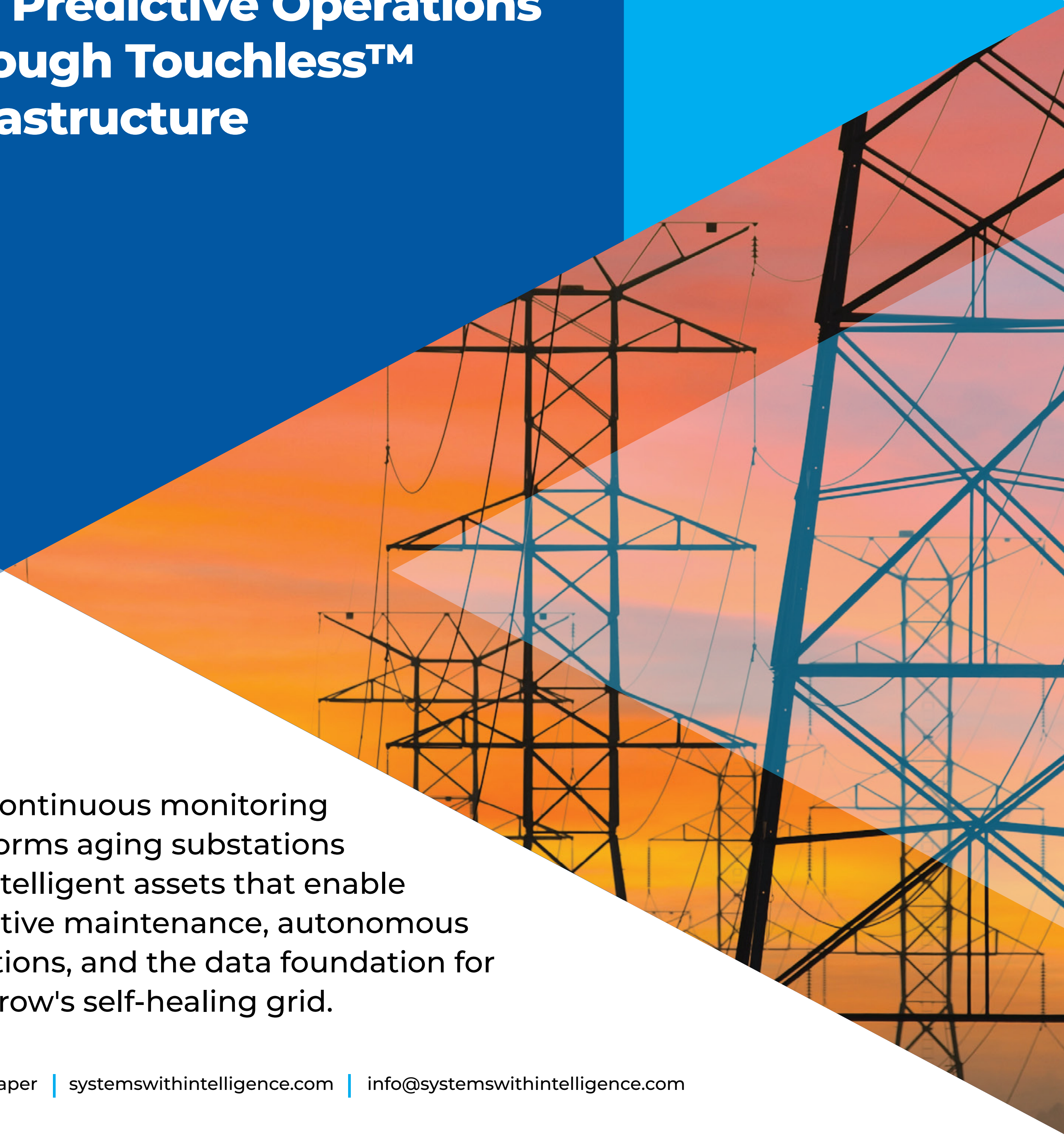
# The Intelligent Grid:

## Enabling AI, Automation, and Predictive Operations Through Touchless™ Infrastructure



How continuous monitoring transforms aging substations into intelligent assets that enable predictive maintenance, autonomous operations, and the data foundation for tomorrow's self-healing grid.

