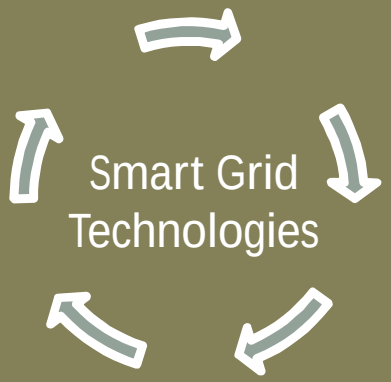

Risk Assessment ⇨ **Asset Management** ⇨ **Asset Optimization**

DO WE KNOW WHAT WE DON'T KNOW?

Presented by: Eric Stojkovich

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Overview

- In today's rapidly expanding and evolving electric power system environment, utilities must manage electrical grid assets effectively and efficiently

- Properly managed assets will significantly reduce operational costs and also improve service levels and financial controls

- There is mounting pressure by legislators, the business community and the general public to disclose how both the Board and Senior Executives of the utility oversee and monitor their risk management practices to provide a reliable and cost effective power supply

Overview

- As processes that drive mission-critical physical assets become ever more automated, the benefits of real-time information management and enterprise-wide visibility are key differentiators in a highly competitive sector

- Blackouts during the last ten years in Europe and Northern America have demonstrated an increasing likelihood of supra-regional blackouts with accompanying large economic losses

- The earthquake, tsunami damage and power shortages in Japan and massive flooding in Thailand idled thousands of factories in 2011

Overview

Based on a foundation in Enterprise Risk Management, through a formal Risk Assessment and development of strategies for the Key Risks, a resulting Asset Lifecycle Management (ALM) program can be developed to proactively monitor and track electrical grid assets, and ultimately result in Asset Optimization.

Risk Assessment ⇨ **Asset Management** ⇨ **Asset Optimization**

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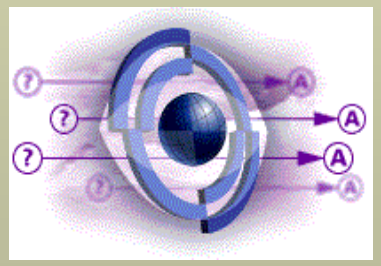
Enterprise Risk Management - What is it all about?

- Enterprise Risk Management (ERM) meets the need for identifying, assessing, managing and monitoring an organization's opportunities and risks
- ERM redefines the value of risk management by elevating its focus from the tactical to the strategic
- ERM is about designing and implementing capabilities for <u>managing the risks that matter</u>

RISK: Effect of uncertainty on objectives i.e. every transformer has an end-of-life, so the result of the event is known. The risk comes from not knowing when it will occur – the frequency of failure.



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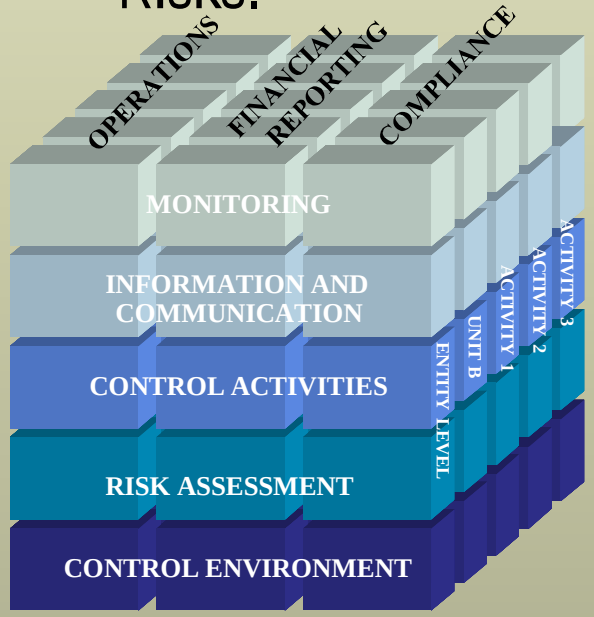
Enterprise Risk Management - What is it all about?

