New Education and Healthcare (E&H) Facilities Committee*

Power Services and Distribution, Infrastructure Systems, and Electro-technology Systems

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Abstract: A new committee* under the Industrial and Commercial Power Systems (I&CPS) Department of the Industry Applications Society (IAS) received approval at the October 2014 IAS Annual Meeting, in Vancouver. This committee will be dedicated to the special needs and characteristics of the Educational and Healthcare segments of the US and World economies. For example, these two segments of the US economy, alone, annually spend $60 billion on electrical and telecommunication systems; yet, these two segments are either underrepresented, or not represented at all, in most electrical engineering forums, code writing, and/or standards writing institutions.

This committee was formed to address many of these largely unmet electrically needs of the Educational and Healthcare segments of the economy. This committee will provide a venue for the exchange of ideas among E&H colleagues about safety, sustainability and Total Cost of Ownership; allow for the creation and approval of needed new IEEE standards or recommended practices; and/or the revisions of existing codes to better reflect the special needs of the Education and Healthcare communities.

* *While this paper refers to this new group as a 'Committee', in actuality for the foreseeable future, it is organized as a sub-committee of the Power Engineering Committee of I&CPS*

Index Terms: Education, colleges, universities, K-12 schools, facilities, building codes, safety codes, health care, Total Cost of Ownership

I. INTRODUCTION

The US and many other economies have moved from a mainly manufacturing one to one that is more of a service economy. Two of this service economy's major components are the Educational and the Healthcare (E&H) industries. The buildings that support these two industries – K-12 schools, technical schools, community colleges, research universities and academic healthcare centers -- are the largest non-residential construction market in the United States [1].

This committee seeks to expand the participation of, professionals from the facilities operations, maintenance, and engineering staffs of these two facility classes. It will also target manufacturers, suppliers, as well as professional engineers and consultants who specialize in these facility classes in this market. Many manufacturers and architectural consultants with engineering staffs not only have electrical power engineers but those engineers are further broken down into institutional markets such as education and health care. There is good reason for this:

***Education**:* The education industry comprises about 7 percent of US Gross Domestic Product [2]. It includes all venues of learning run by public, private, parochial and other institutions such as state agencies and federal military academies. In the US alone there are approximately 13,925 school districts, 98, 916 K-12 public schools, 3200 4-year degree-granting institutions and 1100 community colleges [3].

Under the colleges and universities classification are community colleges, technical schools, and fine-arts academies that have only a few buildings supplied individually by the public utility. Also included are the larger campuses with hundreds of buildings used for instructional, administrative, research, athletic, medical, energy, information and computer technology (ICT) and many other needs. Some of these campuses are large enough to be considered a medium sized city; at least in terms of infrastructure. The University of Michigan in Ann Arbor, for example, has a 250 MVA distribution system across 6-square-miles; with a 60 MW power plant nested within the DTE Energy public utility system that generates about 300 million kilowatt-hours of the University's own electricity for about 150 buildings in the Central Campus area.

Healthcare: The healthcare industry comprises about 17 percent of US Gross Domestic Product [4]. There are 5686 hospitals in the US [5] and, of these, there are approximately 140 university-affiliated health care systems that combine teaching, medical research and clinical delivery [6]. These facilities can range from single provider offices, to group-practice offices, to urgent care, imaging and other single purpose facilities,

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all the way to multi-purpose out-patient and in-patient facilities.

A significant portion of these larger facilities are the university-affiliated hospital campuses with many buildings similar to government facilities such as the Centers for Disease Control, Tennessee Valley Authority, Brookhaven National Laboratories and military bases. We intend to focus a significant portion of our attention on these university-affiliated health care complexes because of the linkage they have with the main teaching campus; the sharing of power systems, of telecommunication systems, and management which all move closely together.

All healthcare facilities, of course, have special needs compared to other commercial facilities, especially the needs of larger outpatient and especially in-patient facilities. A case in point of these special needs is the need for reliable and clean power as defined in National Electrical Code (NEC) Section 517 [7].

