ELECTRIC UTILITY GRID, DISTRIBUTED ENERGY, RENEWABLES, AND TRIBAL ENERGY

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INTRODUCTION - SANDIA

Sandia's National Security Mission

- Nuclear Deterrence
- Nuclear Nonproliferation
- National Security Programs
- Energy & Homeland Security
- Advanced Science & Technology

Sandia is one of 17 U.S. National Laboratories

- National Nuclear Security Administration labs
- Science labs
- Nuclear energy lab
- Environmental management lab
- Fossil energy lab
- Energy efficiency and renewable energy lab

SANDIA HAS FACILITIES ACROSS THE NATION

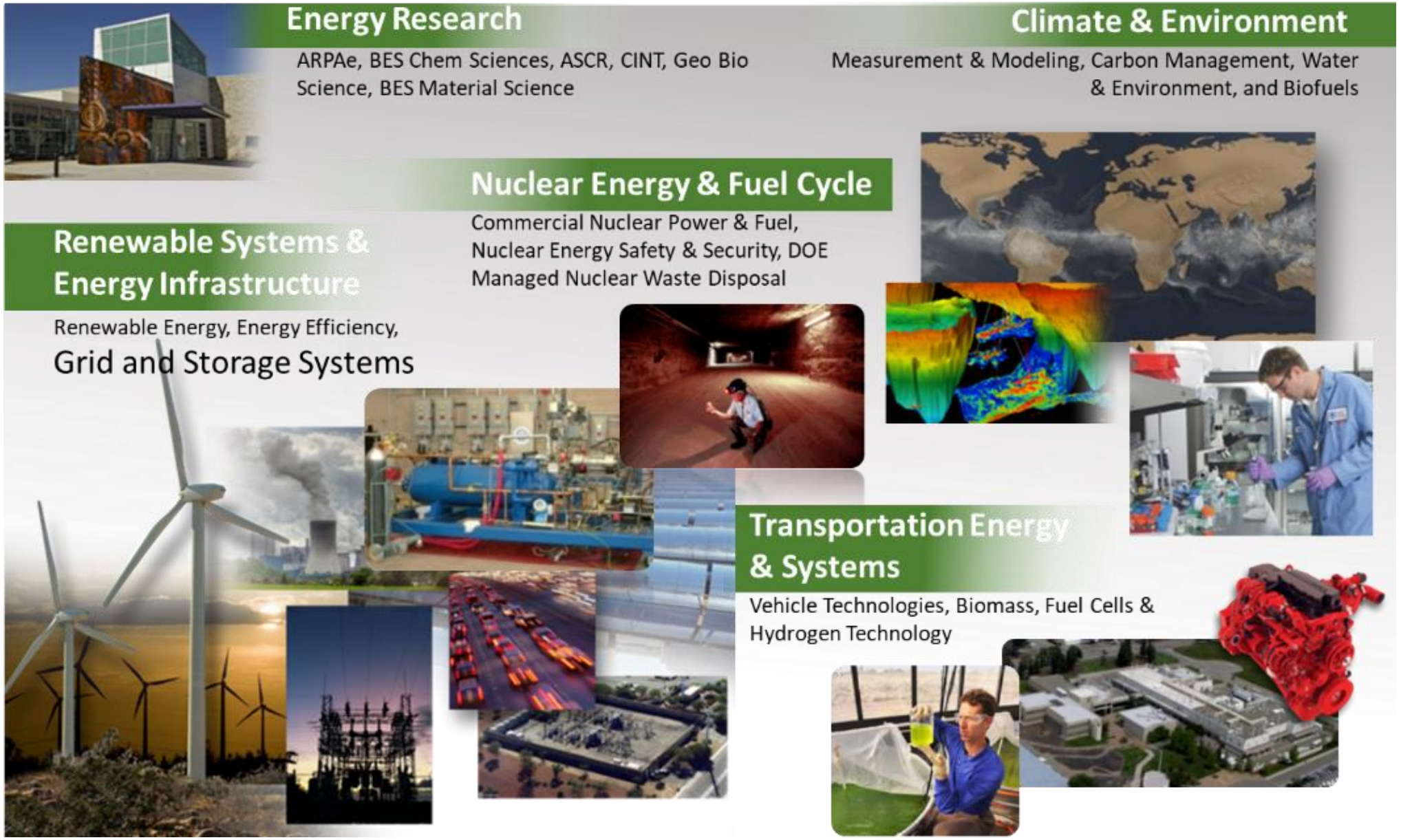
Activity locations

- Kauai, Hawaii
- Waste Isolation Pilot Plant, Carlsbad, New Mexico
- Pantex Plant, Amarillo, Texas
- Tonopah, Nevada

Main sites

- Albuquerque, New Mexico
- Livermore, California

SANDIA ENERGY & CLIMATE



ENERGY STORAGE R&D AT SANDIA

BATTERY MATERIALS
Large portfolio of R&D projects related to advanced materials, new battery chemistries, electrolyte materials, and membranes.

