Achieving the vision of a “Smart Grid”

KEMA Perspectives and Observations

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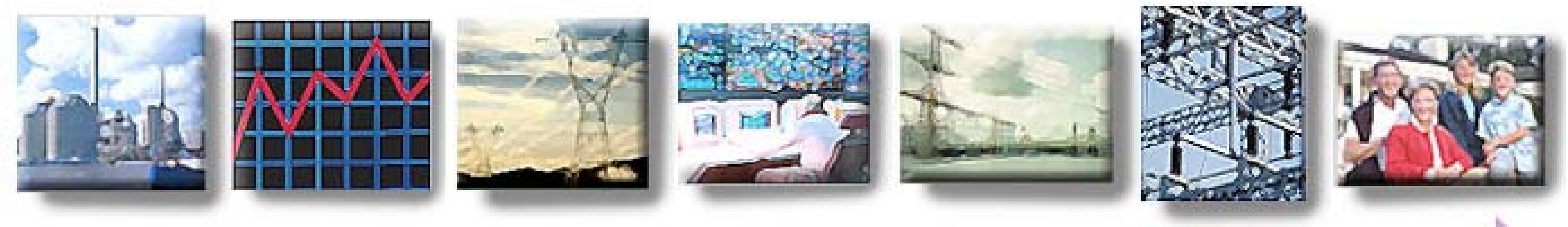
New Orleans November 2008

KEMA has been serving clients for more than 80 years



Serving electric utilities' diverse needs from generation to retail

- Established in 1927, Arnhem, the Netherlands
- Three primary business lines:
  - Consulting
  - Testing
  - Certification
- 1,600 professionals in more than 20 countries
- Annual revenue of $300+ million

Independent experts to the global energy and utility industry

Our future grid requirements will be very different

20th Century Grid	21st Century Smart Grid
Electromechanical	Digital
Very limited or one-way communications	Two-way communications every where
Few, if any, sensors – “Blind” Operation	Monitors and sensors throughout – usage, system status, equipment condition
Limited control over power flows	Pervasive control systems - substation, distribution & feeder automation
Reliability concerns – Manual restoration	Adaptive protection, Semi-automated restoration and, eventually, self-healing
Sub-optimal asset utilization	Asset life and system capacity extensions through condition monitoring and dynamic limits
Stand-alone information systems and applications	Enterprise Level Information Integration, inter-operability and coordinated automation
Very limited, if any, distributed resources	Large penetrations of distributed, Intermittent and demand-side resources
Carbon based generation	Carbon Limits and Green Power Credits
Emergency decisions by committee and phone	Decision support systems, predictive reliability
Limited price information, static tariff	Full price information, dynamic tariff, demand response
Few customer choices	Many customer choices, value adder services, integrated demand-side automation

There are numerous variations in architecture and naming conventions, all focused on similar core issues

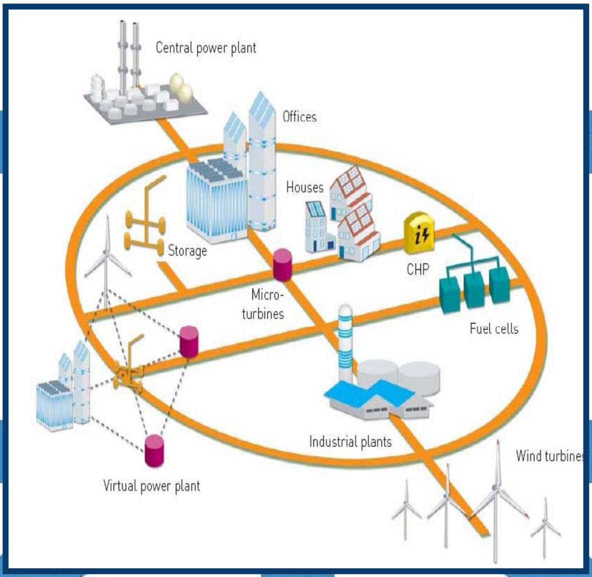
Selected Utility Smart Grid Efforts

- *Utility of the Future* - Duke Energy
- *gridSMART* – American Electric Power
- *Intelligrid* – CEMIG (Brazil)
- *Blueprint for the Future* – Pepco Holdings, Inc.
- *Avanti: Circuit of the Future* – Southern California Edison
- *Circuit of the Future* – Kansas City Power & Light Co.
- *Intelligent Utility Grid* - CenterPoint Energy
- *Power the Future* – WE Energies

- How can initial investments in AMI or Smart Metering be leveraged into a broader Smart Grid architecture?
- Which technologies are ready for investment now? Which ones should be deferred?
- What is the right regulatory recovery scheme (short and long-term)?
- How will consumers accept and interact with these applications?
- How will incremental CapEx requirements be integrated into existing grid resource plans?
- What rate and service offerings are needed to maximize consumer participation?
- How well will standards drive innovation, while maintaining security and reliability?

