Energy Surety and Renewable Energy Approaches and Applications

Federal Utility Partnership Working Group Meeting
May 5, 2009

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Presentation Overview

- **Common Energy Infrastructure Protection and Reliability Challenges and Pitfalls**
- **Energy Risk Assessment and Management Framework**
- **Energy Surety Concepts and Process**
  - Optimizing system designs and operations to achieve energy safety, security, reliability, and cost-effectiveness
  - Example of military electric power reliability and security project

Sandia Energy Futures Organization

6337
Solar Technologies
Jeff Nelson

6335
Solar Systems Department
Charlie Hanley, Acting

6333
Wind Energy Technology
Jose Zayas

6331
Geothermal Research
Douglas Blankenship

6336
Energy Infrastructure & DER
John Boyes

6332
Energy Systems Analysis
Juan Torres

6338
Fuels & Energy Transitions
Ellen Stechel

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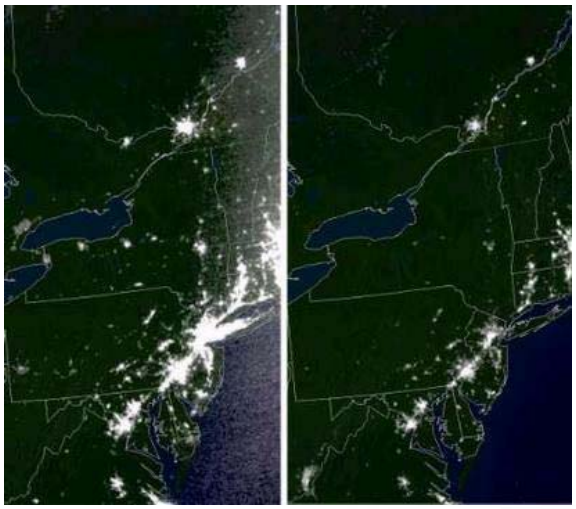
Energy Infrastructure Security and Reliability Issues and Challenges

- **Energy infrastructure is distributed and often remote**
  - Difficult to protect using common approaches
- **Expanding interdependencies of the energy infrastructure**
  - SCADA and telecommunications
  - Water and energy
  - Electricity and gas
  - Railroad congestion
- **Growing safety, security, and reliability issues**



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Energy Infrastructure Security and Protection Issues and Challenges

Front

Common Energy Pipeline Security Approach

Back

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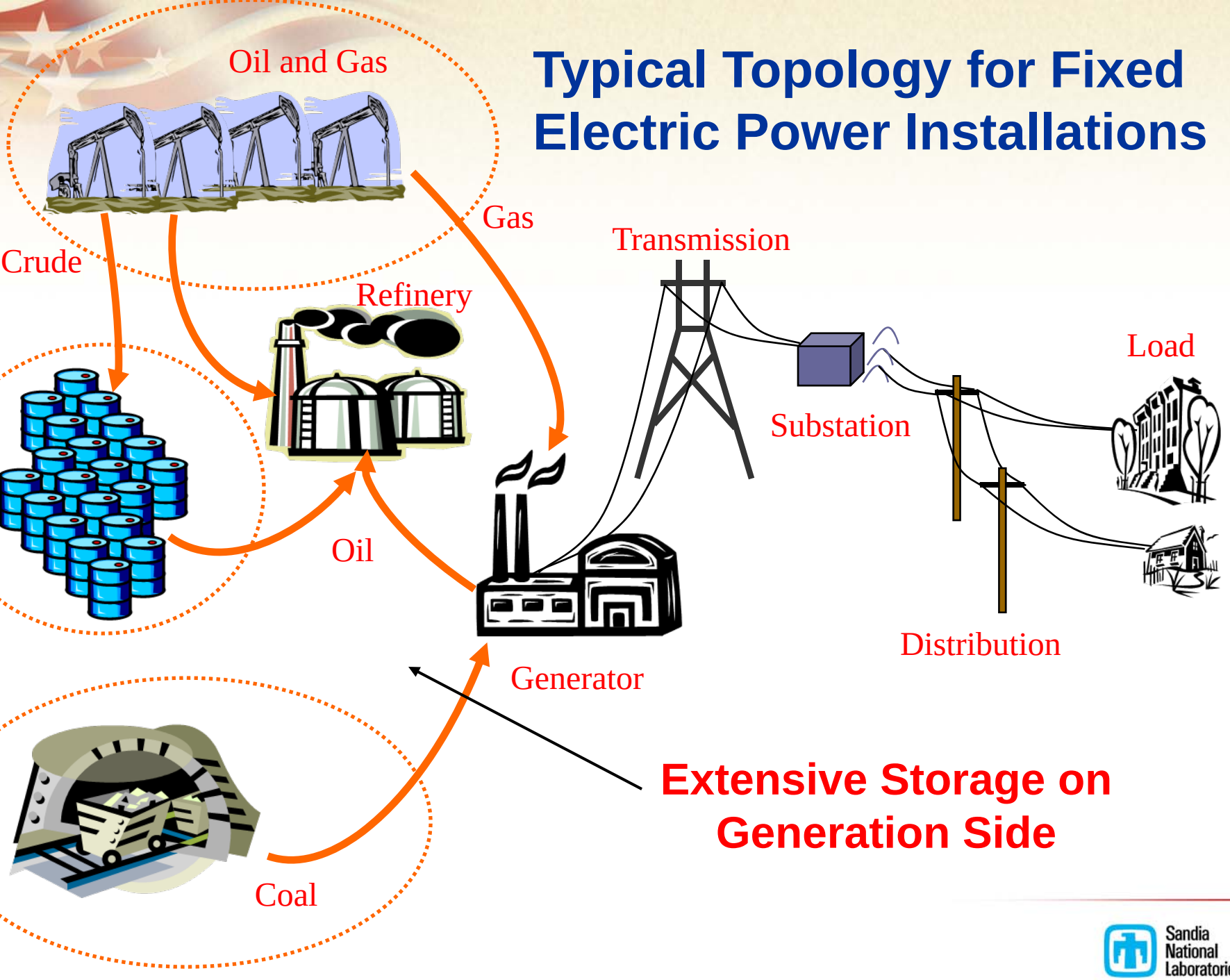
Typical Topology for Fixed Electric Power Installations



