beverages
Name badges are required. You will not be allowed to the Welcome Reception without it.

ATTENDEE BREAKFASTS

Monday,17 July 6:30AM – 7:45AM Sheraton Grand Chicago Hotel

Tuesday, 18 July 7:00AM – 9:30AM Sheraton Grand Chicago Hotel

Wednesday, 19 July 6:30AM – 8:30AM Sheraton Grand Chicago Hotel

Thursday, 20 July 6:30AM-8:30AM Sheraton Grand Chicago Hotel

Complimentary continental breakfasts for all conference registrants will be available Monday through Thursday. Note that a general breakfast is not offered on days other than these.

PRESENTERS BREAKFASTS

Monday, 17 July 6:30AM – 7:45AM – Sheraton Grand Chicago Hotel
Tuesday, 18 July 6:30AM – 8:30AM – Sheraton Grand Chicago Hotel
Wednesday, 19 July 6:30AM – 8:30AM – Sheraton Grand Chicago Hotel
Thursday, 20 July 6:30AM – 8:30AM – Sheraton Grand Chicago Hotel

Presenters must attend a special breakfast on the day of their sessions where final plans for the session at which they will present will be made. See additional information in the "Information for Presenters" section of this program.

PES MEMBERS MEETING

Monday, 17 July *8:00AM - 9:00AM*

PES President, Damir Novosel, will update the membership on various PES activities. Candidates for the office of PES President Elect, PES Treasurer and PES Secretary will speak. (*Meet the candidates face-to-face at a reception that will be co-located with the Monday Night Poster Session Location to be announced, 5:00PM-8:00 PM, Monday, 17 July.)*

PLENARY SESSION - LOC

Monday, 17 July *9:00AM - 11:00AM* *Sheraton Grand Chicago Hotel*

PES President Damir Novosel will moderate the Plenary Session which begins immediately following the PES Members Meeting

COMMITTEE MEETINGS

Most administrative and technical committee meetings are scheduled from Monday 11:00AM (following the Plenary Session) through Friday morning. Some additional committee meetings are scheduled on Sunday, 16 July. See the Committee Meeting section of the program for details. Last minute updates to the program will be posted on the message board in the Registration area as well as via push notifications for those who will be using mobile app.

TECHNICAL SESSIONS AND OTHER TECHNICAL EVENTS

See the "Technical Session and Other Events" section of the program for a complete listing and description of all technical sessions. Descriptions include an abstract of each event and papers presented during each session. Last minute updates to this program will be posted in the Registration area as well as via push notifications for those who will be using mobile app. Technical meetings are planned for Monday afternoon and evening and all day Tuesday, Wednesday and Thursday. The following types of sessions are scheduled:

Super Sessions: a series of presentations in composite sessions designed to fully explore topics from different perspectives. Experts from several PES technical committees will address subjects that are of significant interest to the profession:

- Late Breaking News
- Extreme Events and Grid Resiliency
- Energy Storage
- Cyber and Physical Security
- Distributed Generation (DG) Regulation, Engineering, Modeling, and Impacts

Panel Sessions: Invited papers on a wide variety of noteworthy subjects.

Transactions Paper Sessions: Presentation of high quality IEEE PES Transactions papers on many issues of significance to energy and power professionals.

***Paper Forums*:** Multiple authors present brief overviews of their quality papers followed by time for a discussion with the individual author(s) of your choice.

***Poster Session*:** A Monday evening special event with hundreds of authors representing all aspects of the industry, each presenting a poster version of his/her paper. Enjoy hot and cold hors d'oeuvres and refreshing beverages as you browse the posters and discuss the papers one-on-one with their authors.

Student Poster Contest: The Student Poster Contest will be held in conjunction with the Tuesday morning attendee breakfast (on 19 July) in the *Exhibit Hall D, Hynes Convention Center*

