THE QUIET BACKBONE OF GRID RELIABILITY:

Why Laboratory Services Are Critical in Today's Energy Landscape

Every day, utilities face the complex challenge of keeping power systems running safely, efficiently, and without interruption. While condition monitoring, asset management platforms, and automation often steal the spotlight, there's another element powering reliability behind the scenes: laboratory services.

From dissolved gas analysis (DGA) to advanced forensic testing, lab services give utilities the insights they need to detect emerging problems, pinpoint asset degradation, and make informed maintenance decisions before a failure occurs. In today's environment marked by rising demand, aging infrastructure, and accelerating complexity, this capability is not a nice-to-have. It's essential.

In this eBook, we explore how lab services are helping utilities solve real-world challenges, reduce operational risk, and extend the life of critical assets. Through technical insight, expert guidance, and proven case studies, we'll show how Doble's lab capabilities empower utilities to move from reactive to proactive grid management.

Chapter 1: The Role of Lab Testing in Modern Grid Reliability

The electric grid is facing unprecedented pressure: from the rise of AI-fueled infrastructure and demand to workforce shifts and unpredictable climate events. Utilities are being asked to do more with fewer resources, all while maintaining and improving system reliability.

While technologies like condition monitoring and AI are transforming grid management, their effectiveness depends on one thing: good data. That's where lab services come in. Lab testing provides definitive insight into what's happening inside grid assets: detecting dissolved gases that signal overheating, uncovering insulation breakdowns, or validating suspected failures through forensic analysis. Lab data helps utilities:

- Detect hidden issues before failures occur
- Extend the useful life of equipment
- Ensure regulatory compliance and safety
- Inform capital planning and asset strategy

Moreover, lab testing provides critical validation. When sensors or field observations indicate something may be wrong, lab analysis confirms what's happening, or uncovers what others missed. This precision is vital to balancing asset performance with cost-effective maintenance.

Laboratory insights also complement and enhance field diagnostics. While online monitoring tools capture real-time conditions, offline testing evaluates aging, contamination, and material degradation with a depth of detail field tests can't always match. Together, they form a complete picture of asset health, enabling smarter, risk-informed decisions across the utility.

In short, lab services turn symptoms into diagnoses—and diagnoses into decisions.

Chapter 2: Deep Dive: Core Lab Services that Support Grid Reliability

Comprehensive laboratory diagnostics give utilities the insight they need to monitor asset health, reduce unplanned outages, and make smarter maintenance decisions. While field sensors and online monitors capture important real-time data, lab analysis offers deeper, more nuanced visibility into what's happening inside critical substation equipment.

The following diagnostic techniques—performed by specialized electrical testing labs, form the foundation of a resilient, risk-informed grid strategy.

Transformer Diagnostics

Transformers are the heart of the electric grid. When they fail, the impact is significant—both operationally and financially. That's why transformer testing is one of the most essential areas of lab-based analysis.

What Is Dissolved Gas Analysis (DGA) and Why It Matters

DGA is one of the most powerful tools for detecting incipient faults within transformers and other oil-filled equipment. It detects fault gases produced by arcing, overheating, and insulation degradation. Both absolute values and gas trend patterns help utilities identify abnormal behavior early.

Other Key Tests include:

- **Furan Testing:** Evaluates the degradation of cellulose insulation (paper) to estimate remaining life.
- **Corrosive Sulfur Screening:** Identifies reactive sulfur compounds that can lead to copper sulfide formation and insulation breakdown.
- **Moisture and Acidity Testing:** Assesses overall oil health and degradation of both insulating fluid and paper.
- **Metals-in-Oil Analysis:** Detects metals that signal contact wear, overheating, or mechanical damage.

These tests offer critical insight that supports asset life extension, load planning, and capital investment decisions.

Getting Ahead of On-Load Tap Changer and Breaker Failures

Tap changers and oil circuit breakers experience significant electrical and mechanical stress. Over time, that stress can lead to arcing, sludge formation, and carbon buildup that reduce performance or cause failure.