- ERM is about establishing the oversight, control and discipline to drive continuous improvement of an organization's risk management capabilities in a changing operating environment

- The ERM framework advances the maturity of the organization's capabilities in managing its priority, or Key Risks.



The ERM framework is presented in the form of a three-dimensional matrix (COSO II)

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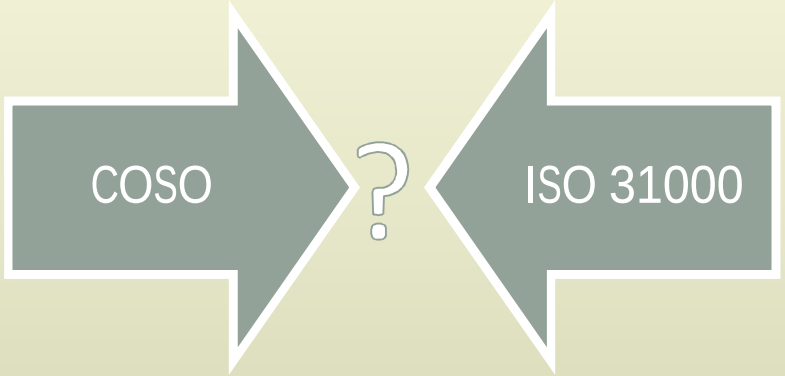
Enterprise Risk Management -- ISO 31000 (quickly)



- ISO 31000 provides an 'umbrella' for more than 60 recognized standards and guidelines that refer to risk management
- Despite being labeled as an ISO standard, it is:
  - A set of guidelines – "Risk Management – Principles and Guidelines"
  - Voluntary application – not prescriptive – no legal requirement
  - Specifically not intended for certification
- ISO 31000 provides a globally applicable risk management reference guide with a generic three – pillar architecture (principles; framework; process)
- ISO 31000 provides for a continuum of improvement through the iterative process and feedback loops /opportunities for 'lessons learned' at each stage in the process

The ISO 31000 two-dimensional structure is notably more simple to apply than COSO II

Enterprise Risk Management - What is it all about?

- Just as potential future events can affect the value of tangible physical and financial assets, so, too, can they affect the value of key intangible assets
  - customer assets
  - employee/supplier assets
  - organizational assets such as reputation

Enterprise Risk Management - What is it all about?

The five broad categories of assets representing sources of value, and examples within each category