***Tutorials*:** Thirteen tutorials will be presented during the meeting. Classes are taught by top professionals in the field. Earn PDHs and CEUs for your attendance (see below for an explanation of PDHs and CEUs). Full or one-day conference registration plus an additional fee is required in order to attend any of these courses. For complete information about the tutorials including pricing, information about the instructors and schedule, see the Tutorial section of the program in the pages that follow, or the GM website. Tickets may be purchased at the Registration desk if seats remain. The tutorials are:
— Surge Protection of Power Systems According to IEEE C62.22
— Energy Storage: An introduction to Technologies, Applications and Best Practices— Energy Storage
— Shunt Compensation for Transmission – Principles, Planning, Operational Experience & Future Trend
— Smart Inverters for Distributed Generators
— Planning and Integration of Flexible HVDC Into Today's Grid
— Synchrophasors Estimation and Control of Power System Dynamics
— Smart Grid 308 – Distributed Energy Resources
— IEEE 1547 Standard for Interconnecting Distributed Energy Resources with Electric Power Systems
— Design and Implementation of Microgrids in Modern Power Systems
— Industry Best Practices, Needs, and Challenges in Cascading Analysis: Tutorial and Training
— Managing Uncertainties in the Future Grid: Evolution of EMS Control Centers - Synchrophasor Solution
-Distribution Automation/Management Systems and Integration with DERs and Microgrids
-Cybersecurity of the Electric Power Transmission and Distribution System

Technical Tours*:** Four half-day inspection trips are offered. Registration is permitted through 11 July only. No on-site technical tour registration is available****.* Valid photo ID must be presented at the beginning of each tour. See the Technical Tour section of the program for descriptions and details of each tour.

MONDAY NIGHT POSTER SESSION and RECEPTION
Monday, 17 July *5:00PM-8:00PM* *Sheraton Grand Chicago Hotel*

(co-located with the Fellows' Reception, the Meet the Candidates Reception and an opportunity to meet the donors who have contributed to the PES Scholarship Plus program)

A popular feature of the PES General Meeting technical program is the Poster Session, where papers from each represented committee and all topics will be presented. A complimentary hors d'oeuvre buffet will be served and cash bar will be available. Attendee or Companion badges are required for entrance to the Poster Session; Photo ID will be required to purchase alcoholic beverages at the bar. (*The Student Poster Contest will be held Tuesday morning, 7:30AM - 9:00AM, during which an Attendees' Breakfast will be available.)*

CANDIDATES MEET & GREET RECEPTION

Monday, 17 July 5:00PM-8:00PM Sheraton Grand Chicago Hotel
(co-located with the Poster Session and New Fellows Reception)
The PES candidates for the President-Elect, Secretary and Treasurer will each make a short presentation of his/her views for the Society and IEEE so you can make an informed decision when you vote during this year's election.

NEW FELLOWS RECEPTION

Monday, 17 July 5:00PM-8:00PM Sheraton Grand Chicago Hotel
(co-located with the Poster Session, Candidates Reception)
As part of PES's recognition of extraordinary achievements in the technical and professional fields of energy and power, during the reception held in their honor you are cordially invited to stop in and congratulate the IEEE Fellows elected to the class of 2017 who are members of PES.

SCHOLARSHIP PLUS RECEPTION

Monday, 17 July 5:00PM-8:00PM Sheraton Grand Chicago Hotel
(co-located with the Poster Session, Candidates Reception and New Fellows Reception)
Meet the individuals who will help shape the future of the Power Industry and congratulate them on being selected as IEEE PES Scholars.

STUDENT POSTER CONTEST –

Tuesday, 18 July 7:00AM-9:30AM Sheraton Grand Chicago Hotel
(co-located with Attendee Breakfast)
Take this opportunity to see the work done by hundreds of the top students in our field. Plan to spend some time discussing topics of mutual interest with the participants.

AWARDS CEREMONY AND BANQUET

Tuesday, 18 July 7:00PM—9:30PM
Sheraton Grand Chicago Hotel
US$80/$85
Join us for a banquet dinner where IEEE and PES award winners are honored for their outstanding achievements. Vegetarian/vegan meals are available upon request. Seating is limited. This is a ticketed event. You may purchase tickets on-site at the Registration Desk if there are seats remaining. A cash bar serving beer and wine will open at 6:30 pm and be available thru dinner. Photo ID will be required to purchase alcoholic beverages.

STUDENT PROGRAM

An exciting student program for IEEE PES Student Members includes a Poster Contest, and the Student/Industry/Faculty luncheon (ticket required) as well as the Student/Industry/Faculty Job Fair. Student members are invited to participate in all other aspects of the General Meeting as well. After registering for the General Meeting, students may visit http://www.pes-gm.org/2016/ for more information about the program. Students must be prepared to verify their status by providing their ID and IEEE Membership number when picking up their registration packets on-site.