Of all of these classes of healthcare facilities having the need for reliable and clean power, the needs for this quality power often seems highest at university-affiliated hospital campuses. The reasons for this, among others, are that these facilities are often the 'place of last resort' for the most seriously ill patients; and/or these facilities are designated as regional; trauma or pandemic facilities. These facilities also often carry a larger than average 'brand risk' – related in large part to their affiliation with their University's Medical School. Examples of these complexes include the medical centers at Harvard, UCLA, Michigan, Cincinnati, Texas, and many others.

Taken together, education and health care industries comprise about 25 percent of economic activity in the US. The facilities-only component, which includes *all building disciplines*, has over \$300 billion annual spend. This includes construction, energy, maintenance and operations, security, and related facility administration [8]. At this rate the spend is twice the annual sales of General Electric though, since power and ICT spend is only about 20 percent of the \$300 billion, the work of the E&H committee would influence about \$60 billion of electro-technology spend annually [9].

Demographers are now calling college towns "Knowledge Metros" because they are among the fastest growing towns in the US [10][11]. Campuses are the near-perfect study unit for cities of the future. They contain the majority of occupancy types found in most cities. College towns have a population that is eager to contribute to the Green Agenda and often have specific characteristics in their infrastructure that increases the likelihood that these Green Agenda concepts can be proven and be scaled upward. Academics seeking grants can study in their own backyard as the Illinois Institute of Technology has done with its pilot of "The Perfect Power System" [12]. The University of California San Diego has received significant funding for electrical storage capacity in its district energy plant [13]. Princeton University's district energy plant held forth during Hurricane Sandy, likely avoiding millions in losses to federal research projects.. Another system would be the High Reliability Distribution System developed and implemented for the University of California at Santa Barbara as reported by the Galvin Project [14]. The University of Michigan's Central Power Plant provided 9 MW of power to the University of Michigan Hospitals during the August 2003 North American major regional contingency, saving lives. During the same outage the University also provided a safe haven of light for the entire city of Ann Arbor; supporting the claim that E&H professionals will have an increasing role in the energy security of campus communities as US distributed resource ambitions are realized.

The prospect of *massive online open courses* (MOOC) is a noteworthy complication for the traditional teaching mission of the education industry [15]. MOOC's will be an important consideration in the expansion and/or contraction of square-footage under management but the net effect will only be known in the fullness of time. Given that MOOCs are already present we assume that MOOCs will continue to present challenges in campus telecommunications systems -- both within building premises and outside plant. Many larger universities are running *de-facto* telecommunications utilities at the same scale they are running power utilities with their district energy plants. Many universities have global outreach programs that require a high degree of power and ICT reliability for off-site teaching and research enterprises.

II. ADVANTAGES OF THE NEW COMMITTEE

The IAS Society, I&CPS Department, the standards writing activities related to the 3000 Standards Collection (Color Book replacement project) and other projects (PAR's), as well as the I&CPS Annual Conference, all need to increase membership and/or participation. A broadening discussion among E&H membership about technical topics will likely elicit ideas about how we should develop our recommend practice documents up to date but also form the core of working groups necessary for developing new consensus documents for this industry.

We are beginning to see power engineering programs forming, or re-forming, in many universities that gave them up years ago. This renewed interest, in part, is related the challenges of distributed generation, micro-grids, sustainable energy and the like – all subjects being dealt with in I&CPS. Students who might have previously considered a career in business or finance in the job markets of the past may be drawn to engineering profession and our particular mission. The E&H committee intends to tool up to receive these

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students and nurture their interest; supported by other IEEE initiatives such as the *IEEE Power & Energy Society Scholarship Plus Initiative.* Often it is the university power system that university students come into contact with. They may be included to do "capstone" projects at least on the university's own power system or on a research project of a faculty member.