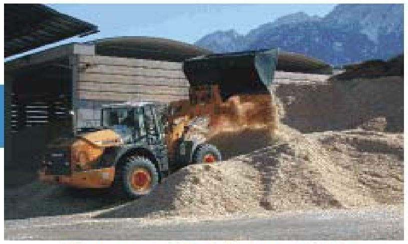
The Smart Grid will operate as an Intelligent Network, with a portfolio of technologies and advanced communications

Efficiency in Buildings, Industry and End-Use Products



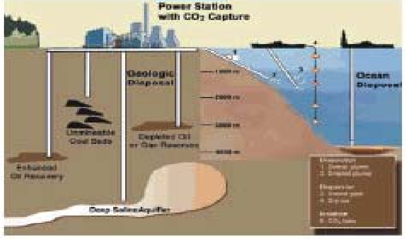
Renewable Energy Technologies

Vehicles: Efficiency, Hydrogen Fuel Cells

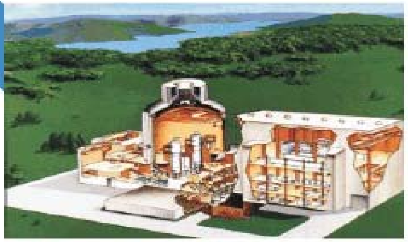


Biomass, Synfuels, CHP

Advanced Power Generation and Grids



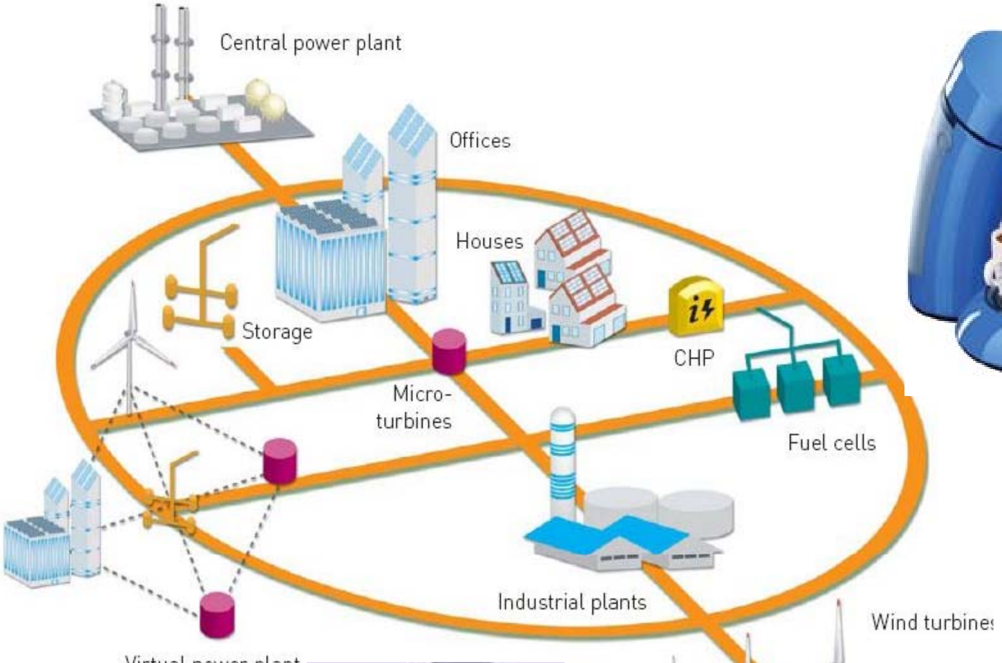
CO$_2$ Capture and Storage



Advanced Nuclear Fission and Fusion

Source: International Energy Agency (Vigotti)

This will, in turn, drive the development of new generation technologies and products



Convenience & health

Smart power electronics

Mini- and micro turbines

Smart grid technologies are potentially disruptive to the traditional utility value chain, particularly for consumers

Traditional Utility Value Chain

	Power Production	**Transmission**	**Distribution**	**Consumption**
Leading Smart Grid Considerations	• Carbon sequestration • Integrated Gasification Combined Cycle • Advanced nuclear design	• Synchronized Phasor Measurement Units (PMUs) • High Temp cable • Flexible AC Transmission • High Voltage DC	• Automated Metering Infrastructure • Line fault sensors • Automated reclosers • Automated Volt/VAR control • Substation energy storage	• Home area networking • Autonomous DR • Smart appliances • Distributed generation • Integration of building controls • Plug-in Hybrid Electric Vehicles • Micro energy storage • Rooftop solar energy • Pre-payment systems • Time-based pricing • Third-party service providers (e.g., DR)
Degree of Market Disruption	*Minimal*	*Moderate*	*Large*	*Transformational*

Smart Grid deployment will open a $100B market in smart technologies[1]

Note 1: Department of Energy; The Reform Institute, "The Smart Alternative: Securing and Strengthening Our Nation's Vulnerable Electric Grid"

Energy storage applications are becoming more feasible for both large and small scale applications

	Technology	**Power Density**	**Energy Density**	**Efficiency**	**Comments**
Emerging Technologies	Flow Batteries (Vanadium and Polysulfide/Bromide redox)	20 to 28 (kw/ton)	16 to 33 (kWh/ton)	60 to 85% (Wh in/out)	Low energy density
	Sodium Sulfur	160 to 220	100 to 200	75%	High cost Safety factors
	Lithium Ion	700 to 1300	100 to 150	95%	High cost Charging circuit req.
	Flywheels	2000 to 5000	50 to 900	90%	Low energy density
	Superconducting Magnetic Energy Storage (SMES)	16 (kW/M^2)	Varies	95 to 97%	Low energy density High cost
Traditional Systems	Nickel Cadmium or Metal Hydride	500 to 1000	60 to 90	85 to 90%	Toxicity of cadmium High cost
	Lead-acid (flooded or vented)	100 to 500	0 to 30	85%	Limited cycle life
	Pumped Hydro Storage	Varies	Varies	65%	Special site req.
	Compressed Air	Varies	Varies	65%	Special site req. Gas fuel
	Capacitors	800 to 8000	0.3 to 10	95%	Low energy density

