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Book Review

Operational Resilience of Hospital Power Systems in the Digital Age

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Operational Resilience of Hospital Power Systems in the Digital Age
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INTRODUCTION

Professor Guiseppe Parise and his team at the Sapienza – Università di Roma continue finding ways to improve security for hospital power systems; the most technically complicated risk aggregations operating on dry land in Italy, in the United States, and everywhere else. Nothing happens in any industry -- not the least clinical delivery and medical research enterprises -- without reliable electrical energy. information and communication systems. How best to build and maintain power systems resistant to interruption is a continuous conversation in the electrical power industry.

Healthcare sector codes, standards, regulations and recommended practices form a large and dynamic catalog. Best practice literature published by the International Electrotechnical Commission, and the Institute of Electrical and Electronic Engineers (IEEE) gets thin quickly, however, on the obligation of leadership in the social negotiation of technical change. Electrical engineers have a limited toolbox when solutions to power system reliability lie outside the boundaries of their influence. When technical solutions venture into the realm of policy engineers are not always welcomed. Many societies are deeply ambivalent about engineers as leaders; as indicated by the professional affiliation of most members of state and local government in the United States. Engineers themselves are deeply ambivalent about management.

The ontological claim of many business schools is that leadership and management skills can be learned and conveyed among economic sectors. The skill set to lead Coca-Cola is readily transferable to Apple Computer, for example. So goes the claim. The leader-versus-manager conundrum does inspire reflection on a large part of the health care sector; thus our interest in connecting the dots between electrical power research coming out of Rome and the ambitions of a relatively new committee administered by the International Organization for Standardization in Geneva; described in the link below.

Business Plan ISO/TC 304 Healthcare organization management:

According to the World Health Organization, 7.2 trillion US$ or 10% of global gross domestic product (GDP) was spent on health in 2015. Administrative costs now make up about 34% of total health care expenditures in the United States. This compares with the healthcare expenditure of the UK (16%) and the Netherlands (20%). A 2019 report from the WHO states that the health sector "continues to expand faster than the economy. Between 2000 and 2017, global health spending in real terms grew by 3.9% a year while the economy grew 3.0% per year.

The paper we have selected to enlighten this discussion is representative of Dr. Parise's entire *oeuvre,* consisting of over 300 papers and several patents over a 30+year career. Underlying the technical problems discussed in the paper (published in January 2021 in which this reviewer was co-author) is a reckoning that the study unit for power system resilience needs expansion outside the four walls of the hospital out to the regional transmission grid -- the "*line side*" of the service point, in the parlance of power engineering -- where technical solutions become political problems with hardly any effort at all. He observes, correctly, that global healthcare sector organizations such as the World Health Organization -- with a broad charter detailed in its Constitution -- does not have a template for best practice for regional public utilities providing the primary source of power to hospitals. Neither does any other specialized agency or international standards setting body with a footprint in the healthcare domain.

But should there be? In large measure, standards setting organizations everywhere are supported by conformance and certification bodies, product manufacturers and insurance interests. Which organization would devote resources to administer the discovery processes to produce a standard suitable for incorporation by reference into public safety law that is not already in state public utility legislation? If damages and loss of life owed to power outages land in court what is the criteria for *force majeure* claims?

Dr. Parise's inquiry is highly technical so we have offloaded many technical specifics to an "overflow link" shown below so that we use our space to focus on his recommendations for policy makers, leaders and managers. Much of the content in the overflow link is recognizable to engineers working to conform to the standards set for power systems on the *load side* of the service point.

The paper identifies "benchmark" calamities:

- August 2003 Hurricane Katrina in the US
- March 2011 Tōhoku earthquake and tsunami
- October 2012 Hurricane Sandy in the US
- August 2016 Central Italy earthquake
- September 2017 Irma Hurricane in Florida
- September 2018 Storm Leslie hit Portugal, France and Spain

Engineers learn from these calamities. It is not possible to forecast a natural event so engineers devise methods to limit outages in such a way as not to transform a minor outage into a disaster.

Engineers have devised scaled down versions of large public utilities into "microgrids"; a term of art popular with policy makers. Arguably, the "new" microgrids are simply adaptations of the neighborhood direct current generation facilities of Thomas Edison's original conception. In large measure, Dr. Parise argues, the backup power network of a hospital conforming to local codes and standards published by the National Fire Protection Association (NFPA) and the IEEE, is essentially a microgrid when internal sources -- such as energy storage batteries and solar sources -- operate interactively with the public utility.

For example, district energy systems of colleges and universities such as the University of Michigan (average base load of 50 megawatts for a daily population of 50,000 including the medical research and clinical healthcare delivery facilities) are microgrids. So are rooftop solar panels. Large public utilities (with base much load much greater than 100 megawatts and a population of millions) have been forced to accommodate distributed energy resources by local public utility commissions that regulate essential utility services.