Key diagnostic tests include:

- **DGA for OLTCs and OCBs:** Identifies fault gases associated with internal arcing or abnormal switching conditions.
- **Oil Quality Analysis:** Evaluates dielectric breakdown voltage, resistivity, water content, and sludge potential to assess insulation performance.
- **Carbon and Particulate Testing:** Identifies wear debris, metallic particles, or carbonized oil that may indicate internal degradation.

These insights help utilities make informed maintenance calls, often avoiding costly unplanned outages or unnecessary replacements.

Oil Testing: Not All Fluids Are Equal

Insulating fluids degrade over time and can become contaminated through operational wear, environmental exposure, or chemical reactions. Regular testing of these fluids supports safe and reliable system operation.

Common tests include:

- **Dielectric Strength Testing:** Measures the fluid's ability to withstand electric stress without failure.
- **Interfacial Tension and Acidity Testing:** Indicates the breakdown of insulating properties and presence of contaminants.
- **Moisture Content and Viscosity Testing:** Evaluates flow characteristics and
- insulation effectiveness.
- **Oxidation Inhibitor Testing:** Determines whether stabilizing additives remain effective.
- **Fluid Type-Specific Testing:** Mineral oil, natural esters, and silicone fluids all have unique aging and performance characteristics that require targeted testing protocols.

These results influence oil replacement decisions, transformer service intervals, and overall fluid management strategies.

When Something Goes Wrong: Forensic Failure Analysis

When components fail, or show signs of unexpected degradation, labs perform forensic testing to determine the root cause. This supports preventive action and informs future asset strategies.

Key areas of analysis include:

- **Paper and Pressboard Aging:** Testing for moisture content, tensile strength, and degree of polymerization to assess insulation health.
- **Metallurgical and Surface Analysis:** Examining weld quality, contact erosion, and fatigue cracks through microscopy or spectroscopy.
- **Contaminant Identification:** Analyzing insulation residues, foreign particles, or chemical breakdown byproducts that may have triggered failure.
- **Cross-sectional Imaging:** Reveals internal mechanical damage, thermal degradation, and wear patterns invisible to the naked eye.

Whether a failure has occurred or is suspected, this testing supports targeted remediation, warranty validation, and lessons learned across the fleet. Across all testing, clear reporting and expert interpretation ensure that lab results lead to action—not just observation.

Chapter 3: Real-World Impact: Preventing Failure, Informing Strategy

Condition monitoring and lab analysis don't just produce data, they produce decisions. From catching transformer faults in progress to identifying silent deterioration trends, Doble's labs help utilities avoid failures, reduce outages, and extend asset life. Here are two real examples where laboratory testing directly informed action and improved grid reliability.

CASE STUDY 1

Catching a Failure in Progress

A large U.S. utility submitted a transformer oil sample to Doble's laboratory for routine DGA. The test results showed unusually high concentrations of fault gases, indicating a potential low-energy arcing or hot spot condition. Doble flagged this immediately and recommended resampling within days.

The follow-up test showed further elevation of acetylene: a key indicator of high-energy arcing.

While the transformer was still in service, the utility was able to coordinate an emergency outage. Once offline, further lab tests and field inspections confirmed that a lead inside the transformer was overheating and degrading insulation. Left unchecked, this could have led to a catastrophic failure and extended outage.

Outcome:

Thanks to DGA monitoring and rapid lab diagnostics, the utility avoided an unplanned failure and reduced potential repair costs. The transformer was repaired and returned to service with no downstream disruptions.

CASE STUDY 2

The Power of Trending and Testing

Another utility was conducting routine condition monitoring on a high-value transformer. Over a period of months, DGA results showed a slow but steady increase in combustible gas concentrations. No individual result triggered alarm thresholds, but the trend was unmistakable—and Doble's lab teams flagged it.