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Energy System Reliability and Vulnerability Issues

- **Southwest Army base served by two feeders**
- **May 2002 forest fire takes out both feeders**
- **Base down for 16 hours**
  - Est. cost $3M
  - Loss of mission capability

- **Southwest semiconductor plant served by two feeders**
- **Forest fire takes out both feeders**
- **Chip fab shuts down for 3 months**
  - High-value customers cancel orders due to delay
  - Economic loss forces plant to shut down permanently

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Common Electric Power Security and Reliability Concerns

- **Current practice of providing power security often relies on back-up generators**
  - *Frequently over-sized and under-maintained*
  - *Low probability of start when needed*
  - *Dedicated to one building or facility – does not share power with other facilities*
  - *Operations for extended periods often problematic*
- **Supply redundancy often not effective**
- **Stating 9's of reliability – does not factor in the erosion of critical mission capability for extended outages**

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Energy Surety Concept
Improving Energy Safety, Security, Reliability

Energy Surety Elements	
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

Distributed Infrastructures (like the Energy Infrastructure) are Hard to Protect

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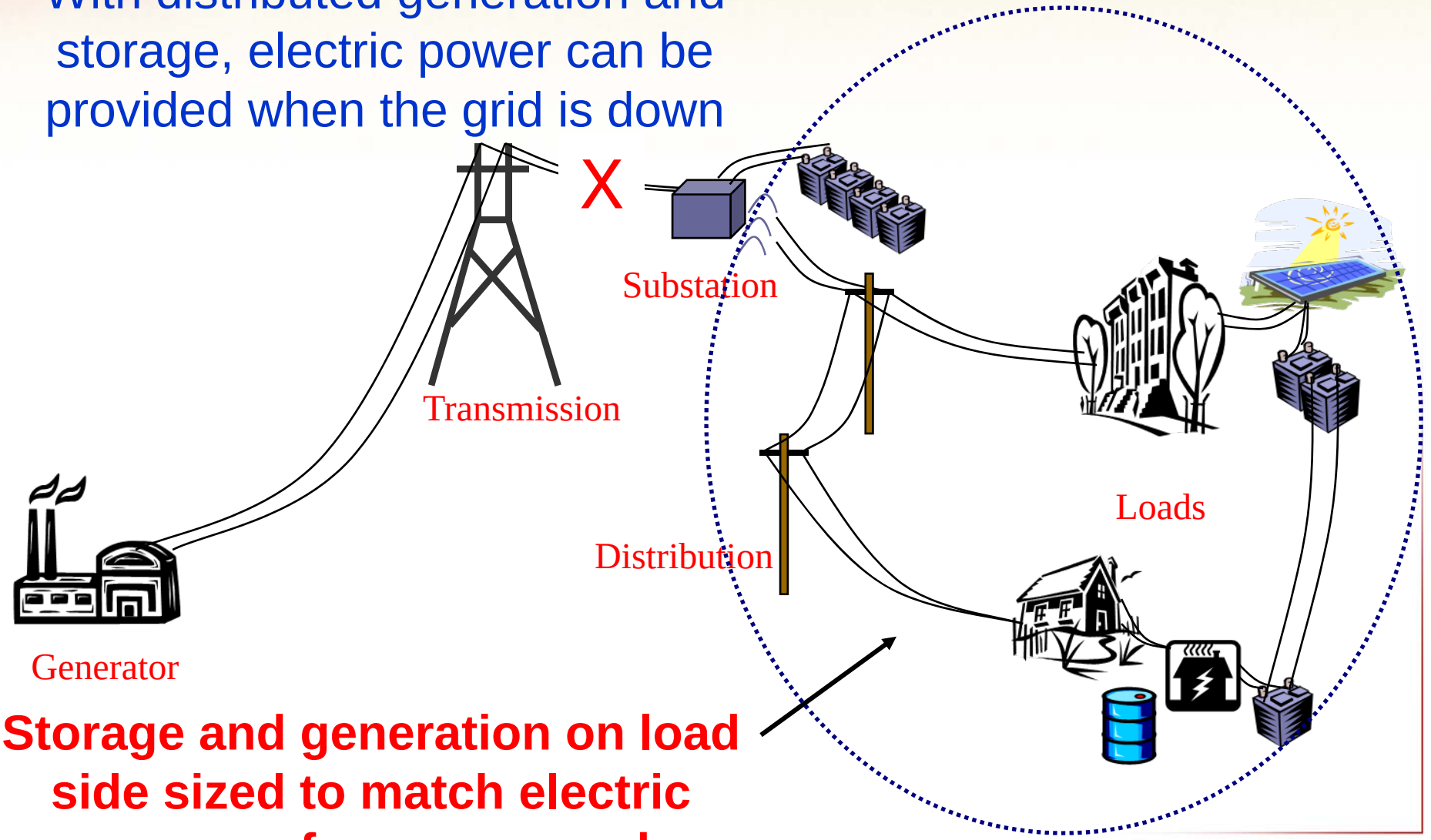
Energy Surety Approach