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## Executive Summary

Electric utilities face significant operational complexity as aging infrastructure collides with renewable integration, workforce attrition, and extreme weather events. Traditional calendar-based maintenance cannot scale to meet these converging challenges. Systems With Intelligence's Touchless™ Monitoring provides the essential visibility layer that transforms passive substations into intelligent grid nodes.

## Today's Challenge

Utilities are confronting a perfect storm of operational challenges that threaten reliability, financial performance, and strategic positioning. Aging infrastructure operates beyond design life while distributed energy resources multiply complexity. Meanwhile, institutional knowledge walks out the door as experienced workers retire, leaving gaps that technology must fill. The traditional playbook of scheduled inspections and reactive maintenance cannot scale to address these converging pressures. Without a fundamental transformation in how utilities monitor and maintain critical assets, cascading failures and regulatory penalties become inevitable.

The infrastructure crisis manifests in stark numbers. Legacy substation equipment averages 40 years in service, operating well past original specifications [1]. When transformers fail, replacement lead times now exceed 60 weeks, creating extended vulnerability windows. Calendar-based inspections consume up to 20% of O&M budgets, dispatching crews on predetermined schedules regardless of actual asset health. These costly visits miss load-dependent failures and intermittent faults that emerge between inspection cycles. System reliability degrades accordingly, SAIDI metrics climbed from 106 minutes in 2013 to 125.7 minutes in 2022, triggering both regulatory scrutiny and customer dissatisfaction [2].

The renewable revolution compounds these challenges. As Richard Harada, Vice President Marketing and Product Management at SWI notes, "Renewables are growing, and they're finding out, oh, we should have visibility on our renewable sites as well. That's something that traditional grids have already learned."

Thousands of inverters and battery storage systems demand equal vigilance, yet utilities lack the workforce to monitor this expanded infrastructure. The utility workforce is experiencing a dramatic transition, with over 50% of the utility workforce having less than 10 years of experience, the industry faces a critical knowledge gap as the remaining experienced workers approach retirement, requiring robust knowledge transfer programs [3]. Extreme weather events impose stress that manual checks cannot address in real time. The operational model that sustained utilities for a century no longer suffices.

*"Calendar inspections consume up to 20% of O&M yet miss load-dependent failures, intermittent faults, faults that occur in between inspections"*

## From Reactive to Predictive

Continuous, sensor-based monitoring represents the fastest path to operational excellence, closing critical visibility gaps while enabling the transition from reactive to predictive maintenance. This approach proves inherently scalable, delivering immediate ROI that funds progressive automation. Unlike wholesale infrastructure replacement, utilities can overlay intelligence onto existing assets through phased deployments that generate value from day one. The strategy spans both conventional and renewable portfolios, creating a unified visibility layer that becomes the foundation for AI-enabled grid operations.

The transformation begins with multi-sensor nodes that convert manual checks into uninterrupted data streams. "Since the power system was built, they didn't really have eyes on those substations," explains Harada. "What we do is we give them visibility of the substations with the technology that's evolved over the years." These sensors capture thermal, visual, and environmental data every 60 seconds, streaming insights into existing SCADA and historian systems using IEC 61850 protocols. By leveraging standardized communication frameworks and familiar workflows, adoption accelerates across operations teams [4].

Cloud analytics transform raw sensor data into actionable intelligence. The system employs edge computing for immediate anomaly detection while cloud platforms apply machine learning to identify patterns, predict failures, and optimize maintenance strategies. Critically, intelligent filtering maintains less than one nuisance alarm per site per month through adaptive thresholds and secure edge computing that learns normal behavior patterns. A major power system disturbance could trigger hundreds and sometimes thousands of individual alarms and events.

The advanced alarm processor approach takes advantage of enhanced protective relay data in explaining cause-effect relationships between alarms. [5].

*"Continuous, sensor-based monitoring closes the visibility gap, enables data-driven maintenance, and lays the groundwork for AI-enabled autonomy"*

## Results: Case Studies

Field deployments across diverse utilities validate the business case for continuous monitoring. These implementations demonstrate consistent results regardless of utility size, geography, or operational philosophy. Each success story reinforces that Touchless™ monitoring delivers transformative value through proven technology rather than experimental concepts.

Southern Company's deployment exemplifies enterprise-scale transformation. Utility deployments of IoT-based transformer monitoring systems demonstrate significant operational improvements, with continuous thermal and visual monitoring enabling utilities to extend inspection intervals, reduce maintenance costs, and prevent failures through predictive analytics and real-time anomaly detection [6]. "Over the past year, they've sent us half a dozen examples of catches that they've made using the thermal sensor," notes Harada. "They found bad connections on a bushing... which could cause a flash over on the transformer."

