

Eaton Corporation – Microgrid Overview

Enabling Advanced Power Electronics Technologies for Next Generation Grid



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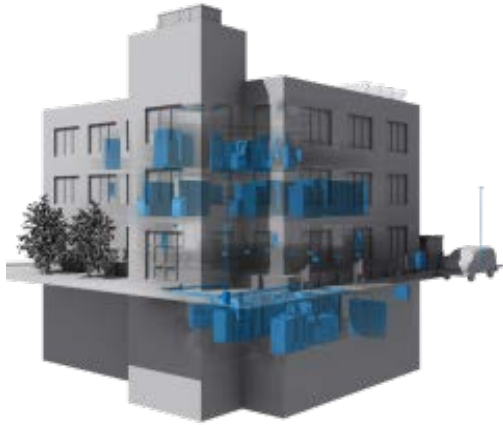


Powering Business Worldwide

Eaton – a global \$20B+ manufacturer of safe, reliable and efficient power management solutions

Electrical Sector

Products

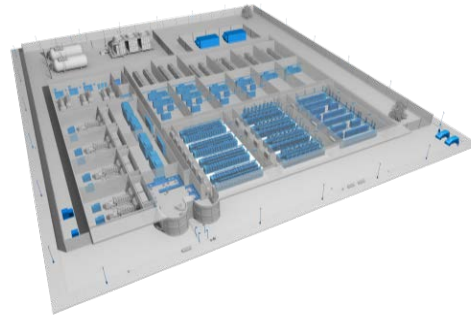


2015 Sales: \$7.0B

33% of sales

Providing safe and efficient electrical solutions from generation through distribution and control