CELL & MODEULE LEVEL SAFETY
Evaluate safety and performance of electrical energy storage systems down to the module and cell level.

POWER CONVERSION SYSTEMS
Research and development regarding reliability and performance of power electronics and power conversion systems.

SYSTEMS ANALYSIS
Test laboratories evaluate and optimize performance of megawatt-hour class energy storage systems in grid-tied applications.

DEMONSTRATION PROJECTS
Work with industry to develop, install, commission, and operate electrical energy storage systems.

STRATEGIC OUTREACH
Maintain the ESS website and DOE Global Energy Storage Database, organize the annual Peer Review meeting, and host webinars and conferences.

GRID ANALYTICS
Analytical tools model electric grids and microgrids, perform system optimization, plan efficient utilization and optimization of DER on the grid, and understand ROI of energy storage.

Wide ranging R&D covering energy storage technologies with applications in the grid, transportation, and stationary storage

DOE OFFICE OF ELECTRICITY
ENERY STORAGE PROGRAM

- The goal of the DOE Office of Electricity (OE) Energy Storage Program is to develop advanced energy storage technologies and systems in collaboration with industry, academia, and government institutions that will increase the reliability, performance, and sustainability of electricity generation and transmission in the electric grid and in standalone systems. The program also works with utilities, municipalities, states, and tribes to further wide deployment of storage facilities.
- This program is part of the Office of Electricity (OE) under the direction of Dr. Imre Gyuk.

  "Working with tribal entities to help them achieve energy sovereignty, is a valuable part of the DOE-OE Energy Storage Program. Storage plus renewables and microgrids are not only viable solutions for the Tribes; but are also the way of the future for the U.S. and the world." – Dr. Imre Gyuk

U.S. DEPARTMENT OF ENERGY

http://www.sandia.gov/ess/

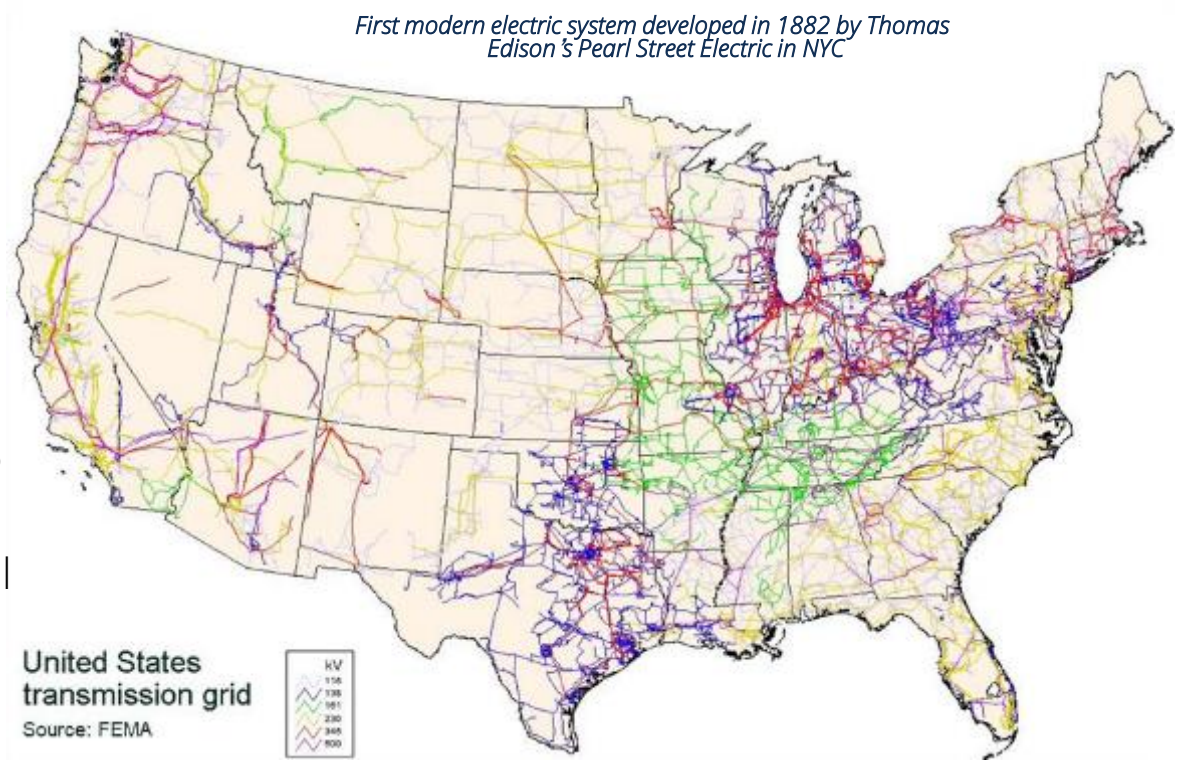
US ELECTRIC INFRUSTRUCTURE – "THE GRID"