With distributed generation and storage, electric power can be provided when the grid is down



Storage and generation on load side sized to match electric power performance needs

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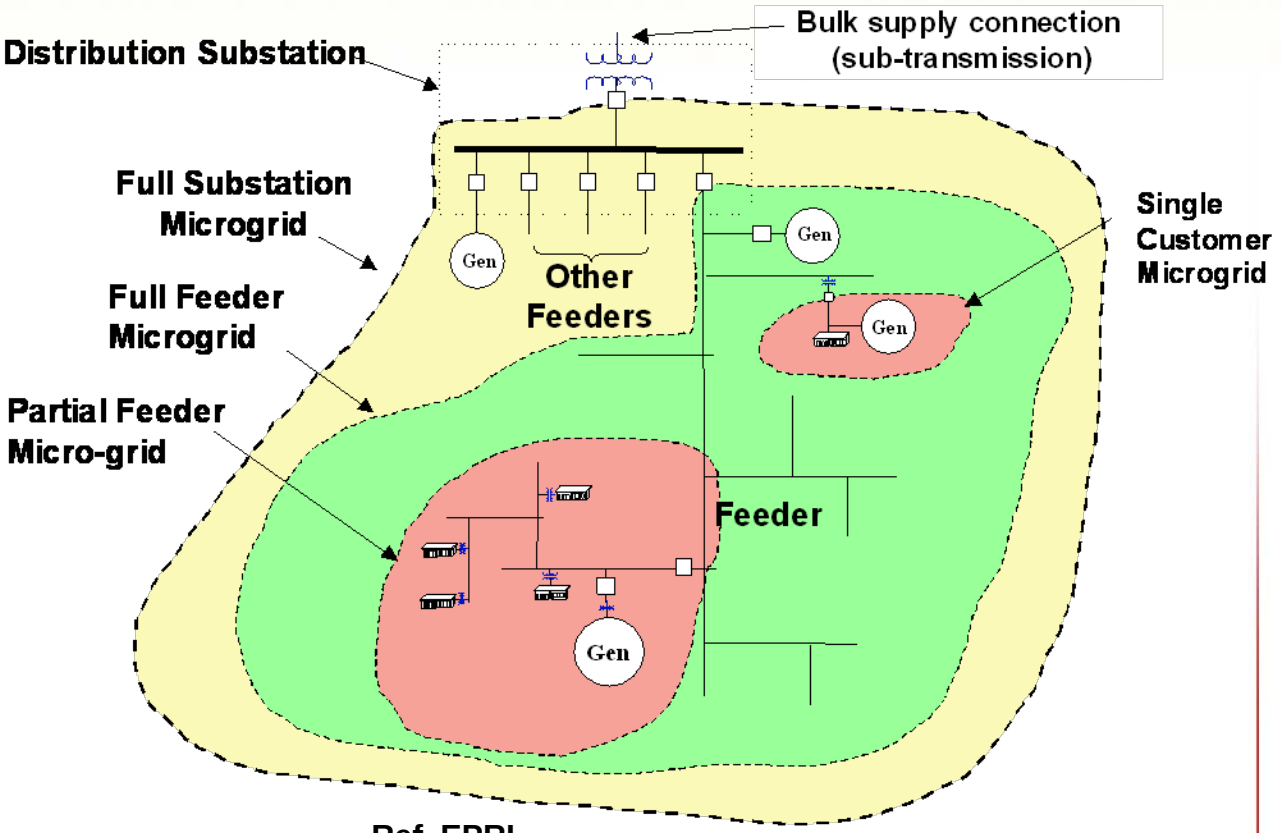
Renewable and Distributed Generation Supporting Microgrids and the Smart Grid

- Small combustion and μ-turbines
- Fuel cells
- IC engines
- Small hydro and wind
- Solar electric and solar thermal
- Energy storage (batteries, flywheels,…)
- Plug in hybrid vehicles



Ref. EPRI

Residential	Less than 10-kW, single-phase
Small Commercial	From 10-kW to 50-kW, typically three phase
Commercial	Greater than 50-kW up to 10MW