Leading renewable operators have demonstrated 15-20% O&M cost reductions through digital monitoring technologies across their portfolios, with critical hotspot detection preventing failures that would cost millions in downtime [7].

PSE&G demonstrates the power of embedding sensors during rebuilds, achieving 50% O&M savings while making the technology essentially CapEx neutral over the asset lifecycle.

Ozarks Electric saved 2,181 technician hours annually through digital system improvements, significantly reducing travel time to remote sites and improving operational efficiency [8].

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## Results

Touchless™ adoption progresses through six reinforcing capabilities, each delivering measurable improvements while building toward operational autonomy. This structured approach ensures sustainable transformation rather than disruptive change, allowing utilities to capture value at their own pace while maintaining reliability throughout the journey.

### *1. Continuous Sensing for Full-Time Visibility*

Always-on sensors fundamentally change the maintenance program by providing persistent awareness that manual rounds cannot match. The shift from snapshots to continuous monitoring reveals degradation patterns invisible to periodic inspections, enabling truly predictive maintenance strategies.

Modern deployments stream data from bushings, breakers, transformers, and security perimeters every 60 seconds. "We've been around 15 years. We came out with online, real-time thermal imaging about 15 years ago," notes Harada, emphasizing the technology's maturity. These systems have evolved through thousands of installations, proving reliability in harsh substation environments [9].

Adaptive algorithms learn each asset's normal behavior under varying loads and weather conditions, then alert only on meaningful deviations. This precision achieves the critical metric of less than one nuisance alarm per site per month. Results manifest immediately as truck rolls decline by 45% as crews respond to actual needs rather than calendars. Inspection cycles can be safely extended from annual to multi-year intervals when continuous monitoring is deployed, as validated by condition-based maintenance studies showing equivalent or improved reliability outcomes [10].

## 2. Cloud Intelligence for Actionable Insights

Edge filtration combined with cloud machine learning transforms sensor streams into operator-friendly intelligence. This dual approach maintains real-time responsiveness while enabling sophisticated pattern analysis that improves continuously through fleet-wide learning.

"We're trying to go further up the technology stack than just being data collection," explains Harada. "We're automating the inspections, providing the data interface to management systems, to enterprise systems." For example, when a transformer begins to overheat or a vibration anomaly is detected on a turbine, edge systems can run machine learning models locally to determine the severity of the event by continuously monitoring electrical parameters, temperature, vibration, and acoustic signatures. [11].

Cloud analytics excel at identifying subtle degradation patterns across entire fleets. Machine learning models surface predictions 10-14 days before traditional thresholds trigger, enabling planned interventions during favorable conditions. High-confidence alerts arrive with thermal images attached, historical trends graphed, and recommended actions outlined. This comprehensive context empowers operators to make informed decisions quickly, reducing alarm-to-resolution time by over 60% in typical deployments [12].

## 3. Prescriptive Maintenance Workflows

"With Southern Company, we provided them with an API so they can bring the data directly into their PI System... they're tied directly into Work Order Generation," notes Harada. Sensor alerts automatically populate CMMS tickets with precise location data, thermal images, historical trends, and even suggested parts based on similar past failures [13].

The impact on maintenance efficiency proves dramatic. Planned work ratios rise to 85% as crews prepare for known issues rather than responding to surprises. Emergency overtime costs halve when problems are addressed during regular shifts. Most significantly, condition-based maintenance extends asset life. Utility case studies demonstrate 5+ year deferrals when continuous monitoring is deployed on aging transformers, with one West Coast utility extending 60-year-old units an additional 5 years through condition-based management rather than age-based replacement [14].

## 4. Digital Twin Integration

Live sensor data transforms static models into dynamic decision engines, making digital twins operationally relevant rather than theoretical exercises. Real-time integration enables virtual testing that accelerates engineering productivity while reducing operational risk.

Continuous monitoring paints heat maps across 3D substation models, revealing thermal patterns impossible to visualize in person. "If someone's walking around a virtual substation, they can see all the data... what are the gauges reading in real time, what are the temperature of these bushings," envisions Harada. Engineers test switching scenarios virtually, evaluating options in minutes rather than hours [15]. This convergence of physical and digital enables holistic grid management where every decision considers actual equipment condition [16].