Current State

Made up of:

- 7,300 power plants
- Over 150 thousand miles of transmission lines (AC & DC)
- Millions of transformers, relays, and controls
- Millions of miles of low-voltage power lines connecting over 145 million customers
- 100s of billions of dollars in total investments in transmission and distribution
- Sometime referred to as "macrogrid"

First modern electric system developed in 1882 by Thomas Edison's Pearl Street Electric in NYC

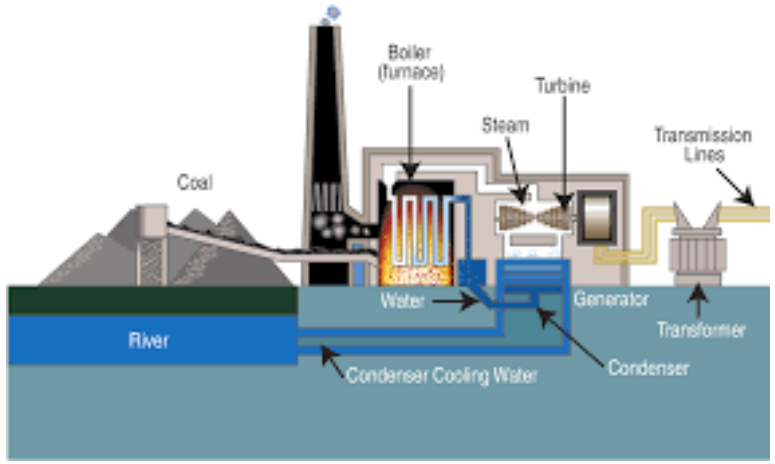


	Common AC voltages
Transmission	• 765kV • 500kV • 345kV • 230kV
Sub-Transmission	• 69kV • 30kV
Distribution	• 15kV • 4kV • 2kV • 600V • 480V • 240V • 120V

Trends challenging the grid:

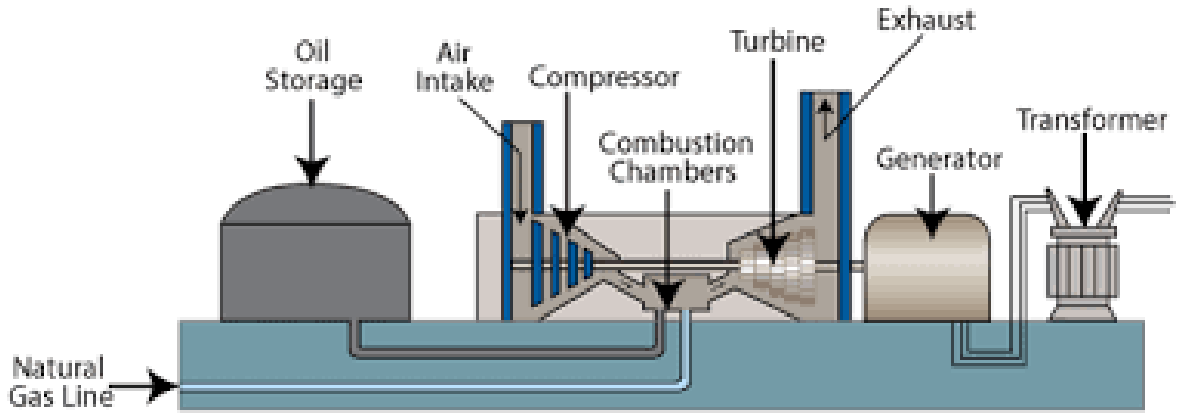
- Changing generation mix
- Aging infrastructure
- Increased variable generation and load mix
- Increased cyber and physical attacks
- Changing demands

