# The Smart Grid Interop Lab

# Advancing the State-of-the-Art for Testing Smart Grid Systems and Elements

**Harry Stephey**

**KEMA PowerTest, LLC**
**4379 County Line Road**
**Chalfont, PA 18914**
**Harry.stephey@kema.com**

**Keywords:** Interoperability, compliance, compatibility, multi-vendor, independent

**Abstract**

As Smart Grid Technologies mature, the need to ensure interoperability of products from multiple vendors will become significant. Utilities want choices among vendors' products. The fact that products are functionally tested for compliance with industry standards such as ANSI and IEEE does not equate to interoperability among similarly tested products. To effectively evaluate these choices and to determine the impact these might have on the operational objectives, ***there is a need to have a managed and maintained reference system*** that would be used to form the baseline for these comparisons and decisions.

Emerging, evolving and new standards will impact today's designs, to evaluate the impact and efficacy of using these, it is necessary to again have a reference system that can be used ***to determine the best solution to fit the business, economic and risk mitigation needs of many utilities.***

Exclusive reliance on vendor testing is risky, particularly since their view often may be limited to their sphere of interest; frequently, it is myopic and does not consider the need to link elements and to evaluate the impact that their element could have on the end to end performance requirements. Therefore, ***there must be a system that links all elements in an end-to-end environment.***

## 1. COMPATIBILITY, COMPLIANCE AND INTEROPERABLITY

Products can be compatible with each other and coexist on the same network, but not be interoperable. Products can be compliant with industry specs (such as ANSI C12.19, IEC 61850), but not be interoperable. Interoperability includes multiple aspects of form, fit and function

The latest version of the **Draft NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0** Defines Interoperability as follows:

*"The capability of two or more networks, systems, devices, applications, or components to exchange and readily use information—securely, effectively, and with little or no inconvenience to the user. The Smart Grid will be a system of interoperable systems; that is, different systems will be able to exchange meaningful, actionable information. The systems will share a common meaning of the exchanged information, and this information will elicit agreed-upon types of response. The reliability, fidelity, and security of information exchanges between and among Smart Grid systems must achieve requisite performance levels."*

### 1.1 Testing Products for Compatibility and Compliance

Typically, products can be tested for compatibility and compliance with existing standards and specifications in a sterile test lab environment involving only the product and associated test equipment. Typically, the test equipment provides an input stimulus and other test equipment measures the output response.

According to the EnerNex Corporation's **Existing Conformity Assessment Program Landscape Version 0.82**, conformance testing …"determines whether an implementation conforms to the standard as written, usually by exercising the implementation with a test tool." The report also states, "Almost all of the available testing programs are for conformity to the standard only; they do not test for interoperability between systems."

### 1.2 The Challenge of Interoperability Testing

The process of testing interoperability requires the following elements:

- Create a real-life functional environment
- Generate a complete set of input stimuli
- Test complete end-to-end system operation
- Test interaction with all system elements
- Test performance in the presence of normal and degraded communications systems
- Simulate and emulate operation of multiple devices
- Measure and document test results

Most importantly, testing interoperability involves not only the device being tested, but also the complete set of additional devices with which interoperability is being tested.

Existing testing labs lack the ability to test interoperability of products and systems with each other. What we need is an independent Smart Grid Interoperability Lab that can create the infrastructure, communications, and t end-to-end system environment to adequately test the interoperability of multiple vendors' products in a real-life operating environment.

### 1.3 Who Benefits from a Smart Grid Interoperability Lab?

- Utilities Benefit:
  - Evaluate smart grid options without having to run many technology pilots;
  - Reduce their risks by demonstrating interoperability of various vendor's offerings against industry (NIST) standards;
  - Optimize configurations by benchmarking performance and enabling managed tests and evaluations;
  - Conduct regression tests to validate design or firmware changes
- Vendors Benefit:
  - Create "fair play" environment with independent baselines
  - Demonstrate compatibility and suitability of products and services for utility needs
  - Provide a test bed for prototype products during the development process
  - Refine offerings to meet emerging needs
  - Gain valuable information on key client performance expectations

## 2. SMART GRID INTEROPERABILITY LAB

The SGIL will enable: optimizing system elements, minimizing key risks and establishing a reference benchmark to test various options.