## 5. Assisted Autonomy in Operations

Early implementations focus on low-risk, high-value actions that demonstrate reliability without endangering service.

Initial deployments automate asset protection, such as cooling fans activate when transformers exceed temperature thresholds, security lights flash when cameras detect intrusion. These "non-regret" actions deliver immediate value while proving system reliability. As confidence grows, more sophisticated automation follows.
Advanced automation systems can isolate faulted equipment and verify spare capacity before executing switching sequences under operator oversight [17].

"We're planning to leverage AI technology to help us with the predictive side of things," confirms Harada. This evolution fundamentally changes operational roles. Field crews can transition from emergency responders racing to failures toward resilience strategists who optimize system configurations [18].

## 6. Renewable Asset Monitoring Expansion

"We do monitoring at wind farms or solar farms, motors, generators, bearings, switch gear," confirms Harada. "These renewable generation facilities are springing up at a pretty high rate, and they're finding problems that they didn't know they would have."
Solar combiners require thermal surveillance to prevent fires. Battery installations need temperature monitoring to detect thermal runaway. Wind benefits from internal cameras catching cable hotspots early [19].

A unified dashboard provides portfolio-wide visibility, harmonizing O&M practices across conventional and renewable assets. By building reliability into renewable assets from commissioning, utilities ensure these critical resources deliver expected performance throughout their lifecycle [20].

## Organizational Levers and Risk Controls for Rapid Adoption

Technology alone doesn't drive transformation, organizational alignment does. Leading utilities recognize that continuous monitoring represents cultural change requiring governance structures, workforce development, and stakeholder engagement equal to the technical deployment.

Board-level sponsorship accelerates adoption by establishing clear accountability across the enterprise. Successful programs link sensor ROI directly to executive scorecards covering reliability, safety, and ESG metrics. When leadership compensation depends partially on digital transformation progress, organizational resistance evaporates. A cross-functional "Touchless Council" should convene quarterly, combining OT, IT, cybersecurity, and asset management perspectives to track value realization and remove barriers [21].

Workforce evolution requires proactive investment in reskilling programs. "They have to send the crew once a week to read 300 gauges at a substation. So if we didn't have to do that, then we can save a bunch of money. And these guys could do something a little more valuable," notes Harada. Converting retiring thermographers into remote diagnosticians preserves decades of expertise while reducing resistance to change. Continuous improvement sprints after each incident refine both technology and processes, building a learning organization [22].

*"Stand up a cross-functional 'Touchless Council' which includes OT, IT, cyber, and asset management, with quarterly value tracking"*

## Next Steps

Southern Company, PSE&G, Iberdrola, and dozens of other utilities demonstrate that continuous monitoring works across diverse operational contexts and asset types. Yet implementation represents more than sensor deployment. Success requires organizational commitment to transform maintenance practices, develop workforce capabilities, and embrace data-driven decision making.

The path forward follows a proven framework. Begin with pilots on critical assets to demonstrate value and build confidence. Document savings meticulously to create compelling business cases for expansion. Scale rapidly once benefits validate, using captured savings to fund broader deployment. Develop workforce capabilities in parallel with technology rollout. Most critically, recognize that continuous monitoring isn't optional, it's the admission price for competing in tomorrow's utility industry.

Delay means escalating costs. Every month without visibility widens the gap between operational demands and capabilities. Aging infrastructure continues degrading while renewable complexity accelerates. Experienced workers retire daily, taking irreplaceable knowledge with them. Meanwhile, early adopters continue capturing value and building capabilities that compound over time. As Harada emphasizes, success comes from partnership: "It's not like we just go back into the drawing board and say *'what technology can we come out with next?'* It's we work with the utility to say, *'what kind of solution do you need to solve this problem?'* "

The intelligent grid isn't a distant vision, it's being built today by utilities willing to transform. The only question is whether your utility will lead or follow in building tomorrow's intelligent grid.

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## About Systems With Intelligence

Systems With Intelligence (SWI) is the trusted global leader in Touchless™ Monitoring solutions for electric utilities and industrial applications. Founded over 15 years ago, SWI pioneered real-time thermal imaging for substations and has deployed thousands of monitoring systems worldwide. The company's sensor networks and analytics platforms enable utilities to achieve dramatic O&M savings while building the data foundation for grid modernization and autonomous operations.