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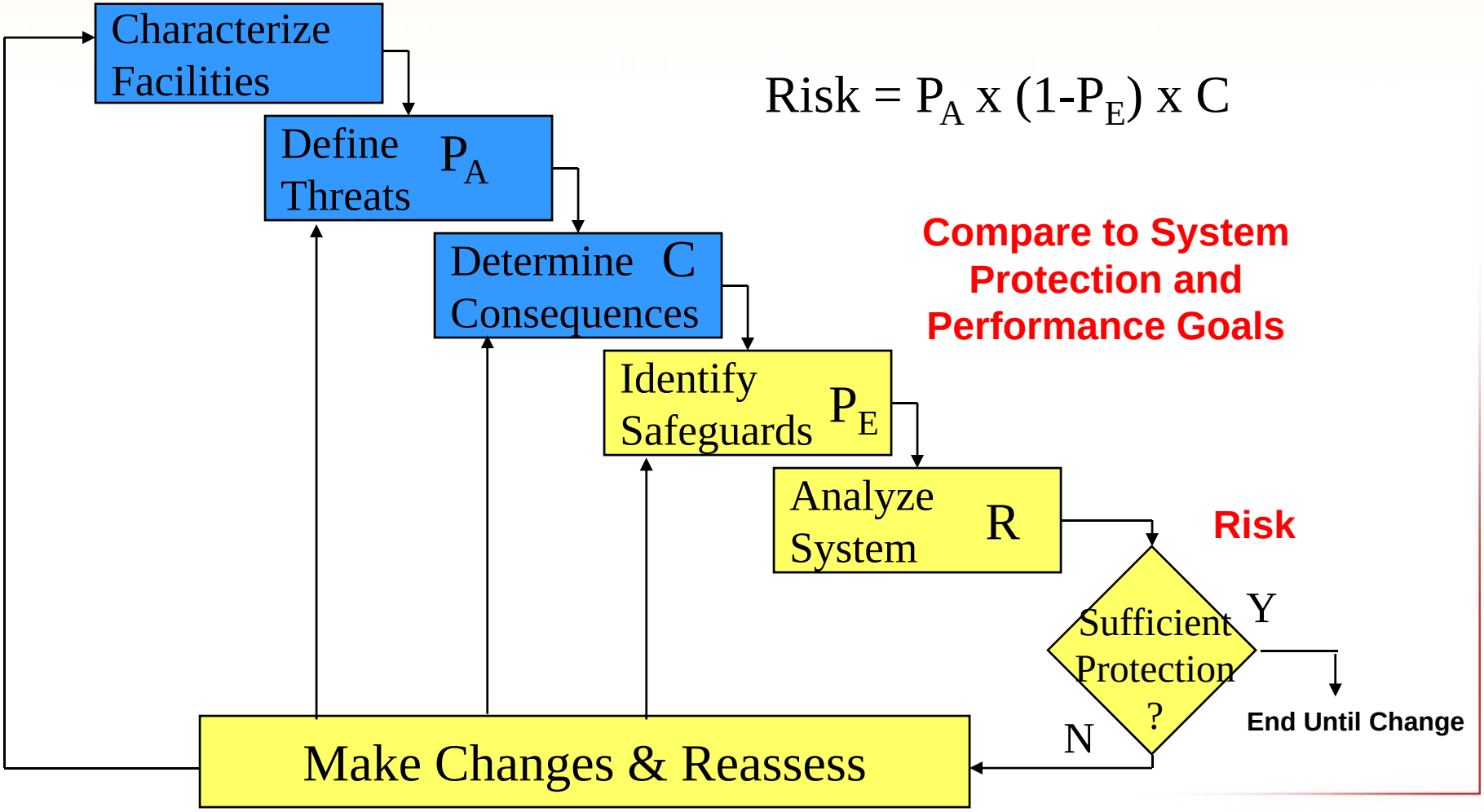
Risk-based Assessment Approach for Energy Systems