GENERATION – CONVENTIONAL



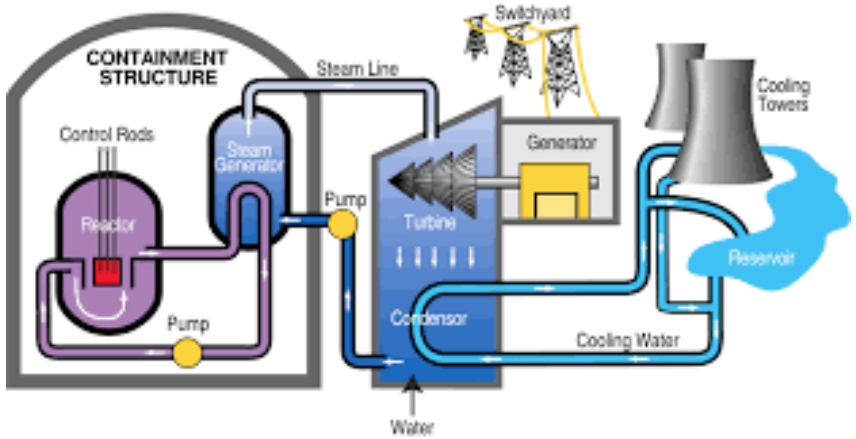
Coal

https://commons.wikimedia.org/wiki/File:Coal_fired_power_plant_diagram.svg



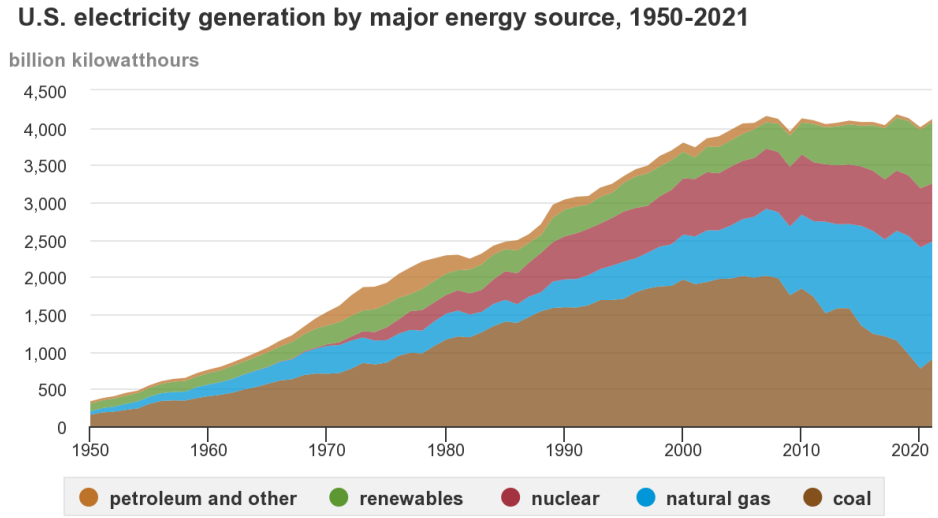
Natural Gas or Oil

https://www.pinterest.com/pin/gas-power-plant-electrical-engineering-pics--428967933238594830/

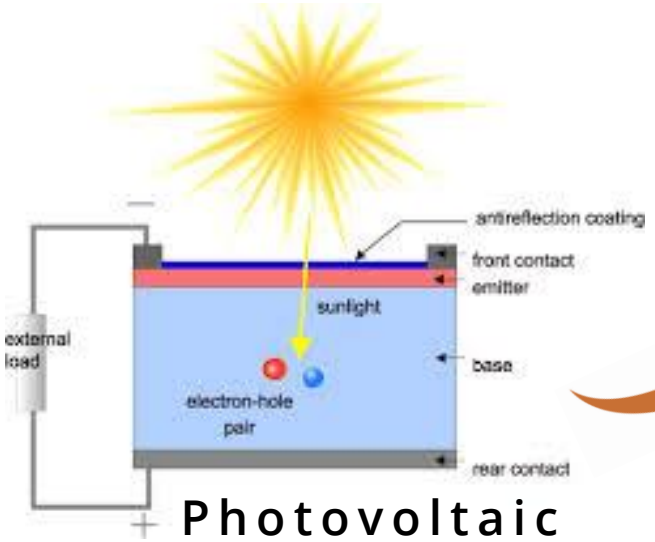


Nuclear

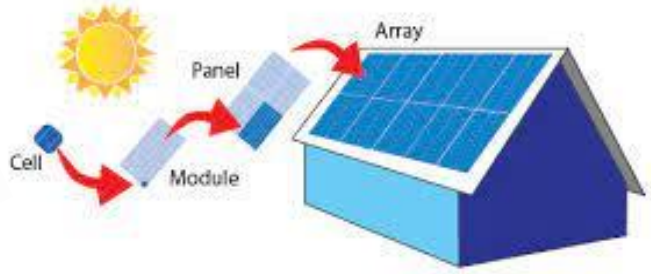
https://commons.wikimedia.org/wiki/File:PWR_nuclear_power_plant_diagram.svg