- Create a limited-scale, but technologically advanced, ***test facility to validate compliance*** of low-voltage automation devices, meters, and consumer products with evolving Smart Grid standards;
- Establish ***a reference architecture*** that is representative of typical smart grid field implementations;
- Permit various ***elements to be either tested or simulated under controlled and repeatable environments***;
- Enable utilities and vendors to test and ***optimize the performance of smart grid elements to achieve their business objectives***;
- Form a system-level smart grid baseline that will be used for ***ongoing compliance and regression tests***;
- Facilitate the evaluation of new and existing products that may could be included in future configurations and ***assess these new offering performance against defined baselines***;
- ***Test the compliance of products to established and evolving interface and security standards, including the NIST interoperability framework***.
- Allow equipment to be appropriately ***exercised in a live electrical distribution environment, prior to deploying these assets into the field***
- Further the understanding how best to ***specify and deploy smart grid elements to meet current and future business needs.***

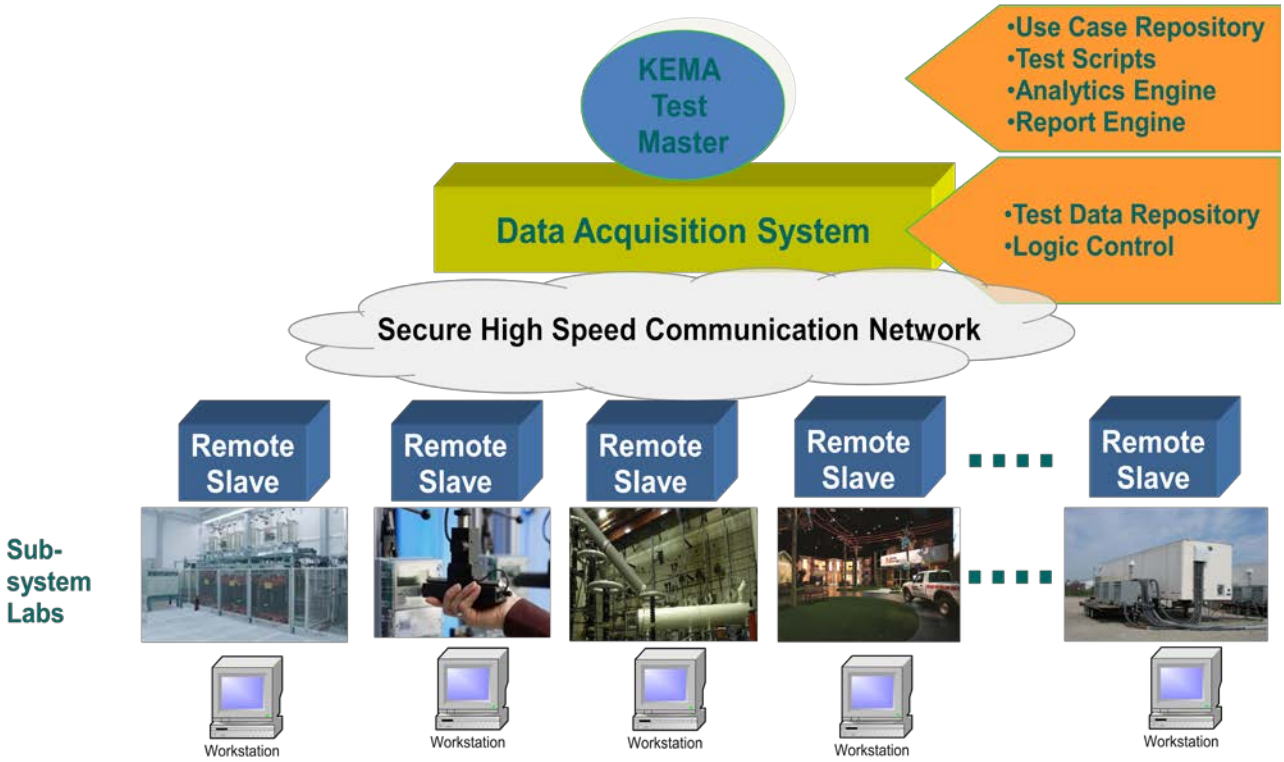


**Figure 1**

**Smart Grid Interoperability Lab Architecture**

### 2.1 SGIL Architecture

The wide-scale adoption of smart grid interoperability standards and the on-going compliance validation of smart grid product performance to these standards are still largely under development. As such, many utility smart grid programs face exposure to critical risks by deploying new technologies and integrating them with existing technologies at an unprecedented scale and scope. Figure 1 shows a proposed Architecture for the Smart Grid Interoperability Lab (SGIL). Primary elements of the SGIL include the following:

- Test Master software to implement use cases, test cases. Test procedures, message generation and data analytics
- Data Acquisition System to generate, collect, record and analyze test data
- High Speed data communications among multiple test site locations
- Subsystem Labs and Vendor Labs with unique testing capabilities

### 2.2 SGIL Prerequisites

It would be nice if putting together pieces of a Smart Meter system was as easy as buying accessories for a TV. You can buy a TV from any vendor, a DVD player from another, a home theater system from yet another vendor and expect them to plug and play. With smart meters it matters which combination of meter, communications and head end systems you pick.

Before we test for *inter*-operability we need to test for *operability.* This means assuring that the individual products are compliant with applicable standards such as ANSI C12.19, IEC 61850 or UL 1741. There are already numerous labs that can perform these certification tests. The real challenge occurs when we connect a bunch of certified products from multiple vendors together and expect them to play nice with each other. This problem is exacerbated when we try to replace a piece of the overall system with a product made by a different vendor.