Dr, Parise's claim is that best practice for line-side hospital transmission supply does not track well enough in the healthcare industry best practice bibliography of the European Union. He recommends that healthcare sector standards must require two service points, independent and *active* – i.e. fully synchronized and able to pick up cold load with minimal loss of load probability of the entire regional transmission network.

By law power utilities in the United States offer a single service to hospitals at a rate approved by the local public utility commission. Engineers always recommend a second independent service to a typical "main-tie-main" service switchgear lineup; though the degree of transmission line independence may be sketchy. In some cases, to make the second "independent" service less sketchy new rights-of-way must be cut; usually expensive and disruptive to the community during construction. A third circuit may be available on a standby or interruptible basis, though at a premium (also approvable by the local public utility commission).

The degree of independence of utility services has always been a matter over which good minds disagree. Accordingly, experts direct hospital leadership continue investing in microgrid resilience solutions. Those solutions, with safety practice found in NFPA 70, 99 and 110, are not cheap in any manner of construction, operation or maintenance. Even as these backup systems continue operating in parallel with the normal source Dr. Parise reminds us that microgrid backup systems should not exempt management from applying regulatory and political pressure to increase reliability at the regional level.

RECOMMENDATIONS

To limit operation of the hospital backup microgrid Dr. Parise recommends that leaders participate in setting the criteria for load shedding of utility power at the regional level. All utilities have procedures for matching generation with load so that the system remains stable in steady state. Healthcare leaders, managers, engineers and operation and maintenance professionals should have a working knowledge of the preferential axes of transmission. This means knowing where the substations are located and understanding the operation of logic during a major regional contingency.

Additionally:

1. Health care centers should be occupied mindful of the risks listed above; especially in legacy installations or rural regions where utility power interties are connected to systems designed to different reliability criteria.
2. Understand the interdependence upon water, gas and primary electric supply. District energy systems -- a type of microgrid -- need gas for fuel to supply power to the pumps that deliver essential water to the hospital.
3. In earthquake prone regions reduce the seismic accelerations by localizing large equipment (such as generators and switchgear lineups) in the lower floors or below ground. Lighter distribution components are positioned on upper floors. In flood zones locate the power and pumping equipment at a safe height in the structures.
4. Large utility accounts are administered by account executives who are assigned a service engineer who is knowledgeable in the local network. Make sure you know who that engineer is.

5. In district energy systems there may be contingencies when only the utility can "close the main" on a supervised main-tie-main distribution regime. Customers may not be allowed to automatically throw over to an energized bus without the utility regulating the voltage on-site. In a major regional contingency, details should be agreed upon if the utility engineer cannot perform the voltage balance operation at the customer plant.
6. Stock quality spare parts. Transformers; mobile generators, switches, cabling; or share them with other nearby large hospital systems.
7. Perform periodic "table-top" exercises with the utility; with a level of rigour similar to healthcare power system testing required of certification and government reimbursement agencies.
8. Share response and recovery data. To model power systems, to make the Smart Grid "smarter" power engineers need to "teach" power system resilience but we need the data. Organizations in many domains are reluctant to share data; especially after a calamity when the hospital is likely to transform into a litigation battlefield.

Not all of these recommendations are explicitly detailed in the paper but are commonly understood as best practice for large utility service to a hospital. More technical details appear in the overflow link.

CONCLUSION

Large public utilities spend less on boosting reliability of power supplies to hospitals because they know their customers must conform to regulations that require them to invest in internal backup power systems that operate interactively public utility as a microgrid. Dr. Parise reminds us that despite the engineering success of hospital microgrids, continual effort to increase resilience of the primary source of power at the regional level should continue with urgency.

The global electrical power system is the largest "machine" ever built. Power reliability in both Italy and the United States is generally high. The authors of this paper, myself included, are mindful that utilities in every nation are in the long game, with investments based on meeting the needs over 30 to 50 years. Uncertainty becomes problematic in a regulated environment that is dependent on certainty for investor support that in turn fuels the capital that enables the investments to keep that machine running.

Michael A. Anthony is a member of the Institute of Electrical and Electronic Engineers and several ISO technical committees, the new ISO TC 304 Healthcare Administration among them. He represents the Institute of Electrical and Electronic Engineers on the National Electrical Code committee on power systems for healthcare facilities. He has been affiliated with both the business and academic side of the University of Michigan since 1982 and has published widely on this topic (https://sites.google.com/a/umich.edu/mikeanthony-us/ieee-publications). He is Co-Founder of the IEEE Education & Healthcare Facilities Committee (https://site.ieee.org/icps-ehe/) and Standards Michigan, LLC (www.standardsmichigan.com). Overflow Biography: https://site.ieee.org/icps-ehe/.