DESIGNING MICROGRIDS & INCORPORATING BESS

David Goetz

March 8, 2023

Powering a sustainable energy future

Agenda

- Define Microgrid
- Discuss Typical Attributes
- Typical Customers and Applications
- Design Considerations
- BESS Discussion

Microgrid Definition

A microgrid is

“a group of interconnected loads

and distributed energy resources

within clearly defined electrical boundaries

that acts as a single controllable entity with respect to the grid

[and can] connect and disconnect from the grid

to enable it to operate in both grid-connected or island-mode.”

*- the **U.S. Department of Energy***

Microgrid Definition

A microgrid is

"a group of interconnected loads

and distributed energy resources

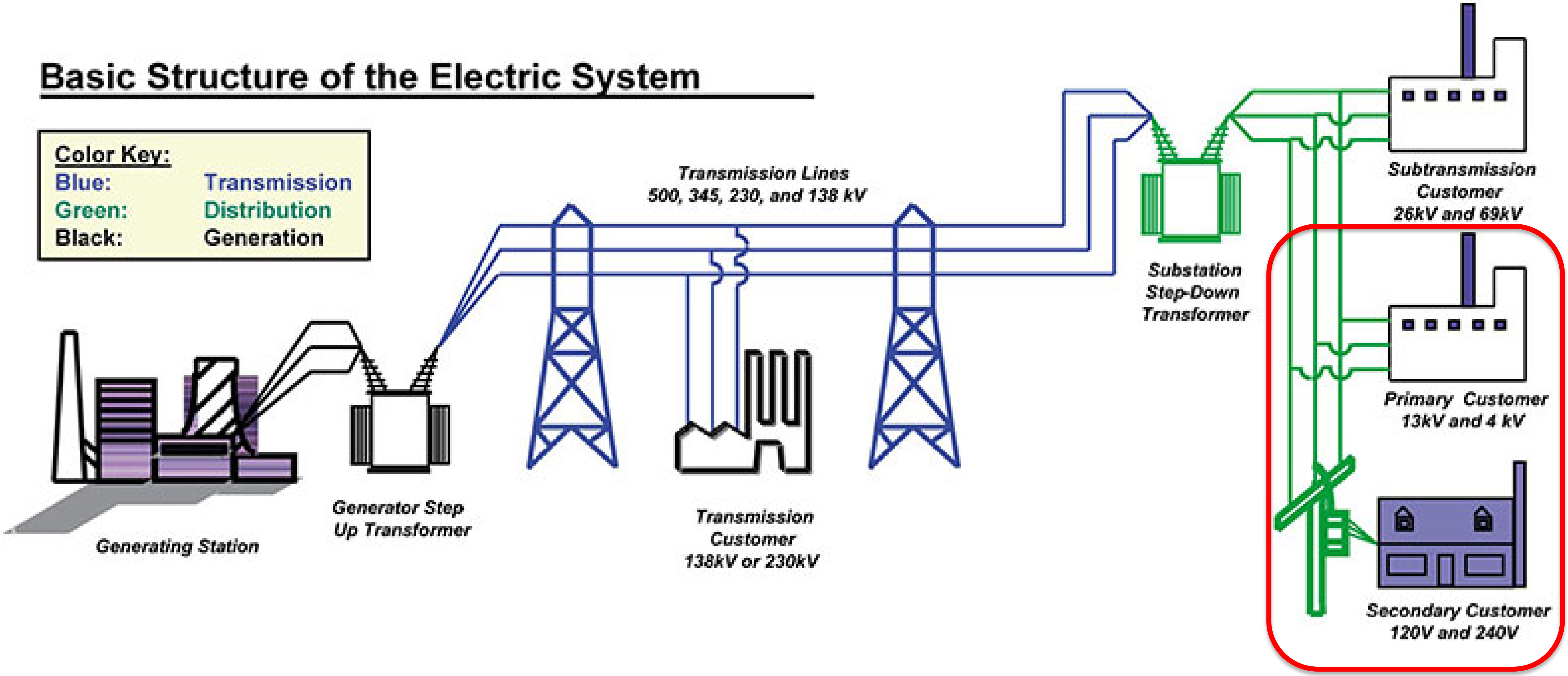
within clearly defined electrical boundaries

that acts as a single controllable entity with respect to the grid

[and can] connect and disconnect from the grid

to enable it to operate in both grid-connected or island-mode."