Neither the private, nor the public sector, has the resources or inclination to participate in I&CPS activities as we are currently configured, targeted and named. This is confirmed by the dwindling conference attendance; nor does the career trajectory of E&H professionals support attendance to our activities. The new E&H committee should make all of this easier. Specifically:

1. The E&H name will provide the kind of visibility that private and public sector professionals need to explain to their management why they need to travel to meetings. Electrical engineers in the institutional divisions of A/E firms can meet with clients in E&H facilities; and vice-versa.
2. These same professionals will be welcomed to present a paper, attending an appropriate seminar, or work on a standard. With the increased political visibility of this committee participants might move into higher paying, financial and/or policy making positions. This would set some foundation for more policy makers with electrical engineering skill and that would be good for our national political life.
3. The E&H committee can be made visible to academia even before the student graduates. For example, a student's faculty sponsor may pair up with the university's business unit to study a specific characteristic of the university's power or telecommunications system.

Please note that in no respect will this committee in any way try to reverse the many industrial power systems or industry specific standards and traditions which seem to have worked and continue to work well. We will draw inspiration from other industry-specific committees such as the cement, petroleum and chemical, metals, mining, and pulp and paper departments [16].

III. TECHNICAL CONCEPTS

In broad terms – as far as safety concerned -- the work of the campus power distribution engineer is work that straddles two worlds:

- The world of the NFPA 70-suite of consensus documents which govern building premises wiring – typically low voltage feeders, branch circuits, telecommunications and life safety circuitry [17][18][19]. In the E&H industry the bulk of economy activity involves renovations to lighting, HVAC systems and supply circuits to end-use equipment such as elevators, special clinical equipment and sometimes generators and UPS systems. The inspection authorities with whom he must collaborate typically will have no authority for anything that happens outside the building or upstream from the point of common coupling with the utility.

- The world of the National Electrical Safety Code (NESC) [20] which sets safety standards for power supply systems outside the building even if the entire land mass of the campus medium voltage system is regarded as "premise" wiring by the local electrical inspector.. The NESC also covers both underground and overhead; community lighting systems, and telecommunications cabling. (Customer owned overhead wiring is common in agricultural colleges and universities).

The NEC and NESC engineering "cultures" are different in many ways; largely owing to the safety issues inherent in the voltages within their scope. The E&H engineer must be proficient in both. Not only that, s/he may have a district energy plant to run that supplies power to all the buildings you would expect in a city: administrative offices, classrooms, libraries, hospitals, clinics, athletic facilities (often well-known facilities), residential housing, an innumerable number of outlying buildings in different parts of the world; thereby requiring the E&H engineer to be sensitive to the electrical standards in other jurisdictions.

A number of questions about campus power systems have already begun to accumulate:

1. Impedance grounded power systems have been in use since the earliest days of the power industry. They continue to be used in industries where reliability and safety are essential to the mission. They are permitted in section 250.36 of the National Electrical Code and have been found to work well at the University of Washington and the University of California Berkeley. So what do we need to do to migrate their application on our educational and health care campuses?
2. The cost of a second service to a hospital is usually a significant incremental cost. How do we apply Failure Mode and Effects Criticality Analysis to fairly compare the cost of investing more in a second service versus investing more in our district energy plant?
3. If our steam load is not sufficient to carry the entire electrical load should we install more load shedding equipment at the power house to hold the bus or should we install backup power at individual buildings?
4. Where a district energy system is the primary source of power the NFPA codes permit use of a perimeter utility as a "backup power" source. Should we be supplying more of our emergency systems from the perimeter utility?

5. How do I rank my power reliability numbers against the reliability of my peer institutions? IEEE 1394 [21] is a guide for utility distribution reliability but there is no equivalent for campus district energy systems even though the topic of reliability ranks high on the agenda of organizations such as the International District Energy Association [22].
6. How can I make renovations less disruptive, and more effective, functionally and financially?

If we are successful the foregoing list will grow. Of particular interest is the multi-discipline engineer who must wear "many hats" in a school district, community college or small university. S/he may be in charge of everything: the utility contract, the fire alarm systems, elevators, generators, fuel cells, UPS systems and maybe an experimental fuel cell. S/he will find a professional home, and shared expertise, with global leaders in the E&H committee that we visualize.