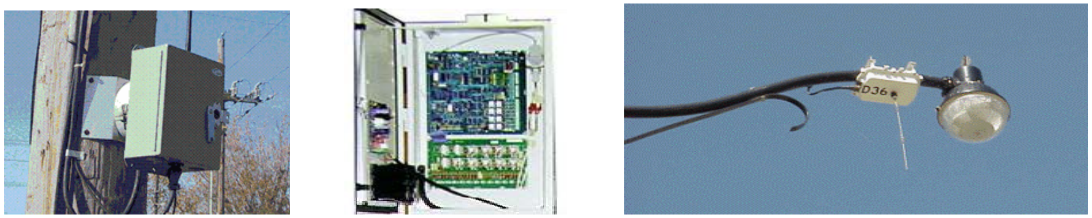
Tangible Applications

- Enhanced Grid Stability and Voltage Support
- Enhanced Demand Response for End Users
- Mitigate Volatility and Transmission Limits
- System Regulation and Energy Balancing
- Ancillary Services such as Frequency Regulation and Spinning Reserve
- Assist in Integrating Wind / Solar technologies Into the Grid

Source: KEMA research and analysis; Electricity Storage Association

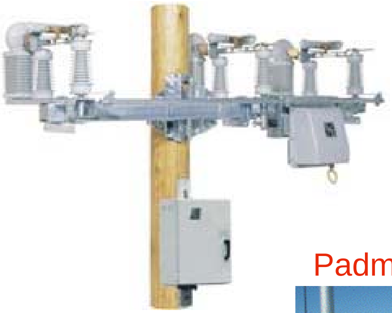
Feeder and distribution automation consists of mostly discrete sensors and control equipment

Low-latency, high bandwidth communications and back-office data management have been one of the barriers to overcome for successful deployment


Distribution RTU


SF6 Switch


Load Break Switches

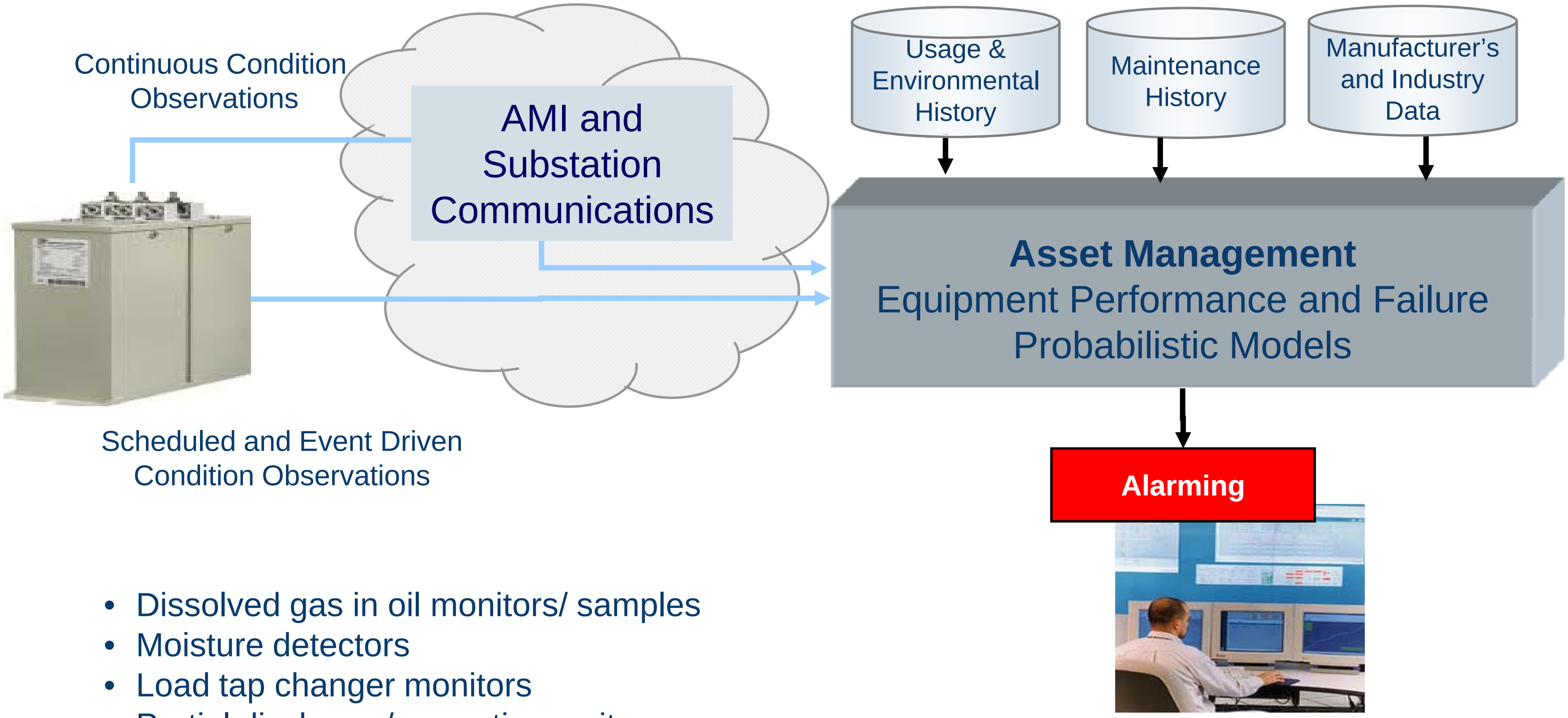

S&C Omni Rupter


Faulted Circuit Indicators


Line Post Sensor


Padmount Switches

With condition monitoring – sensors plus analytical/ probabilistic models – asset management benefits can accrue