GENERATION – RENEWABLES (SOLAR ENERGY)

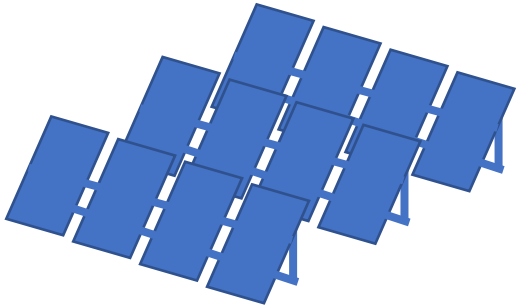


Photovoltaic



Residential

to



Photovoltaic Power Station

Source: NTUA

Source: NTUA

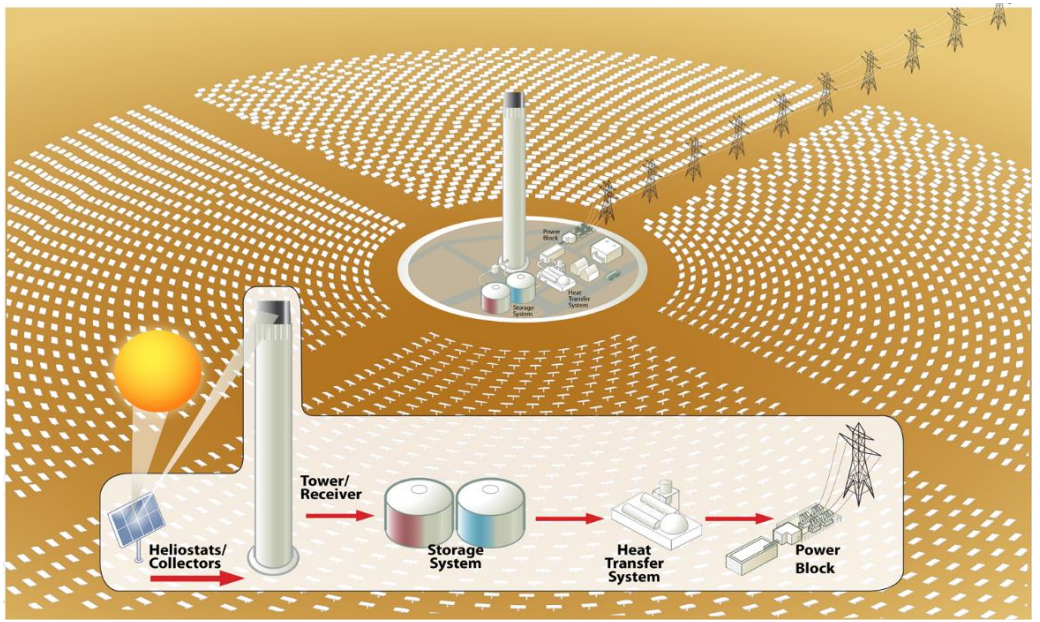
250 acres, 100MW, Datong China

https://www.pinterest.com/pin/the-panda-shaped-solar-farm-in-datong-china--27092035242904938/

GENERATION – RENEWABLES (SOLAR ENERGY, Cont.)

Ivanpah Solar Power Tower California (near Las Vegas, NV)

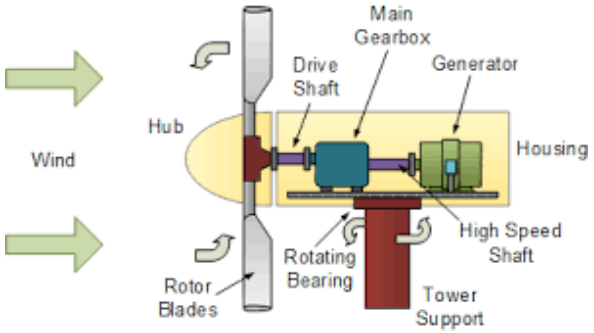
https://www.discovermagazine.com/technology/giant-desert-solar-plant-powers-on



Concentrating Solar Power

Three towers, 392 MWe, superheated-steam at 540 C (1004 F), 160 bar, air-cooled (2014)

GENERATION – RENEWABLES, CONT.