Systems and Services



2015 Sales: \$5.9B

28% of sales

Industrial Sector

Hydraulics

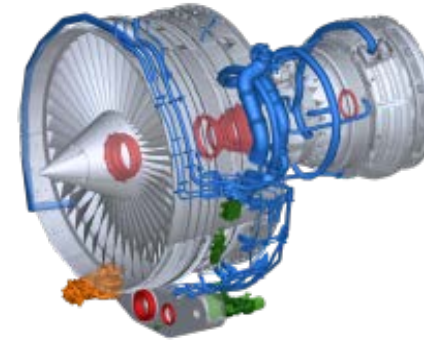


2015 Sales: \$2.5B

12% of sales

Solutions for the world's most demanding power needs

Aerospace



2015 Sales: \$1.8B

9% of sales

Mission critical, safe, and reliable solutions

Vehicle



2015 Sales: \$3.7B

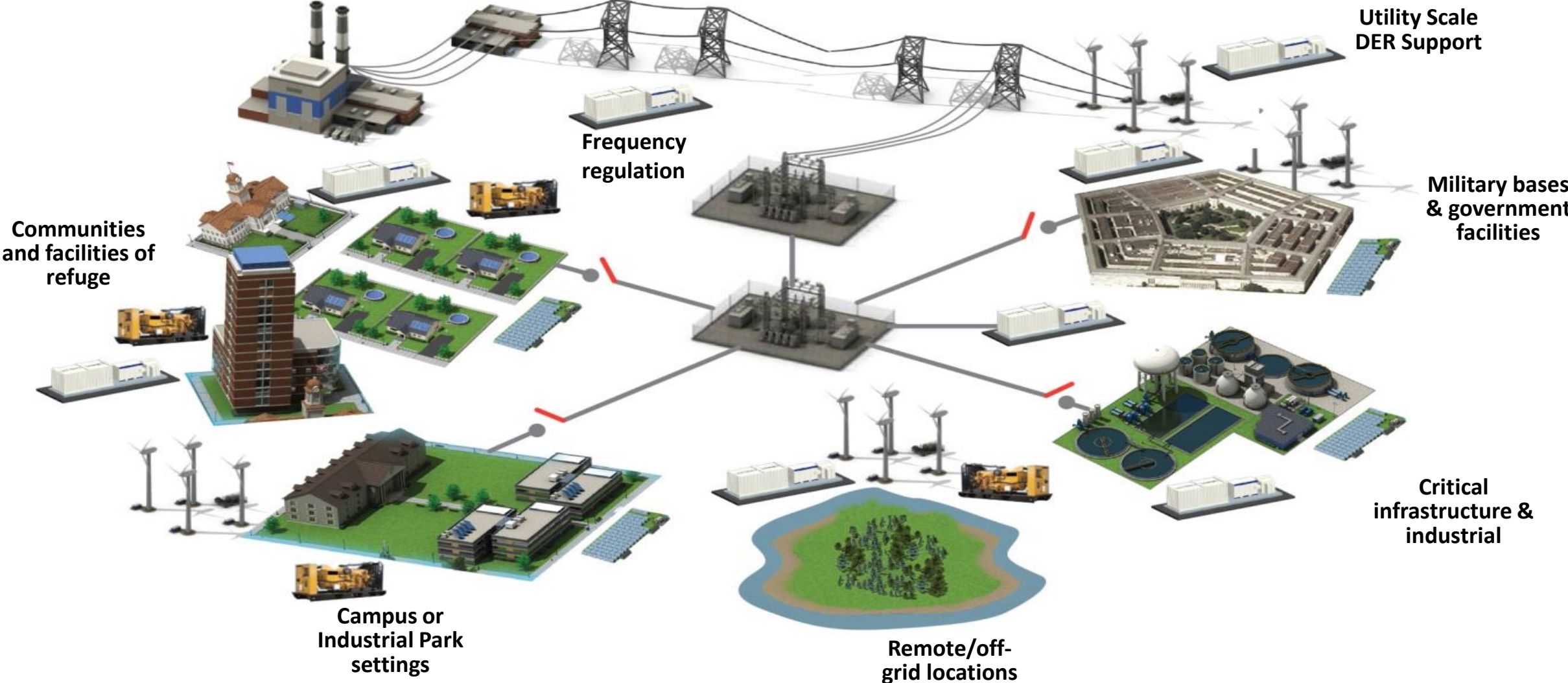
18% of sales

Leader in fuel economy and emissions reduction

Microgrid – What it is

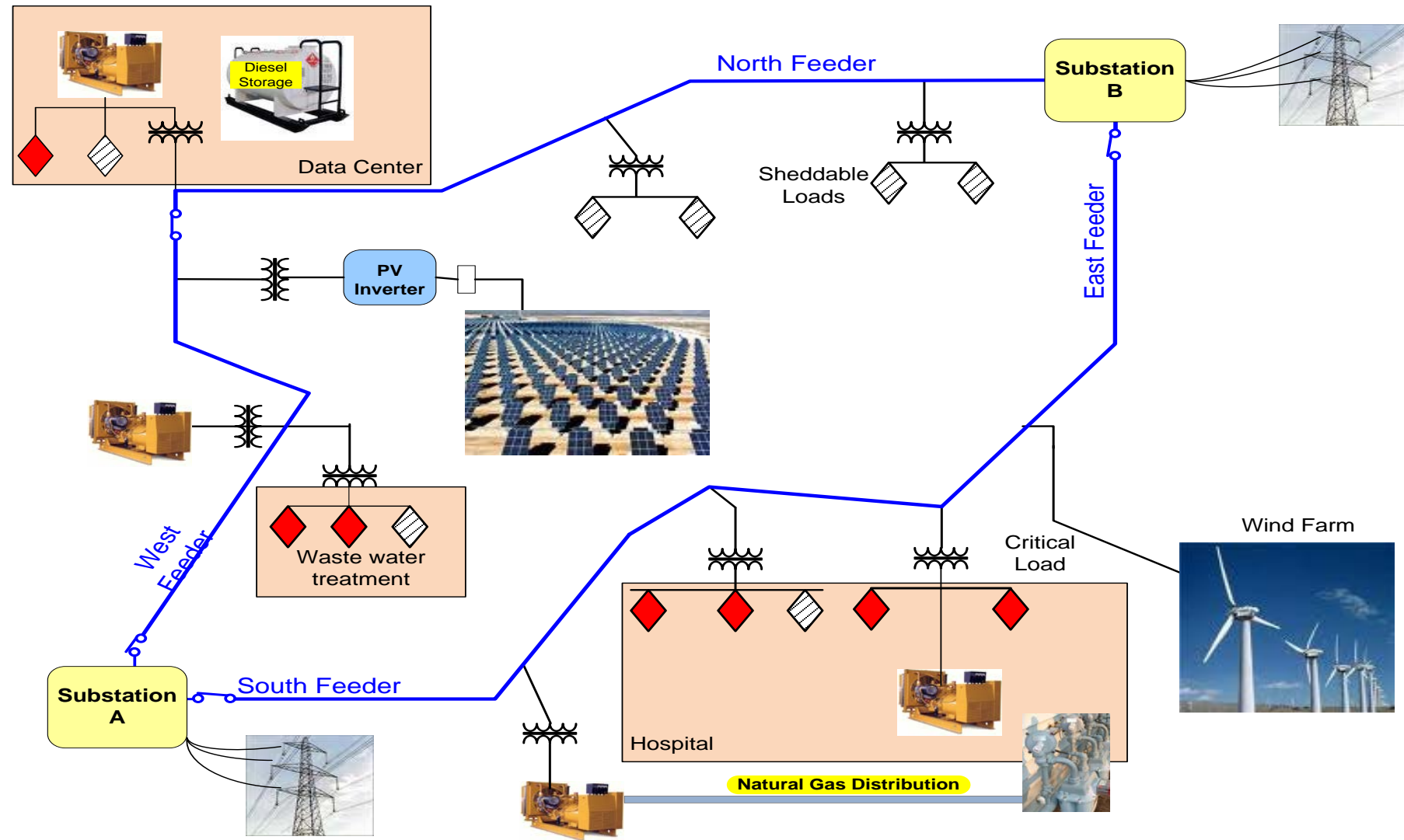
An integrated energy system consisting of a distributed energy resources (DERs) and multiple electrical loads operating as a single, autonomous system...in parallel to, or islanded from, the existing utility power grid.

