Understanding Microgrid & Energy Storage Feasibility Studies

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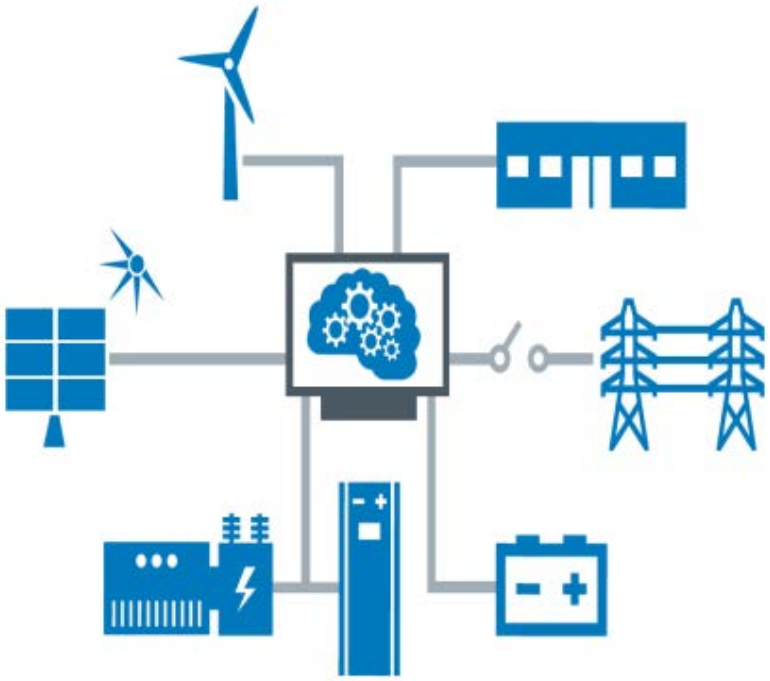
Microgrid uses

Image: Hurricane Irma nasa.gov

- Areas that need energy surety
  - Natural disaster/hurricane prone areas
  - Military installations
- Operate critical assets
  - Hospitals
  - Universities
- Utility feeders in urban areas
- Rural/remote areas with weak electricity grids
- Developing countries with limited/no electricity access
- Areas where electricity is expensive
- Enhance renewable assets to increase availability

Is a microgrid right for you?



- What configuration and components are optimal for your specific power needs?
- Do you need prime generation or standby distributed generation assets and what types?
- What is the most economical way to power your microgrid while keeping it resilient?

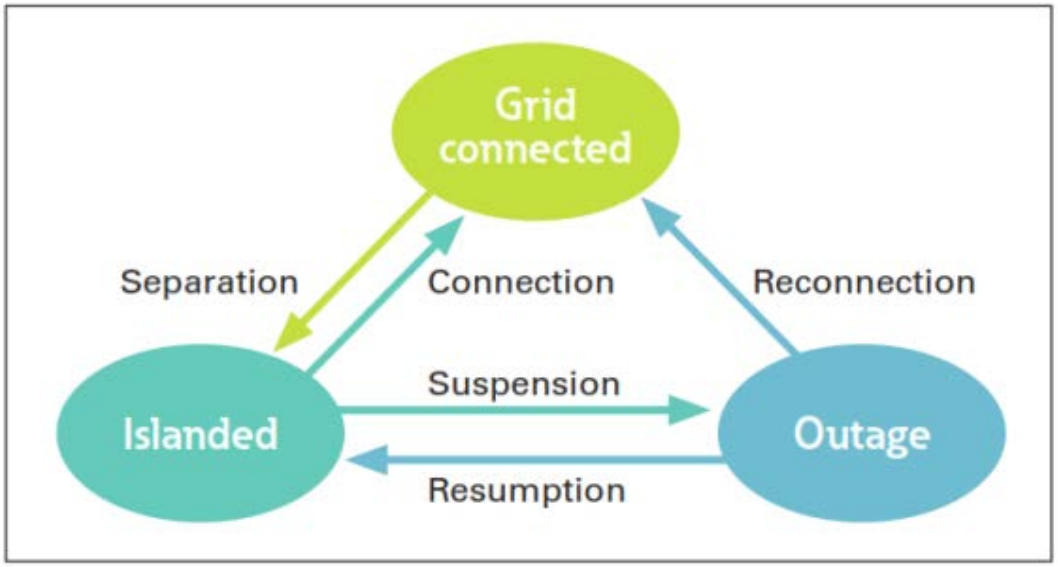
Microgrid feasibility study process – Determining the need