*- the **U.S. Department of Energy***



POTENTIAL MICROGRID CUSTOMERS

Common Features

- Decoupling of Generators from Loads
- Seamless Transitions to/from Utility
- Increased Redundancy of Generation Assets

Historical View of Microgrids

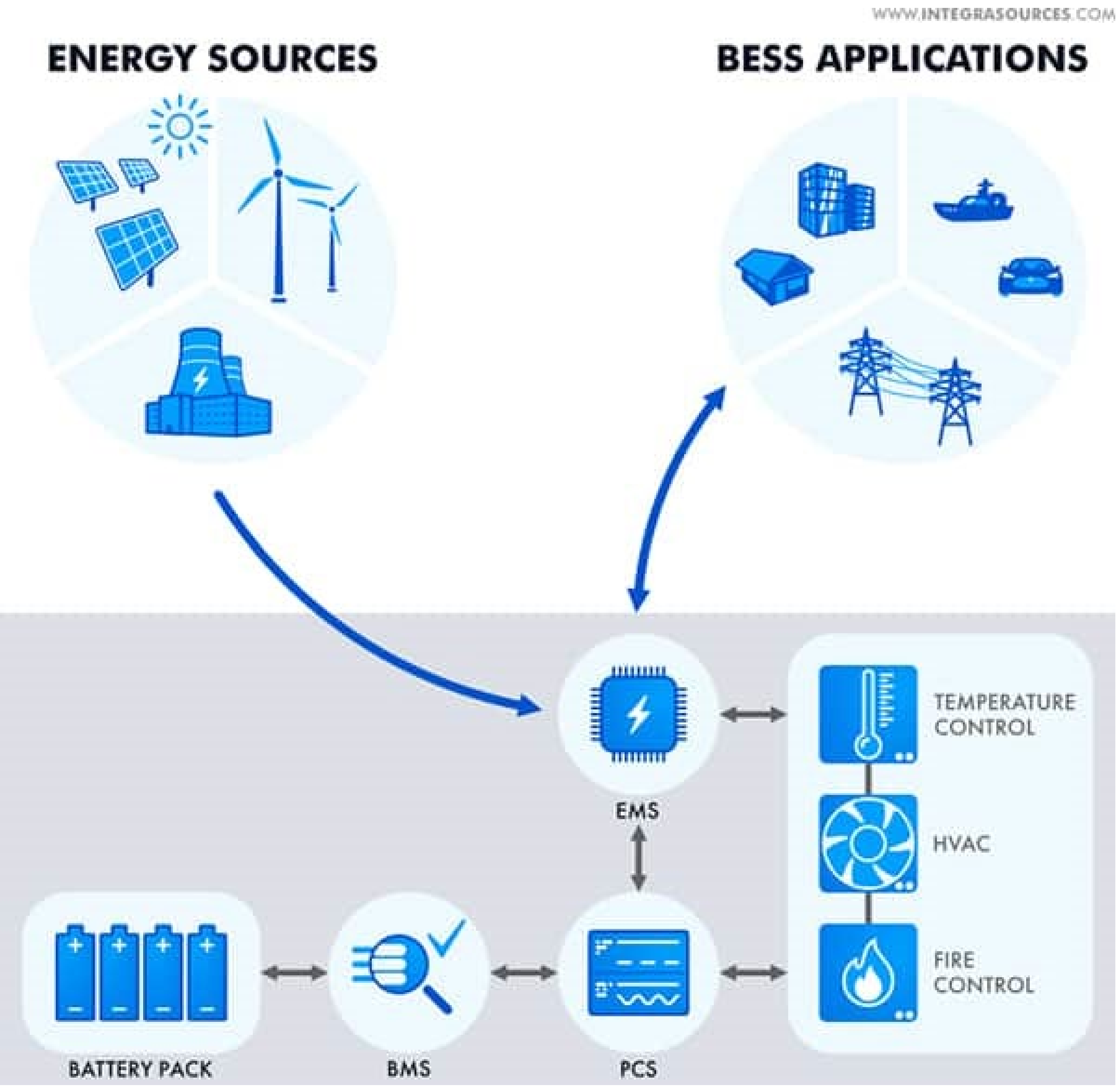
- Strictly for Customer Energy Reliability / Independence
- Heavily Dependent on Diesel Generation
- Operated as Bi-State Systems

