

# Power Generation Opportunities

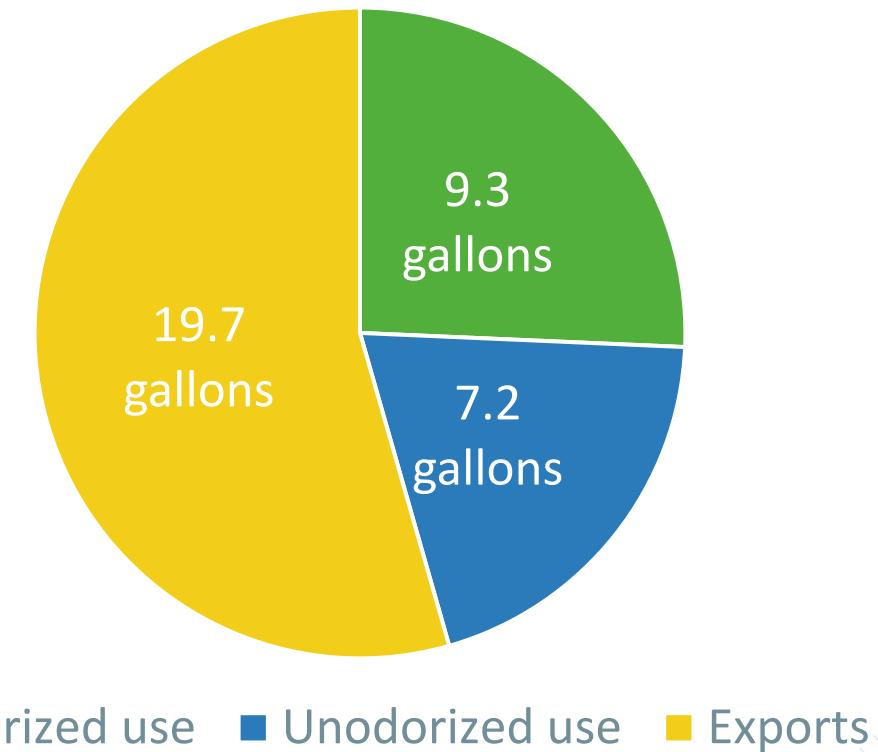
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# Propane Education & Research Council

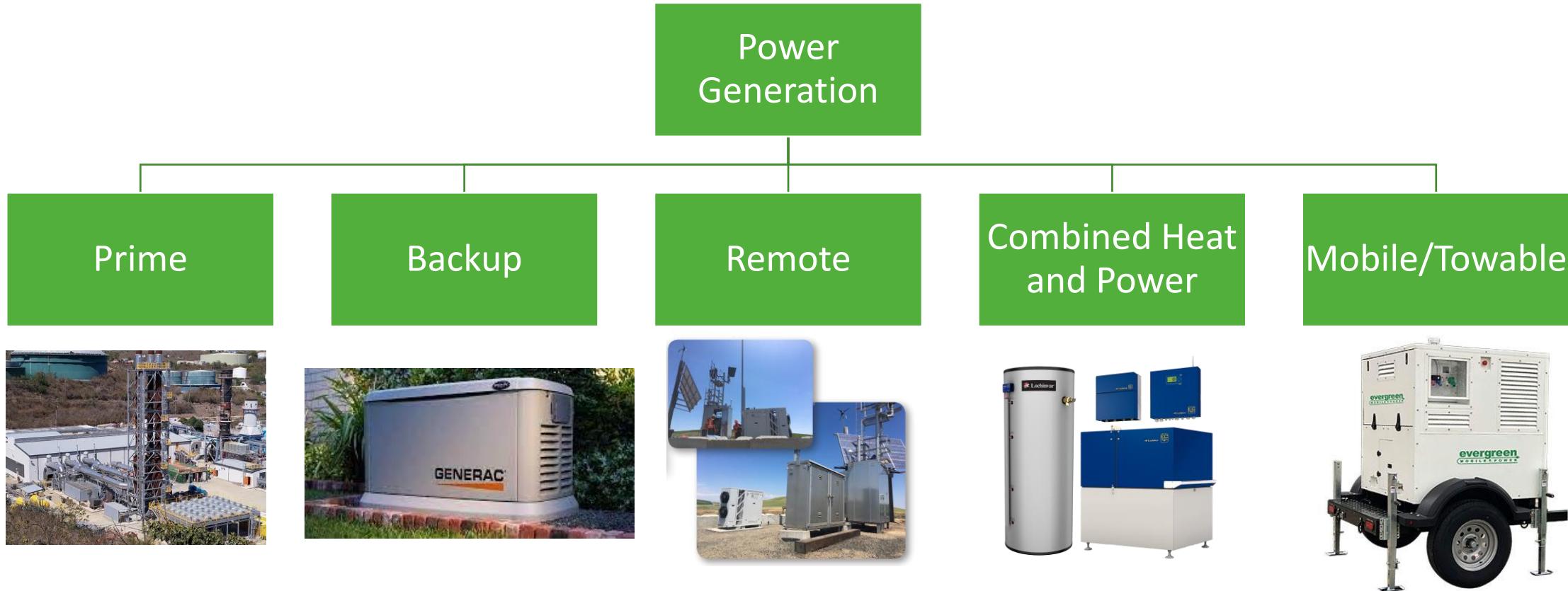
- PERC is a nonprofit that provides leading propane safety and training programs and invests in R&D of new propane-powered technologies. PERC is operated and funded by the propane industry. PERC programs benefit a variety of markets including transportation, agriculture, commercial landscaping, residential, and commercial building.
- PERC was authorized by the U.S. Congress with the passage of the Propane Education and Research Act (PERA), signed into law on Oct. 11, 1996. PERC is governed by a 21-member board appointed by the National Propane Gas Association and the GPA Midstream Association. Each association appoints nine Council members, and they cooperate in the appointment of three public members.
- PERC's operations and activities are funded by an assessment levied on each gallon of propane gas at the point it is odorized or imported into the United States.

