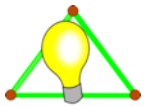
Open DC Grid Project

2021 January



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Agenda

- Microgrid Related Definitions – Bruce Nordman
- Microgrid Market Ontology
- Related Standards / Industry Developments

Local Grid Definitions

Bruce Nordman, LBNL

- Without clear terminology, we will fail to communicate
- "local grid" - infrastructure separate from that operated by electric utilities
  - That within customer sites
- Definitions may address electrical engineering, scale, control/communication, topology, regulation, and more
- Goal: Terminology that we can all work with; may not be anyone's ideal

See: "Local Grid Definitions", A white paper, developed by the Smart Grid Interoperability Panel, Home Building and Industrial Working Group, February 25, 2016 nordman.lbl.gov

Microgrid Definitions

"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.** A microgrid can connect and disconnect from the grid to enable it to operate in **both grid-connected or island-mode.**"

Department of Energy (DOE) Microgrid Exchange Group2

"Microgrids are electricity distribution systems containing loads and DER, (such as distributed generators, storage devices, or controllable loads) that can be **operated in a controlled, coordinated way** either while **connected to the main power network or while islanded.**"

CIGRÉ C6.22 Working Group

- Ability to island is central - **Capability**
- To utility, microgrid is a black box
- No mention of scale
- Must connect to a larger grid sometimes (no actual islands)
- Some say that a diesel generator is not a DER

Nanogrid Definitions

Early/other definitions
- DC only
- Renewable only
- Small capacity (electrical)
- Always islanded

Nordman & Christensen (2013)
- "A single domain of power; single physical layer of power distribution, reliability, quality, capacity, price, and administration." - **Simplicity**

- Concept works better with DC – can more readily decouple
- Notebook PC **IS** a nanogrid
- Nanogrid is an *atomic* entity – **cannot** be subdivided, but **can** be combined

What really IS a Microgrid?

- Microgrids are common
  - Almost all single-customer
  - Most a subset of customer site
  - Many diesel-centered
  - Almost all a single customer site
- Multi-customer microgrids
  - Rare
  - Expensive / Custom / Hand-built / Brittle

- Question: Is / Should Microgrid technology be **distinct from** regular power technology, or a **basic feature** of it?

- Proposal:
  - **Microgrid** refers to only single-customer microgrids
  - **Multi-customer microgrids** should really have their own term

Summary

Microgrid – Capability

Nanogrid – Simplicity

Picogrid – Singularity

> "An individual device with its own internal battery for operation when external sources are not available or not preferred, and managed use of the battery" *(Adapted from Ghai et al. 2013)*

Single-Customer Microgrid

- The vast majority

Multi-Customer Microgrid

- Better thought of as a (very) small utility grid

Microgrid Market Statistics

* GMInsights (Oct 2020)
  * Market size: $8.2 billion (2019)
  * CAGR 2020-2026: 24.3%
* Grandview Research (Aug 2017)
  * 1.48 GW (2016)
  * CAGR 2017-2026: 16.3%
* Verified Market Research (Oct 2020)
  * Market size: $26 billion (2019)
  * CAGR 2020-2027: 11%

Bruce observes and I agree these numbers are very dependent on how one defines a microgrid – we need finer grain distinctions to be useful.

Microgrid Market Ontology

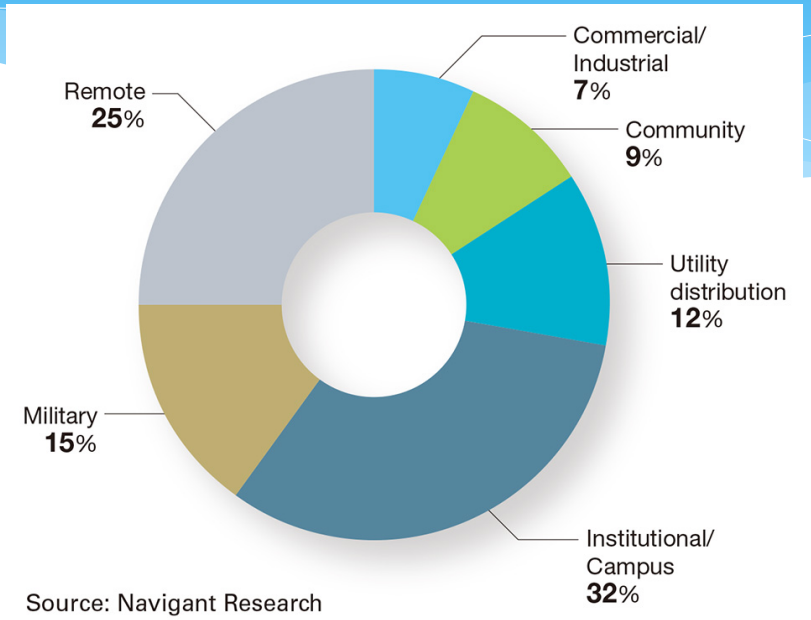
- "If you've seen one microgrid, you've seen one microgrid"*?
  - As opposed to.. you've seen them all...
  - Implies that every microgrid is unique
- Microgrids are diverse but...
  - Compare by end-use categories
  - Compare sub-components combined to create microgrid
  - Compare key functions
  - Partition by common properties
  - Partition by vendors
- Big picture look at ODG
  - Where does ODG fit as measured by these dimensions?
  - Emerging trends that ODG should join?
  - Growth path for ODG compliant installations?

