Part 1: By the Numbers IEEE I&CPS 10-Year Montreal

(Abstract) | Prezi

V3.22 References, Bibliography, Footnotes

10 min intro | 20 min summary | 25 min discussion | 5 min outro

Part 1: By the Numbers

In any highly regulated industry – one that presents the largest non-residential building construction market in the world [1] – technical and management standards developed by ANSI accredited organizations such as the IEEE, ASHRAE, NFPA, etc. govern nearly everything – either voluntarily, or when such standards are incorporated by reference into public law.

ANSI Essential Requirements [2.0] assures that standards are developed by a balance of experts in the field, leveraging specialized knowledge that government agencies generally lack. While incorporating voluntary consensus standards into public law leverages expertise, saves costs, and aligns regulations with industry practices, it simultaneously raises concerns about accessibility, democratic accountability, and influence of for-profit entities. Balancing these factors requires careful consideration, such as ensuring public access to standards and maintaining robust oversight in the incorporation process.

An enduring characteristic of the standards development system in every domain and in every nation is the paucity of identified "user" interests. IEEE itself identifies itself as a user-interest, representing the public at large and is, by design, set against the opposing producer and enforcement interests. Manufacturer, labor insurance, inspection and installation interests all have a way to finance their participation in the global standards system – by billing expert time and travel into the price of their product or service. Alas, the user interest does not. Organizations such as ASTM International and Underwriters Laboratories go the extra mile to support the user-interest within their charter and their means but with limited success if you read the roster of technical committee membership.

This condition is described in more detail in the Standards Michigan ABOUT and conveyed it is logo; with the grayscale pillar representing the weakness of the user-interest. The obscurity of the user interest in facility design, construction and operation satisfies the criteria for obscurity that is ideal for academic study and enlightenment.

Not since the Higher Education Facilities Act of 1963 [x] has the US education industry has undergone such dramatic change. The run to excess of the education industry in recent years is well documented. Headlines speak for themselves.

This paper explains the inspiration of this subcommittee and how it found opportunities in those standards to make all US educational facilities safer, simpler, lower-cost and longer-lasting. It explains why continued collaboration with IEEE IAS has been effective and benefits students, faculty administrators, the supporting public and families

The start date for this discussion begins February 1983 – one hundred sixty-years after the founding of the University of Michigan in 1817; and about sixteen years after the formation of the Industrial Applications Society in 1967. The Education & Healthcare Facilities Sub Committee was formed under the Energy Systems Committee in 2014 and has since met bi-weekly online and presented at every conference since. Approximately XXX online sessions 4x per month in US and European time zones and two sessions per year at general conferences.

Working Vocabulary:

Industry. The education sector in any nation is a vast economic ecosystem that is simultaneously an "industry" and a "culture". In the U.S. alone, public K-12 education spending exceeds $700 billion annually, with higher education adding another $300 billion; not including the 150-odd medical research and clinical delivery enterprises domiciled on US campuses.

As a culture, education is a cornerstone of human development, transmitting knowledge, norms, and critical thinking across generations. It fosters identity, creativity, and civic responsibility, embedding values like collaboration and curiosity through classrooms, extracurriculars, and peer interactions. Schools reflect neighborhoods where young people learn academics in beautiful spaces [Plato], art, literature, and social movements.

Education's cultural roots ensure it remains a public good, while its industrial scale demands efficiency and adaptability. Together, they shape young people into informed citizens and skilled workers, reflecting society's values and economic ambitions in a dynamic, evolving system.

[BvC] We default to use of the word "industry" to reflect similar dollar cost considerations as for-profit entities. The assertive advocacy we undertake on behalf of the user-interest in the United States Standards Strategy is not unlike retaining a law firm to represent said interest in commenting on proposed regulations or interpreting standards that already exist.

We use the admittedly unprosaic term – "code writers and vote getters" – as a rhetorical device to emphasize that standards-making is not purely technical but economic and political. Standards setting requires productive relationships with incumbent interests.

[ABOUT]

Settlement. To account for the full span of real assets that support K-12 schools, community colleges, large university fundamental research and healthcare delivery centers we use the term "settlement" to capture the aspect of land ownership, typically embedded within a larger city, town or village. The term "settlement" evokes a defined, organized community established on a specific territory, historically associated with colonies or towns. School districts are widely scattered buildings; though the physical scale of higher education infrastructure, governance, and societal functions are much larger. US campuses, particularly those of large universities or colleges, can be considered a "settlement" when they occupy significant real estate due to their self-contained, community-like characteristics and their role as semi-autonomous hubs of social, economic, and cultural activity. The term "settlement" evokes a defined, organized community

established on a specific territory, historically associated with colonies or towns. Campuses fit this analogy through their physical scale, infrastructure, governance, and societal functions.