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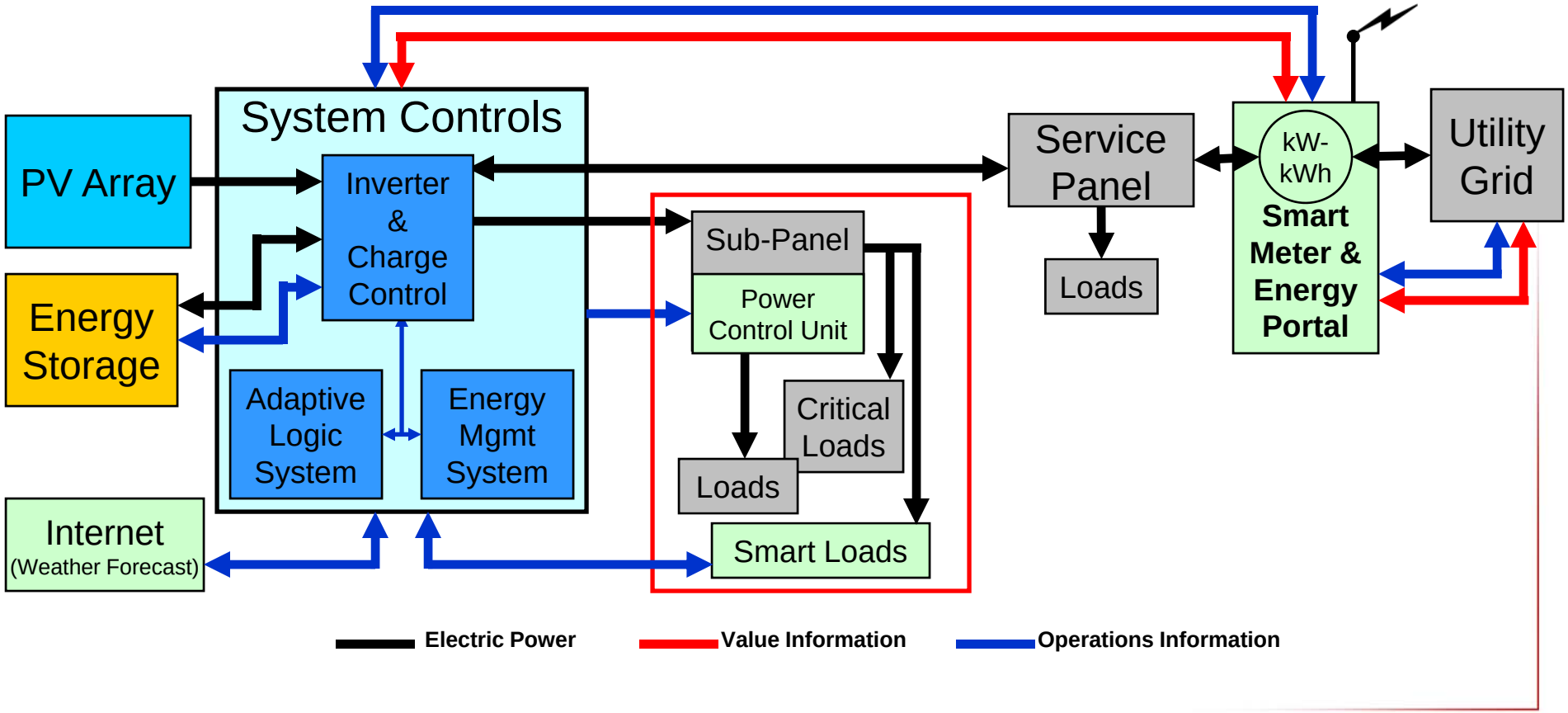
Complexity of Microgrids with Intelligence and Control

System for Supporting Advanced Distribution Infrastructure Operations



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Enabling the 21st Century Grid with Enhanced Reliability and Security

- **Major Issues and Challenges**
  - Future electric grid incorporating extensive distributed generation will require more complex system control and integration to ensure energy safety, security, and reliability including:
    - Real-time or near real-time assessment, control, and optimization of extensive distributed generation resources while maintaining power quantity and quality
    - Significantly improved control system cyber security
    - Improved intermediate and large-scale energy storage technologies to maintain renewable energy delivery reliability
    - Bidirectional power flow requires new advanced safety standards for distributed generation connection and operation in grid-tied and islanded modes
    - System control and hardware design and operational standards scalable for micro, intermediate, and utility-scale grid applications
    - Extensive testing and monitoring of control and operations approaches to verify cost and performance to reduce operational and safety risks to utilities and the public

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Application of an Energy Surety Microgrid for the Army

US Army Corps of Engineers

- **Army Construction Engineering Research Lab (CERL)**
  - Army perspective, Consequence Model development, Base selection and interface w/candidate Base, Roll-out Energy Surety Microgrid to Army/DoD complex
  - Ft. Sill, OK, proactively volunteered to be the first base from a competition of four Army Bases

- **New Mexico State University:**
  - Optimization of energy and fuel storage

- **Leveraging Other Unique Sandia Expertise:**
  - NISAC/Sandia Infrastructure Modeling provides Consequence Model
  - Sandia Intelligent Agents work develops advanced controls for DG sources in Energy Surety Microgrid

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Ft. Sill Evaluation of Energy Surety Microgrid Approach