- Use of prime or standby distributed generation assets during times when the grid is healthy
- Disconnect from the grid and operate in an islanding mode for extended periods of time powering critical infrastructure
- Each circumstance and set of requirements is unique
- Requires careful analysis of risks and needs specific to each situation

Microgrid feasibility study process - Developing the plan

- Based power-critical assets, load sizes and profiles, identify the location of supply and storage infrastructure necessary to support
- Renewable energy assets, if desired, can also be incorporated into the microgrid design
- The type and availability of the fuel to power distributed generation assets is evaluated under the foreseeable contingencies and environmental rules

Three basic microgrid operating modes

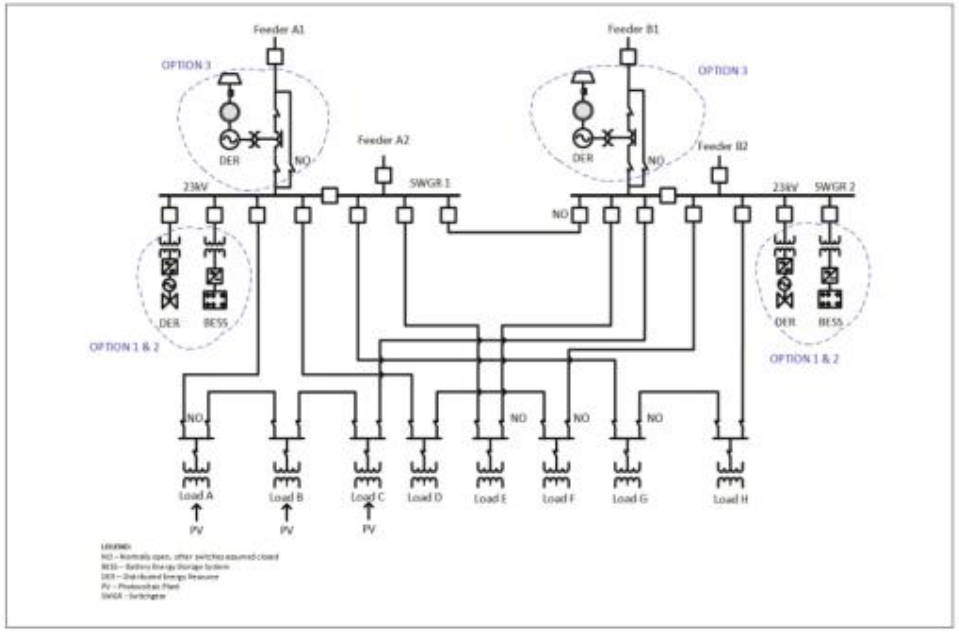


Normal grid connected operation	Islanded operation	Outage (or Black-start) mode
The microgrid is connected to the grid and the loads are powered by a power mix of grid and DER power.	The microgrid system is not connected to the grid and the load is powered by the DER independently, off the grid.	When generation type and size are not adequate for seamless islanding, normal connection to the grid is suspended, resulting in a blackout and island mode operation being started with proper sequencing of generators and loads.

Feasibility study aspects

- Analysis of the current electrical power system infrastructure, existing generation sources and available utility incoming sources
- Identification of microgrid configuration and point(s) of interconnection with utility grid
- Evaluate existing and future distributed energy resources (DERs) such as solar, wind, combined heat and power (CHP), fuel cells and energy storage
- Plant site visual audit of electrical equipment types, ratings and operating conditions

Evaluate configuration options



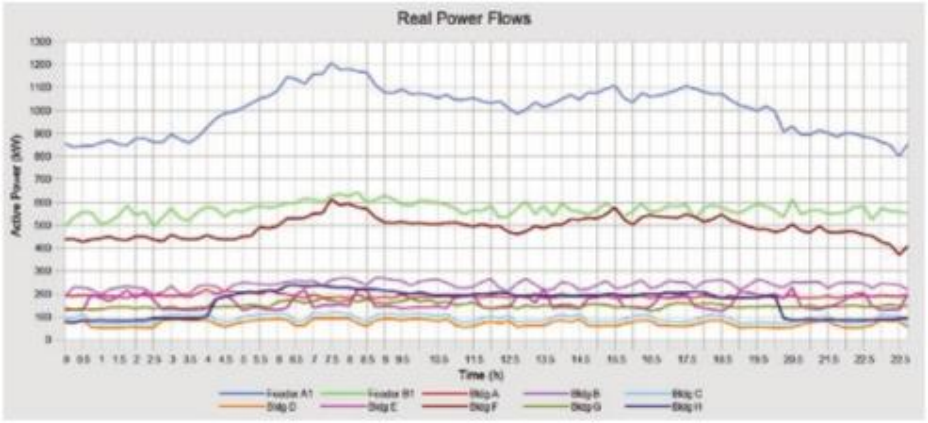
Develop and analyze scenarios to address short term and long term microgrid system configurations