The Electric Utility Grid Ecosystem



The Emerging Power Grids

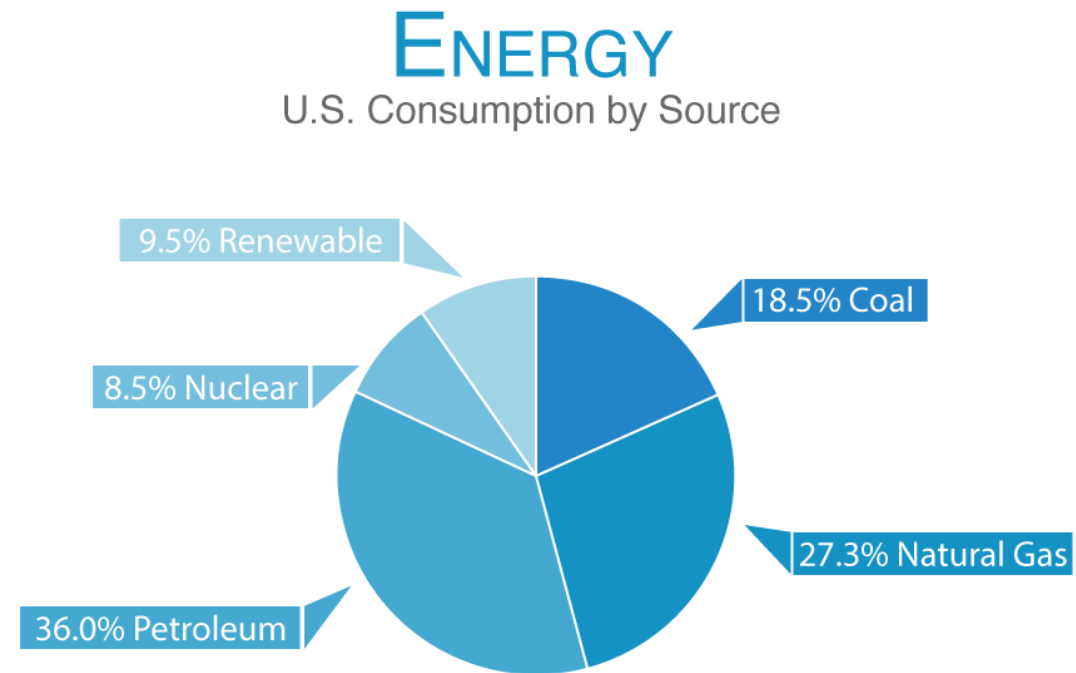
1. Solar PV plants
2. Wind farms
3. Dispatchable Diesel Generators
4. Natural gas generators
5. Critical loads
6. Controllable loads
7. Sectionalizers
8.
9.