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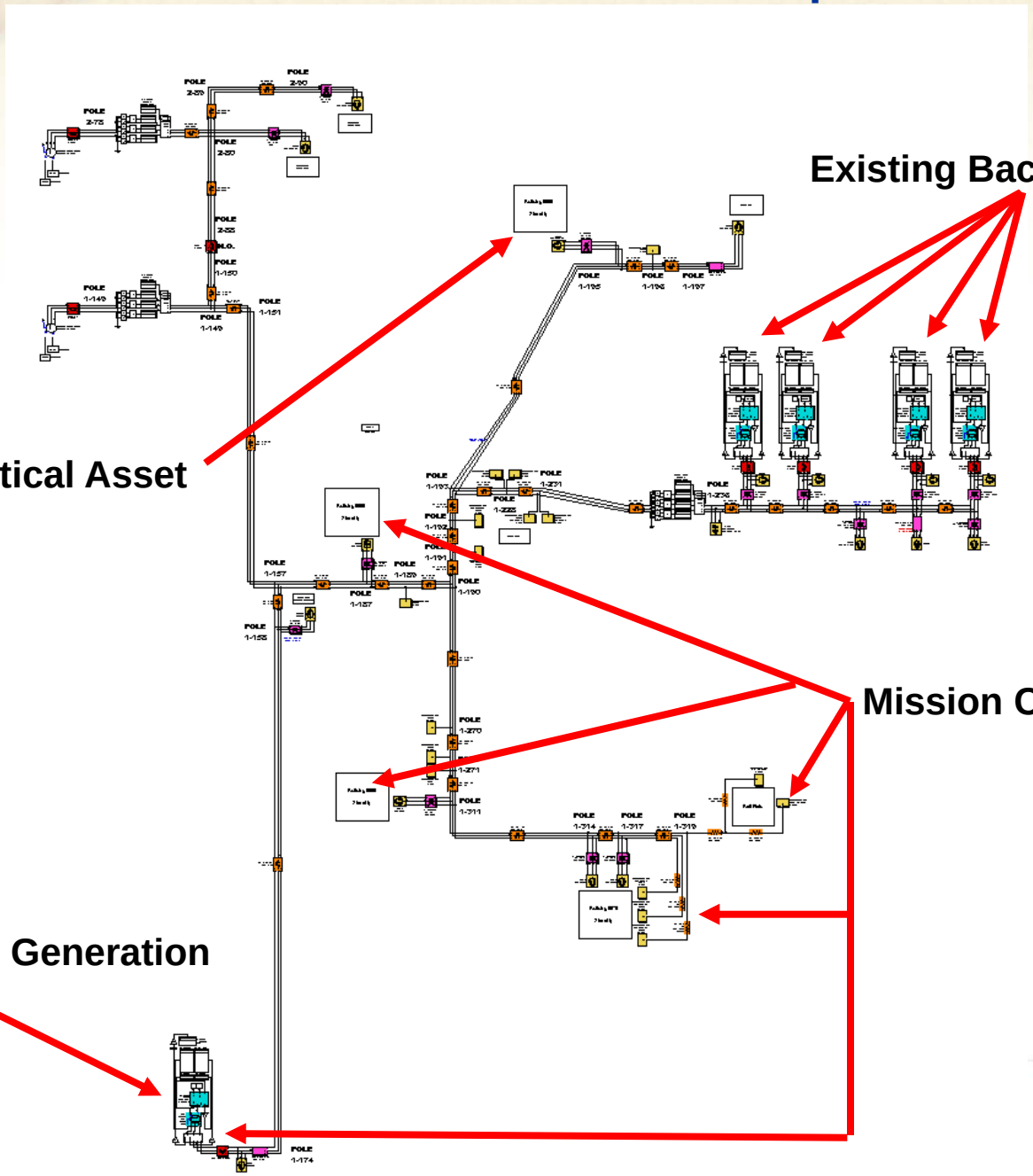
Ft. Sill Electric Distribution Representation



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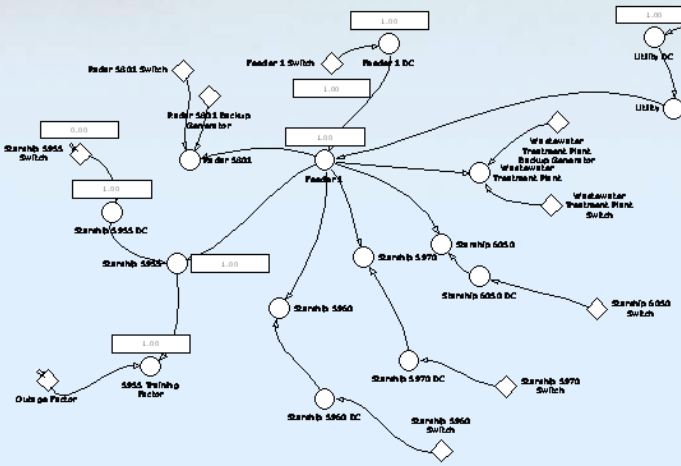
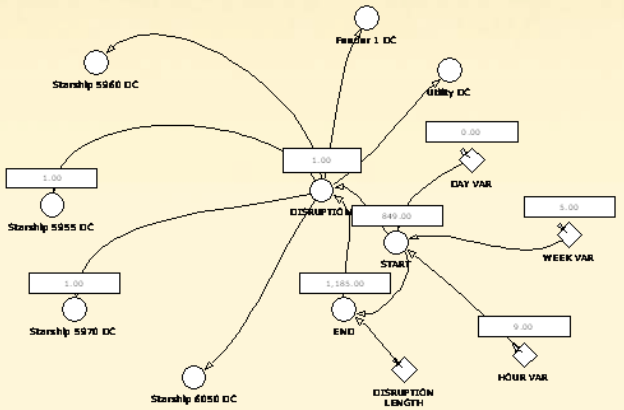
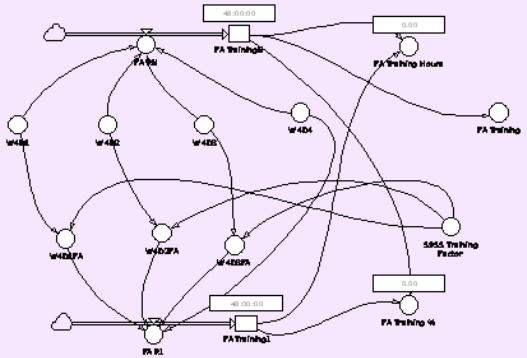
Consequence Modeling