Continuous Condition Observations

AMI and Substation Communications

Usage & Environmental History

Maintenance History

Manufacturer's and Industry Data

Asset Management
Equipment Performance and Failure Probabilistic Models

Alarming

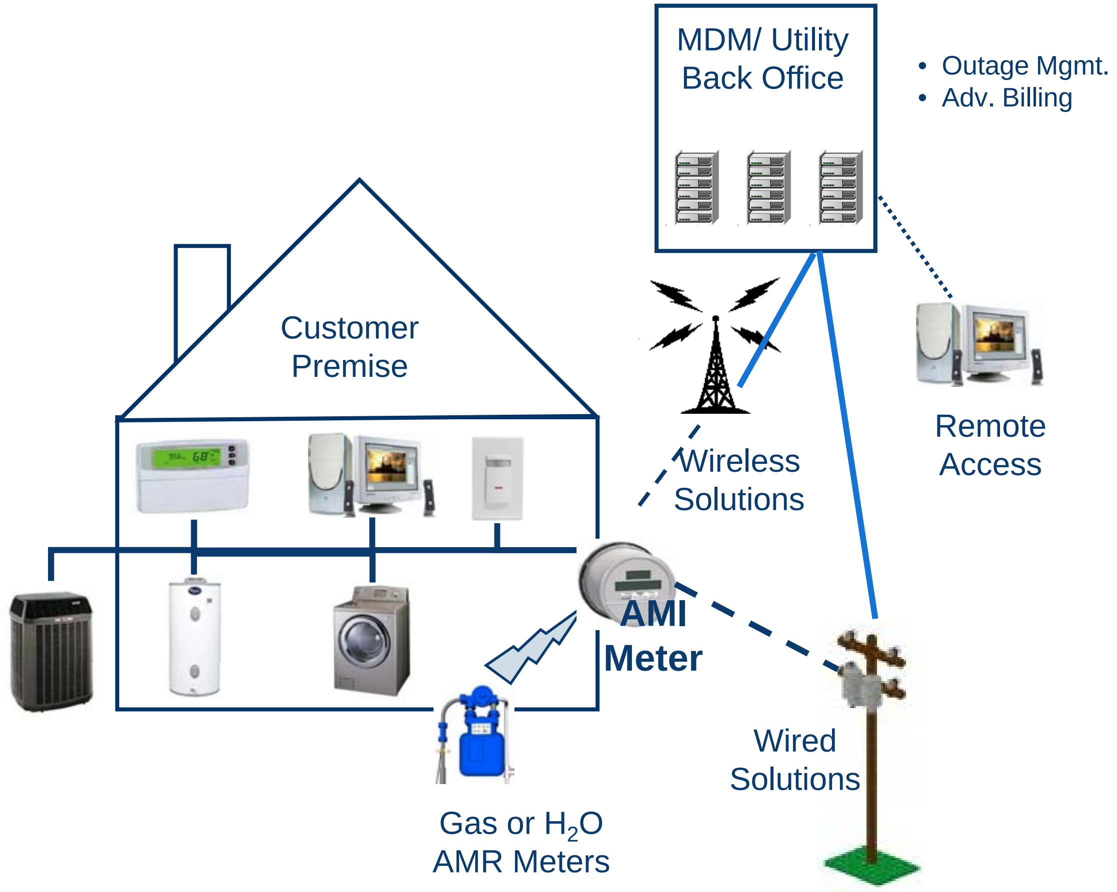
Scheduled and Event Driven Condition Observations

- Dissolved gas in oil monitors/ samples
- Moisture detectors
- Load tap changer monitors
- Partial discharge/ acoustic monitors
- Bushing monitors
- Circuit breaker monitors
- Battery monitors
- Expert systems analyzers

- Asset Management
- Condition Based Maintenance

AMI provides increased network connectivity and communications between the customer and the utility

AMI Connectivity (illustrative)