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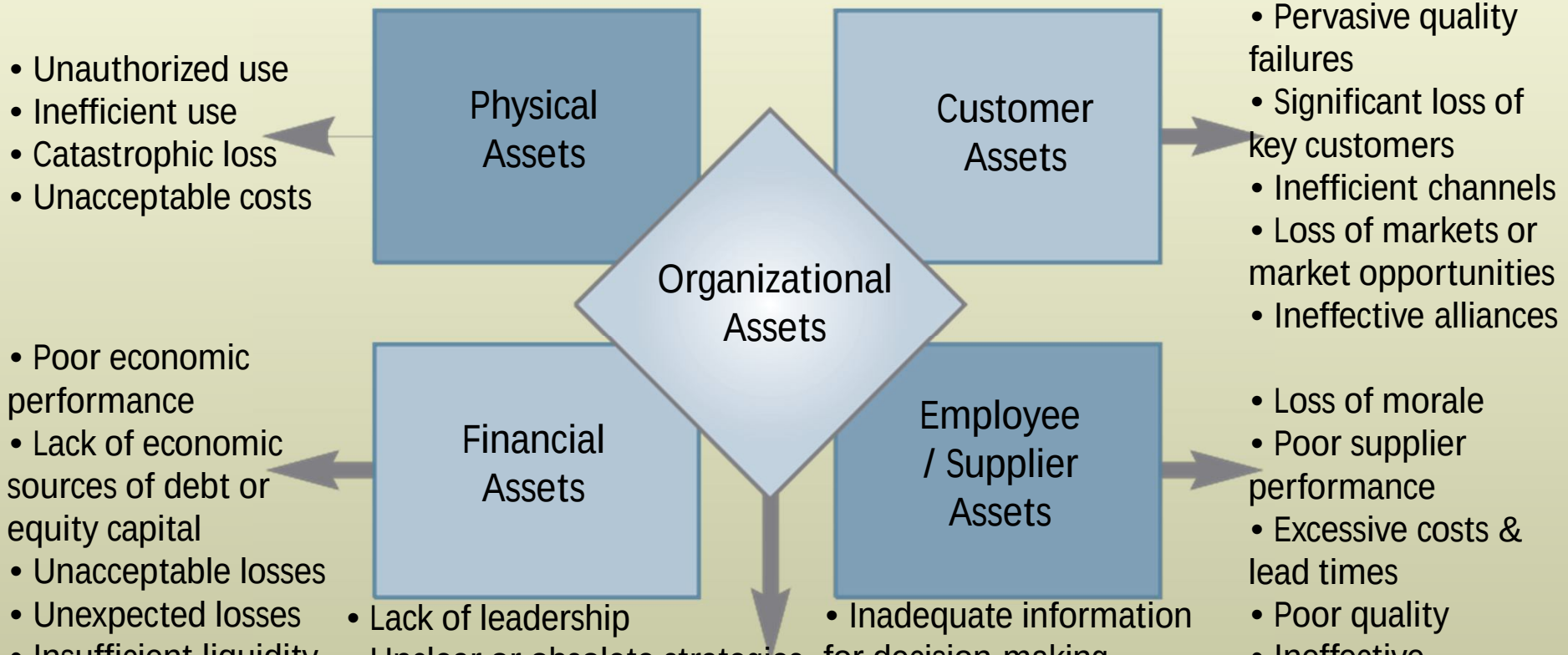
Enterprise Risk Management - What is it all about?



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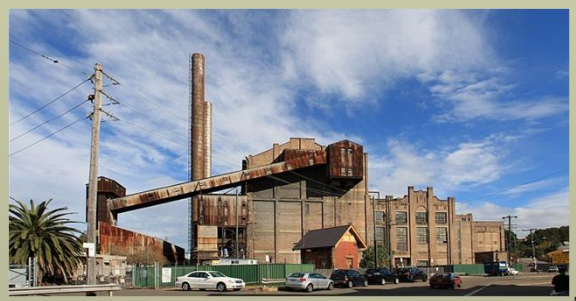
Risk Assessment & Prioritization - Big Picture

- In ERM, the primarily focus is on KEY Risks to the organization, not necessarily ALL risks
- Risk management goals and objectives should be consistent with and supportive of the organization's business objectives and strategies
- Generally a utility would consider grid reliability and reduced frequency of unplanned outages as a critical business objective

If the financial crisis has but a single lesson, it is this: What we don't know can be more important than what we do know.
This raises the ultimate rhetorical question: Do we know what we don't know?

Risk Assessment & Prioritization - The Reality

- The power system infrastructure (electric grid) is aging and many components are operating beyond their design life
- There is a growing risk of unplanned outages occurring more regularly and of failure rates increasing to a point where the industry will be unable to provide replacements fast enough
- It is crucial that critical components of the network be monitored continuously to prevent unplanned outages, while at the same time their lives are extended without sacrificing a high level of reliability