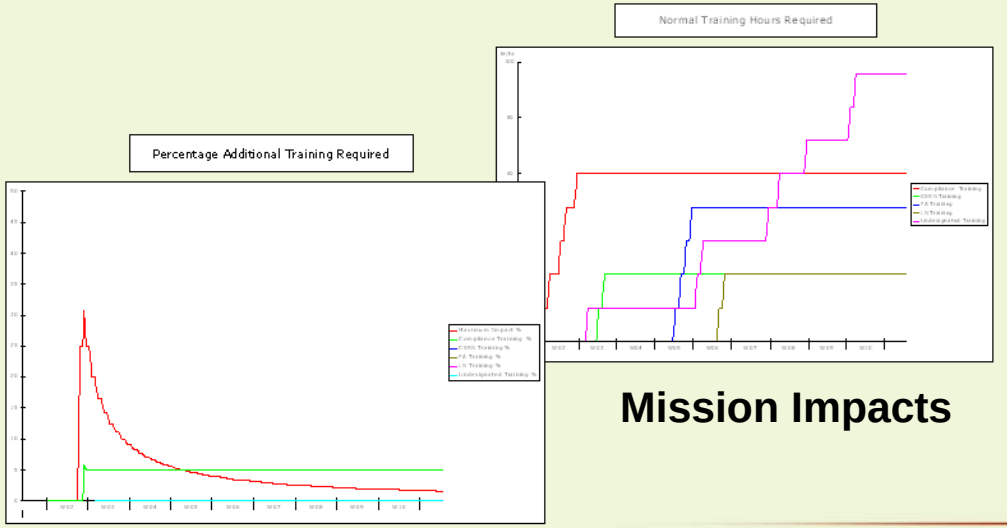
Electric System Model



Interruption Control Model



Mission Consequence Model



Mission Impacts

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Test and Validation

Distributed Energy Technology Lab

Grid

Center for Control System Security

480V Microgrid

Other Remote DER sites

Various Loads

Distributed Energy Resources

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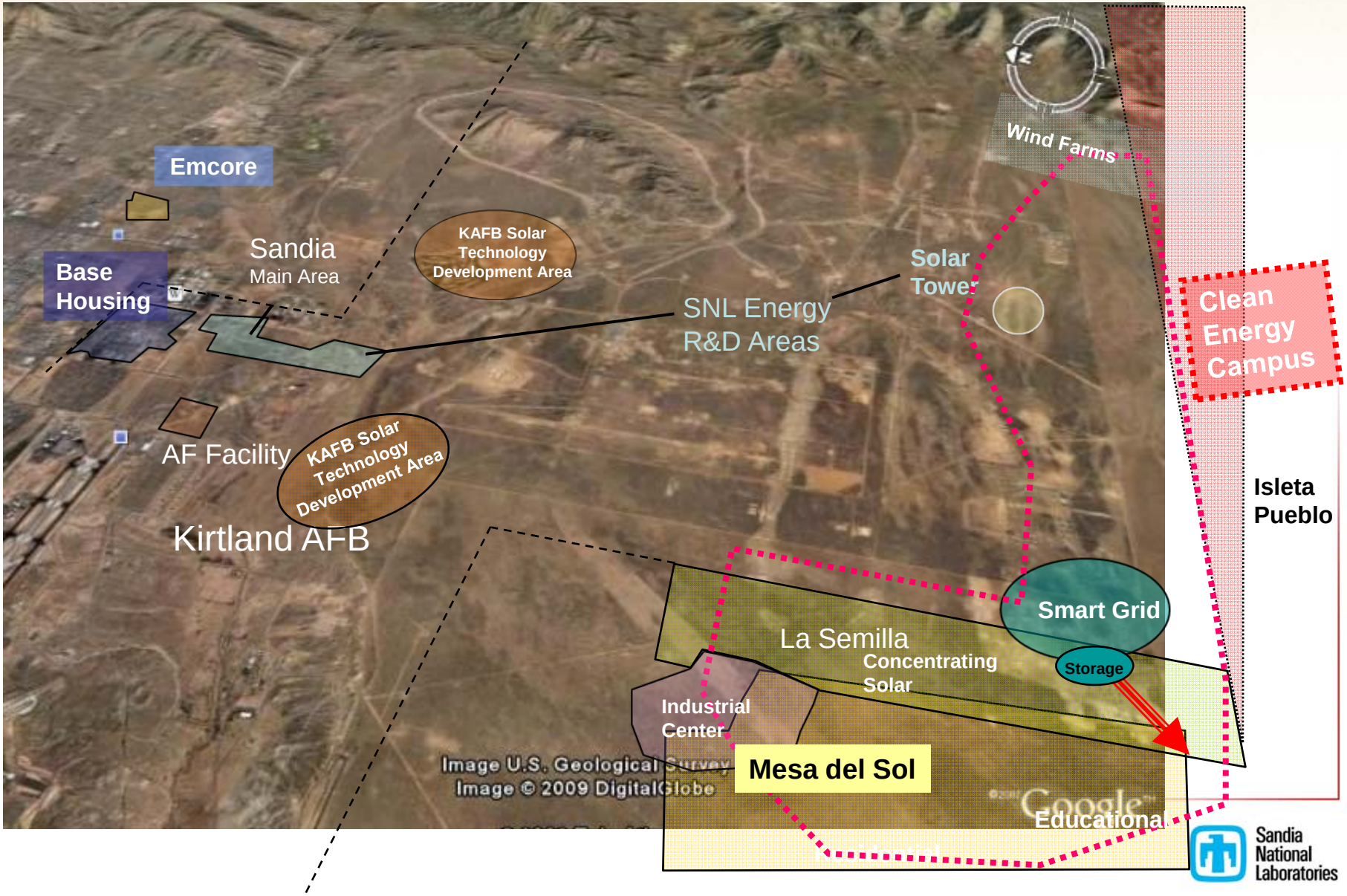
Proposed Clean Energy Campus Layout