[STD]

University.

In US colleges and universities, business units devoted to physical properties (often called Facilities Management, Campus Operations, or Physical Plant) and units that are academically and research-oriented (such as academic departments, colleges, or research institutes) serve distinct but complementary roles. Their differences stem from their primary functions, goals, operational focus, staffing, funding, and interaction with the campus community. The Business and Finance Division is a non-academic unit servicing the entire Ann Arbor campuses. It has undergone organizational changes and includes design, construction, operations and maintenance. There is working similarity with the University of Michigan's facility and operations units and other universities with co-mingled enterprises. Our use of the term should be understood in context.\

Detroit Edison & Michigan Bell. Each of these organizations changed mightily during the span of time in this history. Detroit Edison, founded in 1903, was the primary electric utility serving Southeast Michigan, including Detroit, for most of the 20th century. The 1980s marked the beginning of this transformation with the 1988 formation of DTE Energy as a holding company, laying the groundwork for Detroit Edison's evolution from a local electric provider to part of a multifaceted energy corporation. Michigan Bell was the local provider in Southeast Michigan before the current AT&T branding took over, but it was always tied to the AT&T ecosystem through the Bell System. The transition from Michigan Bell to AT&T reflects corporate restructuring rather than a completely new player entering the scene.

Annual spend of the US industry overall - instructional, research, healthcare delivery, art, athletic and administration, etc. – runs about 5 percent of the US $30 trillion gross domestic product; nominal. Within that domain University of Michigan Ann Arbor campus, and its two other satellite campuses in Dearborn and Flint were in 1983, and remain so, as the largest university in the world in terms of square footage under management in nearly every occupancy class identified in the prevailing building codes [BOCA].

Michigan's estimated 40 million sq ft of building space across its three campuses exceeds most U.S. universities: Harvard (25 million), Texas A&M (23 million), Ohio State (23.5 million), Michigan State University (21 million) and University of California Los Angeles (~17 million). While exact rankings depend on idiosyncratic data presentation involving land grant [Morrill[UM's scale, including its medical and research facilities, positions it as a leader in building square footage among American campuses [2]

Corporations like Amazon with 475M sqft surpasses UM in widely scattered square footage, UM's concentrated multi-campus total is unmatched by any single corporate facility. Not even well known organizations like Apple, the Pentagon, Boeing or the New Century Global Center in Chengdu, China come close to 40M square feet in a such a dense concentrated area under single ownership. [2]

The University of Michigan joins a select few universities with constitutional autonomy under the Michigan Constitution of 1963 and instead of the legislature its Board of Regents, an elected body, general supervision over the institution and control of its funds, shielding it from excessive state oversight. This autonomy allows the University to independently manage its academic, administrative, and financial affairs. Stemming

from a historical precedent set in 1850, this unique status has been upheld by courts, ensuring the University operates as a quasi-independent entity, free from many State of Michigan regulations. [CONST AUT]

In practical terms for the Ann Arbor campus,, the University was and remains its own building contractor, commissioner and inspector. [CONST AUT] Also, itss own independent power producer and telecommunication company; running close-coupled with Detroit Edison and Michigan Bell Telephone. The close coupling with DTE Energy in 2003 permitted the Central Power Plant to generator reactive power to hasten DTE's return to normal.

It was a management philosophy in vogue throughout the 1980's which embraced decentralization, shifting away from rigid, top-down hierarchies toward distributed decision-making. This approach empowered lower-level managers and employees, fostering flexibility and responsiveness amid economic turbulence, including deregulation and global competition.

An understanding of how much, and where we shared overhead and underground outside plant was incomplete and widely scattered across units in charge of land ownership, easements and service contracts. The widely scattered responsibility (then, called "de-centralization" in business management parlance) and autonomy was thought to be Michigan's strength and weakness.

Companies like General Electric under Jack Welch exemplified this, flattening structures to boost innovation and efficiency. Decentralization aimed to speed up operations, cut bureaucracy, and tailor strategies to local markets, contrasting with the centralized control of the post-war era. It reflected a cultural shift toward entrepreneurialism, though it sometimes risked inconsistency and accountability gaps, requiring robust communication to balance autonomy with corporate goals.

The microcomputer transformation, starting with electrical and telecommunication maps became the "killer application" for de-centralization in one respect – we had the capital to start our own way of managing the system but it meant that electrotechnology de-centralization meant centralization toward us and the OE's resisted at first.

