

When Microgrids Are The Answer: An Overview



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MICROGRID DEFINITION

(From US Department of Energy)



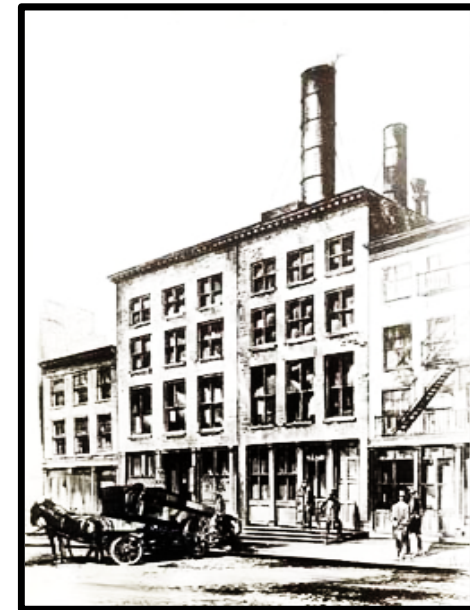
- **A Microgrid Is A Group Of Interconnected Loads And Distributed Energy Resources (DERs) Within A Clearly Defined Electrical Boundary To Keep “Critical” Loads Supplied With Electricity.**

- **If Local Grid Exists:**
 - **The Microgrid Acts As Its Own Single Controllable Entity With Respect To The Local Grid.**

 - **The Microgrid Connects And Disconnects From The Local Grid To Enable It To Operate In Both Grid-Connected Or “Islanding” Modes.**

Microgrid Types

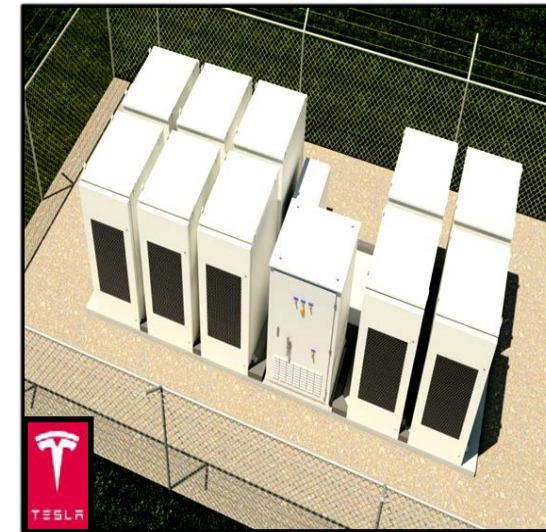
- Microgrids Which Are Not Able To Connect To A Local Grid Are Always Operated In An Islanding Mode
- World's First Microgrid / Power Plant Had 600kW_{dc} Capacity And Initially Powered 44 Light Bulbs.
Owners: Tom Edison & JP Morgan.
This Microgrid Was Later Connected To Other Edison - JP Morgan DC Microgrids.
- Institutional / Campus Microgrids
- Commercial / Industrial Microgrids
- Military Base Microgrids



World's First Microgrid / Power Plant (255 to 257 Pearl Street, NY City) 600kWdc, Sept. 4, 1882.

Microgrid Components Can Include:

- **Local Generation** (e.g., Diesel, PV Solar)
- **Critical Electric Loads** (e.g., Data Centers/Server Farms; Hospital Operating Rooms, Airport Control Rooms, Military Command/Control Centers, Industrial Processes)
- **Energy Storage** (e.g., Battery, Compressed Air, Flywheel, Heat/Cold Storage)
- **If Connected To Local Electric Grid, Need:**
 - Protection Relays (From Short Circuits)
 - Automatic Transfer Switch
 - Point of Common Coupling (PCC)



*Tesla Powerpack 2
Battery Module
(250kW - 4 Hour Rating)*

Benefits & Challenges



➤ Benefits

- Provide Emergency Backup Power During Blackouts (Min./Hrs./Days)
- Provide Backup Power During Shortages/Power Interruptions (Sec./Min.)
- Provide Revenue From Local Grid Owner; e.g., When Duty Cycle Is Power/Ancillary Services (For Volt/VAR Support, Black Start, and/or Freq. Reg.)
- Reduces Imported kWh \$'s (e.g., When Microgrid Includes PV/Battery)

➤ Challenges

- Capital Cost (\$/kW Expense Is Higher at Smaller Scale) & Maintenance Cost
- Bi-Directional Power Flows (Which Can Cause Safety & Equipment Failures)
- Short-Circuit / High Current Transients (e.g., from Grid or from Microgrid)
- Power Flow Instability (e.g., From Low Rotational Mass, Resonant Freq. Events)
- Control System Complexity and Cyber-Security
- Land and Emissions (CO₂, Water, Noise)

