Energy Surety Microgrids™ a Framework for Architecting the Smart Grid

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Rush D. Robinett
Senior Manager, Operational Energy Security

…Exceptional service in the national interest

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Energy Security Program

Energy Security Roles

$250M DOE Energy Research Program

Support DoD on energy system, physical, and cyber security

System integrator for the DOE/NNSA

DoD Installation Security Projects

Energy Security Focus

Operational Energy Systems
- Electric Power Assurance
  - Microgrid, renewables, nuclear, storage, control systems, cyber
- Transportation Energy Assurance
  - Combustion research, renewable fuels

Climate Change Science
- Operational Impacts
- Assessments

Nuclear Design & Fuel Cycle

Combustion Research Facility

Distributed Energy Technology Laboratory

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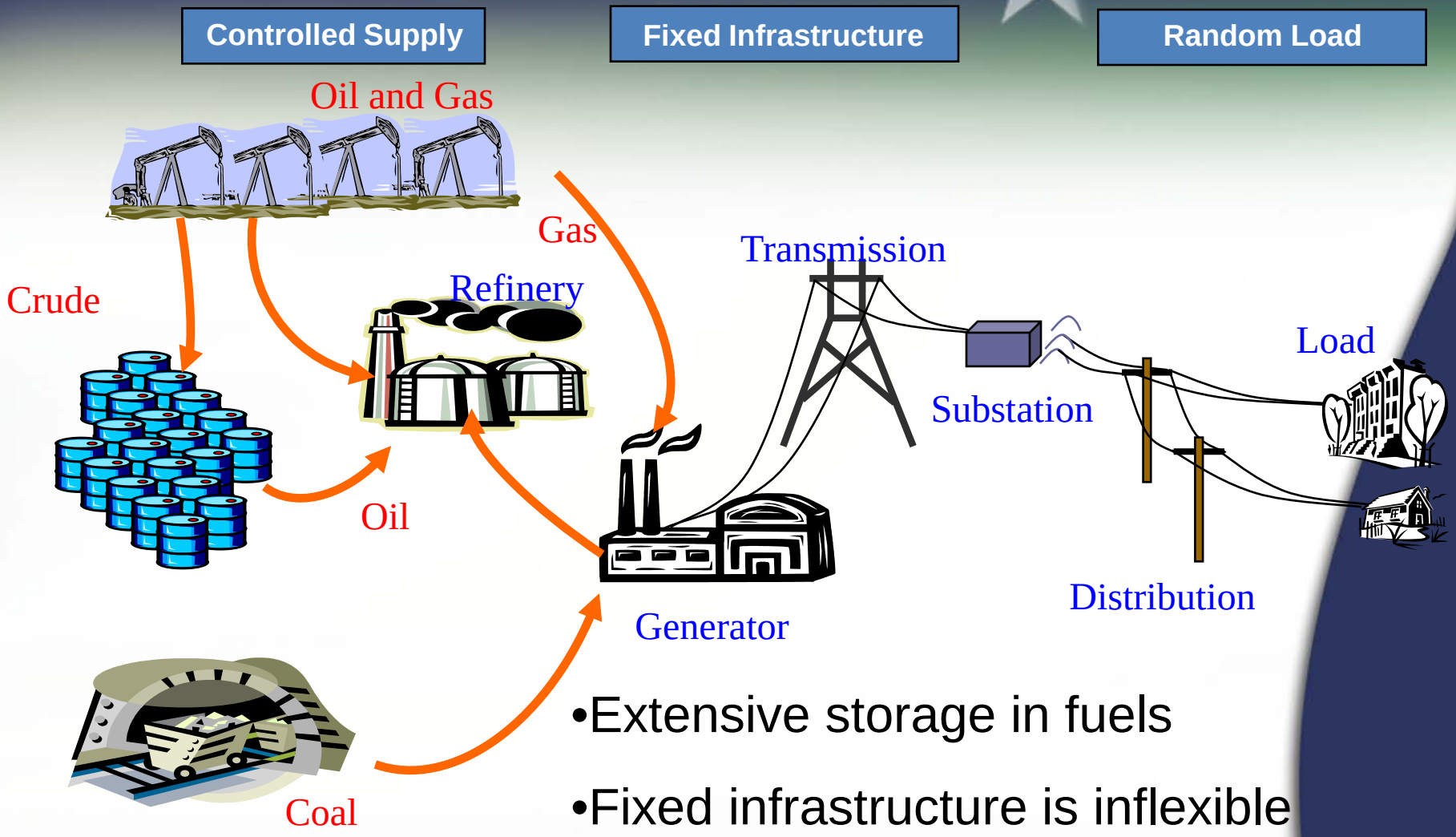
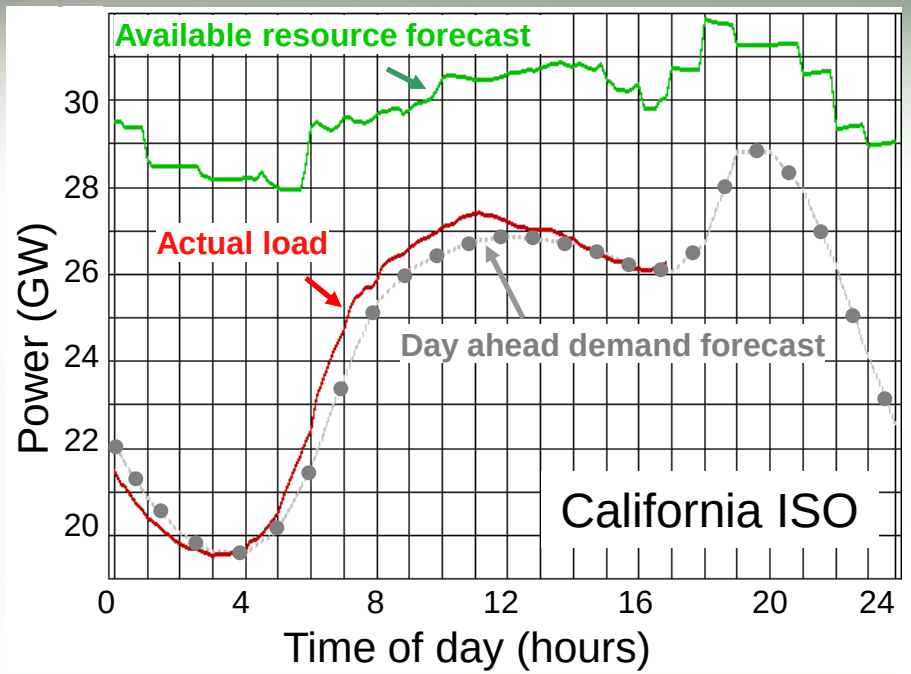
Today's Power Grid is Designed for Dispatchable Centralized Generation