Renewables – Trends and Challenges

Major energy sources and percent shares of U.S. electricity generation at utility-scale facilities in 2016

1. Natural gas = 33.8%
2. Coal = 30.4%
3. Nuclear = 19.7%
4. Renewables (total) = 14.9%
 1. Hydropower = 6.5%
 2. Wind = 5.6%
 3. Biomass = 1.5%
 4. Solar = 0.9%
 5. Geothermal = 0.4%
5. Petroleum = 0.6%
6. Other gases = 0.3%
7. Other nonrenewable sources = 0.3%
8. Pumped storage hydroelectricity = -0.2%4

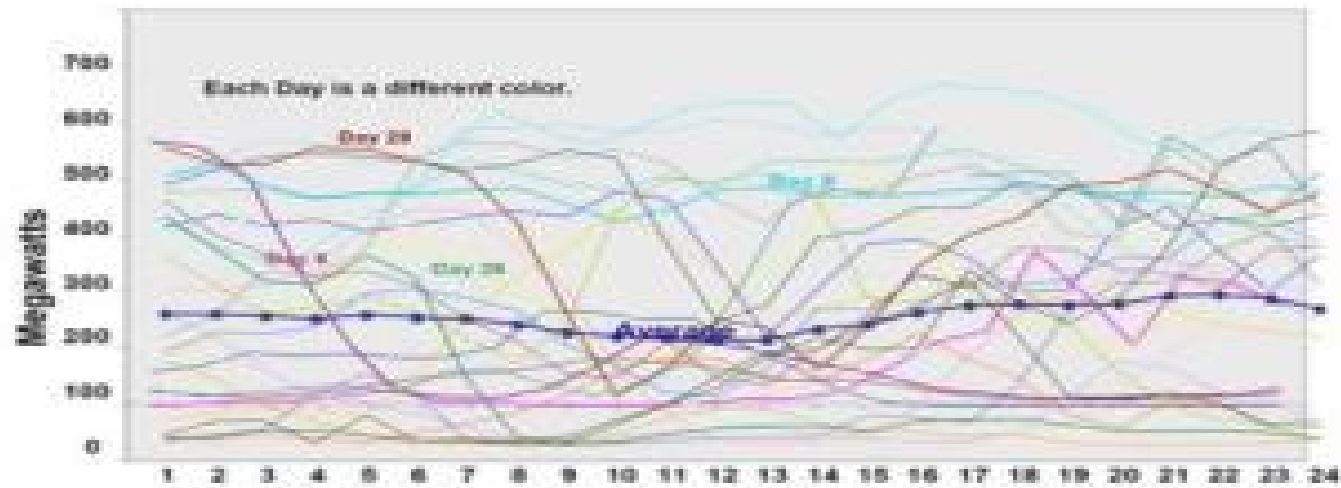


Source: EIA July 2014

IER INSTITUTE FOR ENERGY RESEARCH

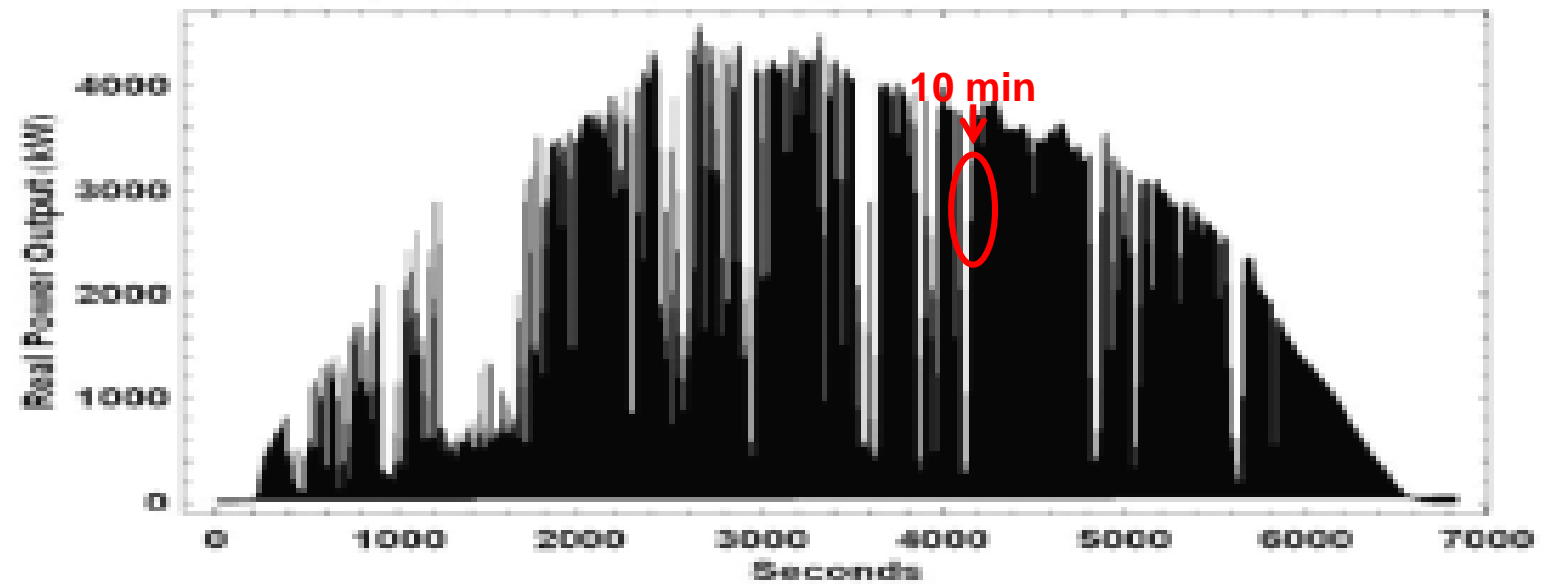
High Penetration Renewables

Renewables: Wind Profile



Renewables: Solar Profile

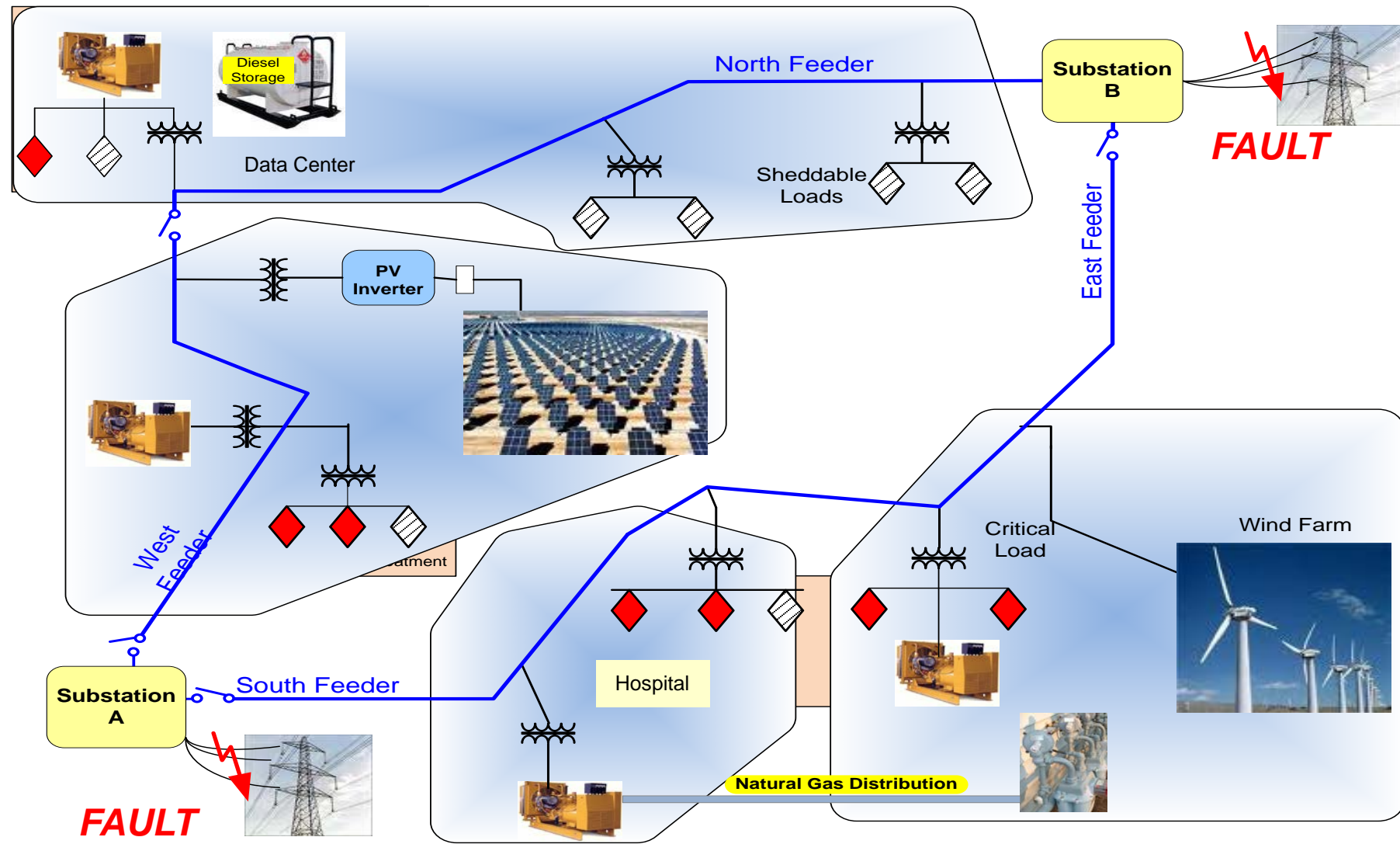
Springerville AZ, One Day at 10 Second Resolution