Illustrative Example Of Military Microgrid



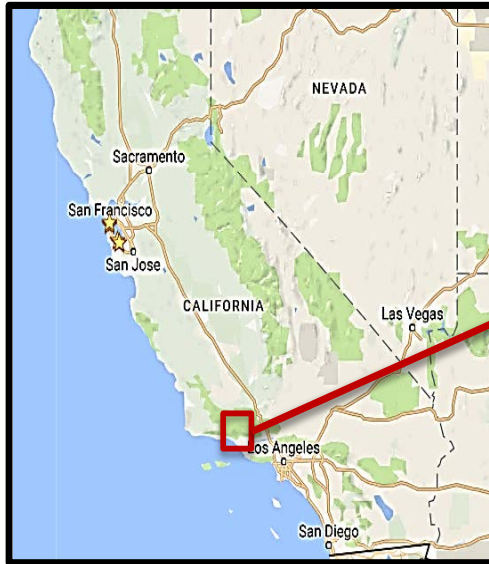
➤ Problem Statement

- At A Navy Base Server Farm Building, Reduce Electricity Usage & Backup Diesel Emissions, Increase Renewable On-Site Energy Generation, and Improve Energy Security & Resiliency

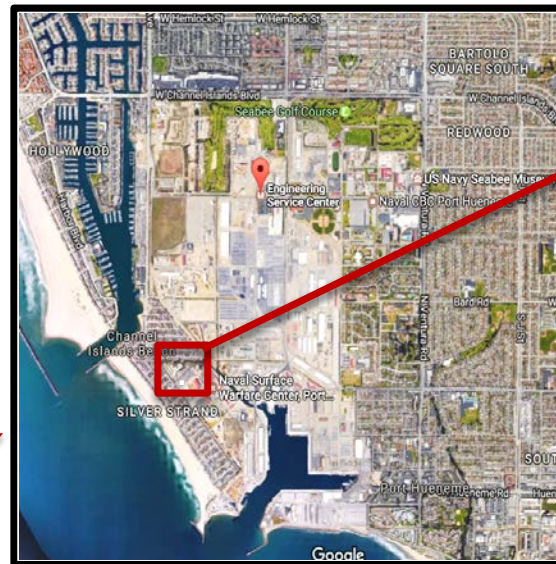
➤ Response

- Design, Construct, Install, Test, And Monitor Performance (for > 4 Yrs) Of An Innovative Microgrid (With Solar PV, Battery Storage, Synchronous Condenser, and Updated HVAC and Building Energy Management Systems) At A Navy Base Server Farm Building, Which Is Superior To Existing Practice & Technology and Uses Standardized Components

EPRI's Planned "Adaptive Microgrid" At Navy Site Location



**Location of CA Navy Base
(Source: EPRI and Google Map)**



**Naval Surface Warfare Center –
Port Hueneme Division
(Source: EPRI and Google Map)**



**Server Farm Site Location Where EPRI's
Adaptive Microgrid With Adaptive
Protection Relays, Battery Storage,
And Synchronous Condenser Is
Planned To Be Installed
(Source: EPRI and Google Map)**

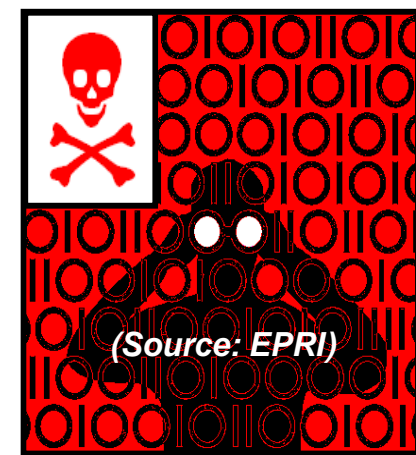
Technology Innovations

- **No Loss of Power During Islanding and Resynchronization Events**
- **Integrated PV-Battery System**
 - Reduces Demand & Peaking Power Costs
 - Reduces Diesel Fuel & Emissions
- **Synchronous Condenser**
 - Keeps Microgrid On-Line During Wide Variety of Short Circuit Conditions (e.g., at Commercial, Industrial, Institutional, and Military Sites)
 - Provides “Copper” To Satisfy High Current Transients During Islanding and Resynchronization Events
 - Provides Rotational Mass To Improve Power Factor & Voltage Support