Instead of guessing, the utility submitted multiple additional samples and partnered with Doble to correlate gas generation trends with operating conditions. The data suggested localized overheating rather than a system-wide fault.

Armed with this insight, the utility scheduled a controlled outage and performed internal inspection. Sure enough, they found loose connections and minor insulation degradation—enough to cause the gas buildup but caught before it escalated.

Outcome:

Proactive trending and collaborative lab analysis helped the utility plan a timely maintenance event, saving both equipment and service reliability.

The Takeaway

These cases underscore why lab services matter. It's not just about finding problems, it's about giving utilities the time and clarity to act. By providing early visibility into degradation, Doble's labs help utilities:

- Shift from reactive to proactive maintenance
- Optimize outage planning
- Preserve high-value assets
- Reduce safety and regulatory risks

Behind every test result is an opportunity to act and avoid what can't be undone.

Chapter 4: Elevating Utility Operations: From Testing to Decision-Making

For many utilities, lab testing is the first step in understanding asset health. But at Doble, it's never the last. What sets Doble apart is how we help utilities translate complex test results into confident, timely decisions. That means going beyond sample analysis to offer full-spectrum support—technical, operational, and strategic.

Integrated Support Across Services

Doble doesn't operate in a vacuum. Our laboratory services are closely aligned with engineering consulting, field diagnostics, and condition monitoring programs. This integration ensures that lab insights are contextualized with real-world equipment behavior and grid performance trends.

Whether it's investigating an anomaly spotted by online monitoring or validating findings from field testing, Doble's lab teams work in tandem with our engineers to give utilities a complete understanding of what's happening, and what to do next.

Expertise That Extends Beyond the Report

Every test result includes more than just a number. Doble's staff of chemists, engineers, and diagnostic specialists offer interpretation, historical comparison, and next-step recommendations based on decades of equipment behavior data.

We help utilities:

- Determine severity levels and urgency of action
- Understand whether a finding is routine or abnormal
- Prioritize maintenance based on actual risk, not assumptions

This expertise becomes especially valuable when staffing is limited or institutional knowledge is in transition.

Scalable, Responsive Service

With multiple laboratories across North America, Doble can meet fast turnaround needs without compromising quality. Whether it's a rush job for a transformer under load or a long-term asset benchmarking program, we tailor service levels to fit utility workflows and urgency.

We also offer customizable reporting formats, portal access, and dedicated account support—making it easy for utilities to track trends, flag anomalies, and coordinate with operations teams.

A Partner in Education and Preparedness

In a changing energy landscape, Doble is committed to helping utilities build internal confidence and capability. That includes:

- Hosting training on diagnostic test interpretation and lab fundamentals
- Offering webinars and resources on trending failure modes
- Guiding customers through post-failure root cause analysis
- Providing insight into the evolving standards and regulatory environment

This consultative approach helps utilities upskill teams, reduce reliance on one-time fixes, and plan strategically.