2021 Projected Supply and Demand



# PERC's Power Generation Focus

- PERC 2020-2022 Strategic Plan calls for exploring the future of power generation and establishing a roadmap

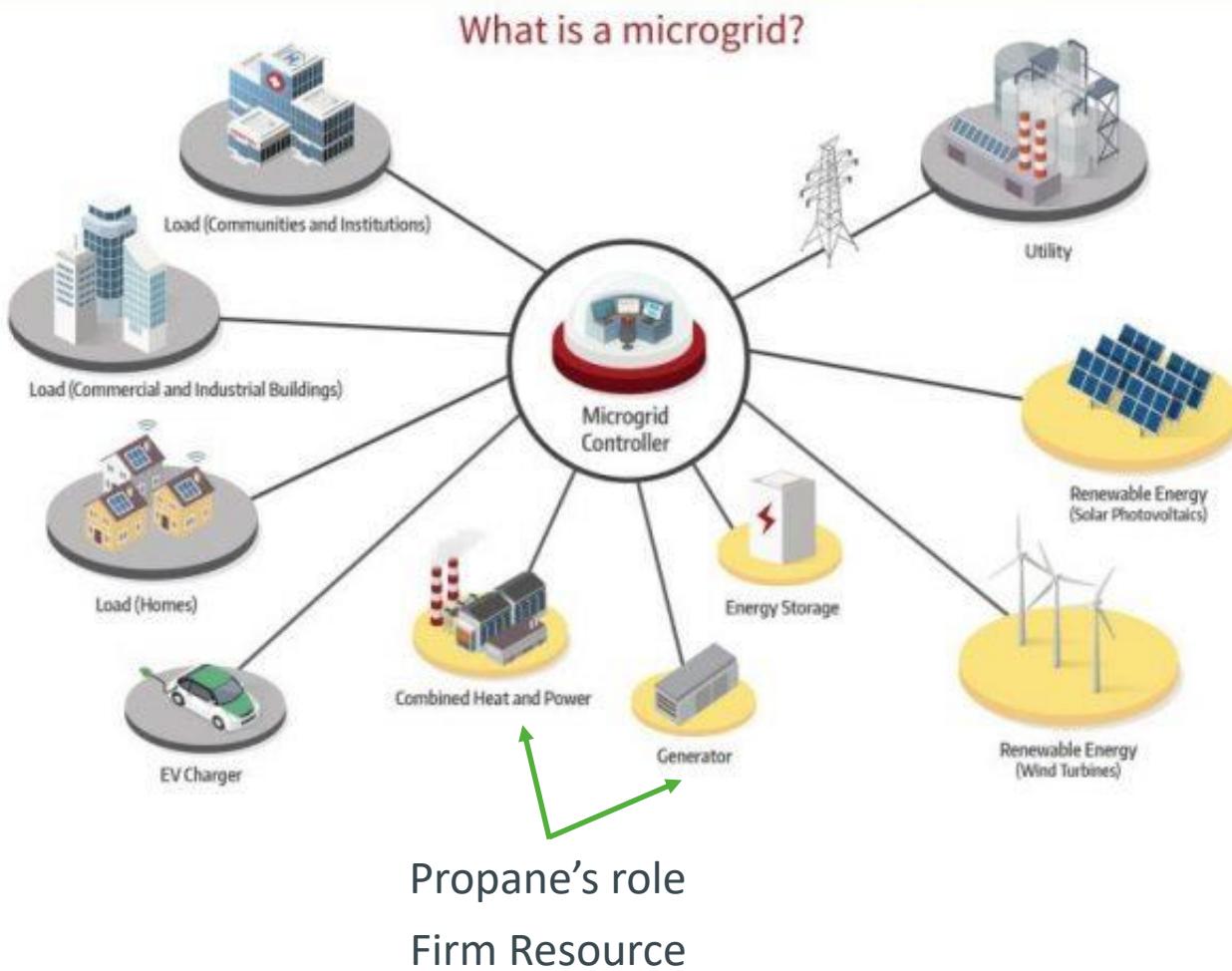