STUDENT / INDUSTRY / FACULTY LUNCHEON

Wednesday, 19 July 12:00PM-1:30PM Sheraton Grand Chicago Hotel

US$40/45;
Students US$20 $25;

***Student/Industry/Faculty Luncheon*:** Attend a luncheon designed to bring together students, industry representatives and faculty advisors. The recipients of the IEEE PES Student Prize Paper Award in Honor of T. Burke Hayes and the recipients of the Student Poster Contest will be recognized. This is s ticketed event. All meeting registrants are invited to purchase tickets and join the luncheon as long as there are seats remaining. Seating is limited.

STUDENT / INDUSTRY / FACULTY Job Fair

Wednesday, 19 July 1:30PM- 3:00PM Sheraton Grand Chicago Hotel

International Job Fair for Students: Employers and university graduates and undergraduates can participate in an International Job Fair for Students following the luncheon. This job fair will provide a forum for employers and students who share a common interest in the power and energy industry to meet and discuss career opportunities. It enables one-to-one conversations between company engineers or recruitment professionals and students who will soon be in the job market. Students will sit with a potential employer during lunch. Students may circulate among recruiting tables for further conversations. Doors will open following the conclusion of the Luncheon.

NETWORKING RECEPTION - Hosted by PES and IEEE PES WiP (Women in Power) COMMITTEE

Wednesday, July 19 5:00PM – 6:30PM Sheraton Grand Chicago Hotel

All registered attendees are invited to this complimentary informal reception held to encourage networking between industry, government and university participants. This year, an exciting new format is being introduced. From 5:00PM – 6:30PM, interact with one or more of the woman successful in the power industry who has been invited to share experiences and wisdom with those attending the reception. There will be plenty of opportunity to network with other attendees at the reception as well. Light refreshments will be provided.

YOUNG PROFESSIONALS - SEMINAR AND RECEPTION

Wednesday, July 19 6:00PM – 7:30PM Sheraton Grand Chicago Hotel

The Young Professionals reception and seminar provides an opportunity for all conference attendees, in particular, current students and engineers that have graduated within the last ten years to network, meet officers of IEEE PES, and to make contacts among their peers in the Power & Energy community. Find out how you can contribute to PES and how it can help you.

All registered attendees are invited. Light refreshments will be provided. A 20 minute seminar will begin at 6:45PM.

COMPANION ACTIVITIES

Access to the activities described below is limited to registered companions and registered children in the company of a registered companion.

Registered companions and children are invited to mingle and relax in the Companion Hospitality Lounge, located in the *Sheraton Grand Chicago Hotel*,. The lounge will be open
Sunday 12:00PM - 5:00PM
Monday through Wednesday, 7:00AM - 5:00PM
Thursday 7:00AM – 12:00PM

Complimentary breakfast will be served Monday through Thursday, 7:00AM -9:30AM.

Many fun activities are being planned for the lounge. Please check on-site in the lounge for more details and activity sign-up.

COMPANION TOURS

A full program of optional tours has been planned for registered companions.

PLAIN TALK ABOUT THE ELECTRIC POWER SYSTEM FOR POWER INDUSTRY PROFESSIONALS

IEEE PES PLAIN TALK courses for the power industry professional will help you to understand technical aspects of the electric power industry, even if you do not have an engineering background. You will gain insights into the concerns of engineers, the demands of regulators and consumer groups, and the factors and trends that impact the operation of today's electric power systems. These courses are also appropriate for new engineers to the industry, or for engineers in other fields who are transitioning to the electric power industry. These courses aim to increase your understanding of the electric power system by providing you with practical knowledge that you can use as you work in or with this important industry.

IEEE PES PLAIN TALK courses are co-located events rather than parts of the General Meeting, and thus, conference registration is not required to attend these courses. The fee to register for the courses on-site is US$2,150 for three courses, US$1,510 for two courses and US$795 for a single course. (If you register on or before 27 June, prices are lower. See the Plain Talk web page noted below for specifics.) The course fee includes continental breakfast, lunch and all course materials. Breakfast and registration: 7:30AM – 8:00AM. Courses start promptly at 8:00AM. You may register on-site if seats are available.

Information and Registration can be found at: http://www.ieee-pes.org/plain-talk-in-chicago-il-2017

Power System Basics – Understanding the Electric Utility Operation Inside and Out

Tuesday 18 July *8:00AM - 5:00PM*

The focus of this course is to provide a fundamental foundation in electric power systems, from basic formulas to the planning, operations, and equipment involved in generating, transmitting, and distributing electric power. Basic electrical terminology will be explained in simple to understand language with regard to design, construction, operation and maintenance of power plants, substations and transmission and distribution lines. Topics covered in the course include an introduction to the fundamentals and basic formulas of electricity as well as the equipment involved in the electric power system. An overview of generation, substations, transmission, distribution, and utilization is provided. Protection, reliable operation, and safety are among the topics covered.
Instructor: William J. Ackerman

Distribution System – Delivering Power to the Customer
Wednesday, 19 July *8:00AM - 5:00PM*

(Prerequisite for this course is Power System Basics or a familiarity with basic formulas and power system equipment.)