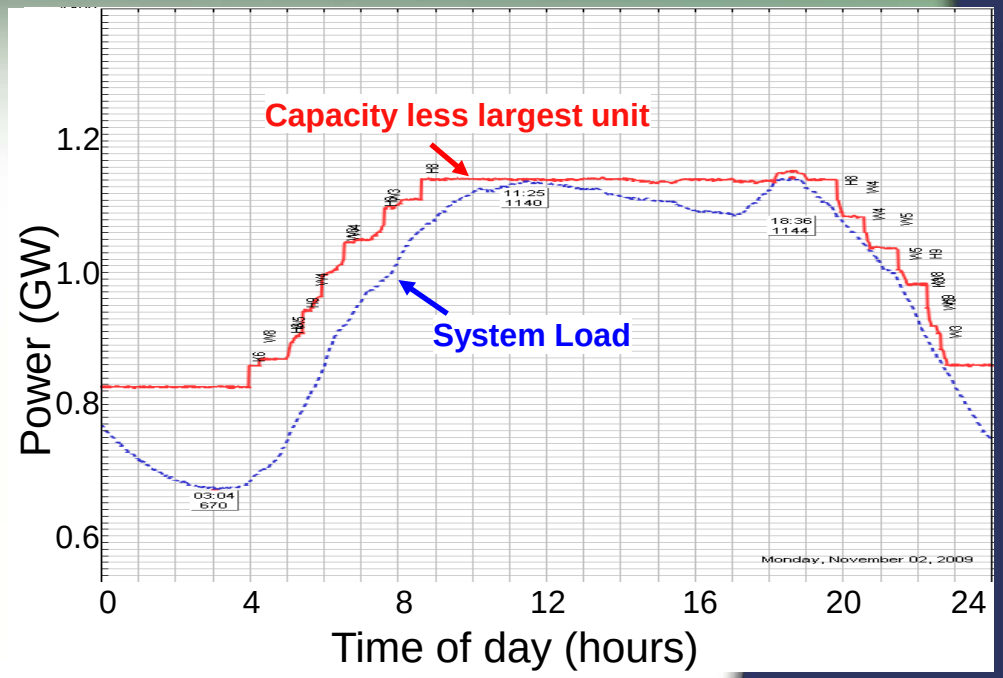
- Extensive storage in fuels
- Fixed infrastructure is inflexible
- Significant human interaction

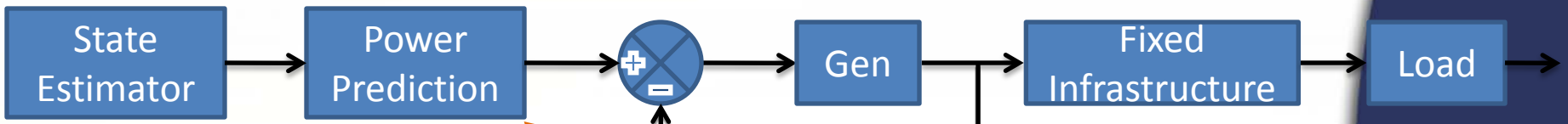
Loads are Predictable, Allowing Essentially Open-loop Grid Control

Forecasting is used to set generation



Hawaiian Electric Co. daily load vs capacity





Feedback loop controls minor frequency variations and output voltage and power

Feedback is often through people

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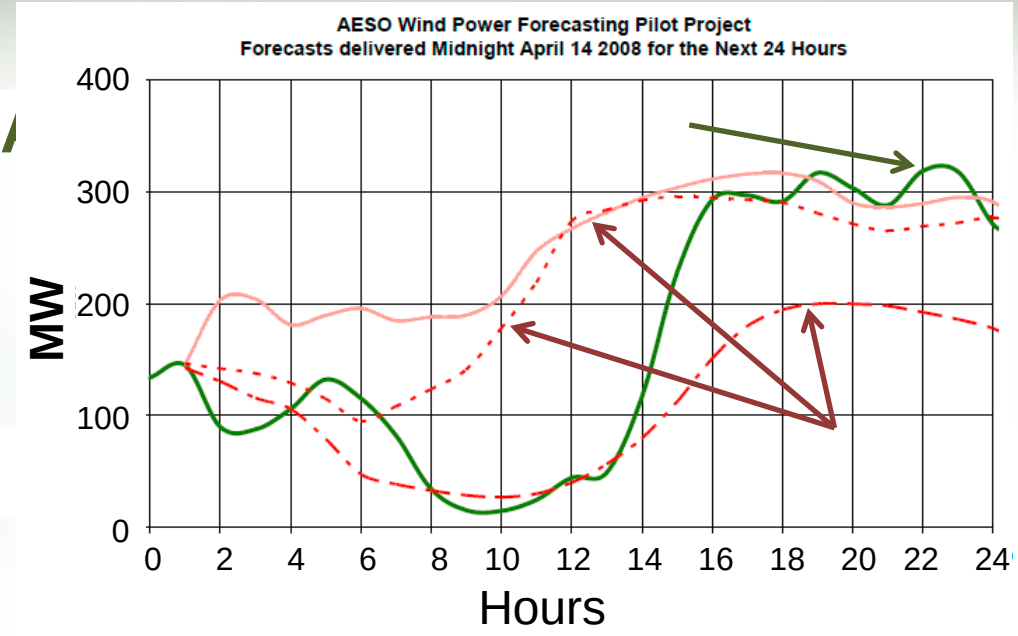
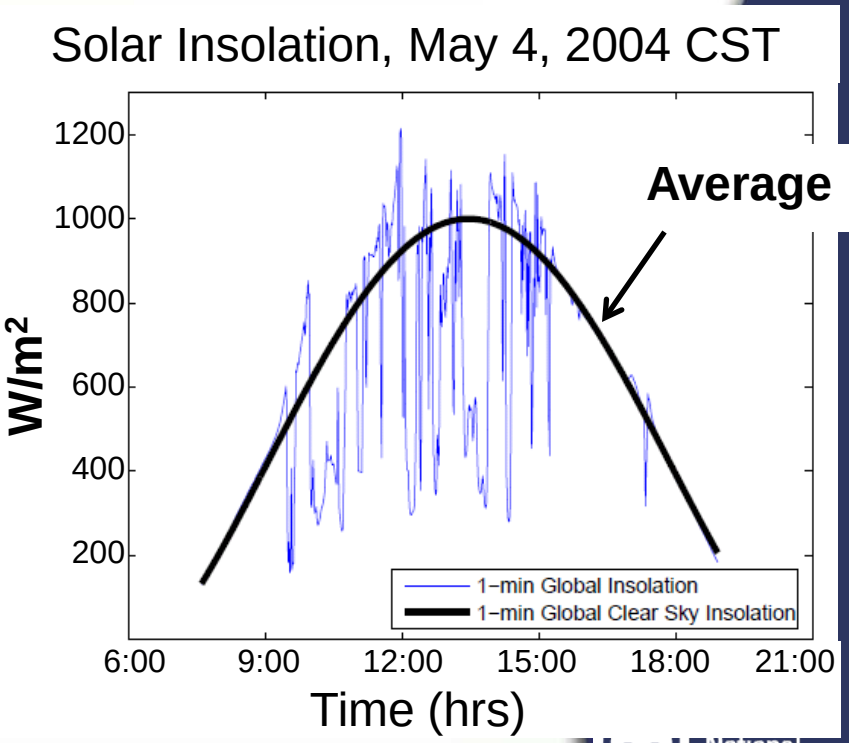
Stochastic Sources (Negative Loads) Complicate Load Forecasting