Chapter 5: The Future of Lab Services: Readiness for the Grid Ahead

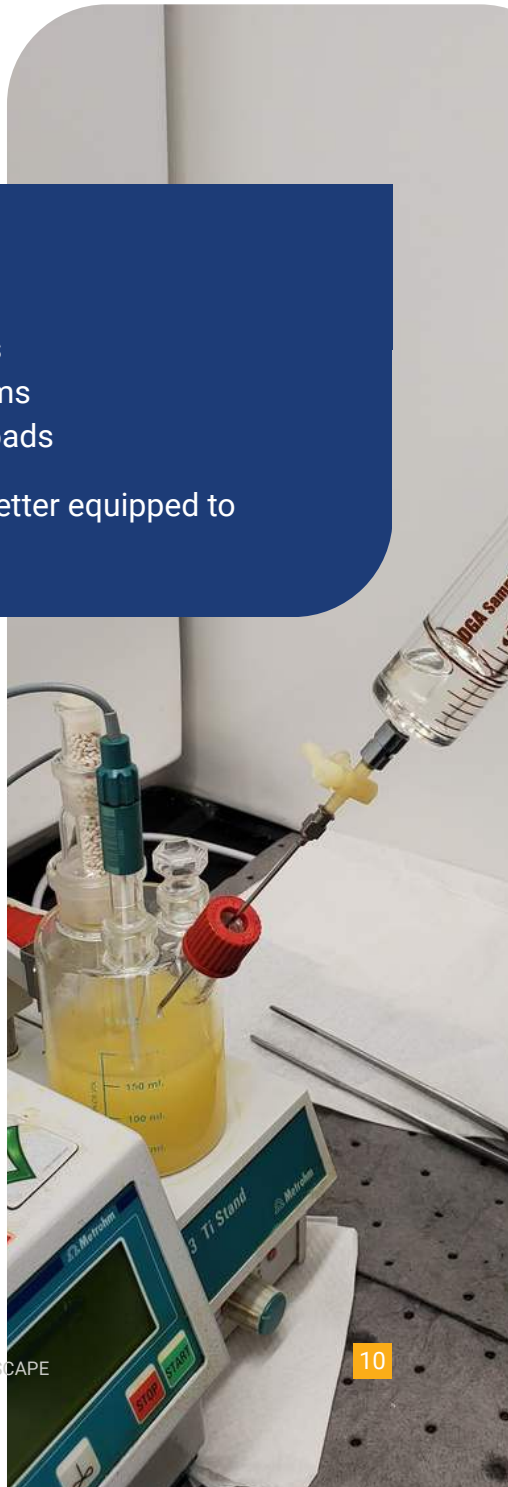
The future of the grid is more dynamic, distributed, and digitally enabled. But none of that will work without foundational reliability. As AI, renewables, and grid automation evolve, the need for trusted lab diagnostics will only grow.

Tomorrow's Challenges Require Today's Investment

Emerging demands include:

- Monitoring new transformer fluids like natural esters
- Analyzing assets under high-frequency and harmonics stress
- Diagnosing failures in hybrid substations and modular systems
- Validating grid components supporting EV charging and AI loads

Utilities that modernize their lab testing approach today will be better equipped to manage the risks of tomorrow.



Doble's Ongoing Innovation

Doble continues to expand its lab capabilities to meet tomorrow's needs, including new analytical tools and test methodologies, greater lab capacity and efficiency for faster turnaround, and closer integration with digital asset platforms. We're also working to ensure the next generation of utility engineers has access to lab-driven training, mentorship, and support.

Whether utilities are modernizing infrastructure, planning for DER integration, or managing transformer fleets under greater stress, lab services will remain an essential reliability tool. At Doble, our goal is simple: empower utilities with the insights to act—confidently, quickly, and always in the best interest of grid reliability.

Data You Can Trust. Action You Can Take.

The electric grid's future is more dynamic than ever, but reliable performance still hinges on one principle: informed decision-making.

Laboratory diagnostics are the unsung foundation of that process. They uncover the invisible, verify the uncertain, and guide the critical. With trusted data, utilities can act faster, extend asset life, and reduce the risk of failure.

At Doble, we help make that possible. Through advanced lab services, expert interpretation, and a deep commitment to partnership, we support the utilities keeping the lights on, today and tomorrow.

Looking to strengthen your diagnostic strategy?

Let's talk about how Doble's lab services can support your goals. From transformer programs to fleet-wide testing, we're here to help.

Learn more about Doble's Laboratory Services here.

ABOUT DOBLE ENGINEERING

Doble is the world's most trusted brand in electrical diagnostics. We provide energy system engineers with the tools, insights and confidence to anticipate and overcome tomorrow's power demands today.

Doble is part of the Utility Solutions Group of ESCO Technologies Inc. (NYSE: ESE). For more information, visit: www.doble.com and connect on LinkedIn