Microgrid Evolution

- Microgrids Now Contain Assets which are Installed Primarily for Utility-Tied Operation
- No Energy Source is Out of Bounds
- Multiple Modes of Operation - Both Grid Tied and Islanded

Where are we headed:

- Microgrids Designed to be an IPP 99.99% of the Time with Customer Energy Security as a Secondary Requirement
- Utilities Adopting New Rate Structures and Capital Plans to Profit from Microgrid Capabilities
- Cyber Security is a Big Hurdle to Clear



Microgrid Platforms

Combined Heat & Power

- Central Energy Plant Approach
- Focused on Highly Efficient Utility Tied Operation
- Common on University Campuses

Traditional Critical Infrastructure

- Central Backup Power Plant Approach
- Only Operate in Absence of Utility
- Common at Data Centers and Hospitals

Next Gen Critical Infrastructure

- Distributed Generation Approach
- Focused on Flexibility and Sustainability
- Emerging Technology

Universities

- Energy is a Significant Portion of Total Operating Costs
- Loss of Research can be Very Costly
- Students Expect Uninterrupted Utilities

Hospitals

- Codes Only Require “Triage Quality” of Care
- During Disasters, People Migrate to Hospitals, Police Stations, Etc. as Places of Refuge
- High Efficiency Buildings and Technology-Based Care do not Permit “Limp Mode” Operation

Manufacturing

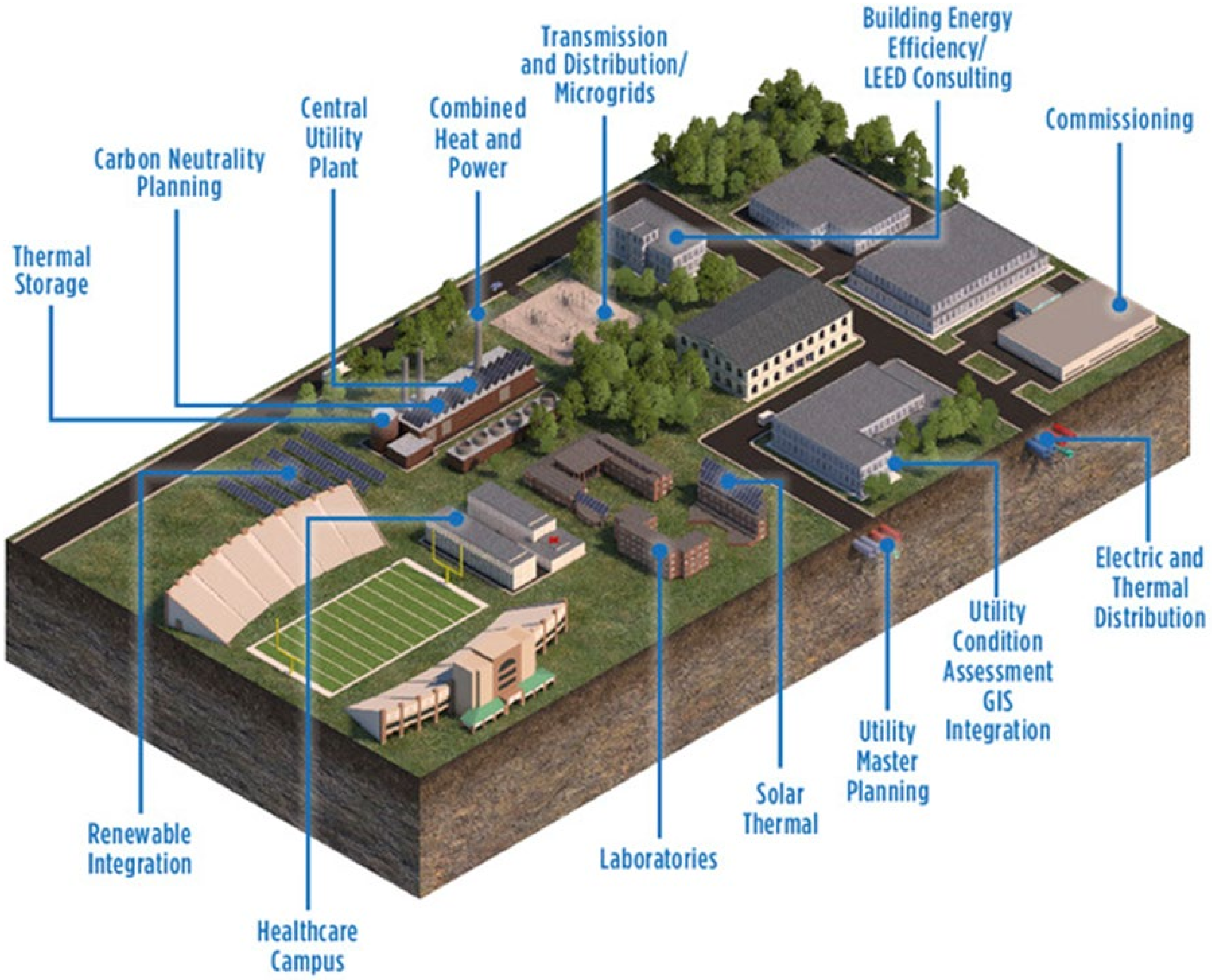
- Automation has Increased Susceptibility of Overall Manufacturing Process to Electrical Issues
- Just in Time Inventory Practices Reduce or Eliminate Cushion of Already Manufactured Products
- Rolling Blackouts can Result in Dramatic Costs of Lost Production and Lost Material