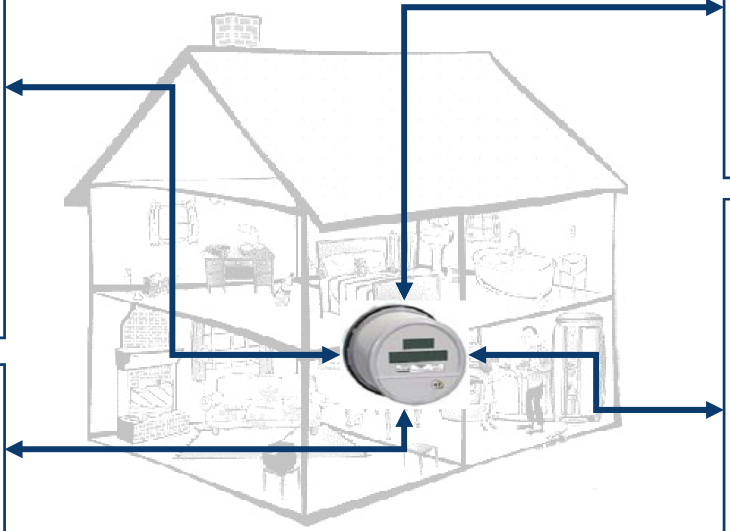


AMI Communications Trends

- Full two-way (bi-directional)
- Near real-time data read/access
- Higher bandwidth
- Increasing number of communications nodes
- Robust Meter Data Management systems to interface with back office
- Peer-to-peer mesh networks
- Distributed generation control
- Multiple backhaul integration
- Device interoperability
- Open communications protocols
- Self-diagnostics and programming
- Minimal network administration
- Self-registry capabilities
- Price signals to smart appliances
- Meter as a premise "portal"

The number of vendors seeking the Home Area Networking market is significant – many expect to follow the AMI path to commercialization

Home Area Network Vendors



Load Control Switches

- Intermatic
- Leviton
- RAM Industries
- Baco Controls
- Corporate Sys. Engineering
- Invensys
- Domosys Corp.
- Dencor
- Brayden Automation Corp.

Lighting Controls

- Electric City
- Lightstat Inc.
- Douglas Lighting Controls Inc.
- Powerline Control Systems, Inc.
- Vantage Controls

In-Home Display Devices

- Comverge
- Invensys
- Broadband Energy Networks
- Intellicom Innovation AB

Smart Thermostats

- Johnson Controls, Inc.
- Honeywell
- Carrier
- Domosys Corp.
- Comverge
- Delta Controls
- Adjala Controls and Technologies (Log-One Ltd.)

The key to success of this "next generation" of products will be through industry-wide, open communications protocols and interoperability

On the consumer side, the potential impact of Plug-in Hybrid Electric Vehicles is significant and highly anticipated

Toyota Prius

Anticipated PHEV Impacts

- Potential impacts to the U.S. grid are significant:
  - – 15 kW (avg.) X 256M vehicles = 3,840 GWs
  - – Power generation today = 986 GWs
- Vehicle can provide energy storage in response to appropriate pricing plans
- Intelligent plugs would communicate with the electric utility to automate nationwide billing and control
- Battery storage provides spinning reserves and ancillary services
- New business models for utilities and others to provide secondary battery markets/swaps
- External firms such as Google are investing in PHEV demonstration projects

Market realities and consumer economics will dictate how rapidly PHEVs will be adopted as a viable supply/ demand option for the smart grid

Source: KEMA Research, Energy Information Administration, US Dept. of Transportation

Duke Energy’s “Utility of the Future” program (U.S. utility)

Key Objectives

- Create a reliable and scalable networked infrastructure capable of delivering and receiving information from intelligent devices distributed across our power systems
- Automate components of the distribution systems
- Leverage the linked networks for improved operational efficiencies and customer satisfaction
- Provide the future platform for changing the customer experience and their use of energy in support of Duke’s Energy Efficiency programs

Size and Scope

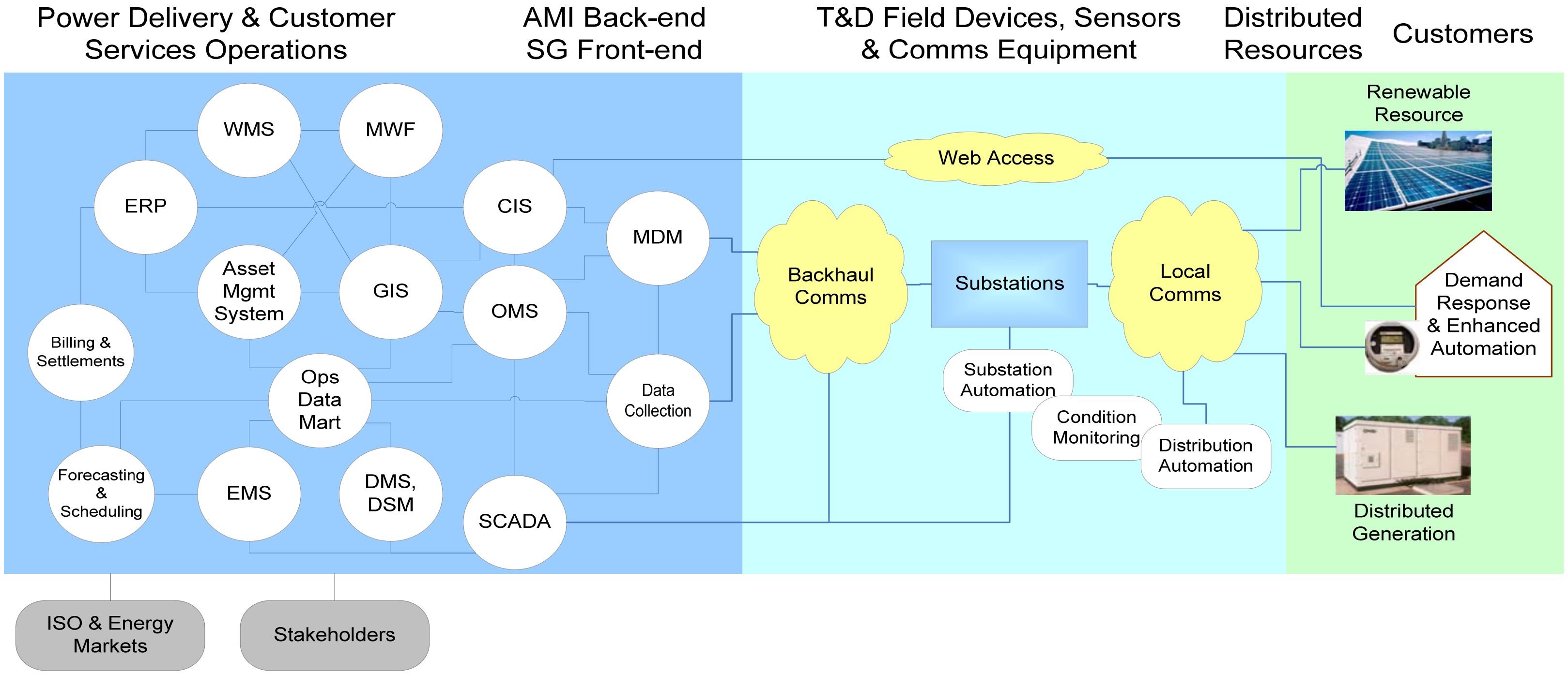
- 4.3M total electric and gas customers
- Five different regulatory jurisdictions
- Full deployment by 2012-13