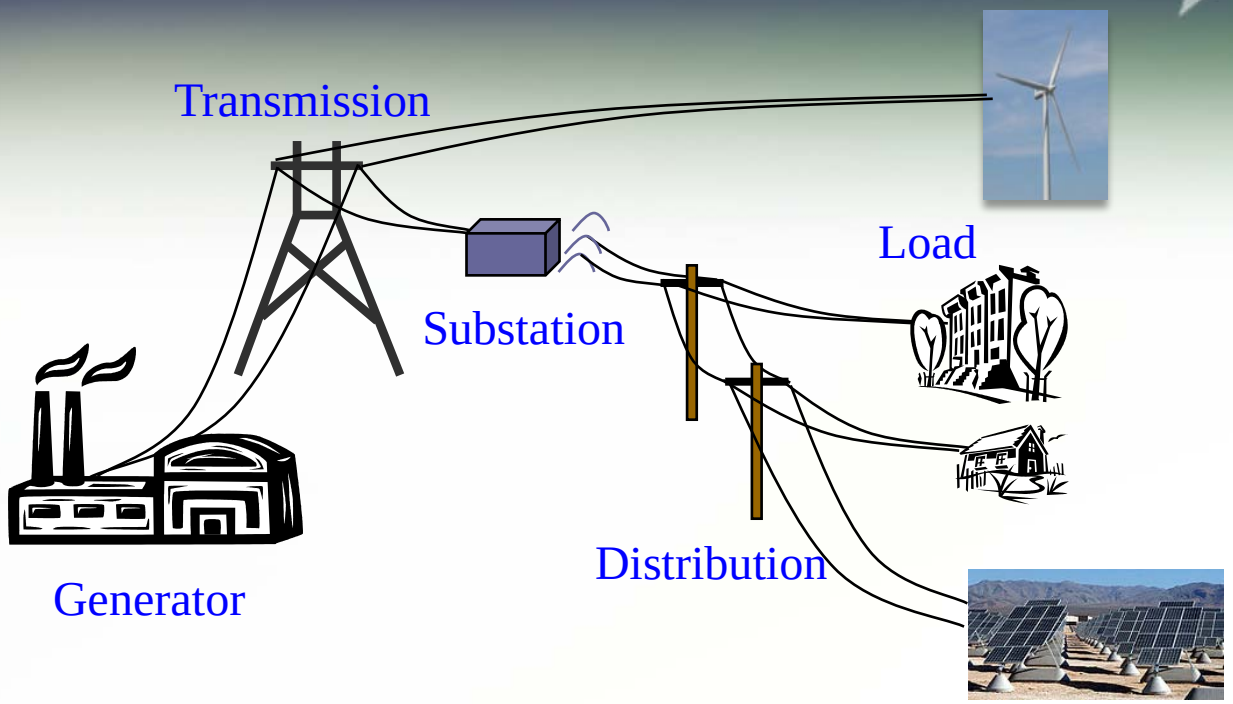
Wind power forecasting examples

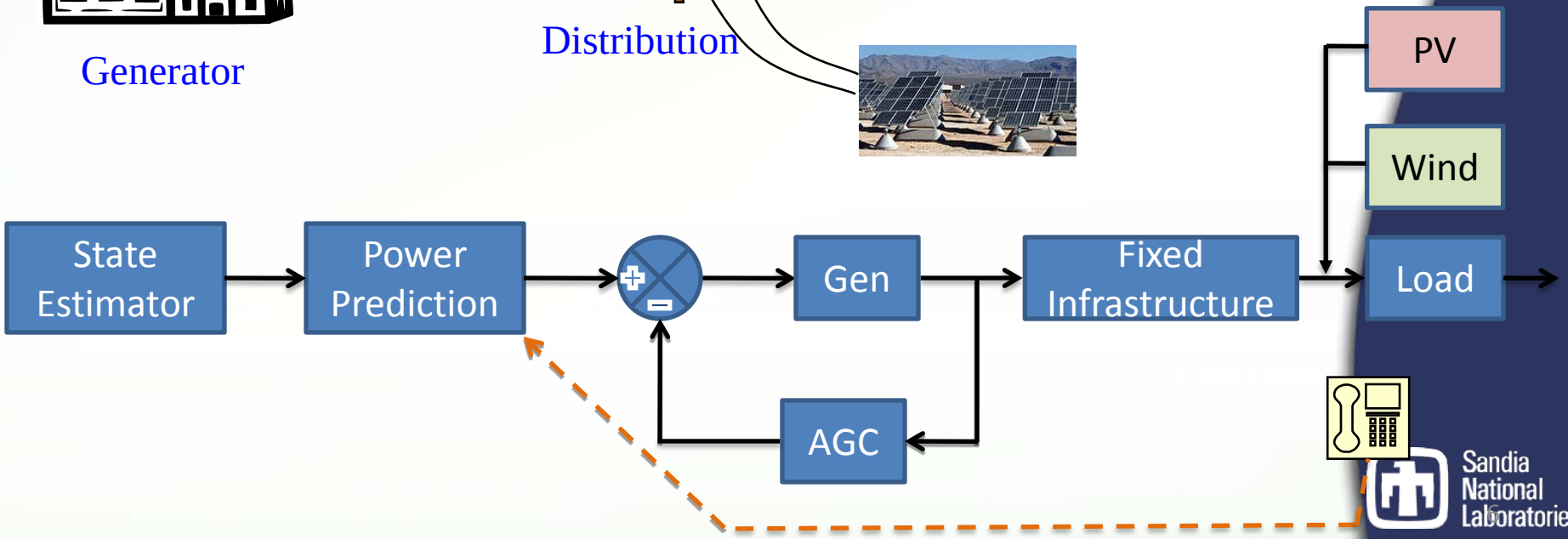




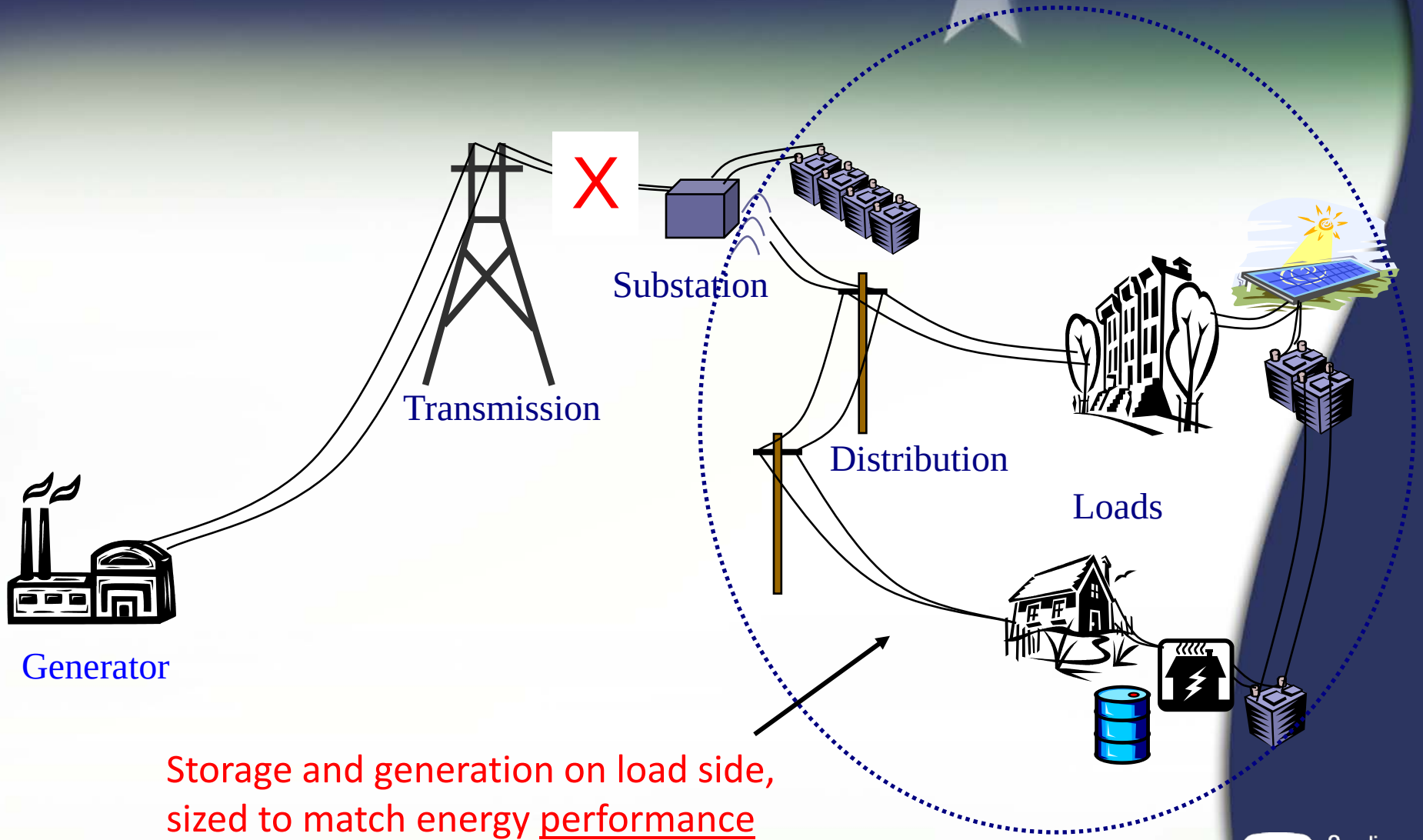
This is weather forecasting!

Today, Stochastic Renewable Sources are Treated as Negative Loads