Department of Defense

- Greater Dependence on Electronics at all Levels of Military
- Leaner Military has Resulted in a Great Deal of Theater Command and Control being Located in US
- Very Large Renewable Generation Installations which Are Unavailable During Outages

Microgrids – Why not everyone?

- ► Existing infrastructure
  - Distribution not suited
  - Utility Interconnection Challenges
  - Load Profile not a fit
  - Control System Requirements
  - Cyber Security



Starting Point – Establish Basis of Design

- Establish Functional Criteria
  - What the System Can Do
  - What the System Can't Do
- Document Key Design Decisions
- Obtain Stakeholder Buy-in
- Carefully Plan Level of Automation
- Mind the Budget

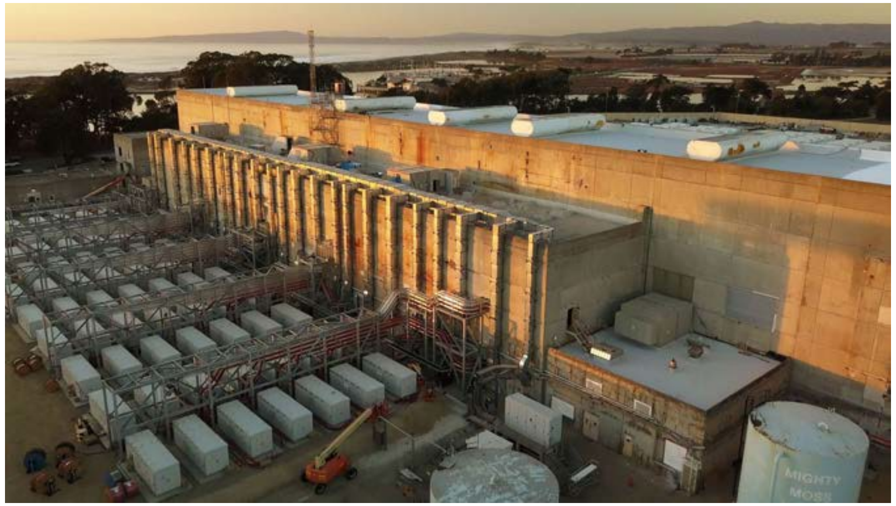
Battery Energy Storage Systems (BESS) – The Basics

Battery Energy Storage Systems (BESS)