Risk Assessment & Prioritization - Risk Map

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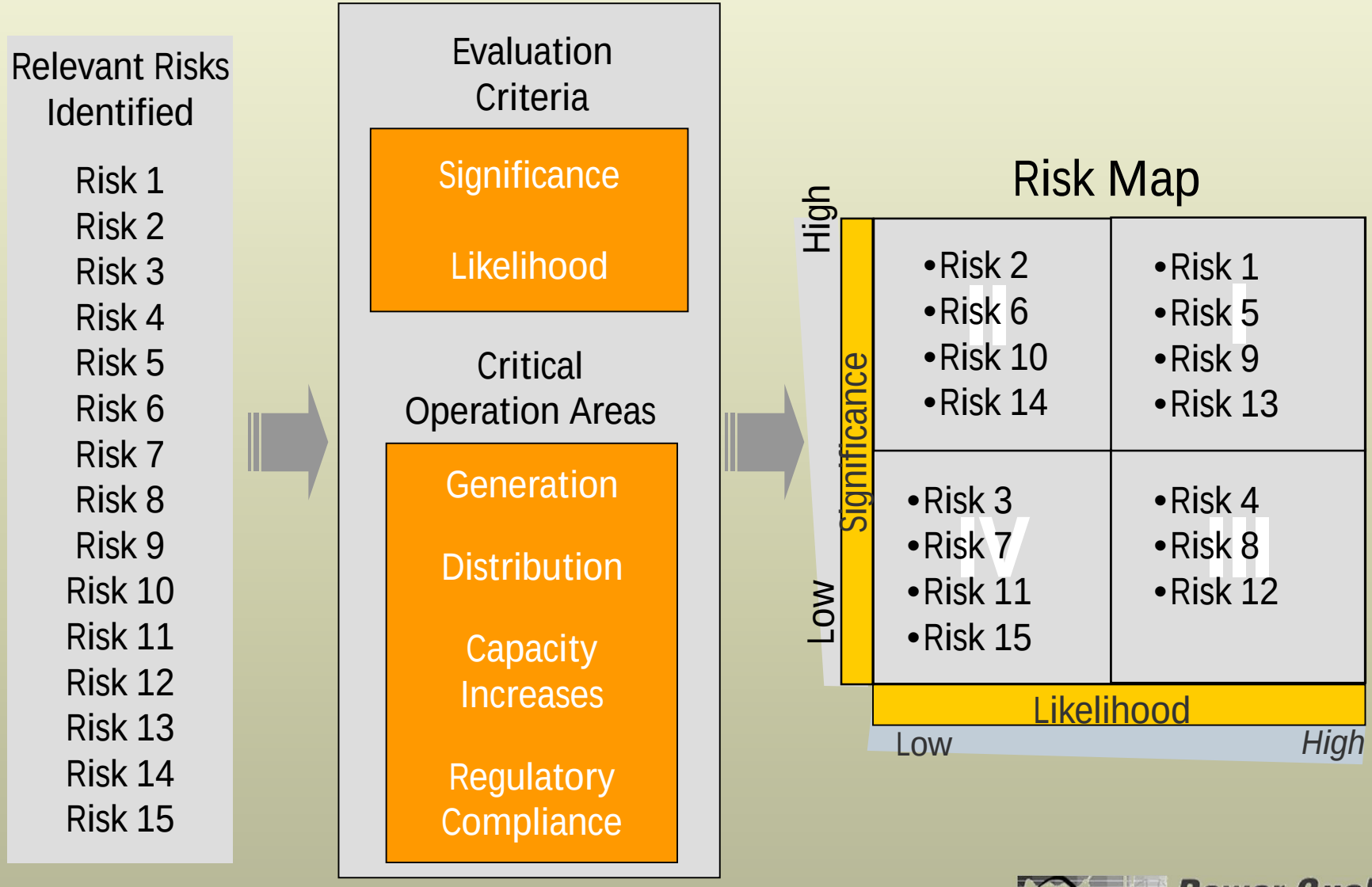
Risk Assessment & Prioritization - Risk Map



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Risk Assessment & Prioritization - Risk Map

Important Qualifiers

- Identify the threat environment and protection goals for the asset, balancing expected outcomes against the costs associated with proposed mitigations

- Take a holistic approach, with specific focus on determining the appropriate balance of resilience, restoration, and protection

"Despite all the rhetoric and money invested in it, risk management is too often treated as a compliance issue that can be solved by drawing up lots of rules and making sure that all employees follow them…But rules-based risk management will not diminish either the likelihood or the impact of a disaster such as Deepwater Horizon, just as it did not prevent the failure of many financial institutions during the 2007–2008 credit crisis."

