Strategic Undergrounding for a More Resilient and Sustainable Grid

by **Ben Lanz**

What is the life-cycle cost of our electric infrastructure per capita? What is the cost to society to have our power turned off proactively by our utility to protect us from wildfire threats or reactively due to natural disasters? Our industry stands at a critical juncture. Our aging infrastructure struggles to consistently withstand natural disasters or even strong weather events, even as electric power becomes increasingly essential for critical tasks. According to the U.S. Energy Information Administration (EIA), the average American endures seven hours of electric service outages annually. Furthermore, the U.S. Census indicates a growing percentage of the population is choosing to reside in areas at high risk of fire or storm damage. As we aim to electrify more of our residential energy needs, natural disasters and strong weather events repeatedly highlight our vulnerabilities. Many households are unable to maintain safe temperatures, protect homes from damage, support in-home medical devices, prepare and preserve food, perform job-related tasks, communicate with loved ones and emergency personnel, or operate electric vehicles (EVs) for daily use or emergency evacuation. So, what can we do to improve our infrastructure and ensure resiliency?

The Power Delivery Intelligence Initiative (PDI2.org) is a nonprofit organization on a mission to challenge the way we think about power infrastructure decisions. PDI2's purpose is to drive maximum power grid resiliency and reliability at the lowest life-cycle cost.

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With over 30 years in the electric power and energy industry, **Ben Lanz** is responsible for Osmose (Osmose.com) technical outreach and education efforts and is the immediate past Chairman of the Board of the Power Delivery Intelligence Initiative (PDI2.org), a nonprofit dedicated to disseminating grid investment best practices. He is a senior member of IEEE PES and ICC, and a voting member of DEIS, IAS, ACP, CIGRE, SaRA & NETA. He has chaired IEEE technical committees associated with power system reliability, protection, and testing, has published over 100 papers, articles and technical conference contributions on the subjects of power system reliability, asset management, design, work practices, longevity and diagnostics, and is a regular guest speaker at numerous conferences and seminars.

PDI2 FOUND SUCCESSFUL PROGRAMS ESTIMATED INITIAL COSTS, FUTURE SAVINGS, AND RISK REDUCTIONS INSTEAD OF USING OUTDATED AND SIMPLISTIC RULES-OF-THUMB.

The organization gathers and disseminates information to help utilities, regulators, and our society as a whole determine which power delivery solutions to employ. For generations we have installed most of our grid overhead, and while there are many solutions to improve the resilience of overhead lines, more utilities are now turning to undergrounding their lines as a sustainable resiliency solution. What has changed and how are utilities justifying the investment? Late last year PDI2 issued a research report called the "Utility Underground Life-Cycle Cost Guide" to help answer these questions. While this guide was written for electric utilities in the U.S. and Canada who are searching for facts to address most common misunderstandings of undergrounding and a structured approach to capture the lowest life-cycle cost for line segments, the fundamentals are applicable globally.

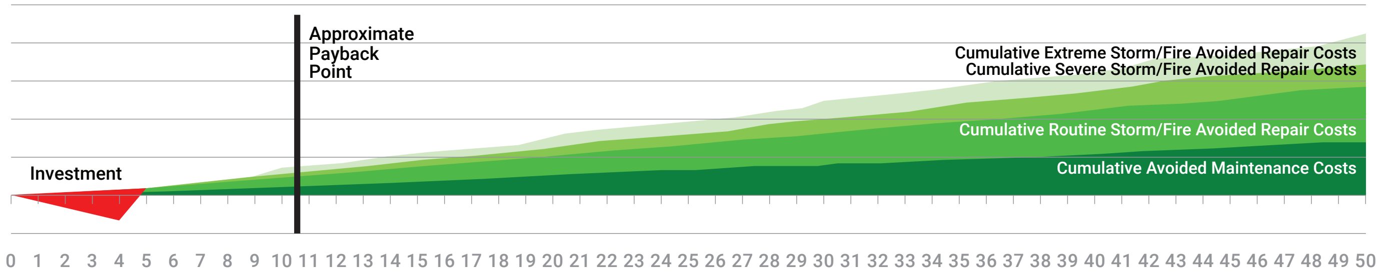
So why are utilities strategically undergrounding? The simple answer is a convergence of technology and a need for resiliency, the ability to withstand high impact low probability (HILP) events with little or no customer outage, has created a new decision landscape. PDI2 researched large scale, bell weather undergrounding programs at Dominion, Florida Power & Light, Georgia Power, San Diego Gas & Electric, PG&E, PEPCO, and WEC Energy Group and found various underground program drivers including performance efficiency, new materials, methods and technology, aesthetics, maintenance reduction, vegetation management, safety, levelized capital spend and rate base growth, and customer satisfaction. The research identified utility goals to underground nearly 40,000 miles in the next decade in all parts of the US. The primary misunderstandings these utilities had to address were initial vs. life-cycle costs, challenges with installation, and fears of frequent and difficult to locate failures.