Tesla on virtual power plant – highly recommended - https://www.youtube.com/watch?v=ggdYts4muu0

* Attributed to David Chiesa, S&C Electric

Microgrid Knowledge Categories

* Campus
* Commercial
* Data Center
* Industrial
* Military
* Renewable
* Utility
* CHP
* Community
* Energy Storage
* Hospital Healthcare
* Remote and Island
* Residential
* Solar
* Wind



Others not mentioned here: shipboard

These are mostly by application. Useful to compare solutions per application.

Microgrid Components

* Microgrid Controller (MCU)
* Battery Energy Storage System (BESS)
* Dispatchable Generation
* Other power sources and associated converters:
  * PV
  * Wind
  * Pico hydro
* Other Components:
  * Cabling / poles
  * Fault protection, isolation, recovery
  * Distribution panels
  * Rectifiers (DC grids)
  * Level shifters: transformers, DC-DC converters
  * Communications
  * Cyber security

Microgrid Functions

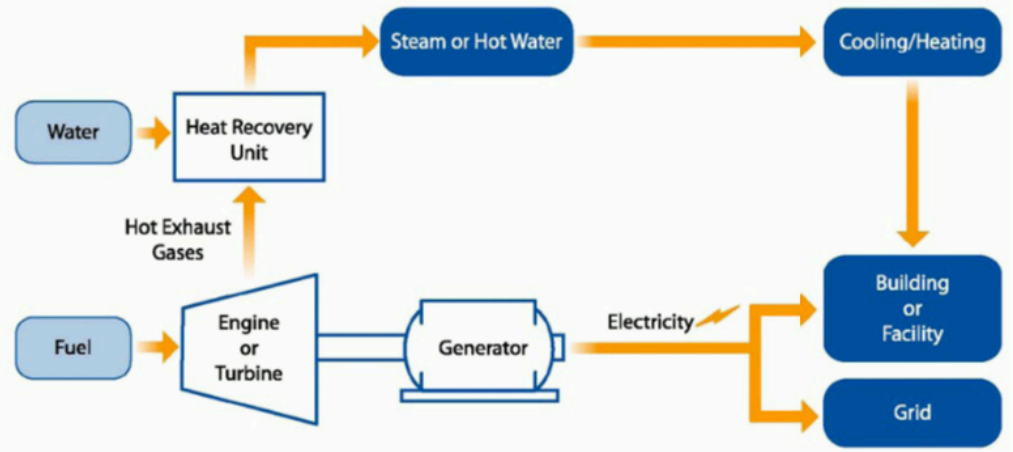
* Microgrid controller manages:
  * Grid-microgrid Interface: islanding, power purchase
  * Load control / prioritization
  * Source dispatch (generator start if available)
  * Central monitoring and reporting
  * Demand forecasting
  * Fault isolation
  * Battery charging policies

Microgrid Properties

* Geographic scope
* Single customer versus multi-customer (community)
* Flat control versus hierarchical (grid of girds)
* Finance Options
* Purchase model (home grown versus vendor package)
* Normal connectivity: Grid-tied, isolated (off-grid)
* Primary DER power Source
* Power type: AC, DC, hybrid

Off-grid Power Source

* Solar PV
* Natural Gas
* Diesel
* Fuel Cell
* CHP
  * Combined Heat and Power
  * Or cogeneration



This parameter is used by some market surveys as a way of partitioning the market. Vendors tend to favor particular power sources.