- Weaved into all of this are microgrids

# What is a Microgrid?

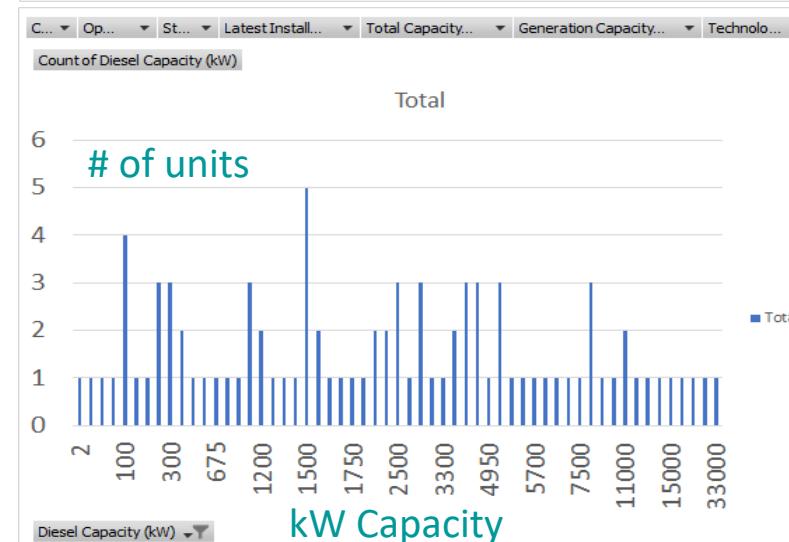
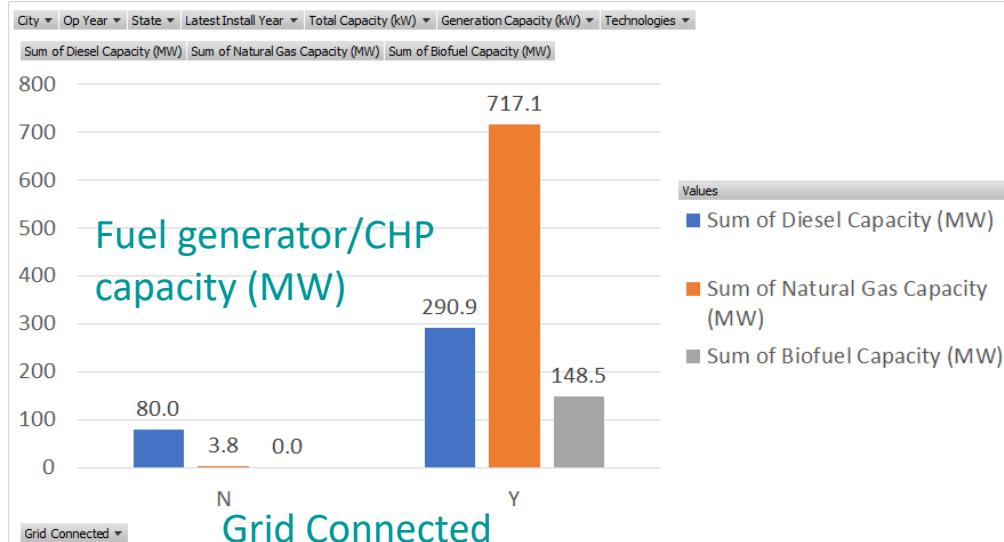
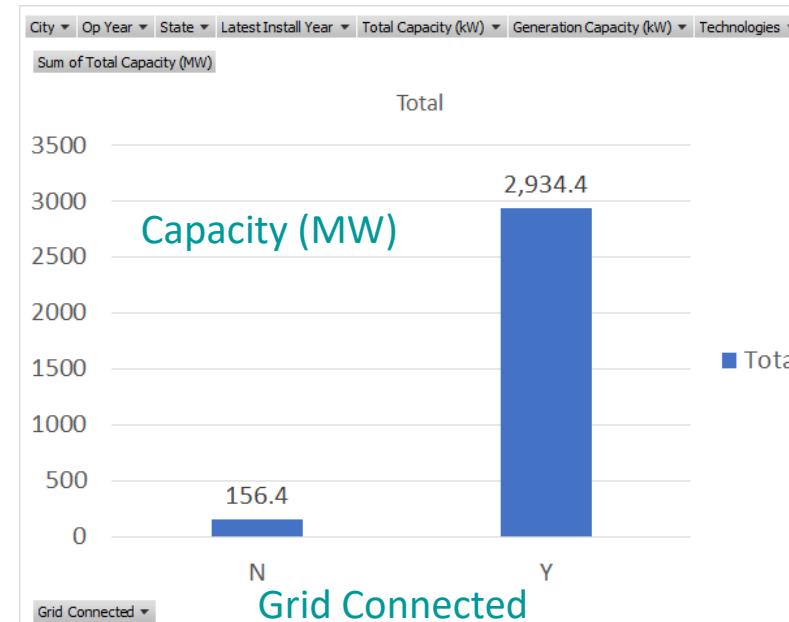
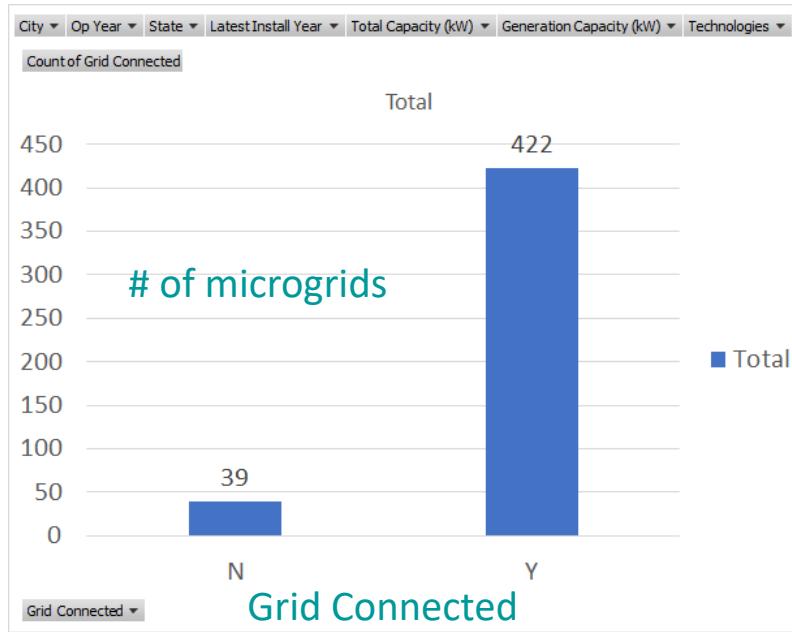