Microgrids Can Provide Power when the Utility Grid is Down



Storage and generation on load side, sized to match energy <u>performance</u> needs

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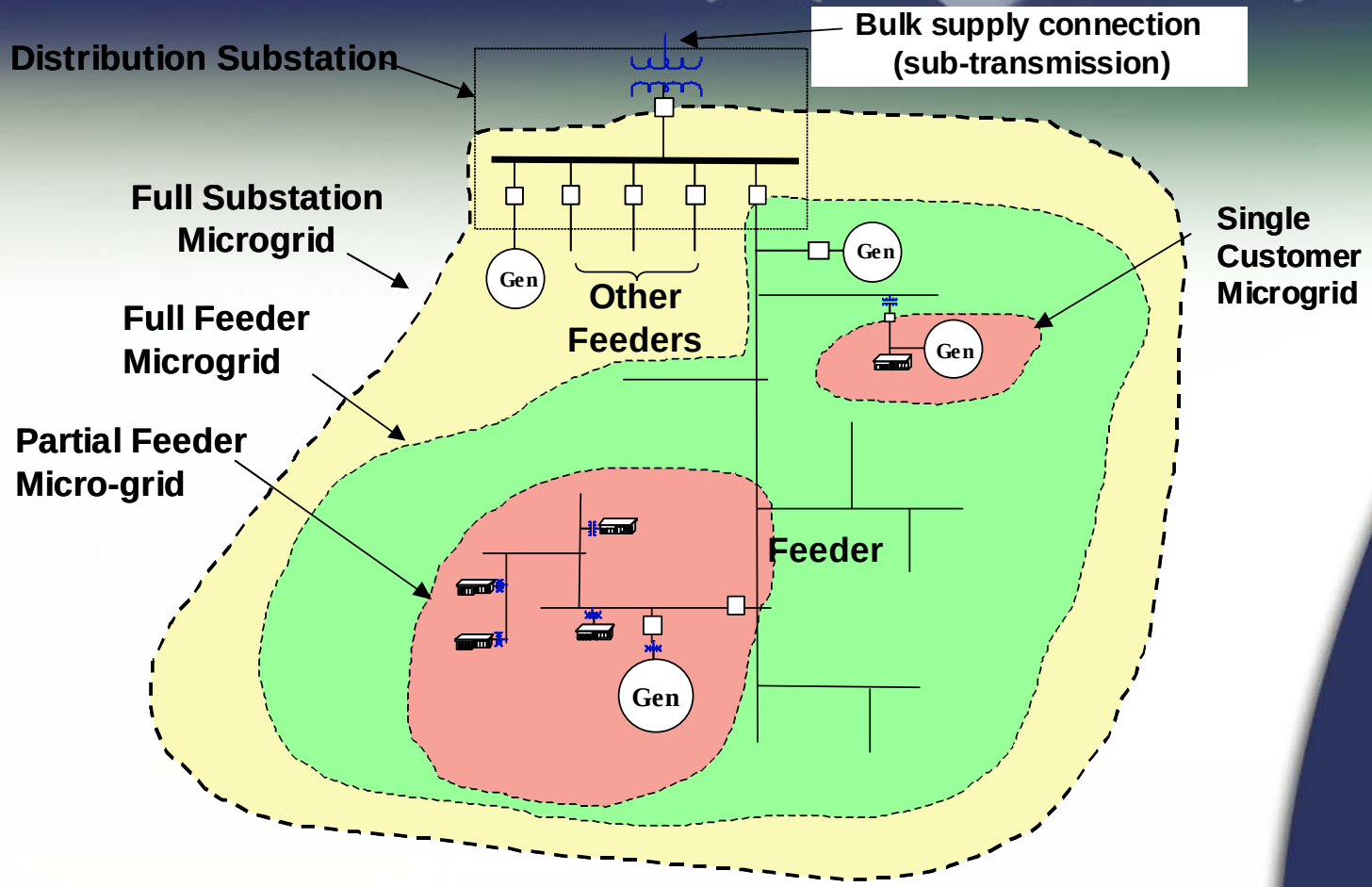
Microgrids are Scalable