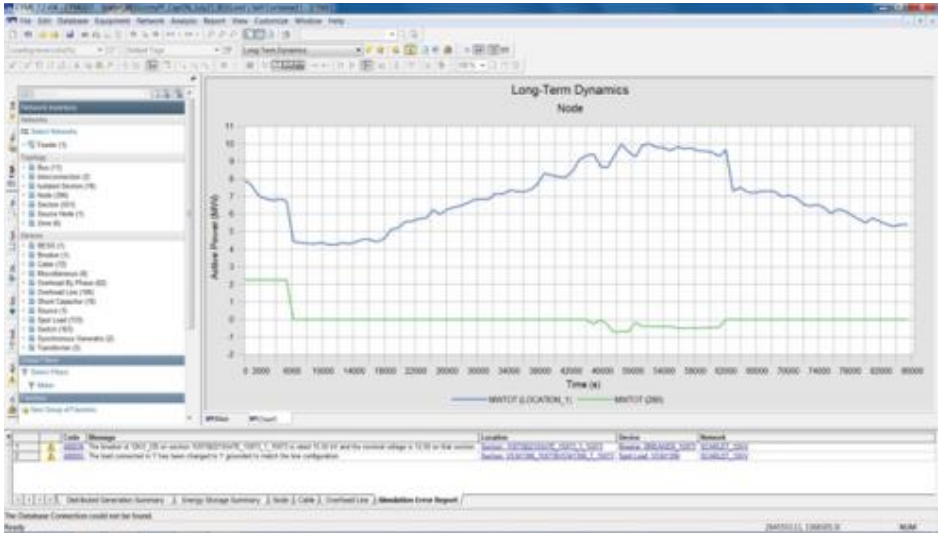
- Critical load uptime and black start capabilities
- Extended outage capabilities: 1hour vs. 1day vs. 1week
- Harmonics and power quality issues and transient response and system restoration
- Microgrid conceptual design—preliminary sizing and siting of DERs and energy storage
- Preliminary electrical single lines and control system architecture

Feasibility study recommendations

- Short term reliability improvement recommendations
- Recommendations for future long term design criteria
- Cost benefit analysis of various DERs and energy storage options including optimal sizing for minimized levelized cost of electricity (LCOE)
- Selection of suitable energy storage technology and applications assessment
- Microgrid options and benefits resulting from the various DERs such as solar, wind, CHP, fuel cell and in house fossil fuel generation
- Recommended modes of operation and switching sequences

Technical considerations





Specific technical topics may be part of the microgrid feasibility study

- short-term reliability improvement recommendations
- site-specific studies of load flow scenarios, short circuit and dynamic simulations to address transients
- review summaries of environmental or noise issues
- microgrid protection tailored to operational modes

Financial considerations

Specific financial / economic topics may be part of the microgrid feasibility study

- peak shaving
- load shifting and/or shedding
- demand charge management
- net metering (power export)
- ancillary services
- frequency regulation
- demand response program participation
- Overall project return on investment