Kauai – Consideration for Energy Surety Grid Research for DOE-DoD

Kauai Test Facility
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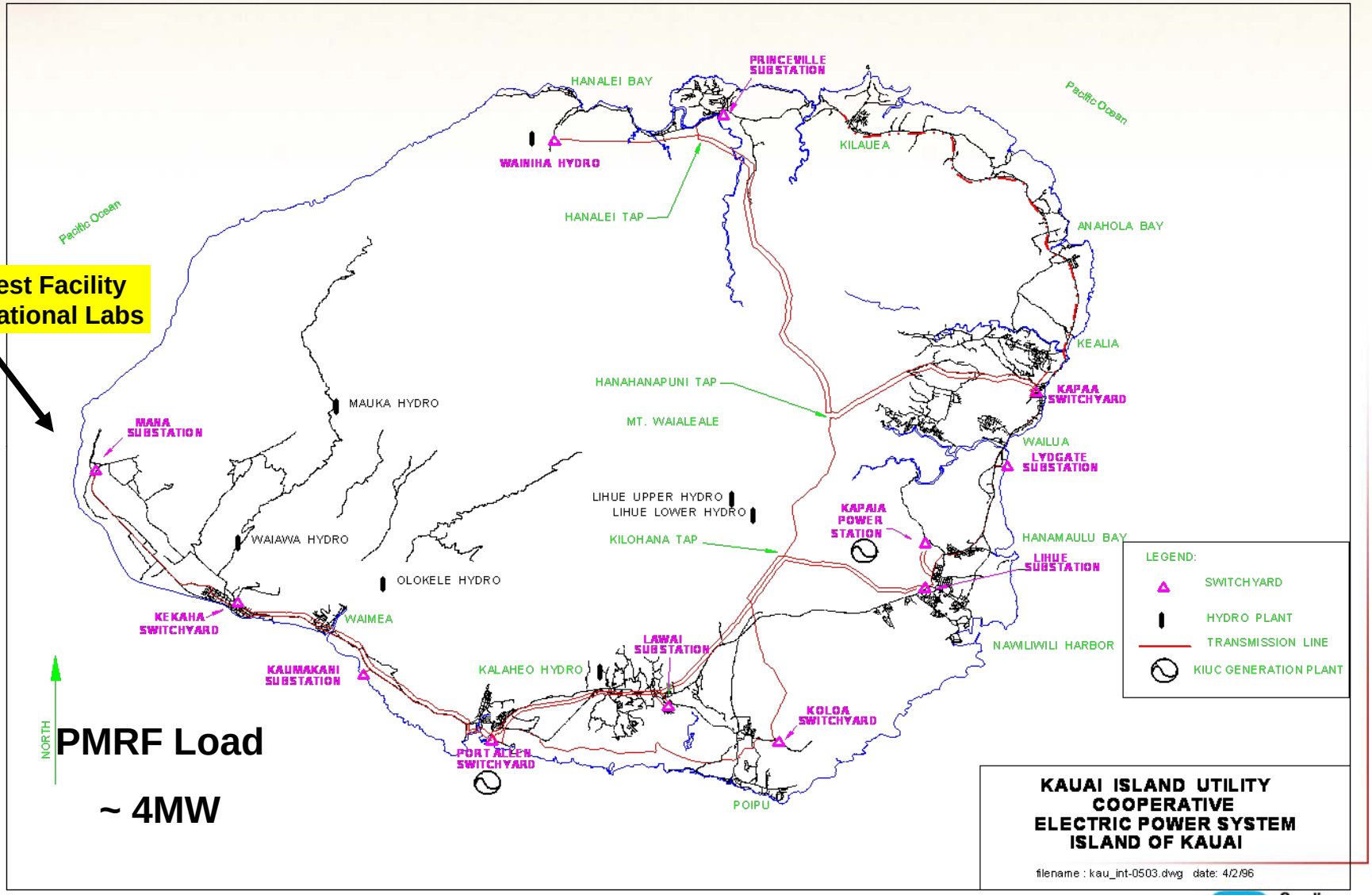

PMRF Load

~ 4MW

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Western Test Range Grid Study

- **Smart Grid concepts can be adapted to large-scale microgrids for multiple federal installations**
- **Large federal land areas provide significant renewable energy development opportunities**

◆ **Major Western DoD Test Ranges**

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Energy Surety Approach for Energy Risk Management

- **Energy Surety Microgrid is an example of energy risk management approach - matching energy supply reliability and security within a base or installation critical mission context**
- **Consequence modeling analysis can graphically illustrate the effect of energy improvements on critical mission capability**
  - Different from stating 9's of reliability – which does not factor in the erosion of critical mission capability for extended outages
- **Supports critical mission readiness and extended operations during loss of utility power**
- **Reduces dependence on fossil fuels – permits integration of renewables into power supply infrastructure without impacting safety or reliability of critical energy needs**

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