Geographic Scope

* Device
  * Laptop as microgrid?
  * Electric vehicle as microgrid (Check out *Long Way Up* on Apple TV+)
* Home
  * Small home – SHS
  * Large home – Tesla Powerwall
* Building
* Campus
* Neighborhood
  * Small scale – Mesh Power, Okra, Libre
  * Large scale – Sunrun separate distribution bus
  * Local organization owns, manages, assigns priorities
* Region
  * Virtual microgrids – Community Choice Aggregators
    * Municipality sources power via DER or grid sources
    * Local power company maintains interconnect
    * Municipality sources battery storage, manages islanding

CCA's should not be called a microgrid unless they can island!

Single Customer vrs Multi-customer

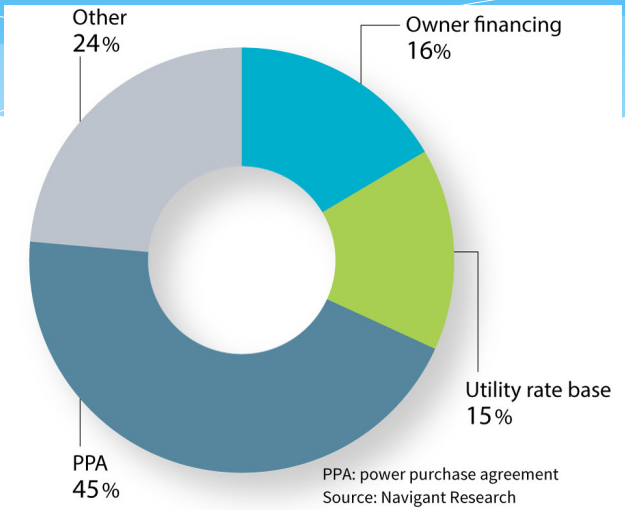
* Single customer
  * Solar home system
  * Building
  * Campus: UCSD, MIT etc
* Multi-customer
  * Neighborhood microgrids
  * Community choice aggregators
    * *Not a microgrid unless it can island…*

Business Models

* Vendor package solution
  * Vendor provides all equipment and integration
* Contractor Supervision
  * Contractor selects equipment from multiple suppliers
  * Contractor maintains
* Home-grown – individual component selection
  * Currently rarely used because of complexity
  * Needs standards for wider use

Finance Options

- Owner finance / support agreement
  - Buyer purchases equipment up front
  - Buyer negotiates with supplier / 3rd parties for support
- Microgrid as a Service / Power Purchase Agreement
  - Buyer pays no up-front capex
  - Buyer commits to long-term energy purchase agreement
  - Can monetize tax incentives
- PACE (Property Assessed Clean Energy)
  - Buyer borrows against property (lien) – no FICO issues
  - Paid off via higher property taxes
  - Funded by municipality or state
  - Interest rates higher than mortgage – debt passed to new owner
- PAYGO (pay as you go)
  - Similar to microgrid as a service with no up-front capex
  - Service terminates if not paid
  - Options / term to pay off and own



Microgrid Vendors

* Large
  * Siemens, ABB / Hitachi, NEC, Scheider, GE, Tesla
  * Eaton, Caterpillar, Toshiba, Honeywell, Bosch
  * Exelon, Lockheed Martin
* Medium
  * Instant ON, Emera, OhmConnect, S&C Electric
  * Saft/Go Electric (Total), SunVerge, AlphaStruxure
  * Power Analytics, Scale Microgrid, Bloom Energy
  * ARDA Power, Alencon
* Small
  * Heila Tech, Form Energy, BoxPower, Gridscape
  * Mesh Power, Okra Solar, Libre Solar

Related Standards / Industry Developments

* P2030.10
  * Important ballot comment ballot review meeting Jan 21
* P2030.10.1
  * Getting ready for ballot – no recent activity
* GOGLA Interop activities
* OpenPAYGO Link
* Angaza Nexus Channel / Nexus Channel Core
* Open Connectivity Foundation / IoTivity
* LFEnergy

Next Meeting / Feedback

* Next Meeting
  * 9 February 2021 – 1500 UTC
  * Zoom – Meeting ID 87518284403 password: opendcgrid
* Sharing Portals
  * Web site: https://open-dc-grid.org/
  * GitHub: https://github.com/open-dc-grid
* Feedback?