IV. OTHER ORGANIZATIONS

Apart from the National Fire Protection Association, whose fire safety concerns were the basis for the NEC, there are other organizations claiming ownership of electrical concepts in E&H campuses:

1. The National Electrical and Medical Imaging Manufacturer Association (NEMA) develops standards for motors, roadway lighting, and now campus security [23]. It is now the US Technical Advisory Group Secretariat for IEC sYC Smart Energy Committee [24]
2. The Illumination Engineering Society of North America (IESNA) sets benchmarks for illumination models and power consumption for education and healthcare facilities and public safety [25].
3. The American Society of Heating and Refrigeration Engineers (ASHRAE) develops consensus documents for lighting and motor power and now data centers [26].
4. The American Society of Mechanical Engineers (ASME) develops standards for generators, elevators and now risk analysis methods for educational institutions [27].
5. The Building Industry Consulting Services International (BICSI) now develops design and standards for telecommunications, information and computer technology for educational facilities [28].

Most of these topics deal with electrical technology in educational and health care setting and, arguably, should have been standardized by electrical professionals in the IEEE all along. While we cannot change the past we can prepare the E&H engineer from this point forward. The top of the agenda should be to drive the relevance of the new 3000 Standard Collection into all of the documents developed by organizations on the foregoing list [29]. Either I&CPS does it or another organization will. There is a great deal of "scope creep" among ANSI accredited standards developers. Many of them are reaching out into surprising technical areas.

V. E&H CAMPUSES AND SMART GRID

Much of what is being celebrated in the trade press and energy policy literature as "microgrid" or "smart grid" is just a new name for systems that have been in place for decades – cogeneration plants run in parallel with a utility with supervisory signaling between the two. In the case of the University of Michigan; its "microgrid" has been in place for one hundred years. Because the transformation of campus power systems is seen to contribute to national energy policy goals, to present a significant new revenue stream for the private sector, and to present research funding opportunities for academic experts, the electrical professionals on the facilities side of the education industry will need a forum to discuss standard of care, benchmarks and economics with his counterparts. Green activists will be promoting glossier power system models without quite knowing technical specifics or understanding why it is unwise to build a new system upon old inefficiencies under the care of the E&H professional. The E&H member may bring a practical outlook to inform speculative initiatives about the wise use of public money. That outlook may suggest that the school, college, university or hospital may be able to net at least as much value-add in Total Cost of Ownership gain by doing the simple things (like maintenance) better. For example, s/he may ask:

1. Before we go too far with smart grid how much incremental improvement can we net by simply expanding existing building automation systems to manage load? While faster status update speeds with smaller, interactive sources and with storage and bi-directional information flow is nice on paper, are we not doing the bulk of demand control already? We might already be getting to 80% of whatever Smart Grid achieves by simply doing better maintenance or working harder to change occupant behavior. Where do I find others who are knowledgeable about the tipping point at which it is more cost effective to start a new power delivery platform versus making incremental improvements on the one already in place?
2. Before we go too far with smart grid should we not ask ourselves why our service transformers are so oversized to begin with? We should first wring out all wasteful behaviors before we overlay a new supply chain platform. For example, in the business occupancies that are most common in higher education the majority of 1000 kVA service transformers owned by the institution could be re-

sized at 500/667 kVA thereby making the service safer, smaller, less wasteful.