The focus of this course is to provide attendees with an overview of the issues associated with the planning, engineering, design, operation, and automation of electrical distribution systems. Types of distribution systems and network circuits, as well as engineering issues related to distribution systems will be explored. New concepts in the design, challenges, and operation of smart grid will be addressed. This course is intended for those who are not familiar with the delivery of electricity to the end user.

Topics covered in the course include an introduction to the types of distribution systems, issues associated with distribution planning such as outages and reliability, distribution engineering considerations relating to radial and secondary networks, and distribution automation. The course also provides an overview of electrical distribution operations, including the roles of utility personnel, construction and maintenance considerations, and trends in the industry. Smart grid and its impact on the distribution system will be explored.

Instructors: Joseph L. Koepfinger and Maurice Ney

Transmission System – The Interconnected Bulk Electric System
Thursday, 20 July *8:00AM - 5:00PM*

(Prerequisite for this course is Power System Basics or a familiarity with basic formulas and power system equipment.)

The focus of this course is to provide participants with knowledge of how electric power is transferred from generation sources to distribution systems via the interconnected electric bulk power system known as “the grid.” Basic physical laws governing the grid will be introduced, as well as the regulatory agencies involved in its governance. The great blackouts will be explored. This course is intended to increase participant’s understanding of the electric grid and how it functions in the electric power system. Topics covered in the course include an introduction to

the fundamental concepts of power, energy, and power system stability as they relate to the grid. The grid is explored in terms of its interconnections, power flow, North American interconnections, and governing bodies such as NERC/ERO, ISOs, and RTOs. Reliability standards and contingency analysis are addressed. Issues related to the planning and operation of the grid, such as transmission and economic constraints, determining transmission transfer capability, and dealing with congestion are reviewed. The course also discusses the great blackouts, their root causes, and lessons learned.

Instructor: Robert W. Waldele

TECHNICAL PROGRAM INFORMATION

INFORMATION FOR PRESENTERS

Presenter/Chair Breakfasts

All presenters, panelists and session chairs MUST meet at breakfast the day of their session(s) to discuss session arrangements. Attendance is required. All presenters should have received e-mails providing the dates of their sessions and breakfasts.

Presenter Breakfasts

Monday, 18 July 6:30AM – 7:45AM – Sheraton Grand Chicago Hotel
Tuesday, 19 July 6:30AM – 8:30AM – Sheraton Grand Chicago Hotel
Wednesday, 20 July 6:30AM – 8:30AM –Sheraton Grand Chicago Hotel
Thursday, 21 July 6:30AM – 8:30AM – Sheraton Grand Chicago Hotel

AUDIO-VISUAL EQUIPMENT AND PRESENTERS PREPARATION ROOM

Technical Session rooms will be equipped with an LCD projector and screen, power and extension cords, podium, microphone if appropriate, and a wireless mouse. Speakers who wish to use a computer during their presentations are required to provide their own laptop computers and are responsible for ensuring compatibility with on-site equipment.

Committee meeting rooms will be equipped with a screen, and power and extension cords. ***No projector or computer will be provided.*** Arrangements, including payment via credit card, for any additional audio-visual equipment you wish to rent from the meeting's AV provider must be made in advance.

The Presenters Prep Room, located in the *Sheraton Grand Chicago Hotel*, will be equipped with an LCD projector with the same specifications and compatibility as those in the Technical Session rooms. The equipment is provided to allow presenters to become familiar with, and to ensure that, their laptop computers are compatible with on-site equipment provided. Please check at the Information Booth or Paper Sales area for exact location, hours and access.

PDHs AND CEUs FOR ATTENDEES

Continuing Education Units (CEUs) offered by IEEE

A Continuing Education Unit (CEU) is ten contact hours of participation in an organized continuing education experience under responsible, qualified direction and instruction. A unit generally consists of courses of study that refresh, update and enhance knowledge, skills and experience of professional personnel. Any course that offers CEUs which is presented by an IEEE entity has been reviewed and approved according to standards set by IEEE. All registered students who complete an IEEE course offering CEUs will receive a certificate via email from the IEEE attesting to the CEUS earned by the attendee.