- **Applicable to small, large, and even regional scale energy infrastructure security and reliability**

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Energy Assurance = Energy Surety

- **2010 QDR Defines Energy Security**
  - "Energy security for the Department means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs"

Performance Parameters	Energy Surety Metric
Safety	Safely supplies energy to end user
Security	Maintains power in a malevolent environment
Reliability	Maintains power when and where needed
Sustainability	It can be maintained for mission duration
Cost Effectiveness	Produces energy at lowest predictable cost

A Sandia developed risk-based approach to implement and measure Energy Security effectiveness

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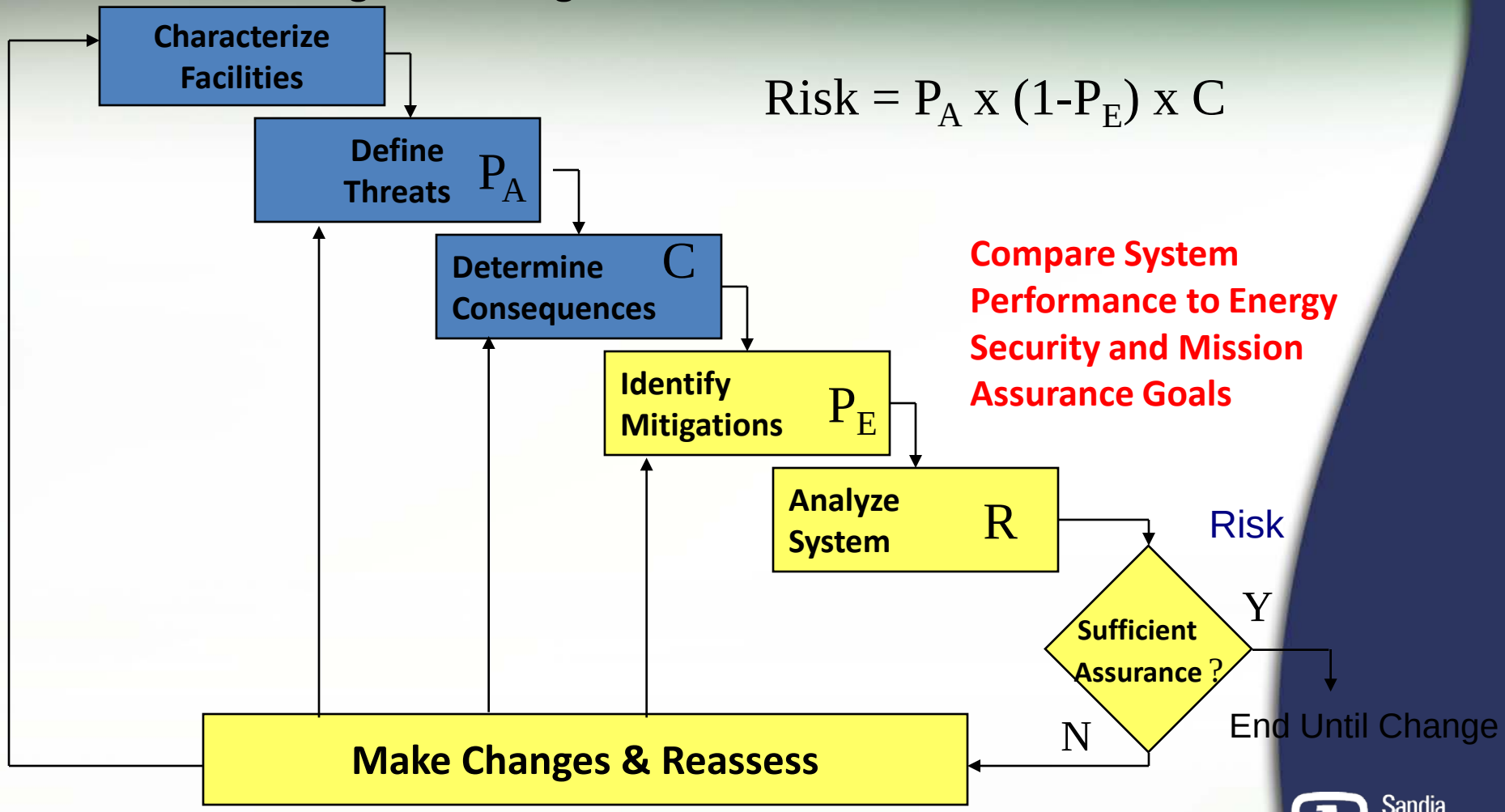
Risk-based Energy Surety Assessment