3. The building internal distribution transformers, typically 480/208V, are also oversized; in most cases significantly so. Like the service substations that supplies them the over-specification of building feeder systems leads to waste heat, unnecessary flash hazard, oversized HVAC units, and material waste throughout the building [30][31].
4. Before we go too far with smart grid should ask why we need so many on-site generators in a small area to begin with? The standard one-generator-per-building approach is not the optimal way of providing life safety backup power when there is a reliable district energy plant and a reliable perimeter utility. When we use aluminum wiring for long standby feeder runs we have opportunities for reducing the number of on-site generators by up to 20 percent, thereby advancing our industry's ambition to reduce greenhouse gas emissions [32].
5. Before we go too far with smart grid on our larger campuses should we not compare its value-add against investment in smarter switchgear architectures, arc-resistant buses, switchgear maintenance and load shedding schemes of the central generating system? When aluminum medium voltage cabling is used, as it is used in most public utility underground systems, the cost of running "service feeders" to buildings of the same load class is much less expensive; thereby permitting the ranking of feeder priorities in load shedding schemes and presenting the same "self-healing" possibilities as more expensive smart grid solutions.
6. Before we go too far with smart grid we should ask why we have so many medium voltage substations to begin with? Most buildings on E&H campuses run in the 5 watt per square foot range. More of these buildings could be supplied between one another at low voltage thereby putting downward pressure on the number of medium voltage feeders at the utility service switchgear.
7. Before we go too far with smart grid are we sure that the privacy issues of E&H campuses have been resolved?

Doing simple things well will be high on the agenda of the E&H committee we visualize; so will data gathering and analysis. Our job is to support the primary educational mission of the institutions who employ us. Becoming the global authority for campus power system information will help us in meet this objective.

VI. REACTING TO SIMILAR ORGANIZATIONS AND SUPPLIERS

Finally, we believe this committee is necessary because nearly twenty years of effort to get education industry trade associations to support electrical engineers have not been successful [33]. There are good reasons for this:

- There are twenty five core non-profit trade associations that service the US education and health care facilities industry. Nearly every branch of an organization chart of the typical college or university has a trade association. All of them think that the other trade association should be supporting electrical professionals; but not them.
- All of them find so much financial success in the "gathering place" business model for middle managers and executive directors that they see relatively little revenue to be gained in supporting engineers of any discipline.

Therefore I&CPS will grow again if it can provide a platform for experience exchange and career development in this large industry. We would like to see the E&H electrical professional carry that competencies he learned in the E&H meetings between organizations as his/her career progresses. In the US alone the number of electrical engineers working full time on electrical systems in the education and health care industry runs in the range of 1,000 to 10,000. Because of the size of the industry and the prospective pool of expertise, recruiting organizations will likely be interested in the talent pool among E&H members. Conversely, the E&H committee can provide networking opportunities for practitioners that will lead their next career move and refinement in engineering skill and judgment.

VII. CONCLUSION

The leadership of the E&H committee will focus primarily on getting new members; not taking members from existing committees. We hope to build closer associations with the top university academic and healthcare departments

The next generation of engineers will be savvy in social media and it is not too early to start reaching out to the next generation of ICPS engineers on platforms like Facebook, LinkedIn, Twitter, Google Hangouts, Wordpress, etc. Necessarily, there will be more social interaction on a near 7 x 24 basis. The next generation of electrical engineers will think of being on-line all the time as completely natural and so should the EHE committee be. The committee has a working web site: http://sites.ieee.org/icps-ehe/. Teleconferences have been held globally twice a month since October 2014; aimed at identifying problems, getting them solved, writing papers and presenting them to the industry at large.

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He has been employed at the University of Michigan since 1982 where he began as Plant Operations first full-time electrical engineer; guiding the growth of the UM system from 60 MVA to 120 MVA until 2001. He and co-author, James R. Harvey, designed and built the 10 MVA intertie between the UM Central and Hospital campus for Y2K that was ultimately used during the August 2003 North American major regional contingency that saved lives at University Hospital. After Y2K he began to transition into technical standards development and regulatory advocacy where he now works full-time. The web site for this work is linked here: http://standards.plantops.umich.edu/.

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He is chair of the Power Systems Design sub-committee, of the Power System Engineering (PSE) Committee. The PSE Committee is a part of the Industrial and Commercial Power Systems Department, of the Industrial Applications Society of IEEE. Most recently he assisted in the formation of a new committee, under I&CPS, directed at the Educational and Healthcare communities

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