It is up to each student to determine if a specific course or program fills the needs of the discipline or certifying body for which the CEUs are intended.

Professional Development Hours (PDHs)

Continuing professional education for licensed engineers is measured in Professional Development Hours (PDH). A PDH is one contact hour of instruction or presentation. Currently, approximately thirty states mandate Professional Development Hours to maintain P.E. licensure, each with varying requirements. CEUs readily translate into PDHs (1CEU=10 PDHs), though PDHs do not convert automatically to CEUs.

The licensee is responsible for maintaining records to be used to support PDH credits claimed. PES does not track this information. Unlike the procedure for CEUs, courses are not pre-approved by the IEEE for PDHs.

At many PES meetings, forms are readily available that can be completed by attendees of any session and signed by the session chair to verify attendance. The completed forms are held by each attendee. They are not submitted to IEEE. It is up to each licensee to provide the forms to the certifying body or employer, and to determine if a specific course or program fills the needs of the discipline or certifying body and/or employer for which the PDHs are intended.

TECHNICAL TOURS

Technical tours are a unique element of the PES General Meeting technical program.

TUTORIALS

Meeting registration plus an additional fee is required to attend any of these courses. Earn CEUs and PDHs for your attendance. You may register on-site if seats are available.

Surge Protection of Power Systems According to IEEE C62.22

Date *Sunday July 16, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructor *Jonathan Woodworth, ArresterWorks*

This tutorial focuses on the application of surge arresters to AC power systems above 1000 volts. It introduces the subject with examples of best practices in Distribution, Transmission, and Substations applications. It also covers the basic AC system fundamentals as they apply to arresters and basic Arrester Fundamentals as they apply to applications.

A detailed overview of how to select the proper arrester rating is covered and includes real world examples. The tutorial is targeted toward engineers with some power systems knowledge, but even the novice can understand the selection method.

Energy Storage: An introduction to Technologies, Applications and Best Practices

Date *Sunday July 16, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructors *Dr. Hamid Zareipour, University of Calgary; Dr. Sudipta Lahiri, Distributed Energy Resources, DNV GL Energy; Dr. Michael Klinberg, Senior Consultant – Energy Advisory, DNV GL – Energy; Dr. Ramteen Sioshansi, the Ohio State University*

Energy storage is becoming an attractive solution for today's smart grid, either being operated independently as asset or interacting with other resources like wind/solar generation or demand response. This tutorial is a full-day course which will provide participants a solid understanding of the basics and the state-of-the-art energy storage application, its implications on the grid's reliability and the system's economics and how-to on evaluating its performance and cost-benefit. Instructors with diverse backgrounds on this subject will bring the field deployment experience of energy storage applications and real-world examples to demonstrate the analytic tools used in assisting utility planning and operation decisions. The course is suitable for non-technical, as well as technical audiences, including regulatory, legislative, and utility staff members.

Shunt Compensation for Transmission – Principles, Planning, Operational Experience & Future Trend

Date *Sunday July 16, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructors *Ben Mehraban, AEP; David Langne, Siemen; Geza Joos, McGill; Anders Bostrom, ABB; Paul Marken, GE; Sep Boshoff, PSD Consulting; Joe Warner, ABB; Mikael Halone, ABB*

AC transmission systems make use of shunt compensation to maximize transmission capacity and ensure power system stability. The retirement of older generation, changes in configuration of existing transmission and the integration of distributed energy resources pose challenges that require new planning approaches and compensation equipment. This tutorial presents principles of available technology, planning approaches for deployment and a comparative evaluation of existing and newly available solutions. Both steady-state and dynamic operation are presented. Uses and specifications of shunt devices for existing and newer applications are also illustrated. These include static var compensators, voltage sourced converters, mechanically switched shunts, hybrid solutions of the above, and synchronous condensers.

Smart Inverters for Distributed Generators

Date *Sunday July 16, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructors *Babak Enayati,National Grid; Tom Key,EPRI; Michael Coddington,NREL; Richard Bravo, Southern California Edison (SCE); John Berdner, Enphase Energy; Rajiv K. Varma, The University of Western Ontario*

Different countries are setting up ambitious targets of PV solar based Distributed Generators (DGs) installations. However, the integration of PV based DGs has led to several challenges, mitigation of which typically require expensive compensating and protection equipment, as well as complex network management strategies.