PDI2 found successful programs estimated initial costs, future savings, and risk reductions instead of using outdated and simplistic rules-of-thumb. Some of the potential factors to consider in the life cycle analysis of undergrounding are: ten times higher reliability, two to three times longer life, ten times less operating and maintenance costs, the value of capital investment with a consistent rate of return, nearly ten times safety improvement, and state or local gross domestic product (GDP) protection. PDI2 research found a simplified internal rate of return (IRR) analysis can yield a positive value over a ten to twenty-year timeline. This was achieved by looking at the avoided future costs as returns, integrating avoided annual maintenance impact, demonstrating accelerated recovery, repair, and replacement after routine storms, and avoidance of the frequency and severity of system impact due to severe or extreme weather or fire risks. It is important to note that the positive return was achieved without incorporating multiple factors such as adjustment in rates, GDP impact, safety benefits, inflation, capital vs. maintenance and revenue loss, reinvestment in maintenance savings, and life beyond 50 years.

Photo: IMCORP

Simplified IRR Analysis of Life-Time Performance of Undergrounding

Demonstration that conservative modeling yields a positive IRR between year 10 and year 20 for a 5-year "Strategic" undergrounding program.



PDI2 learned that successful undergrounding programs availed themselves to modern technology to address installation challenges and failure concerns. Improvements in cable system technology allowing for shallow trench or directly buried cable with longer spans between splices, reduced material costs, easier accessory installations and two to three times longer life even in fully submerged conditions. Some examples of cable system technology improvements are low resistance jackets for longer pulls, range taking cold shrink accessories and shear bolt connectors which make installation faster and easier, and high quality, thinner insulations which lower costs. Improvements with installation technologies such as vibratory plowing, directional drilling, and massive rock saws are now commonplace and accelerate installation in all types of geology. Technologies under development promise tunneling with specialized high energy plasma boring and drone guided direction drilling to lower the civil construction cost even further. And finally, sensor technologies give us 'eyes' underground to help us proactively detect defects and reactively locate failures immediately. Some examples of these technologies are online sensors which can detect and communicate failure location, specialized meters and above ground scanning technology that can detect low voltage cable failures and contact and stray voltage in progress, drones that can scan underground vaults for risks, and factory comparable PD test (a.k.a. an offline 50/60Hz PD test with 5pC sensitivity) that scan medium and high voltage lines and locate defects proactively to predict future performance.

In the past, utilities could dismiss proactive measures to address resilience as too costly. However, today in our hyper cost sensitive industry the data is clear, reactive measures such as mobilizing thousands of line workers after a storm or investing in never-ending tree trimming expenses are not sustainable. Whether utilities have overhead or underground lines, there are numerous ways to proactively improve resilience which can not only benefit the utilities' bottom line but society as a whole. The advancement of technology, the frequency and duration of outages, and fact-based life-cycle analysis is driving more utilities to consider undergrounding. For this generation's engineers and planners who are looking to address many of the legacy rules-of-thumb and discover reasons to consider strategic undergrounding, PDI2's complimentary "Utility Underground Life-Cycle Cost Guide" is a valuable resource.

Photo: IMCORP

IMPROVEMENTS IN CABLE SYSTEM TECHNOLOGY, ALLOWING FOR SHALLOW TRENCH OR DIRECTLY BURIED CABLE WITH LONGER SPANS BETWEEN SPLICES, REDUCED MATERIAL COSTS, EASIER ACCESSORY INSTALLATIONS AND TWO TO THREE TIMES LONGER LIFE EVEN IN IN FULLY SUBMERGED CONDITIONS.