Islands Formed on an Outage

-- Hardware and Tools Required

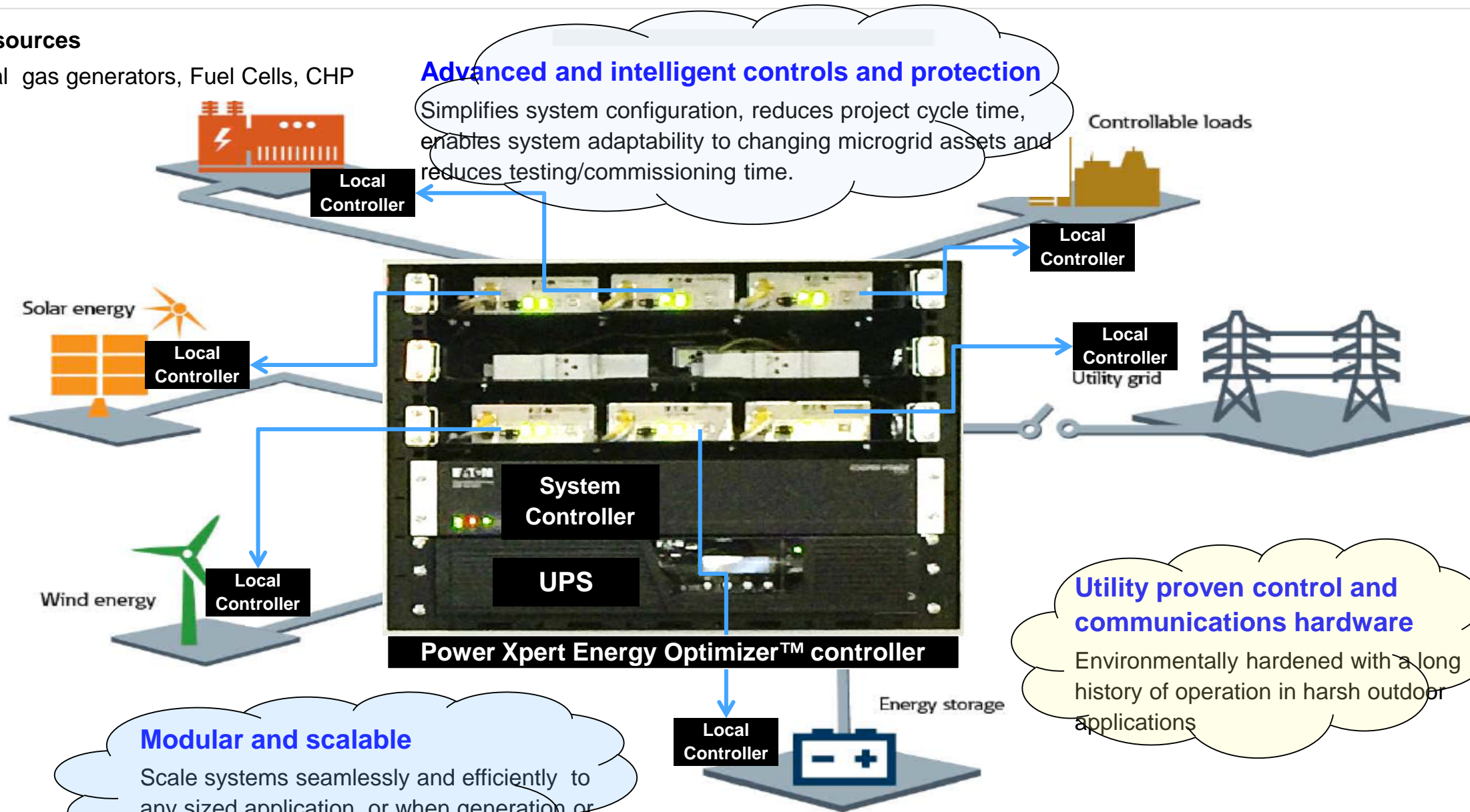
1. Disconnecting devices
2. Resynchronizers
3. Islanding controls for renewable inverters
4. Smart Inverters
5. Diesel storage and Natural gas supply
6. Special generator controls
7. Load and source balancing
8. System configuration tools
9. Load identification and management
10. Communication and controls
11. Power System models