A quantitative approach to assess energy system performance against a range of threats and vulnerabilities



$$\text{Risk} = P_A \times (1-P_E) \times C$$

Compare System Performance to Energy Security and Mission Assurance Goals

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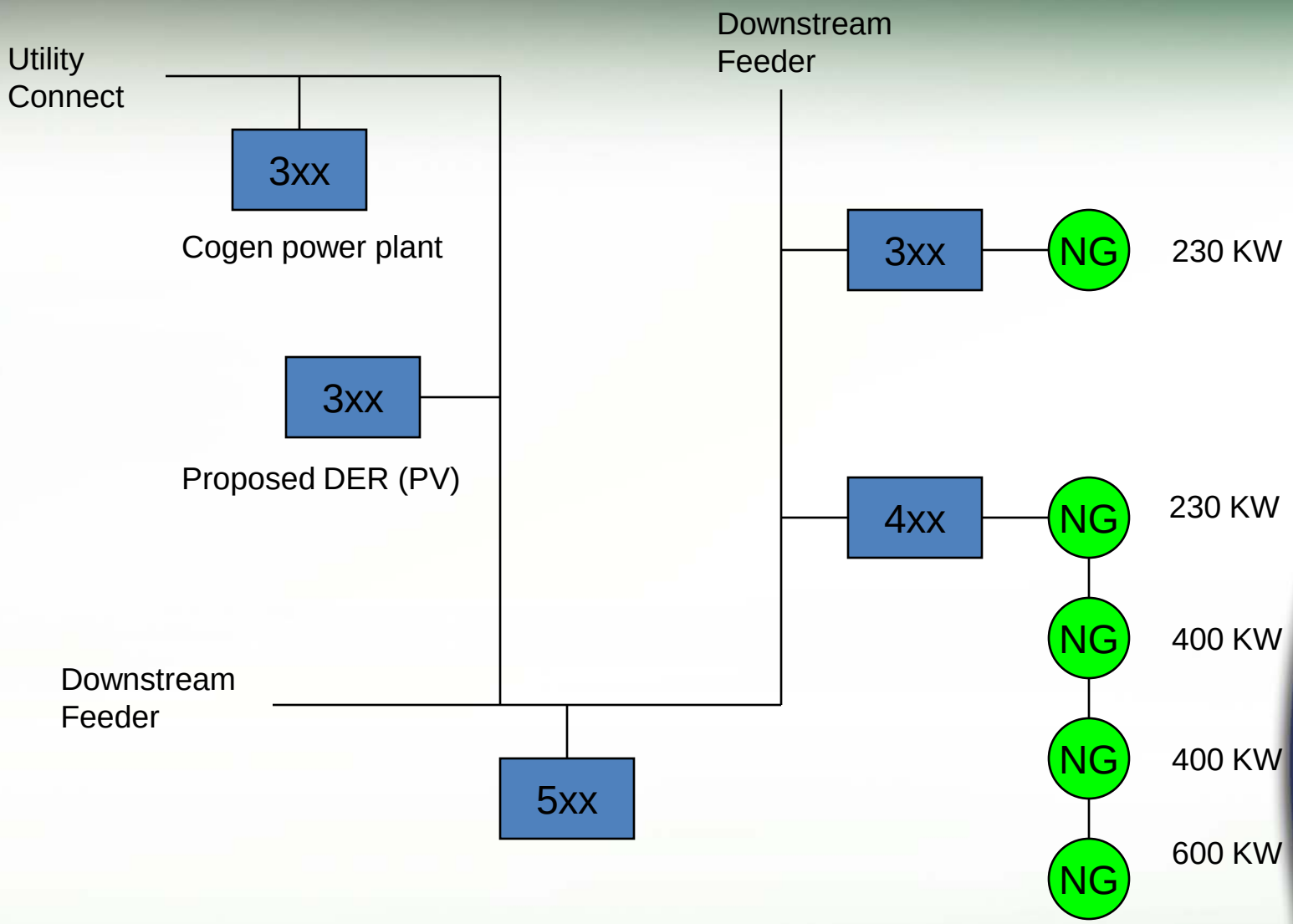
Sample Backup Generation Connection for Critical Buildings



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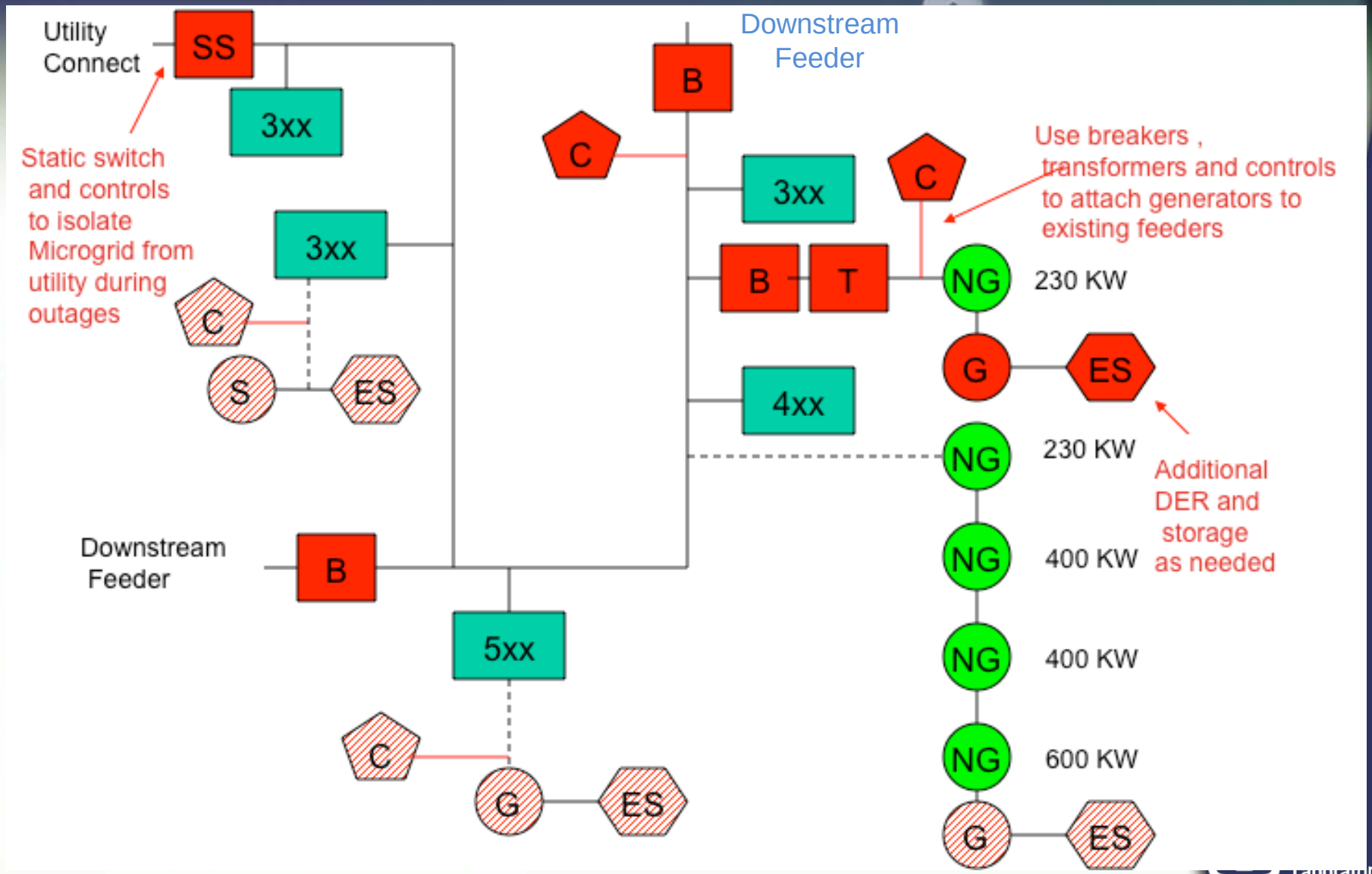
A Sample Energy Surety Microgrid™ Solution