Steps Taken

- Nearly 100k units deployed by end of ’08
- Combination of Powerline Carrier, RF Mesh, and digital cellular communications platforms
- Fully, IP-based and open platforms
- First full-scale, smart grid effort in U.S.

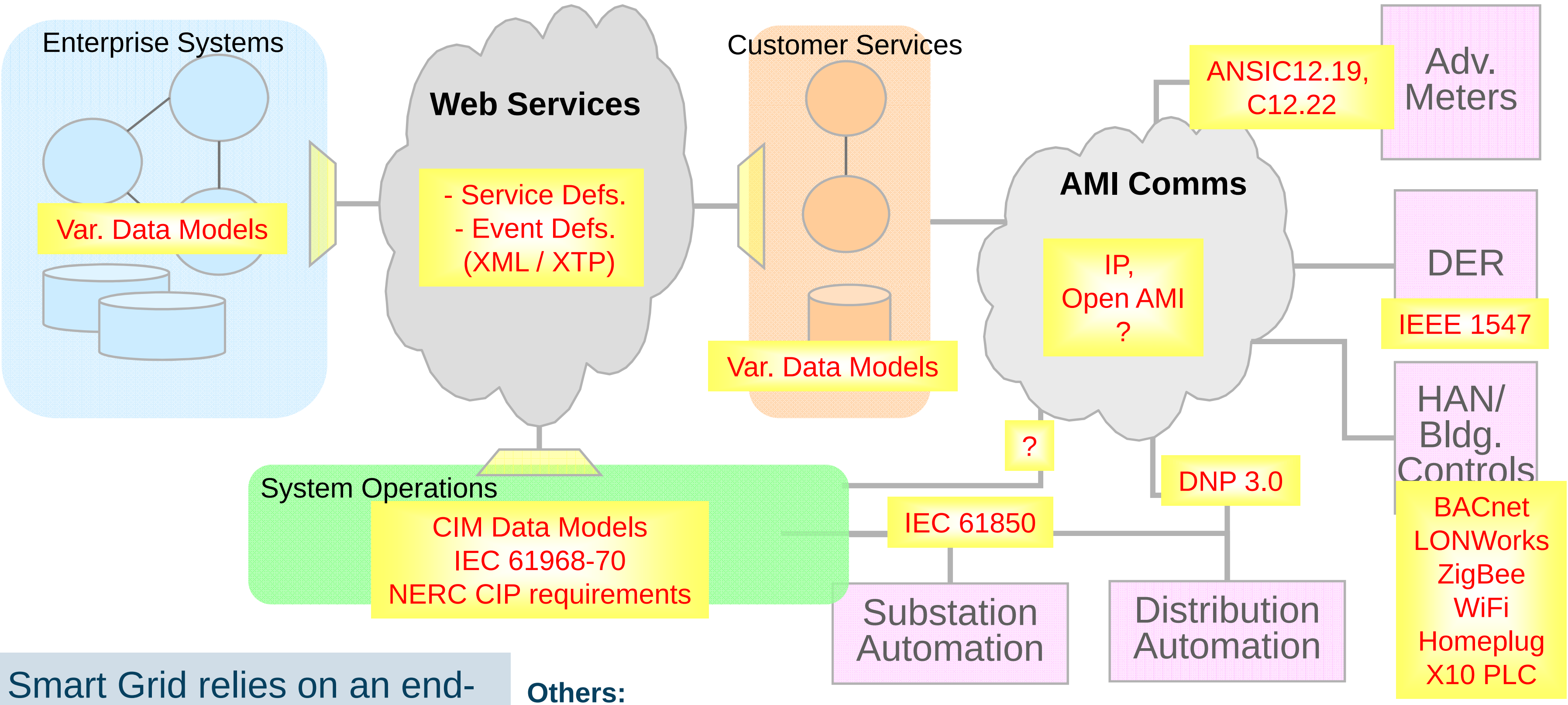
> “A lasting and sustainable shift in the way we use electricity will require a ‘back of mind’ approach – where customers can take energy efficiency for granted, the same way they take for granted that the lights will come on when they flip a switch.” *Jim Rogers, Duke Energy CEO*