Microgrid Energy System Architecture

Generation sources

Diesel/Natural gas generators, Fuel Cells, CHP



Advanced and intelligent controls and protection

Simplifies system configuration, reduces project cycle time, enables system adaptability to changing microgrid assets and reduces testing/commissioning time.

Modular and scalable

Scale systems seamlessly and efficiently to any sized application, or when generation or load assets are added

Utility proven control and communications hardware

Environmentally hardened with a long history of operation in harsh outdoor applications

Microgrid Control and Protection

- General Function Requirements

A Microgrid control system should have both real-time control and energy management functions that operate in the following situations:

- Operation in grid-connected and islanded modes
- Automatic transition from grid-connected to islanded mode to provide uninterrupted power to microgrid loads during abnormal bulk power system conditions and planned interruptions of the system
- Resynchronization and reconnection from islanded mode to grid-connected mode
- Energy management to optimize both real and reactive power generation and consumption
- Ancillary services provision, support of the grid and participation in the energy market and/or utility system operation, as applicable

Dispatch function: dispatching individual devices in given operating modes and with specified set-points.

Transition function: supervising the transitions between connected and disconnected states, and ensures the dispatch is appropriate for the given state.

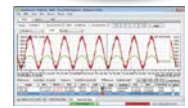
Microgrid-ready product and service portfolio

- Hardened controllers
- Optional redundancy
- IEC 61850 comms modules
- Cyber security
- Yukon Visual T&D HMI
- Relays

Utility Automation Products



System Optimization Software



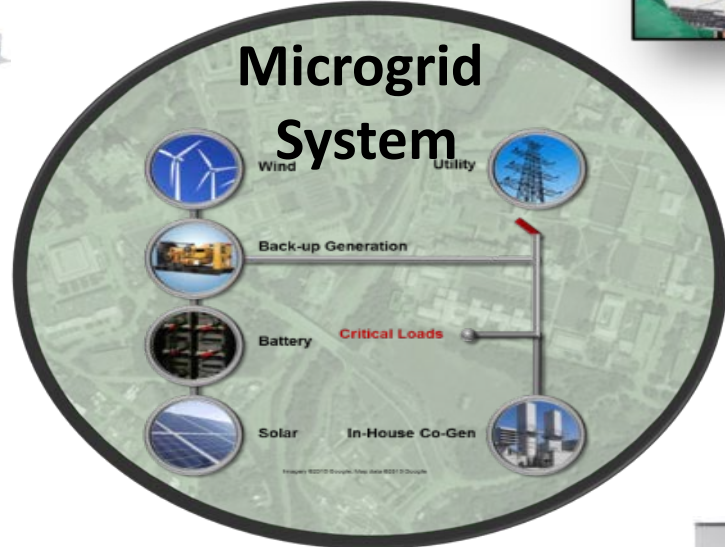
- Overlay supervisory control
- Microgrid/Power System expertise
- CYME dist. system optimization modeling
- Demand Response for gen. / load balance
- Data analytics and cloud data base

Automation and Project Services



- Turn-key supply
- Total project management
- System design/integration /testing
- Lifecycle services

Interconnection Manager



LV Load and Generator Control



- Smart LV breaker
- Built-in comms
- Fit existing panelboards

- Integrated solution
- Reclosers/Breakers
 - Protection relays
 - Microgrid controller

Supporting Electrics



- Switchgear
- Switchboards/Panel Boards
- Transformers
- Regulators
- Services

Smart Inverter Suite



- 1 MW to 2.25 MW
- Smart interface
- PV and energy storage integration