## Microgrid 101



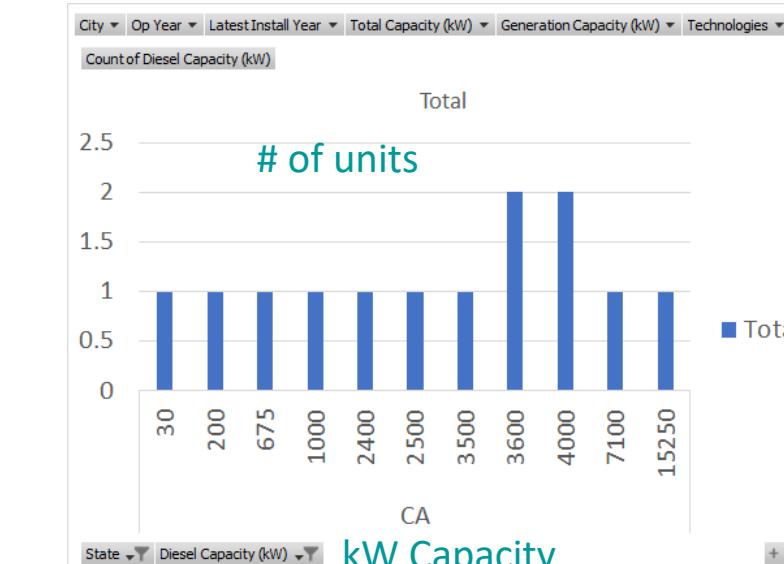
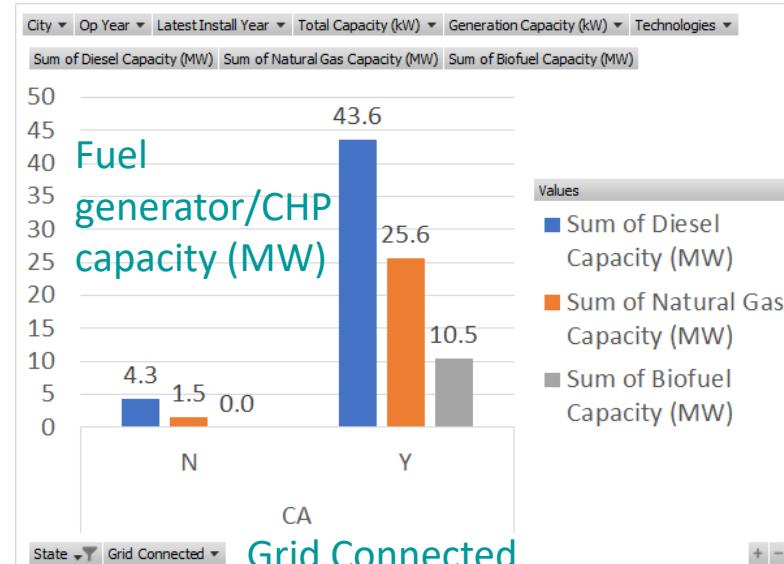
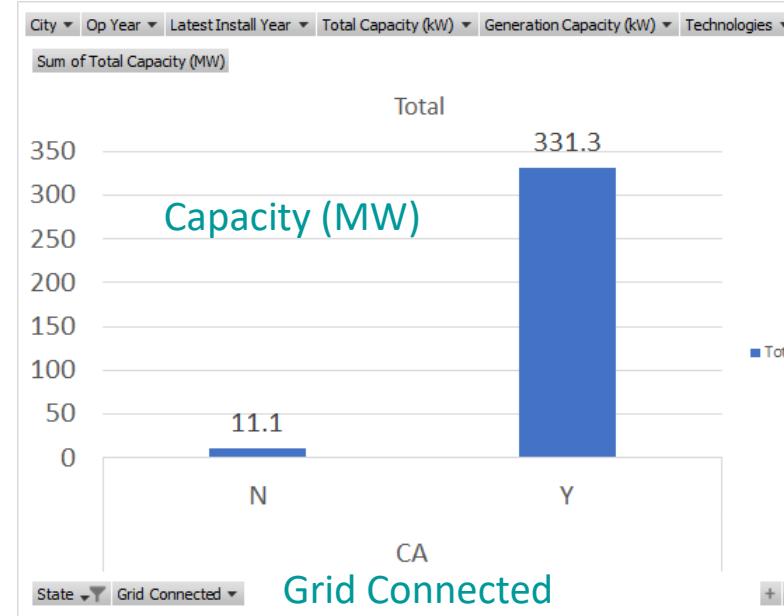
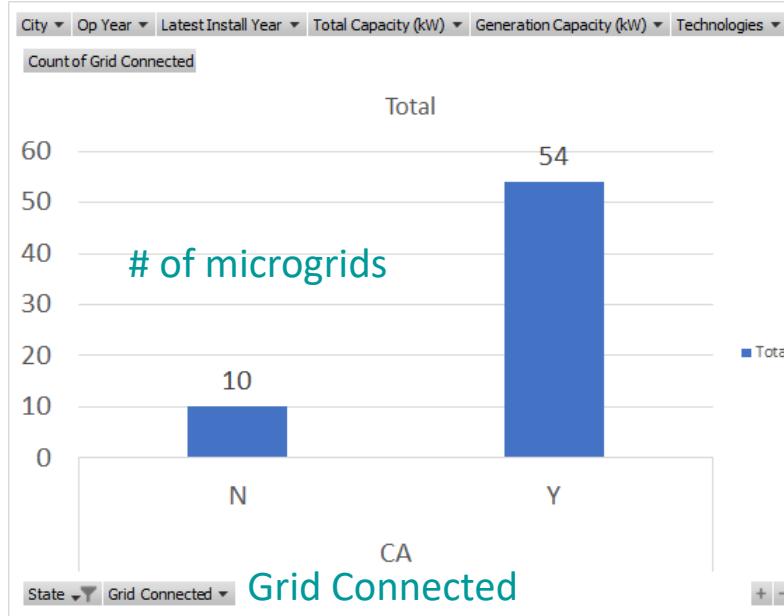
- Microgrid is a self-sufficient system to serve a geographic footprint such as a college campus, business center, community housing etc.
- Microgrids are distributed energy resources (DERs) that may or may not be grid connected.
- However, microgrids that are grid connected can disconnect from the grid (island) and operate independently, if needed. Hence, they provide reliability and resiliency during emergency situations.
- A Combined Heat and Power (CHP) system can be qualified as a microgrid if it is able to island.