Smart Grid deployment will require an end-to-end operational view



- Individual technologies and enablers are critical components - e.g., high-bandwidth, secure, and two-way communications infrastructure
- However, real benefits will be achieved by society when considering the end-to-end impact and integration across the utility enterprise, as well as its interface to the consumers

Interoperability and acceptable standards will be vital to full systems integration for smart grid components

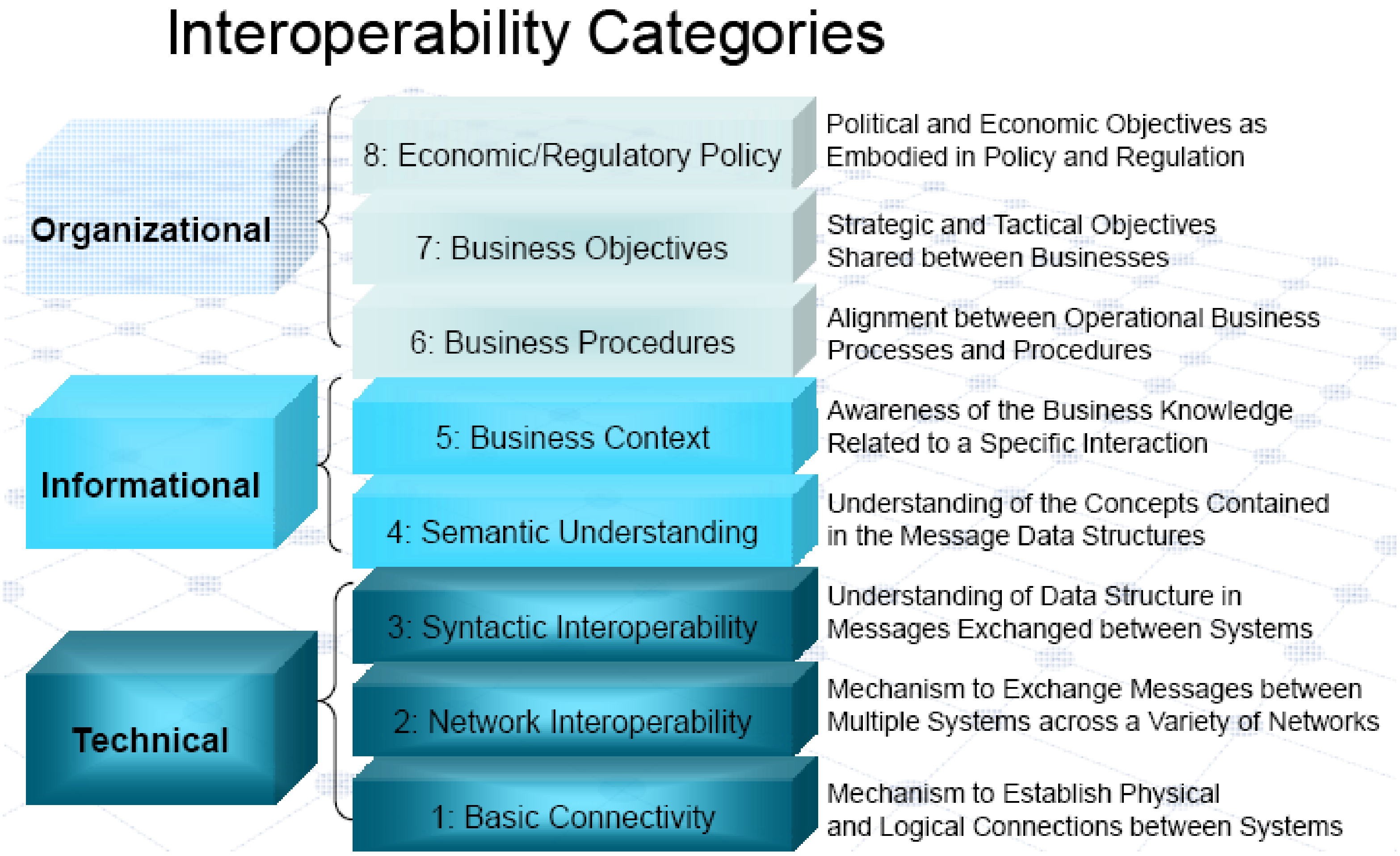


Smart Grid relies on an end-to-end integration capability, but the many integration points (seams) lack commonly adopted standards

Others:

• IEC 61000-3-X	EMC
• IEC 61400	Wind Turbines
• IEC 62351 PS	Control and Assoc. Comm. - Data and Comm. Security
• IEEE 1366	Distribution Reliability Indices
• IEEE 802	LAN / WAN
• C37.1-2007	SCADA 7 Automation Systems

Interoperability principles apply to multiple levels and policies, not just the technical layer