{phasor}

B. Uptake in Microcomputer-Based Engineering

The early 1980's were characterized by rapid expansion of graphic software; ours with Intergraph (which required mainframe) and Autocad which could be used on drafter desks.

In February 1983 the facilities architecture and engineering unit was drawing with straight edges with pencils on mylar. Architects, especially had a deep, almost romantic bond with pencil and paper drawing. This relationship was rooted in the tactile intimacy of the craft—sharpened graphite scratching across crisp vellum or tracing paper, each line a direct extension of thought and intuition. It was a love affair with control, imperfection, and the raw act of creation. Architects also ran the show from design project standpoint on all-trade projects. Key Plan unit kept records of net square-footage to support federal research grants

Microcomputers offered something different. A local expert– Professor Mark Enns– founder of the first computer aided protection engineering software for microcomputers–supported our vision. [ENNS] .

The early 1980's were characterized by rapid expansion of graphic software; ours with Intergraph (which required mainframe) and Autocad which could be used on drafter desks.

Uptake on the CAD transformation was slower among our consultants but not too far behind. Graphic software Autocad 2.1 Transferring all utility information from the University's prime "Owner-Engineer" (who had been so since 1932) was "non-linear" Charity requires credit to the OE's did not have the resources to make a swift, upward investment in information technology; eventually it did. A local expert– Professor Mark Enns– founder of the first computer aided protection engineering software for microcomputers–supported our inquiries into design calculations such as voltage drop and fault current. [ENNS] .

1. New buildings. In 1988 the University of Michigan became the first public university to raise $1 billion through a fundraising campaign some of that financed new buildings, and renovate substation rooms at a clip of about one new dry type substation per month for nearly three years; upgraded from 2.4 kV radial to 13.2 kV loop.

2. Utility information (water, sewer, electric, gas, etc.) was in hands of OE' who were using paper and needed a driver to start its own transformation. Property surveys, easements, rights of way and service contracts dating back decades needed to be re-shored into the University. Space administration – closely held because space audits for government funding depended on it – also followed the lead of the electrical utility mapping enterprise. The new UM telecommunication enterprise needed outside plant maps.

3. Jim Harvey led the construction of the 500-bed replacement hospital required its own services; adding to the six existing 40 kV services from DTE and about 25 outlying primary services; some semi-rural and interstitial including low voltage supervisory circuits connecting our CHP to the Detroit Edison 345/120 kV switching station. We were sharing some legacy overhead with DTE and Michigan Bell even as we began to build out the University's own telecommunication unit and expanding cogeneration.

4. PCB regulation compliance drove service transformer replacement within buildings. Squeezing in a new 13.2 kV dry type substation with 3 primary switches to replace a radially fed 2.4 kV substation (some "package units") meant dealing with NEC rules for flash safety clearances. [Lanny] Chapter 1 dealt with clearances. We had about 150 buildings in the core area with about half needing a changeout.

By the mid-1980s, discussions on energy efficiency, renewable energy, and utility competition were gaining traction amid economic shifts and environmental concerns. The Department of Energy and other agencies began drafting concepts to reduce oil dependence, spurred by the 1988-1989 oil price volatility and growing climate awareness. A federal "National Energy Strategy" morphoned into the Energy Policy Act of 1992 and a new group of people (i.e. non-electrical engineers) descended upon the University which was then, and remains, the largest non-utility cogenerator.

The mostly friendly rivalry between mechanical and electrical engineers over whether the 1912 plant was a heating or a power plant was resolved with the addition of a new steam boiler and generator so that we could generate more of our own power during peaks – thereby reducing our peak demand charges. We were actually both now – the largest district energy plant on the Detroit Edison grid. At about the same time ANSI/IEEE C37 [Power & Energy Society] identified a new standard for distribution transformers.[13.2/13.8]

would – was Arguments over whether we had a Central Heating Plant or Central Power Plant gave way to self awareness that we were a microgrid; the second largest customer-owned cogeneration plant on the Detroit Edison grid. The presence of cogeneration with 13.2 kV transformers that Detroit Edison owned complicated the choice of 13.8 kV that Detroit Edison also owned meant there would always be a 4.5 percent voltage difference between the Central and Medical campuses. This barrier was breached for emergency purposes during the August 13,2003 [OUTAGE]

Voltage regulation phasor image

C. Securing a Vote.

Once the case was made that the University would benefit, meeting the NFPA criteria was next. NFPA) appoints voting members based on expertise, interest, and balance of representation. Candidates must demonstrate knowledge in their fields and have a principal interest in a specific committee scope (e.g., industry, government, or public safety). Members are classified by their affiliation—such as manufacturer, user, or consumer—to ensure diverse perspectives.