Example Synchronous Condenser

Risks and Responses

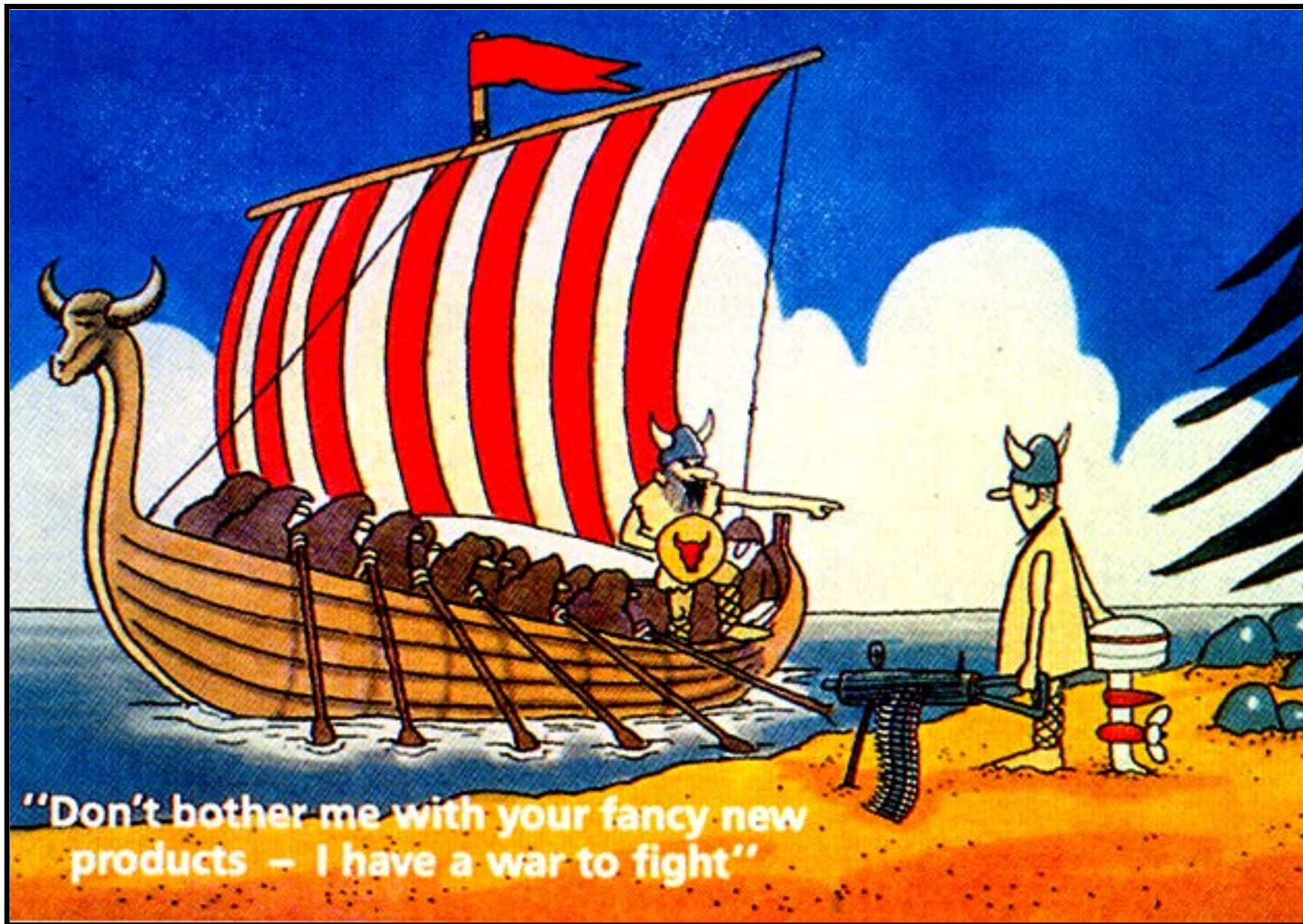


➤ Response to Cyber-Security Risk

- Data Transfer Diode / Serial-Based Communication Protocol
- What-If Cyber Attack Scenario Testing
- Utilizes Lessons-Learned from DoD Risk Management Framework (RMF) and DoD SPIDER Cyber Projects and Testing Results

➤ Response to Battery Degradation Risk

- Tesla Battery System Is Oversized By 50% To Deliver 500kW-4hr **After** 10 Years Of Cycling Duty With > 82% Round-Trip AC Efficiency



“We can't solve problems by using the same kind of thinking we used when we created them.” - - - Albert Einstein