Energy Surety Microgrid™ Implementation

- **Phase I**
  - Assess ability of energy infrastructure to provide critical mission assurance
- **Phase II**
  - Reconfigure existing energy resources to enhance critical mission assurance
- **Phase III**
  - Evaluate improvements such as additional distributed generation, storage, and smart controls and recommend as needed to enhance critical mission assurance

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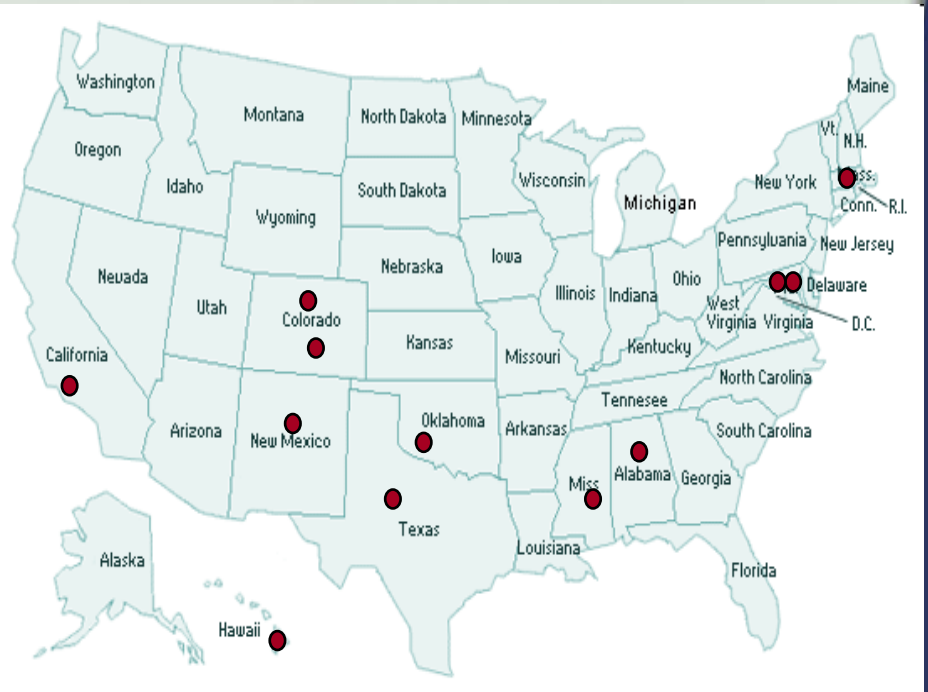
Current Sandia Military Microgrid Efforts

- **Army**
  - Ft Sill*, Ft. Bliss, Ft. Belvoir*, Ft. Devens*, Ft. Carson
  - IMCOM exploring two additional sites
- **Navy/Marines**
  - Indian Head*, Camp Smith
  - Guam/Okinawa* in consideration
- **Air Force**
  - Maxwell AFB*, Kirtland AFB*, Schriever AFB, Vandenberg AFB
  - PACOM/NORTHCOM proposing SPIDERS JCTD in Hawaii and Colorado



* Indicates DOE /DoD Funded
All others DOE FEMP funded

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A Proposed Joint Capabilities Technology Demonstration (JCTD) Based on Energy Surety Microgrid™

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SPIDERS JCTD Overview

CIRCUIT LEVEL DEMONSTRATION

- Renewables
- Storage
- Energy Management

FT CARSON MICRO-GRID

- Large Scale Renewables
- Vehicle-to-Grid
- Smart Micro-Grid
- Critical Assets
- CONUS Homeland Defense Demo
- COOP Exercise

CAMP SMITH ENERGY ISLAND

- Entire Installation Smart Micro-Grid
- Islanded Installation
- High Penetration of Renewables
- Demand-Side Management
- Redundant Backup Power
- Makana Pahili Hurricane Exercise

TRANSITION

- Template for DoD-wide implementation
- CONOPS
- TTPs
- Training Plans
- DoD Adds Specs to GSA Schedule
- Transition to Commercial Sector
- Transition Cyber-Security to Federal Sector and Utilities

VIRTUAL SECURE ENCLAVE CYBER-SECURITY

- **Intended End Result of JCTD:**
  - First complete DoD installation with a secure, smart microgrid capable of islanding
  - Template for DoD-wide installation energy security
- **Technical Manager - OSD Power Surety Task Force, Assistant TM – Sandia Labs**

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Smart Grid Deployment for the Air Force

"Industry has coined the term "Smart Grid," which focuses on using digital technology to save energy, improve reliability, and reduce cost. For the Air Force, however, Smart Grid is much more and is called the Energy Surety Microgrid (ESM)."

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AFCESA

A-Grams are products of HQ Air Force Civil Engineer Support Agency Tyndall AFB, Florida 32403-5319

Contact

Dr. Daryl Hammond
HQ AFCESA/CEOA
139 Barnes Drive
Suite 1
Tyndall AFB FL
32403-5319
DSN 523.6352
Comm 850.283.6352
Fax 283.6488
Email
daryl.hammond@
tyndall.af.mil

TARGET AUDIENCE: Operations, Asset Management & Programs Flights

Energy Surety Microgrid (ESM)
AF Smart Grid Definition

Synopsis

Investigating approaches to locate more secure and robust power sources near critical loads and better managing existing power generation and loads will improve the reliability and security of electric power at military [illegible] Industry has coined the term "Smart Grid," which focuses on using digital technology [illegible]gy, improve reliability, and reduce cost. For the Air Force, however, Smart Grid is much [illegible]d is called the Energy Surety Microgrid (ESM). An ESM is an alternate energy delivery method-[illegible]ogy developed to ensure that the reliability of the electric infrastructure at a military facility will fully satisfy the critical mission needs – the Air Force "Smart Grid."