As per US DOE data, there are 461 microgrids in the US with a total capacity of ~3100 MW



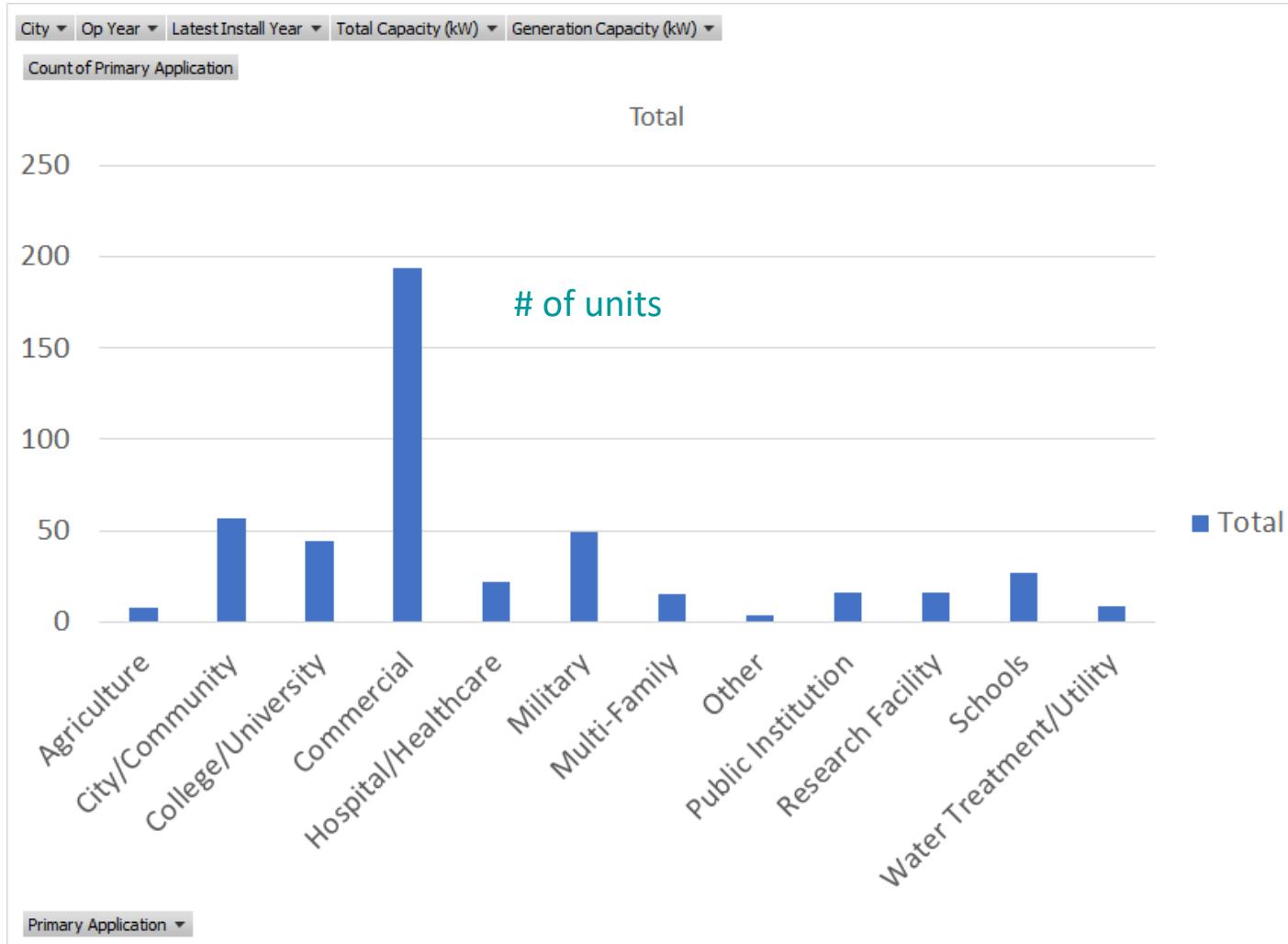
Source:  
<https://doe.icfwebservices.com/downloads/microgrid>