To secure an endorsement the University approached APPA (Association of Physical Plant Administrators) – the non-profit professional organization the University of Michigan founded in 1928 – which had long since picked up stakes to WDC to service the cohort higher up the organization chart than the Physical Plant Administrator; hence the name change. [ABOUT]

The Utilities Department had the operating cash flow that other units did not. . The Business & Finance Division determined that the oversight committee – CMP-1 of the National Electrical Code that administered the foundation for everything else in the NEC – would be the ideal committee to support the first voice of the US education facility industry; collaborating with the Association of Physical Plant Administrators and the Society of Campus and University Planners (headquartered in Ann Arbor) as two organizations to close couple with.

the trade association which determined definitions, general rules and administration of the entire NEC. Much of the technical committee assignments have since been re-organized since 1983 but the following discussion details the subject of CMP-1. [Link to 1993 NEC]

Power factor image

D. Then Priorities

The National Electrical Safety Code was updated on 3-year cycles. The 1984 edditions were followed by 1987, 1990, 1993, 1997 until 2002 when the need to broaden constituencies created the need to widen update cycles to a 5-year cadence when the 2002 NESC perfectly synchronized with NFPA's 2002 National Electrical Code

Not only that, there was no widespread understanding of the NESC within UM electrical workgroups. Unlike the NEC which required periodic training for journeyman card renewal; the NESC was "for engineers" – and in our case, our the Utilities Department's OE.

The University owned several miles of our own 4.8 kV aerial open air conductors on our North Campus and had Detroit Edison 40 kV overhead running interstitially we needed dynamic in-house expertise that an off-site Owner-Engineer could not provide; nor should it have.

NFPA NEC and IEEE NESC

The NEC emerged from a fire safety culture; the NESC an electric and communication pathway.

It takes more than one revision cycle for any new or revised technical definition to become understood in practice.

Because of our constitutional autonomy we needed to engage with Detroit Edison engineers; understanding our contracts, rights-of-way.

Authority Having Jurisdiction. Answering the simple question "Who is in charge?" or "Who has the final word?" or "Who will take the blame if something bad happens?" was not settled science. Next, I would consider any Master Electrician as a Qualified Person in terms of the NEC and otherwise. That training or certification did not prepare to make decisions on negotiating electric service contracts though that training was enough to conform to OSHA Lock-Out Tag-Out procedures.

- Utility. Were we a "utility" or were we not; or, given constitutional autonomy, did it even matter. In the next section we describe the back and forth on what was an (electric) utility. We generated our own power and distributed it to hundreds of buildings but were not subject to the same state regulations. 2002 was the NEC cycle when service point, customer load was determined. We were on the Task Group that determined the language that you now see. It was not so obvious in the 80's and 90's. We wanted harmony with the NESC.

The new IT Division established its own outside plant and, wherever possible, co-develop underground raceway; sometimes (temporarily) using power manholes to run fiber optic. The 2002 NESC expanded coverage for fiber optic communication lines, particularly those integrated with electric supply systems. New rules clarified clearance, grounding, and installation requirements to address the growing use of fiber optics in utility networks, ensuring safe coexistence with power lines.

- Service or feeder. Was it necessary to hew to the one substation per building model that has served so well or could power be run at low voltage between buildings. What were the implications for this with emergency

generation and fire protection systems. We were changing out radially fed 2.4 kV with 13.2 primary selective loop which required much more space. Could we fit it in? Would the campus planners permit all interior substations. Could we feed, say 300 kW at 480v from an adjacent building.

- Qualified Person. The electrician's unions were eager to clarify this; eventually settling upon "Someone who has received training" thereby securing its own business model. The University conformed then, and continues, to conform to local trade labor rates. Could a Master Electrician reject a design sealed by an Engineer. Our qualified person was the person not only a professional engineer but someone who actually help write the code.

The 2007 NESC also introduced clearer definitions of "qualified persons" and mandated specific procedures for working near energized lines, enhancing consistency in utility safety programs. Energized part.

NESC Part 4 (Work Rules) saw updates emphasizing safety training for "qualified persons." The definition of a qualified person was expanded to explicitly require documented safety training on electrical hazards, reflecting a shift toward proactive risk management in utility work.

- Supervised installation. Not unrelated to Qualified Person, the NEC permitted relaxation of Overcurrent protection if the installation was under supervision by a qualified person. We were not a manufacturing plant that had to negotiate levels of protection for continuity of service. We were 200 buildings. Supervised industrial locations are given special treatment because of the high level of engineering and professional maintenance support which is usually available in facilities that could sacrifice a level of coordination if it presented a hazard. But what about running 480V between separated buildings under different managements.