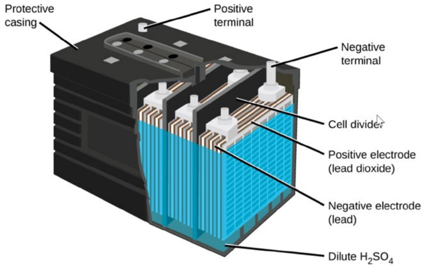
- Energy Storage = System that holds kinetic, potential, or other forms of energy that can be converted to another form.
- Examples of stored energy types: (naturally occurring examples in red/green)
  - Chemical (batteries, fuel cells; fossil fuels)
  - Potential (pumped hydro; water)
  - Kinetic (fly wheels; wind, tides)
  - Thermal (water, earth; geothermal, sun)

Battery Energy Storage Systems (BESS)

- Two energy storage technologies dominate today in the US
- Pumped Hydro (potential to electric energy)
  - Largest in terms of storage capacity – gigawatt-hours
  - Limited future development
- Batteries (chemical to electric energy)
  - The most flexible and most common
  - Portable or stationary
  - Milliwatts to Gigawatts
  - Quick to switch on and off



Battery Energy Storage Systems (BESS)



A Brief History of Batteries:

- Volta discovered the first battery in 1799
- Lead acid battery first reported in 1859
- Alkaline cell was first marketed in the 1960's
- The rechargeable lithium-ion battery was invented in 1972

Battery Energy Storage Systems (BESS)

Why Lithium-ion?

+ Store the most energy per unit weight or volume
+ Minimal maintenance cost
+ Readily available
+ Portable
- Need protection from overcharge/discharge
  - Thermal runaway can result if fires
- Need temperature control for optimum operation

Which Lithium-ion?

- Phosphates (LFP)
- Oxides (NMC)

Battery Energy Storage Systems (BESS)

- System Components:
  - Cells > Modules > Racks
  - Battery Management Systems (BMS)
  - Monitoring and safety components
  - Balance of System equipment

Battery Installation Types

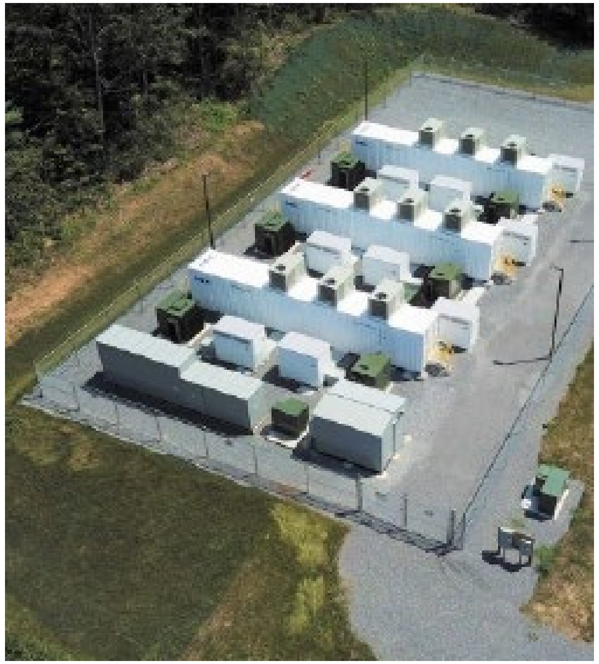
- Residential

- kWh

- Commercial

- kWh - MWh

- Utility-Scale



- MWh - GWh

Establish Basis of Design

- Establish Functional Criteria
  - What the System Can Do
  - What the System Can't Do
- Document Key Design Decisions
- Obtain Stakeholder Buy-in
- Carefully Plan Level of Automation
- Mind the Budget

Summary

- No Two Microgrid Systems are Identical
- Multiple Platforms with Differing Requirements
- Similar Set of Design Considerations
- Competing Agendas Between Stakeholders
- More Automation – More Complexity – Higher Cost
- Establish and Document Design Basis
- Use Case Based Battery Chemistry Selection

BURNSMCD.COM/ONSITE

BURNS McDONNELL

CONTACT

David K. Goetz, P.E.
Business Development Manager
P 314.740.5491
E dgoetz@burnsmcd.com