Harvard Business Review "Managing Risks: A New Framework" - Robert Kaplan & Anette Mikes

Risk Assessment & Prioritization - Risk Map

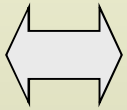
Important Qualifiers (continued)

- Managers cannot view Risk Management as an administrative burden without embracing the benefits
- Understand what is real and what people perceive to be real with input from both the utility sector and government authorities
- It is impossible to fully protect the system from every threat

Risk Assessment & Prioritization - An Example

Key Risks associated with Electrical Grid Operations

- High Grid Utilization or High Power Demand
- Equipment Failure
- Natural Catastrophic Events
- Cyber/Terrorist Attack
- Geomagneticaly Induced Currents
- Shrinking Reserve Margins
- Technical and Commercial Revenue Losses
- Human Failure



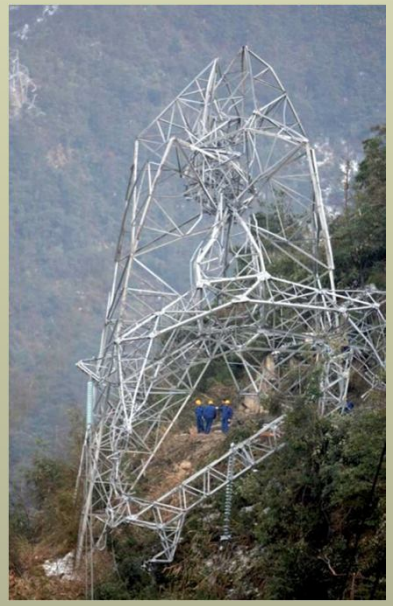
Significant Electrical Power System Processes

- Smart Grid Technologies
  - SCADA
  - IEC 61850 Substation Automation
  - Distribution Feeder Automation
  - Demand Response Management System
  - Power Quality Event & Asset Monitoring System
- Maintenance / Training
- Cyber Security

Risk Assessment & Prioritization - It is all about Money

- The well known 2003 blackout in U.S. and Canada seems to be the highest economical loss ever during an outage with an estimated total cost of US$ 4 bn to US$ 8 bn

- But even short blackouts which occur several times during a year in the U.S. sum up to an annual economic loss between US$ 104 bn to US$ 164 bn



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Risk Assessment & Prioritization - It is all about Money

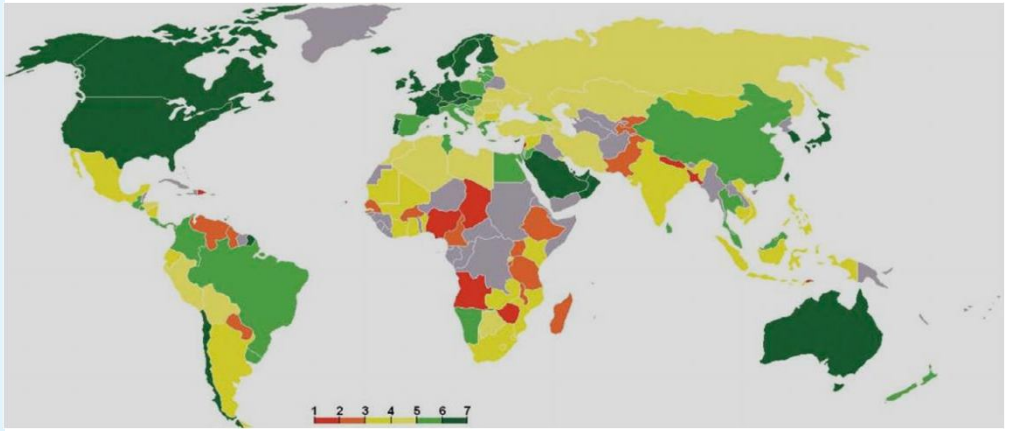
- Costs per customer differ significantly between residential, commercial, and industrial customers
- The costs can be described as the Value of Lost Load (VoLL), which is the estimated amount that customers would be willing to pay to avoid a disruption in their electricity service
- Highest costs accrue during the first hour and then decline slowly thereafter, but they differ according to various elements
  - Industry sector
  - Size of the enterprise
  - Duration and frequency of past events
  - Time of day and by season of the year
  - Proportionate to household income