Structure

The ESM methodology was developed by Sandia Laboratories and uses a formal Risk Assessment Methodology (RAM) process to evaluate the buildings and operations at a military facility, identify those that are mission-critical, and create a secure and reliable power system to support these missions for the durations required.

The risk management process of RAM enables the facility or base utility managers to quantify existing energy assets, assess potential outage possibilities and energy demand requirements to meet critical mis-sion needs, and quantify energy infrastructure improvements based on mission requirements and energy system performance and protection goals.

Energy Surety Microgrid

Developing an ESM at a military base embodies five elements:

- Safety
- Security
- Reliability
- Cost effectiveness
- Sustainability

Priority is placed on developing a balanced energy system that can meet all of a base's critical mission energy needs. This concept integrates Advanced Meter Reading (AMR) initiatives and local control of facility Energy Management Control Systems (EMCS) to optimize available energy capacity.

In most applications, this includes integrating existing back-up generator systems with additional distrib-uted generation technologies such as solar, wind, fuel cells, microturbines, and energy storage systems. This creates a controllable, reliable, and secure internal energy grid, or microgrid, that can operate inde-pendently within the base as needed when off-base power resources are lost or provide peak load shaving for the base as needed to help reduce overall energy demands and costs.

Implementation Guidance

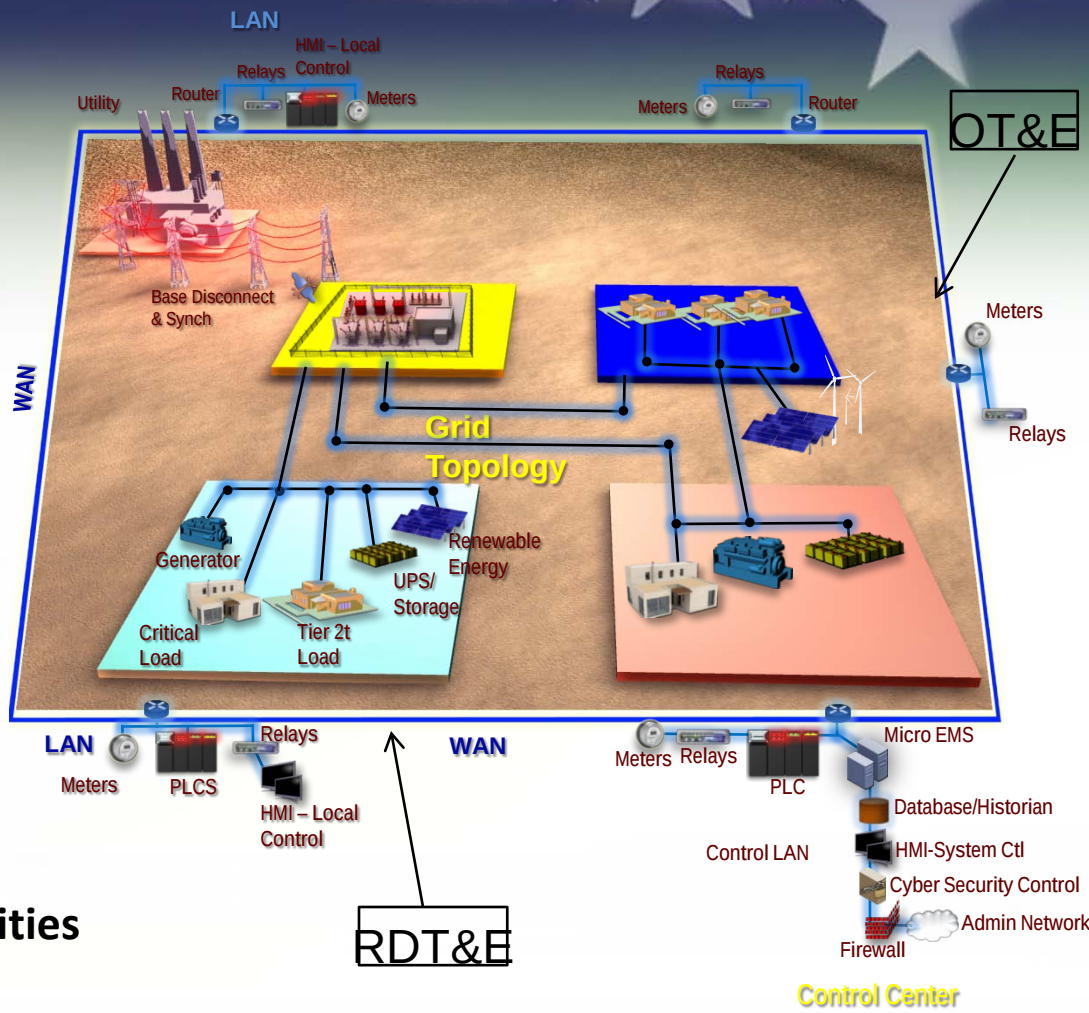
Key building blocks to the ESM concept are the AMR initiative, integrated EMCS, and installation of Utility Monitoring and Control System (UMACS). Currently, AMR provides visibility into energy usage, but it can be integrated with UMACS, an Air Force non-proprietary monitoring and control hardware and software platform that meets new cyber security guidance, to provide control of energy systems consis-tent with an ESM.

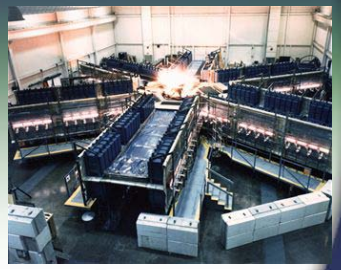
ESM design solutions and implementation guidance is readily available from the experts at the Air Force Civil Engineer Support Agency located at Tyndall AFB, FL. Subject matter experts in power and energy routinely solve tough implementation problems while ensuring compliance with AF energy and cyber security directives.

Dr. Daryl Hammond
AF Chief Electrical Engineer
HQ AFCESA/CEOA

Energy Assurance Test Bed Concept

Large-Scale Energy Testing Facilities





Mission Operations

Energy Research

- **DoD/DOE Cooperation on Energy Assurance RDT&E and OT&E**
- **Accelerate Validation of Approaches to Enhance Mission Assurance**

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Summary

- The Smart Grid offers opportunities to improve grid management, but still essentially uses open-loop control.
- Energy Surety Microgrids™ provide a framework for implementing the Smart Grid
- ESM™ will enable high penetrations of renewable energy resources
- Military installations are providing a proving ground for testing the viability of microgrids as building blocks for the Smart Grid.

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