Feasibility study report checklist

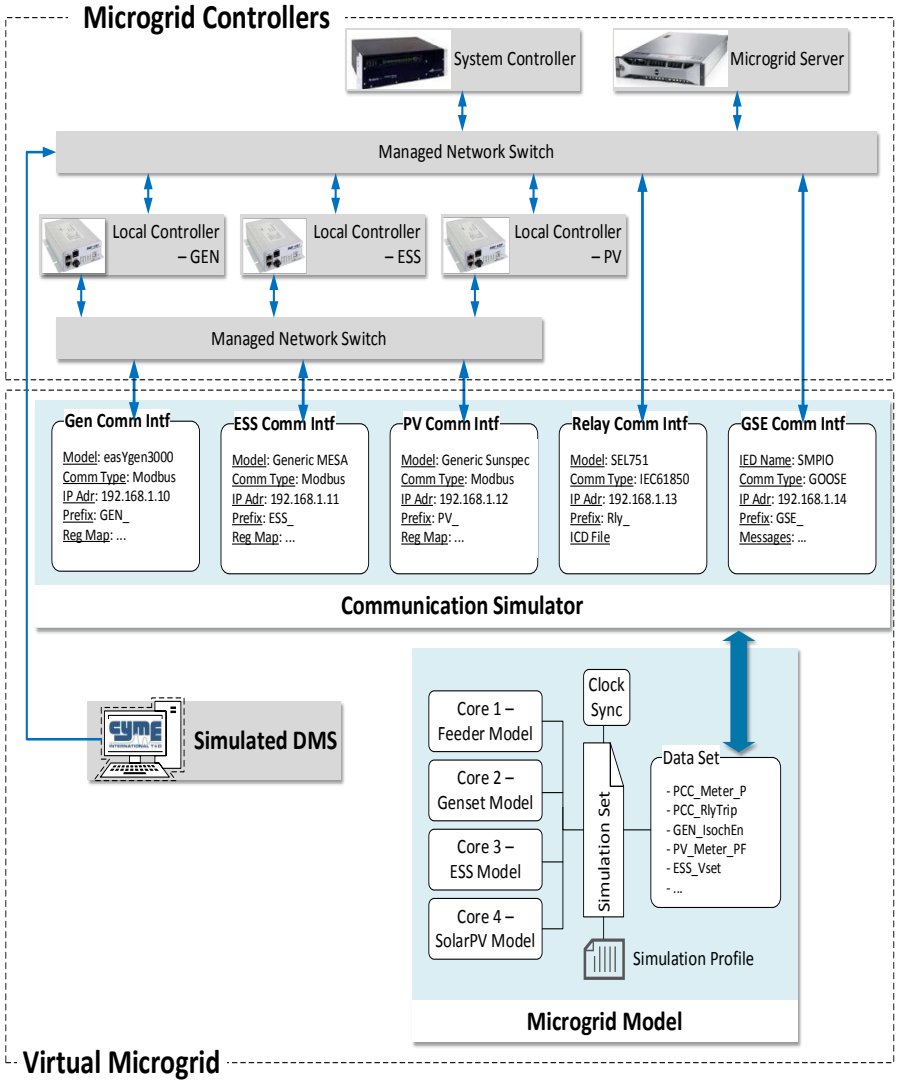
- ✓ Existing System Description
- ✓ Proposed Microgrid Design
- ✓ Intermittent Renewable Energy Sources Sizing and Production Estimate
- ✓ Distributed Energy Resources
- ✓ Energy Storage Sizing and Technology Selection
- ✓ Load Flow Study
- ✓ Short Circuit Study
- ✓ Dynamic Study
- ✓ Environmental Review
- ✓ Microgrid Protection
- ✓ Microgrid Operational Modes
- ✓ Microgrid Controls and SCADA
- ✓ Microgrid Costs and Return on Investment
- ✓ Appendices typically include:
  - ✓ Preliminary one-line diagram
  - ✓ Preliminary layout diagram
  - ✓ Conceptual control diagram
  - ✓ Short circuit analysis input data

From feasibility study to virtual modeling

- Developing a microgrid requires extensive power system automation and control knowledge
- What if you could analyze data to improve performance before the microgrid is installed?
- Distribution system modeling with power system software technologies can provided
  - critical modeling to better show the interdependency among microgrid components
  - more precise simulation of distribution systems and distributed energy generation resources
  - assess functionality and likely future performance

Virtual microgrid (hardware-in-the-loop testing)

- Distribution model portable from CYME
- Generic and customizable DER models
- Easy communication configuration with most popular protocols (Modbus, IEC61850, DNP3, etc.)
- Easy profile integration for case studies
- Capable of integrating LVRT/HVRT/ZVRT with protection coordination
- Flexible in terms of model fidelity
- Use as digital twin for microgrid controller(s) development and validation
- **Simulate system performance before implementation!**