Risk Assessment & Prioritization - It is all about Money

- Direct costs of blackouts are lost production, idle labor and facilities, damage to electronic data, spoiled food and damaged products, damage to equipment or customer refunds

- Indirect costs are looting, accidental injuries, legal costs, loss of water supply. In general indirect costs exceed direct ones by up to 5 times

Quality of Electrical Supply by Country, 2010



1 = insufficient and suffers frequent interruptions 7 = sufficient and reliable

Source: World Economic Forum

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Risk Mitigation – Smart Grid Technologies

- "Smart Grid" generally refers to a class of technology designed to modernize the existing utility grid to improve the efficiency on the power network and in energy users' homes and businesses
- The Smart Grid is made possible by two-way communication between the power generation sources and the power users (consumers in homes and businesses) using computer-based remote control and automation
- Selecting a transformer monitoring solution is a critical step in achieving a Smart Grid asset management program

Risk Assessment – High Significance / High Likelihood

Quadrant I – Key Risks – Power Transformers

- Transformers are an essential part of the system, allowing large loads to travel long distances and smaller loads to flow safely into businesses and homes – *High Significance*

- Large power transformers are the most significant portion of the transmission system assets, and a major concern to every electric utility – *High Significance*

- In many cases, utilities face "asset walls," which appear when equipment installed during earlier high-load growth periods shows rapidly increasing failure rates simultaneously – *High Likelihood*

Risk Assessment – High Significance / High Likelihood

Quadrant I – Key Risks – Power Transformers

- Increased equipment utilization, deferred capital expenditures and reduced maintenance expenses are all part of a modern utility's strategies for T&D Assets – *High Likelihood*

- The need to leverage more out of existing equipment must today be achieved with T&D assets that are nearing the end of their useful life – *High Likelihood*

Risk Assessment – High Significance / High Likelihood

Quadrant I – Key Risks – Power Transformers

- Failure of a single unit can result in widespread loss of service with considerable lost revenue as well as replacement and other collateral costs – *High Significance*

- Transformers have ranked in the top five insured claims by utilities for decades – *High Likelihood*

- Utilities aren't the only businesses at risk - three of the top four transformer property damage insurance claims were in industrial plants – *High Likelihood*

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation

- Smart Grid Technologies with continuous monitoring and analytics have replaced off-line diagnostic tools to reduce the risk of transformer failure

- Diagnostic technologies can monitor and control all operating characteristics including the cooling system, load tap changer, dissolved gas, bushing power factor and capacitance, partial discharge, oil levels, pressures, temperatures, and much more

- Data processing techniques, from artificial intelligence to data mining, coupled with the knowledge acquired from diagnostic markers, enable operators to treat the data flow coming from an asset in a smart way and focus attention on a piece of vital equipment in critical conditions.

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation – Why Not?

- Despite these advances –and despite the likelihood that a large transformer failure could easily cost a utility CEO his job – few transformer owners are willing to spend the investment dollars necessary to provide continuous and comprehensive monitoring
  - Few case studies have demonstrated the benefits
  - In the business-oriented, conservative grid management culture a transformer is often considered a functional block instead of an ASSET

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation – Going Forward

- Risk mitigation should be aligned with the growing trend toward Smart Grid Technologies

- SMART GRID – EGAT
  - From the perspective of a generating utility, there may not be many activities that EGAT does that are relevant to Smart Grid; however, EGAT has several projects that can be considered as support for Smart Grid development in Thailand

Smart Grid Global Monitoring Systems (SGGMS) in Thailand ??