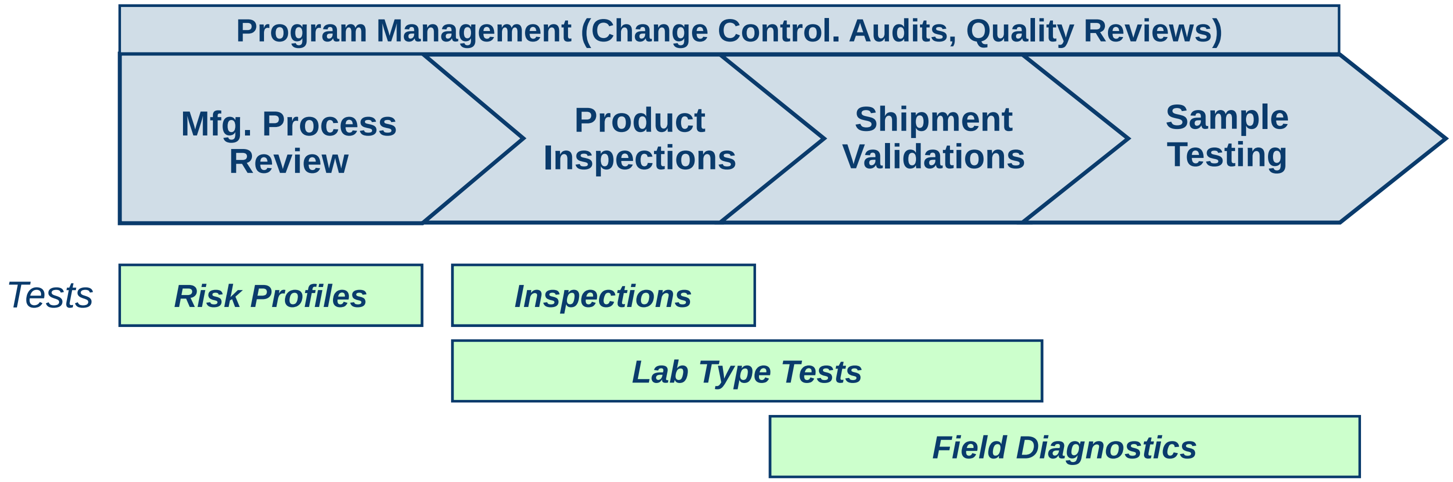
Interoperability Categories

Organizational	8: Economic/Regulatory Policy	Political and Economic Objectives as Embodied in Policy and Regulation
	7: Business Objectives	Strategic and Tactical Objectives Shared between Businesses
	6: Business Procedures	Alignment between Operational Business Processes and Procedures
Informational	5: Business Context	Awareness of the Business Knowledge Related to a Specific Interaction
	4: Semantic Understanding	Understanding of the Concepts Contained in the Message Data Structures
Technical	3: Syntactic Interoperability	Understanding of Data Structure in Messages Exchanged between Systems
	2: Network Interoperability	Mechanism to Exchange Messages between Multiple Systems across a Variety of Networks
	1: Basic Connectivity	Mechanism to Establish Physical and Logical Connections between Systems

Source: *GridWise Interoperability Context-Setting Framework*, GridWise Architecture Council, March 2008

We are also seeing a strong interest in enhanced levels of quality assurance for Smart Grid programs and field demonstrations

Major Steps in a Robust Quality Assurance Program



Program Management (Change Control. Audits, Quality Reviews)

Mfg. Process Review

Product Inspections

Shipment Validations

Sample Testing

Tests

Risk Profiles

Inspections

Lab Type Tests

Field Diagnostics

Steps

- On-site process audit
- Target high-risk areas from Risk Profiles
- Perform for each vendor prior to initial production run
- Profile tracks vendor compliance to utility-specific requirements

- Physical inspections
- Perform at mfg. sites and at Utility central receiving
- Frequency impacted by Mfg. Process Review audit results

- Physical & limited electrical tests
- Diagnostic tests performed on-site with remote equipment
- *Lab Tests* – random checks upon shipment receipt
- *Field Tests* – random checks upon install

- Full electrical tests as outlined in protocols
- Sampling based on ongoing, validated AQL levels
- Lab tests include Meter/ Device Type Tests plus Reliability tests

Demonstration centers, such as the Envision Center, are key in making the technology "real"

Envision Center

- Cincinnati-based, technology demonstration center that seeks to favorably showcase the features and benefits of the "Utility of the Future" to various stakeholder groups
- Creates "laboratory" environments to prototype and demonstrate key components of the smart grid vision
- Integrates the work at the center with related promotional, educational, and marketing activities targeted for various stakeholder groups

KEMA Duke Energy

Expected Opening: October 2008

KEMA

KEMA's experience has shown that select factors will enable greater Demand Response program effectiveness

- Strong policymaker priority placed on demand response
- Sufficient coordination between energy efficiency and demand response program design and implementation
- Simplified pricing options for policymakers and consumers to compare/evaluate
- Avoidance of default service rates that limit customer exposure to time-differentiated rates and price transparency
- Rates based on actual, rather than average, load profiles
- Elimination or absence of retail/wholesale price caps
- Appropriate incentives for emergency DR participation
- Clarity and certainty around utility cost recovery and rate of return incentives for DR investments
- Consistency of interoperability and interconnection requirements
- Rules that facilitate access to meter data for non-utility DR market participants

Demand Response is a primary benefit for recovery of the Smart Grid/ AMI investment

Catch Phrases to Remember

- Customers Want Information, not Instruction
- Information Enables Customer Decisions
  From “The Regulator as the Ultimate Customer”
  To “The Customer as the Ultimate Regulator”

One day, our energy options will reflect a smarter planet

Thank you for your time.

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