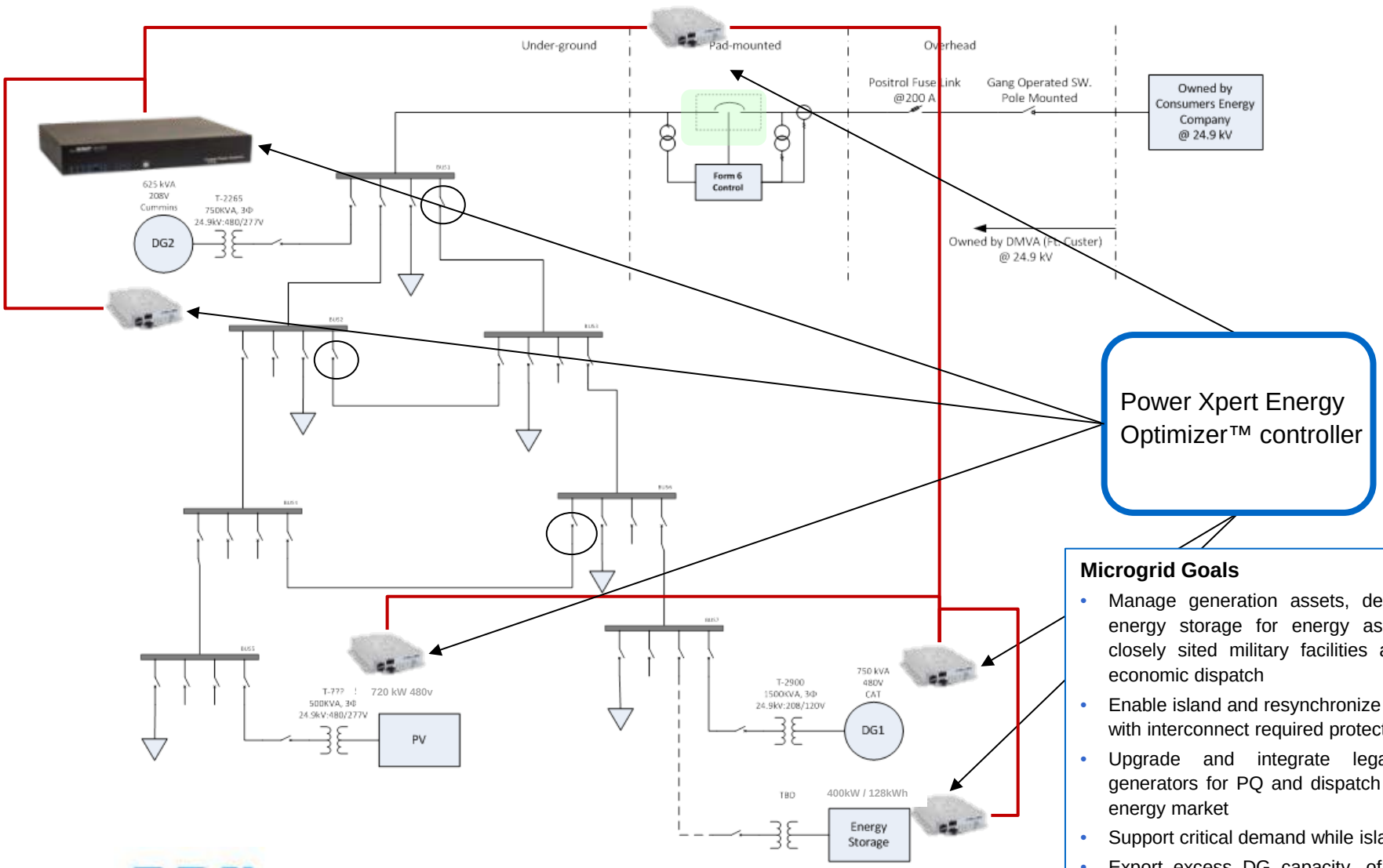


Virtual microgrid advantage

- Understand the system as if the assets and devices were already connected
- Demonstrate how the system is configured and optimized during the design phase
- Drive a better understanding of the system dynamics and feasibility based on data from the simulation
- Site data can be imported into the virtual microgrid to develop the system's load profile and utility rate structures
- Data can be exported from the virtual environment for evaluation and measurement of performance metrics prior to the project breaking ground

Fort Custer MV microgrid project

Virtual microgrid simulation example



Microgrid Goals

- Manage generation assets, demand, and energy storage for energy assurance of closely sited military facilities and enable economic dispatch
- Enable island and resynchronize at the PCC with interconnect required protection
- Upgrade and integrate legacy diesel generators for PQ and dispatch to regional energy market
- Support critical demand while islanded
- Export excess DG capacity, of ≥1MW for 120 consecutive hours with a peak of ≥2MW for 4 consecutive hours