- Protection Engineering.

The 2007 NESC introduced explicit acknowledgment of arc hazards in Part 4 (Work Rules). New rules required employers to assess arc flash risks and ensure workers use appropriate personal protective equipment (PPE) when working on energized equipment. This marked a significant step toward addressing electrical arc-related injuries, aligning with growing industry awareness. Computer analytic software for short circuit and overcurrent coordination.
[Arc Flash v]

The 2012 revision added more detailed requirements for arc flash protection. Employers were mandated to calculate arc energy levels and ensure workers use PPE based on specific exposure risks, aligning with NFPA 70E standards. [NFPA 70E]

- On site source

No single regulation universally "determines" an on-site fuel source; rather, it's a composite of IEEE 446 Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications + IEEE 1547 - Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces + IEEE 3006.5 - Recommended Practice for the Use of Probability Methods for Power System

Are our CHP considered an on-site source. Because of our constitutional autonomy we can declare ourselves a source, thereby avoiding the one-building/on-generator requirement. So who is the AHJ on that decision?

The Master Electrician? In short, we needed a licensed engineer and we needed a network of them among universities of similar scale.

While neither IEEE nor NFPA provides a single, verbatim definition of "independent electrical source" in their catalogs, the term's meaning converges across their standards:

General Requirements for Electrical Installations

- The first papers on non-contact hazard were trickling into the literature stating with "The Other Electrical Hazard: Electric Arc Blast Burns" by Ralph H. Lee, in 1982; others followed and began to inform safety practices that would stabilize and become routine. [K].

The 2002 NESC began laying groundwork by refining rules for working on energized equipment. It included clarifications on protective measures to reduce arc-related risks, aligning with growing industry awareness.

Desire to collaborate with DTE to remove about 5 miles of 40 kV overhead running between Medical and North Campuses and underneath University owned property with easements. Underground co-development with our own emergent IT enterprise with outside plant.

In addition to our six 40 kV services we had 25 commercial services of 1 MVA at 13.2/4.8. Some DTE easements.

Energy Policy Act of 1992. Dismantling of the vertical integration and a new group of people had to be invited to the meetings.

Administration & Enforcement

A new Annex – Administration would be added.

The University of Michigan's total assets, estimated at $30–35 billion, place it among the wealthiest U.S. universities, though it trails private powerhouses like Harvard ($70–80 billion), Yale ($50–60 billion), and Stanford ($50+ billion) largely due to their larger endowments and concentrated wealth. Compared to peers like Penn and Notre Dame, Michigan is on par, and among public universities, it stands out, likely surpassed only by the University of Texas System's unique land-based wealth.

The University of Michigan's Central Power Plant ranks approximately third among DTE's non-utility, customer-owned cogeneration plants in its service area, behind Midland Cogeneration Venture and Dearborn Industrial Generation, based on its 51 MW capacity and regional context.

For all these reasons Mike Anthony became the first in-house electrical engineer in the United States based upon Human Resources. Jim Harvey was hired to manage the UM Replacement Hospital Project, for a 900 bed facility ran upwards of $900 million in today's dollars.

That position came with support for code advocacy in both the IEEE, NFPA and ASHRAE catalog. The Campaign for Michigan drove hiring in other units to track architectural C&D by IEE.

[Another image]

Part 1 Outro:

Our presence began in 1993 and first vote 1999. In the next section we describe our code wins expansion into other catalogs and a way forward.

IEEE Power & Energy / Industrial Applications / NFPA / UL / ASTM / ASHRAE / ICC

The Business and Finance unit saw unclaimed opportunities to make our campuses (and all others) safer, simpler, lower-cost and longer-lasting. Our partnership began with APPA ended in 2011 with management changes. [Article sample] and was re-established with IEEE in 2014. [Founding Paper]

The NESC remains entirely populated by incumbents – utilities, manufacturers, contractors, insurance. But what about a utility that is larger than many municipal or independent power producers.

When Energy Policy Act of 1992 became reality a new group of people (i.e. non-electrical engineers) descended upon the University which was then, and remains, the largest non-utility cogenerator.

Enacted in 1978 as part of the National Energy Act, PURPA's effects matured in the 1980s. It required utilities to purchase power from qualifying facilities (QFs)—small power producers and cogenerators—at avoided cost rates. This broke utility monopolies on generation, fostering independent power producers (IPPs) and laying groundwork for competition.
Not abandoned but not updated

Mike Anthony became the first in-house electrical engineer devoted entirely to high voltage infrastructure.
[Resume]
Self awareness as a microgrid

Soul of a generation from one to next
Plato
Beautiful things
Chesterton
Vetruvius