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation – Leap Forward

- SMART GRID – PEA
  - According to PEA Strategic Objectives, their Smart Grid project is clearly stated as part of new and appropriate technology in order to increase the organization's performance and utilization
  - It is a stated PEA policy that the development of Smart Grid is a tool for electricity infrastructure development

- SMART GRID – MEA
  - MEA policy is still not directly supporting directly the development of Smart Grid

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation – Next Steps

- Complete a diagnostic review of the current assets, using input from all stakeholders, in order to understand the risks and establish a baseline

- Start with the "low hanging fruit," to make use of sensors and technology already installed or available
  - Focus on a modular approach to gradually build up to Smart Grid monitoring system, while proving to stakeholders that the approach works and actually provides the promised range of benefits

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation – Next Steps

- Ensure Smart Grid Technologies are built-in to future systems as opposed to being delivered as a “bolt-on” retrofit which will greatly improve the cost effectiveness

- Integrate Asset Lifecycle Management with Smart Grid monitoring technology to enable the optimization of transformer assets through a structured program that can track the aging, predict failures and proactively manage performance

Risk Mitigation – Smart Grid Technologies - Mitigation

Risk Mitigation – Next Steps

- Any Mitigation plan must include the understanding that often no one department manages the entire asset lifecycle with insufficient communications among the departments
  - Purchasing, engineering, supply chain, field operations, accounting and finance have separate and distinct information requirements
  - The gap between the financial systems and the installed asset base has grown over the years

Risk Mitigation – Smart Grid Technologies

DYNAMIC RATINGS

A World leader in the monitoring and control of power transformers and electrical power apparatus

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Risk Mitigation – Smart Grid Technologies

Power Transformers – Historically

- **Description**
  - Primarily iron and wires (some wood, paper, etc.)
  - In field longer than designed and fully depreciated
  - Overdesigned
  - Overcapacity
- **Maintenance**
  - Periodic
  - Run to failure
- **Operations**
  - Plenty of margin
  - Flexibility in operating options

Risk Mitigation – Smart Grid Technologies

Power Transformers – What's Changing

- Aging infrastructure will impact service reliability
- Regulatory focus on service reliability with metrics important but not the only objective
- Smart Grid introducing shorter lived assets
- Uncertain forecasts of demand and equipment performance complicating risk management and mitigation
- Game changers arriving – roof top photovoltaics, home electric vehicle recharging, demand response, large renewable energy generation