### 2.3 SGIL Requirements

The Smart Grid Interoperability Lab is first a test bed for interoperability testing. There are no "standard" tests for interoperability. Each test of interoperability requires the following steps:

- Define the operational configuration
- Identify appropriate use cases and test cases
- Define communications requirements
- Define "success"
- Run all applicable tests
- Document results

#### 2.3.1 Communications Challenges

Communications is the heart of the Smart Grid. Communications connects the meters to relays, access points, concentrators and even other meters via RF, power line communications, or telephony.

Points of concentration communicate to head end systems via Cellular or other RF technology, dedicated wire line or fiber optic technologies. Different vendors' meters offer different levels of interoperability with different types of communications technologies. Perhaps the biggest challenge of communications technologies stems from the fact that communications characteristics (such as latency, jitter, and packet errors) are dynamic, not static.

The popular use of 3G Cellular for backhaul exemplifies the issues associated with communications testing:

- 3G Cellular is not a "product" with static characteristics that yield consistent test results
- Performance is a function of the number of users and amount of simultaneous communications. An AT&T 3G network in California may not perform exactly the same as a Verizon 3G network in Pennsylvania.
- 3G backhaul is not dedicated to smart meter/smart grid communications. It is a public network shared with cell phones and other cellular data applications
- Unlike RF mesh networks that can be improved by adding additional relays and access points, 3G cellular "is what it is".

So how do you account for all of these variations as part of an interoperability testing program?

#### 2.3.2 Communications testing

Communications testing is the most significant part of interoperability testing. Real interoperability testing involves end-to-end testing of the complete system in a real operating environment. This requires the communications test system to be able to do the following:

- Generate significant message traffic in order to stress equipment to the limits of its capability
- Inject quantified anomalies such as latency, jitter and packet errors into the communications system to verify operation if the presence of these anomalies
- Measure the characteristics of real-life networks so they can be emulated during test

## 3. SUMMARY

The Smart Grid Interoperability Lab provides the framework for testing products and systems in a live operating environment that creates real-life operating conditions.

## 4. REFERENCES

**4.1 Draft NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0**

**4.2 Existing Conformity Assessment Program Landscape Version 0.82**, EnerNex Corporation

**4.3 Smart Grid Testing & Certification Committee (SGTCC) Interoperability Process Reference Manual (IPRM) Version 1.0 November 19, 2010**