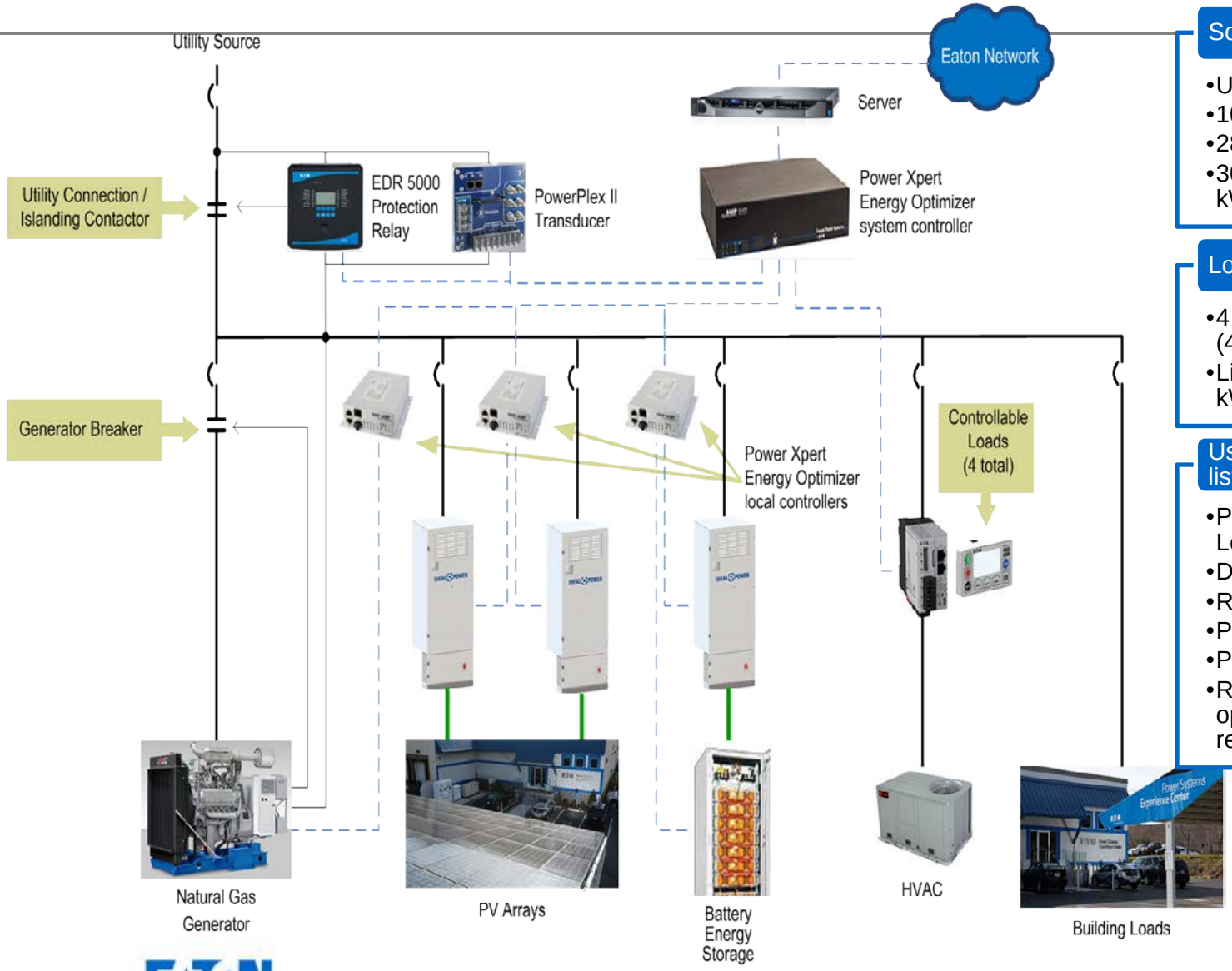
Optimizing microgrid performance

Simulate system performance before implementation

Operational microgrid utilizing real-time modeling and simulation

Microgrid

Eaton Power System Experience Center, Warrendale, Pennsylvania



Sources

- Utility
- 100 kW Generator
- 28 kW Photovoltaic
- 30 kW Battery Storage (30 kWh)

Loads

- 4 Controllable HVAC units (4 -25 kW)
- Lights, outlets, etc. (8-12 kW)

Use Cases (partial list)

- Peak Power Limiting / Load Leveling
- Demand Management
- Renewable Firming
- PV Shifting
- Power Factor Control
- Resiliency: Islanded operation optimizing renewables

Conclusions

- Microgrids provide several benefits
- Several technical and economic considerations need to be addressed
- Feasibility study helps to identify and define technically and economically sound microgrid projects
- Virtual modeling can allow projects to move more quickly and successfully

Thank you

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