Risk Mitigation – Smart Grid Technologies

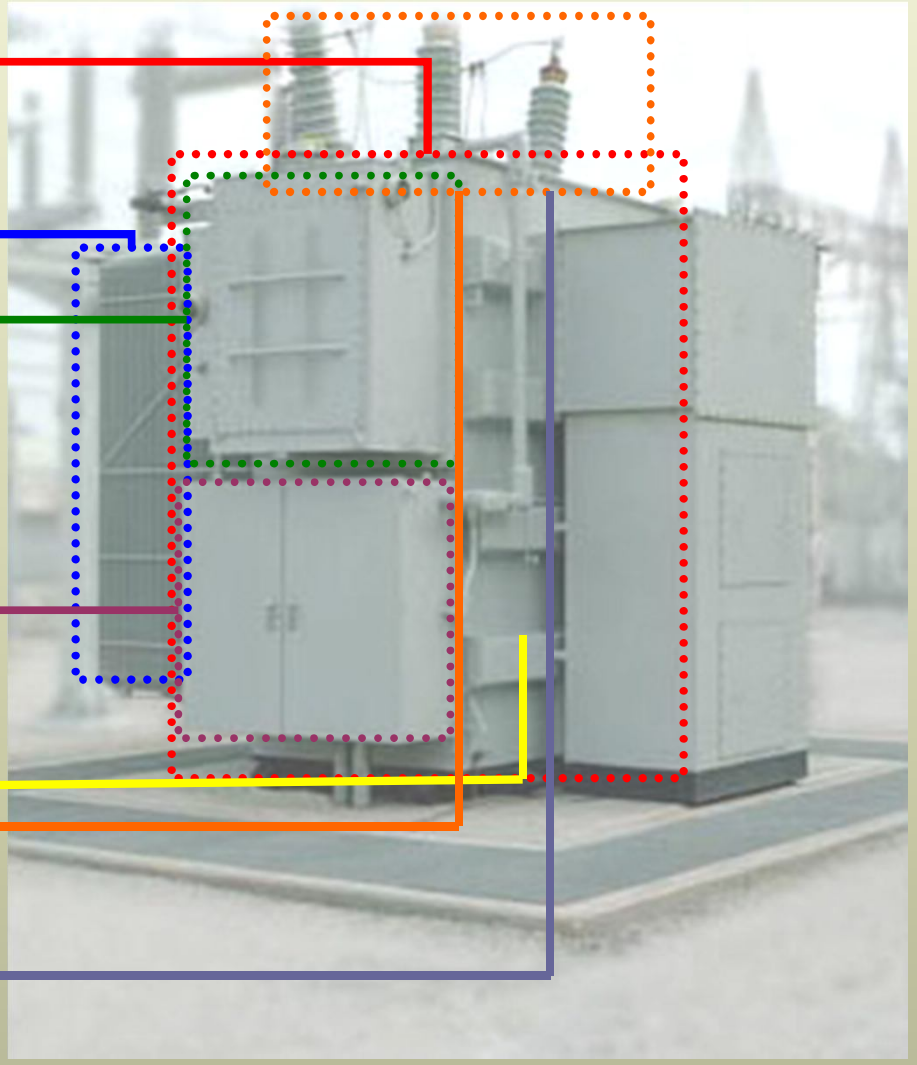
Transformer Health Index (THI)

- Employing the proper online monitoring technologies, one can determine a THI

- The seven key analytics to determine the THI are:
  - Bushings
  - Core and Coil
  - Load Tap Changer
  - Oil
  - Cooling System
  - Thermal Performance
  - Aging Rate

Risk Mitigation – Smart Grid Technologies

- **Temperatures**
- Cooling System
- OLTC Monitoring
- Alarm Contacts
- DGA & Moisture
- Bushings
- Partial Discharge



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Risk Mitigation – Smart Grid Technologies

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About Power Quality (Thailand) Co., Ltd.

Power Quality (Thailand) Co. Ltd. (PQT) was founded in 1986 by a group of professionals with extensive experience that historically offered a full range of power quality services and products throughout the world.

We have expanded our services and product offerings to provide for the opportunities and challenges in the Smart Grid Environment and is a founding member of Smart Grid Asia.US, Ltd.

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About Power Quality (Thailand) Co., Ltd.

- With its knowledge of emerging risk control technology using Smart Grid technologies to monitor transformers, predict failures, and proactively manage performance, PQT can offer risk control and asset management expertise

- PQT understands the issues and can be of vital assistance to the risk manager faced with the unavoidable facts of unprecedented equipment aging, increased failure frequency and increased loss expectancy

- PQT can assist in the discussion of transformer problems and the diagnostic tools available to determine the condition of transformers in an effort to avoid cataclysmic failure and better prepare for the future.

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About Power Quality (Thailand) Co., Ltd.

DRANETZ
THE STANDARD FOR ENERGY & POWER MEASUREMENT

Providing Power Quality and Energy Management products in a range of permanent systems and portable instruments, as well as Electrical Safety Testers, superior Multifunction Meters and Data Acquisition instruments

DYNAMIC RATINGS

A World leader in the monitoring and control of power transformers and electrical power apparatus

POWERMETRIX

For over 15 years, electric utilities from around the world have entrusted Powermetrix to protect their revenue and ensure the billing integrity of their metering sites

ELECTROCORDER

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