DG inverters primarily produce real power at unity power factor. However, power electronics has now made it possible for inverters to perform multiple functions for grid support, in addition to real power generation. Such inverters are termed Smart Inverters as they are capable of effectively minimizing several grid integration challenges of DGs without additional equipment. Recognizing the significant potential of smart inverter technology, utilities across the globe are actively considering implementation of smart inverters.

The technology of smart inverters is i) new, ii) rapidly evolving, and iii) has outpaced the technical regulations and standards which are needed to allow its implementation. Different PV interconnection and testing standards around the world are being revised

to allow the different features of smart inverters to be implemented. US DOE, EPRI, NREL are testing and demonstrating the smart inverter technologies on several pilot projects.

This IEEE Tutorial on Smart Inverters is being proposed to present a comprehensive and structured knowledge on the need, functions, operation and protection, integration and testing standards, system studies of benefits, demonstration projects and actual installations of this new technology. This Tutorial will be very helpful for academics, utilities, practicing engineers, consultants, system operators and planners, DG developers, and inverter manufacturers for understanding the various facets of this technology and to fully exploit its vast capabilities in their T&D grids.

Planning and Integration of Flexible HVDC Into Today's Grid

Date *Sunday July 16, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructors *Michael I. Henderson, NE ISO; dr. Simon Teeuwsen, Siemens PTI; Prof. dr. Rajiv Varma, UWO; Prof. dr. Dirk Van Hertem, KU Leuven; dr. Stefanie Kuenzel, Imperial College London; dr. Tarek Adel-Galil, SNC Lavalin; dr. Bernd Klöckl, Tennet; Dale Osborn, MISO; Prof dr Kyeon Hur, Yonsei University*

The evolving planning process requires competitively solicited projects that efficiently and creatively use limited rights-of-way. In addition, renewable resources from remote locations must be successfully integrated with the system. High voltage direct current (HVDC) provides a viable option to transfer large amounts of power across long distances in an environmentally friendly manner.

This tutorial provides system planners with an understanding of how HVDC applications can reliably and economically improve the system. The tutorial reviews the planning process and discusses the studies necessary for considering HVDC technologies. Attendees will understand: the role of HVDC in the grid of the future; a planner's perspective of basic HVDC technologies; and the technical issues that must be properly considered and addressed to successfully plan, implement, and operate an HVDC project. System interactions of new HVDC assets with the existing AC transmission system are specifically addressed. Case studies of HVDC plans providing reliable and economic service are presented as well as the how and why HVDC overlay networks can be successfully planned. The advantages and disadvantages of state-of-the-art HVDC technologies are discussed.

The focus lies on HVDC for grid development, rather than HVDC technology.

Synchrophasors Estimation and Control of Power System Dynamics

Date *Sunday July 16, 8:00 am-12:00 pm*

Price *Early Bird $195, Regular $240; Student Early Bird $50, Student Regular $75*

Instructors *Dr. Esmaeil Ghahremani, Institut de recherche d'Hydro-Québec (IREQ); Prof. Innocent Kamwa, Institut de recherche d'Hydro-Québec (IREQ); Prof. Bikash C. Pal, Imperial College London; Dr. Abhinav Kumar Singh, Imperial College London*

Power system operates under quasi stationary states. Any random disturbance in a power system (such as a fault) triggers dynamic response of the system. Most of the times response settle to a stable equilibrium, sometimes experiences oscillations which are electromechanical in nature. These oscillations in the past grew in magnitude within few seconds when were not controlled in time, resulted in wide-scale blackouts in many instances. These oscillations are global in nature and in order to control them dynamically and adaptively, the operating state of the whole system needs to be estimated in real-time, with estimation update rates which are in time scales of 100 milliseconds or less. This fast estimation of operating state is known as dynamic state estimation (DSE), and the control methods based on dynamic estimation are referred to as estimation-based control methods. In the literature research efforts are appearing employing various techniques such as various approaches of Kalman filtering. In the absence of any books, IEEE report, standard, there is growing need from the community to understand these methods. This tutorial will demonstrate the necessity and applicability of such methods and algorithms of estimation and control, and would explain the theory used in the development of these methods/algorithms.