As per US DOE data, there are 64 microgrids in CA with a total capacity of ~343 MW



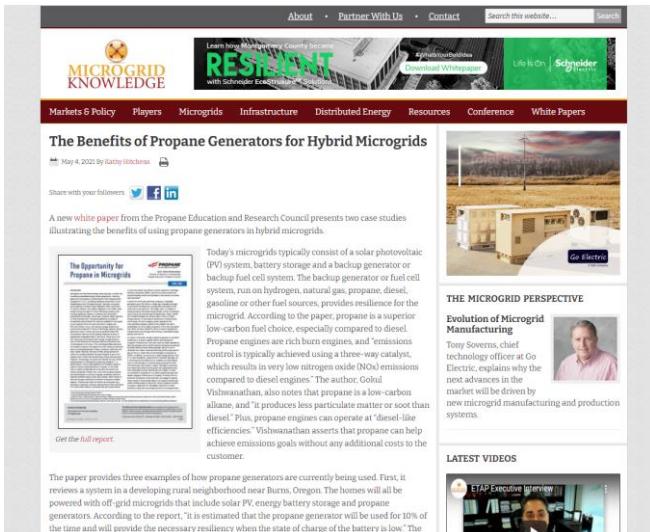
Source:  
<https://doe.icfwebservices.com/downloads/microgrid>

# Applications and Market Potential



- Tremendous growth expected for alleviating grid outages due to weather related catastrophes including forest fires, hurricanes etc.
- Remote data centers and edge computing data centers, a ripe opportunity i.e., commercial
- Guidehouse (previously Navigant) forecasts the global market to be \$39.4 billion by 2028 and global capacity to be 19,900 MW (a growth of over 471% from 2019).

# PERC's Whitepaper on Microgrids



A screenshot of the Generac Industrial Power website. The top navigation bar includes links for Call Us at 844-ASK-GNRC, Find a Distributor, Find Service, Careers, Contact Us, and a search icon. The main menu has categories: All About, Solutions By Industry, Professional Resources, Products, and Webinars. A large black banner in the center features the word 'WHITEPAPERS' in white. Below the banner are four whitepaper thumbnails: 'Hurricane Preparedness Guide 2021', 'Wet Stacking Mitigation Technologies', 'The Opportunity for Propane in Microgrids', and 'Connecting Distribution Centers to the Grid'. Each thumbnail has a 'Download Now' button below it.

- PERC published a white paper on the opportunity of propane for microgrids in Microgrid Knowledge, which is the leading publisher on microgrid news and articles.
- Whitepaper featured by Generac in their whitepaper library.
- Investigates the opportunity for propane in community and commercial microgrids in CA.
- Compares the economics and emissions benefits compared to diesel generators employed in microgrids.

Source: <https://microgridknowledge.com/propane-generators-hybrid-microgrids/>  
<https://www.generac.com/Industrial/professional-resources/news-whitepapers/whitepapers>

# Positioning Propane Relative to Other Fuels

Fuel	Liquid volumetric energy density (MJ/l)	C:H	Ease of liquefaction, transportation and storage
Hydrogen	8.5	0	X
Ammonia	11.5	0	✓
Liquefied natural gas <sup>5</sup>	22.2	0.25	X
Propane or LPG	25.3	0.375	✓
Gasoline	34.2	0.5	✓
Diesel	38.6	0.55	✓

- Propane offers the “sweet-spot” in terms of liquid volumetric energy density (determines storage volume), C:H ratio (decarbonization metric) and ease of liquefaction (cost-effective and level of complexity of storage and transport).
- Hydrogen and Ammonia are zero carbon but >95% of hydrogen in the US comes from steam-methane-reforming of fossil natural gas. Ammonia is currently produced with hydrogen using Haber-Bosch process.