Smart Grid 308 – Distributed Energy Resources

Date *Sunday July 16, 1:00 pm-5:00 pm*

Price *Early Bird $195, Regular $240; Student Early Bird $50, Student Regular $75*

Instructor *Doug Houseman, EnerNex*

This tutorial will cover the following topics:

- Overview of DER and its components
- Understanding variable generation issues
- Limits to DER implementation in a conventional distribution grid
- Interconnect and other standards for DER
- Engineering considerations for DER planning and approval
- Issues in customer owned DER (e.g. maintenance, overrides, etc)

Who should attend:

- Anyone who is interested in Distribution level DER, its impact on the grid and limits in the distribution grid today.

IEEE 1547 Standard for Interconnecting Distributed Energy Resources with Electric Power Systems

Date *Monday July 17, 1:00 pm-5:00 pm*

Price *Early Bird $195, Regular $240; Student Early Bird $50, Student Regular $75*

Instructors *David Narang, NREL; Babak Enayati, National Grid; Jens Boemer, EPRI; Leo Casey, Google; Mark Siira, Comrent; Sudipta Chakraborty, NREL; Charlie Vartanian, MEPPI*

This tutorial will introduce the IEEE 1547 "Standard for Interconnecting Distributed Energy Resources with Electric Power Systems."

Due to the increasing amount of Distributed Energy Resources (DERs) interconnections with the Electric Power System, the IEEE 1547 standard is going through a major revision to address some of the technical issues associated with high penetration of DERs i.e. grid support functionalities, etc.

The participants will learn about the major changes to the IEEE 1547 i. e. voltage regulation, response to abnormal system conditions (including voltage and frequency ride through), power quality, islanding, interoperability, etc.

The participants will also learn about the utility concerns/solutions to adopt the revised IEEE 1547 standard.

Design and Implementation of Microgrids in Modern Power Systems

Date *Wednesday July 19, 8:00 am-12:00 pm*

Price *Early Bird $195, Regular $240; Student Early Bird $50, Student Regular $75*

Instructors Michael Higginson, P.E., S&C Electric Company; Saeed Kamalinia, Ph.D., S&C; Paul Pabst, P.E., S&C

This tutorial introduces the concepts, fundamental theories, practical design process, and applications of various types of microgrids. The course is intended for engineers,

researchers, and industry managers who want to learn more about latest developments of microgrid technologies as well as the design and implementation of microgrid systems. Participants will learn several aspects of the engineering design and analytical studies required for successful integration of modern microgrids. Initial discussion will cover the definition and objectives of microgrids, the current market, challenges and barriers of microgrid development, and real world experiences with microgrid projects will be presented. Engineering challenges will be discussed, including selection and integration of Distributed Energy Resources (DERs), microgrid protection, communication systems, and control hierarchy.

The workshop will also include an overview of actual industrial-scale microgrids commissioned by S&C engineers and group exercises for better understanding of the concepts and processes. One project is the recipient of *2015 Smart Grid Project of the Year award from Power magazine*.

Industry Best Practices, Needs, and Challenges in Cascading Analysis: Tutorial and Training

Date *Wednesday July 19, 8:00 am-12:00 pm*

Price *Early Bird $195, Regular $240; Student Early Bird $50, Student Regular $75*

Instructors *Emanuel Bernabeu, PJM Interconnection; Doug Bowman, Southwest Power Pool; Robert Cummings, NERC; Charles Lawrence, American Transmission Co.; Milorad Papic, Idaho Power Company; Marianna Vaiman; V&R Energy*

Security and safety of a power system network are fundamental aspects of electric utility operation. As the security issues related to the power industry become more critical, the challenge of maintaining secure operation of bulk power systems is growing. The utilities and regional organizations should be able to assess quickly an outcome of a larger impact on the transmission network. Major blackouts are frequently caused by cascading outages. Since cascading outages may have such a wide-spread effect, NERC, under its transmission planning standards requires analyses of cascading events. This tutorial developed by the IEEE Cascading Failure Working Group addresses industry best practices in assessment of cascading outages as a part of NERC compliance studies. This half-day tutorial pioneers hands-on training as a part of the tutorial. It includes training on performing cascading studies to comply with NERC TPL-001-4 and CIP-014-2 standards. The attendees are encouraged to bring their laptops with them to run the studies, or they will be able to observe computations performed by instructors. The tutorial covers industry experience in preparing to the NERC audit and NERC perspective on performing cascading analysis under transmission planning standards. This tutorial, taught by a team of experts from industry, is intended for power system engineers, regulators, transmission owners, power engineering students, and academics.

Managing Uncertainties in the Future Grid: Evolution of EMS Control Centers - Synchrophasor Solution

Date *Wednesday July 19, 1:00 pm-5:00 pm*

Price *Early Bird $195, Regular $240; Student Early Bird $50, Student Regular $75*

Instructor *Jay Giri, GE Grid Solutions*

Managing the future grid will require creative, innovative solutions. This is because of uncertainties being introduced by the growth of less predictable & reliable renewable generation resources, demand response programs, distributed generation, microgrids, potential cyber-security issues and the aging infrastructure. Energy Management Systems (EMS) have been deployed for decades at utility control centers to manage the electricity grid in real-time. Today these EMS capabilities are poised to be enhanced quite dramatically with growth of synchrophasor PMU measurements. Solutions to decentralize management of the grid are also being introduced – these include Distribution Management Systems, Substation Automation and advances in grid control devices. These new solutions will help us manage the uncertainties and challenges of the future smart grid.

This presentation will describe:

- The history and evolution of the EMS from its digital genesis in the 1970's.
- The primary functions of a modern EMS
- Emerging new industry drivers & emerging new technology trends
- Impact of growth of microgrids, renewables and distributed generation on the EMS
- Growth of Phasor Measurement Units (PMUs) and synchrophasor measurements worldwide
- Wide area monitoring (WAMS) and wide area control (WAMPAC) solutions
- Modern advanced fast-acting grid control devices

Concluding thoughts on the challenges and opportunities to manage the future grid

Distribution Automation/Management Systems and Integration with DERs and Microgrids

Date *Thursday July 20, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructors *Dr. Jiyuan Fan, Southern States LLC; John D. McDonald, P.E, GE Energy Connections – Grid Solutions*

This course introduces the intuitive concepts, fundamental theories, practical technologies on distribution system modeling, automation management, including the core functionalities and real use cases of the Distribution Automation and Management Systems (DA/DMS) and the advanced applications in Smart Distribution, as well as the integration with Distributed Energy Resources (DERs) and Microgrids. The potential audience would include power system planning/operation engineers, project/product managers, business leaders in power utilities, smart grid solution providers, system developers, research institutes, as well as individual researchers, college students and other individuals working on or interested in the Smart Distribution Solutions. The course will cover the following break-down topics: Overall Framework and Architecture of DA/DMS Systems in Smart Distribution, Distribution System Modeling for automation and management, Static and Dynamic Data for DA/DMS, Advanced Real-time and Analytic Applications in DMS, DMS integration with other systems (OMS, AMI, DRM) in Smart Distribution, Advanced DMS in integration with DERs through DERMS (Distributed Energy Resource Management) and integration with Microgrids, including DERs/Microgrids connection and disconnection to/from the Distribution Grid; and New Trends in ADMS Development.

<u>Cybersecurity of the Electric Power Transmission and Distribution System</u>

Date *Thursday July 20, 8:00 am-5:00 pm*

Price *Early Bird $295, Regular $395; Student Early Bird $100, Student Regular $150*

Instructors *Dr. Murty V.V.S. Yalla, Beckwith Electric Co., Inc.; Steven A. Kunsman, ABB; Dr. Nathan Wallace, Ampirical; Scott R. Mix, NERC; J. Matt Cole, Sargent and Lundy*

Cyber-attack on an Electric Power T&D communications system can have a devastating impact and cause widespread power outages as evident from the Dec 2015 cyber-attack on a Ukrainian Electric Power Distribution System. Securing Electric Power System from cyber-attacks is of national importance and in North America NERC is spearheading the effort in developing and enforcing Critical Infrastructure Protection (CIP) Standards for Bulk Electric System (BES). Local and state regulating agencies are also looking at cybersecurity of the Electric Power Distribution Systems.

Substation protection, automation and control systems along with distribution field devices have changed significantly in the past decade. These systems have become more interconnected and provide end users with much more information to allow for

higher reliability and greater levels of control. Interoperability between different vendor products and systems has been achieved using open standards. This change in technology has not only brought huge benefits from an operational point of view, it also permits to address cyber security issues similar to other traditional, enterprise systems which have been facing the same industry challenges for years.

The tutorial discusses cybersecurity basics including passwords & access management, authentication, encryption, network security monitoring, techniques in cyber alarming, logging, and auditing. The tutorial also covers NERC CIP requirements applicable to T&D systems along with brief overview of IEEE and IEC standards. Cybersecurity implementation examples of substation protection, automation and controls systems including devices inside as well as outside the substations are also discussed. Utility perspective on Cybersecurity and NERC CIP compliance will be included.