# Renewable Propane

- Renewable propane is a byproduct of renewable diesel and sustainable aviation fuel. Predominantly sourced by Hydrotreated Vegetable Oil (HVO) process.
- HVO – large scale commercial process.

Feedstock	Process	Outputs	Developer
Vegetable oil/ animal fat	HVO	Biodiesel, biopropane (5-8%)	Neste Oil (NExBTL); UOP/Eni Dynamic Fuels, ConocoPhillips, Diamond Green
Cellulosic biomass (wood)/sugar/ starch (crops)	MTG gasification	Gasoline, biopropane (10-30%)	ExxonMobil (MTG); Haldor Topsoe (TIGAS)
	Gasification/direct synthesis	DME, gasoline or biopropane (significant %)	Japan Synthesis Gas Co
	Fischer-Tropsch gasification	Diesel, naphtha, lubes, biopropane (small volumes)	Shell (GTL); UPM Maverick Fuels
	Pyrolysis/hydrogenation	Gasoline, diesel, kerosene, biopropane (up to 15%)	Ensyn (RTP); GTI (IH2)
Glycerine	Dehydration/hydrogenation	Bioethane or biopropane	Bio-fuel Solution
	Methanol gasification	Methanol, DME, biopropane (small volumes)	BioMCN
	Aqueous Phase Reforming	Various fuels, including biopropane	VES (BioForming)
Sugar/starch (crops)	Supercritical fermentation	Various fuels, including biopropane	C3 Bioenergy (US)

Source: Menecon Consulting/Atlantic Consulting

# Examples of Existing Propane Microgrids



Image source: <https://boxpower.io/boxpower-in-2020-annual-recap/>

- Silvies Valley Ranch - Burns, OR:  
~600 homes are being developed.
  - Solar PV, battery energy storage 30-70 kWh and propane generators
  - Capacity factor for gensets ~10%
- Liberty utilities 97% renewable microgrid – Truckee, CA.
  - 20 kW solar PV, 68 kWh battery energy storage and Generac propane genset
  - Capacity factor for genset ~ 3%
  - Wildfire mitigation solution
- Kahauiki Village – Honolulu, HI.
  - Solar PV, battery backup (2.1 MWh) and propane generator (150 kW)
  - Propane generator to charge batteries when state of charge is low or during storms when demand charges are high

# Examples of Existing Propane Microgrids – Kahauiki Village



- A village of 144 housing units and community buildings consisting of a preschool, daycare, laundry facility, management office, police station, and sundry store for homeless families.

## Examples of Existing Propane Microgrids

- As per a Generac case study, "*Liberty Utilities, a regulated utility with about 50,000 customers on the west side of Lake Tahoe, wanted to make upgrades, such as installing covered conductors to its transmission lines that run through a mountainous area to a remote research station operated by University of California, Berkeley. However, after running a cost and feasibility analysis, it realized it would be better to de-energize the line during wildfire season and instead utilize a containerized solar + storage system. That is when the utility company selected BoxPower, an expert in modular microgrid solutions, from a competitive bid process.*"
- Page 319 of PG&E 2021 Wildfire safety plan states: "*PG&E identified the technology combination of Solar Photovoltaic Generation and Battery Energy Storage with supplemental Propane Generators as the most cost effective, reliable, and cleanest solution for initial Remote Grid sites. - PG&E found there was sufficient initial vendor interest and availability to engage in contracting to deploy systems with specifications and terms responsive to PG&E's requirements*"

# Micro-CHP Partners

1-3 kW

- Aisin



3-10 kW

- Axiom Energy
- Brash Power
- Enviro Power



10-50 kW

- Lochinvar



50 kW - 1 MW

- Capstone



Micro-CHP

Large CHP

## Closing Points

- Propane and renewable propane provide low carbon and renewable fuel options, respectively for several power generation solutions.
- Along with reducing the carbon footprint, propane results in lower criteria pollutants such as NOx and particulate matter.
- Overall, a tremendous opportunity for propane in microgrids for replacing diesel with the following advantages:
  - On par LCOE with the “right” generator
  - “*Infinite*” shelf-life for fuel storage
  - Near-zero criteria pollutants capability (NOx, PM, CO, and HC)
  - Greenhouse gas reductions
  - Fuel cell opportunities
- *Reliability and Resiliency especially for Remote Locations*