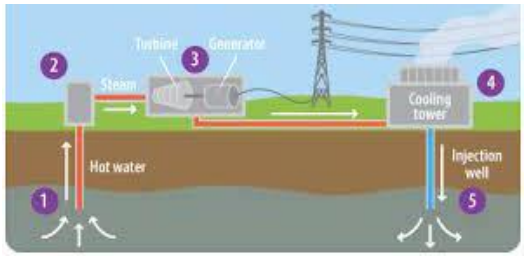


https://www.electrical4u.com/basic-wind-energy//

WIND ENERGY

https://www.windsystemsmag.com/fundamentals-of-wind-turbines/

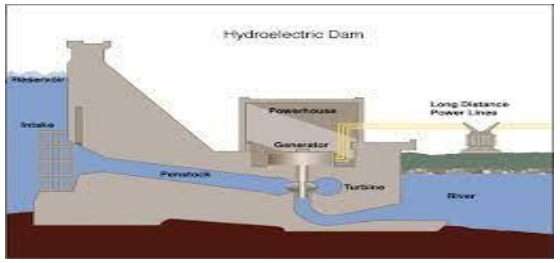
https://www.researchgate.net/figure/Typical-vertical-axis-wind-turbines-Darrieus-left-and-Savonius-right-59_fig4_366621798



https://archive.epa.gov/climatechange/kids/solutions/technologies/geothermal.html

Geothermal Power

https://energyeducation.ca/encyclopedia/Geothermal_power_plants

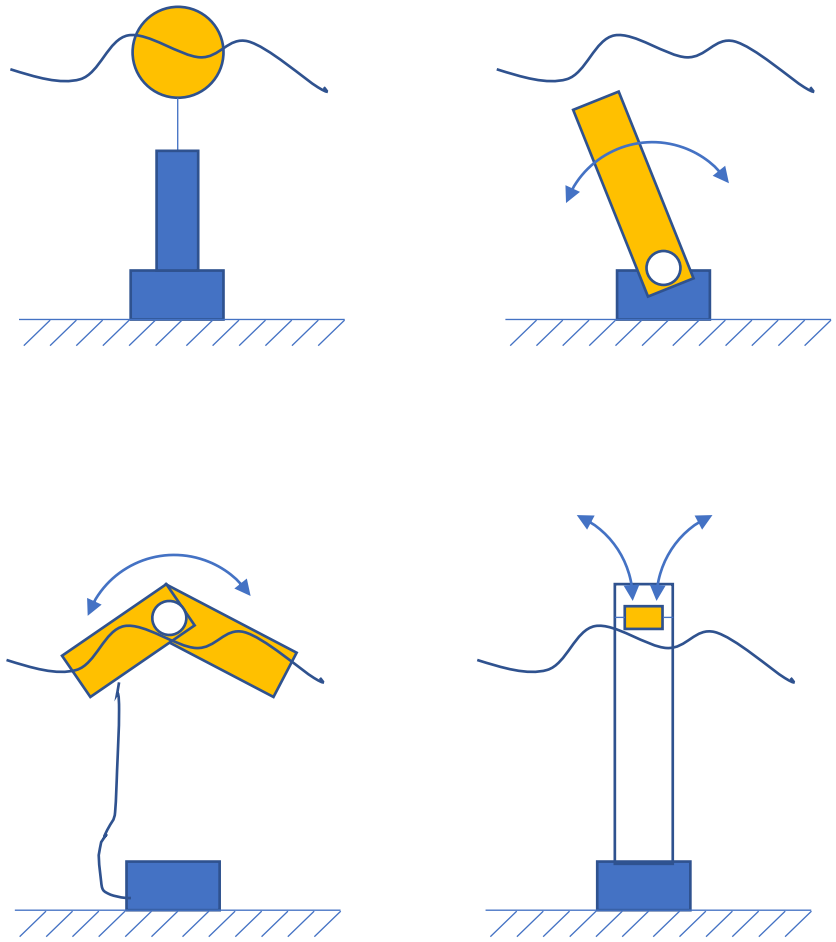


https://energyeducation.ca/encyclopedia/Hydroelectric_facility

Hydroelectric Power

https://en.wikipedia.org/wiki/Hydroelectric_power_in_the_United_States

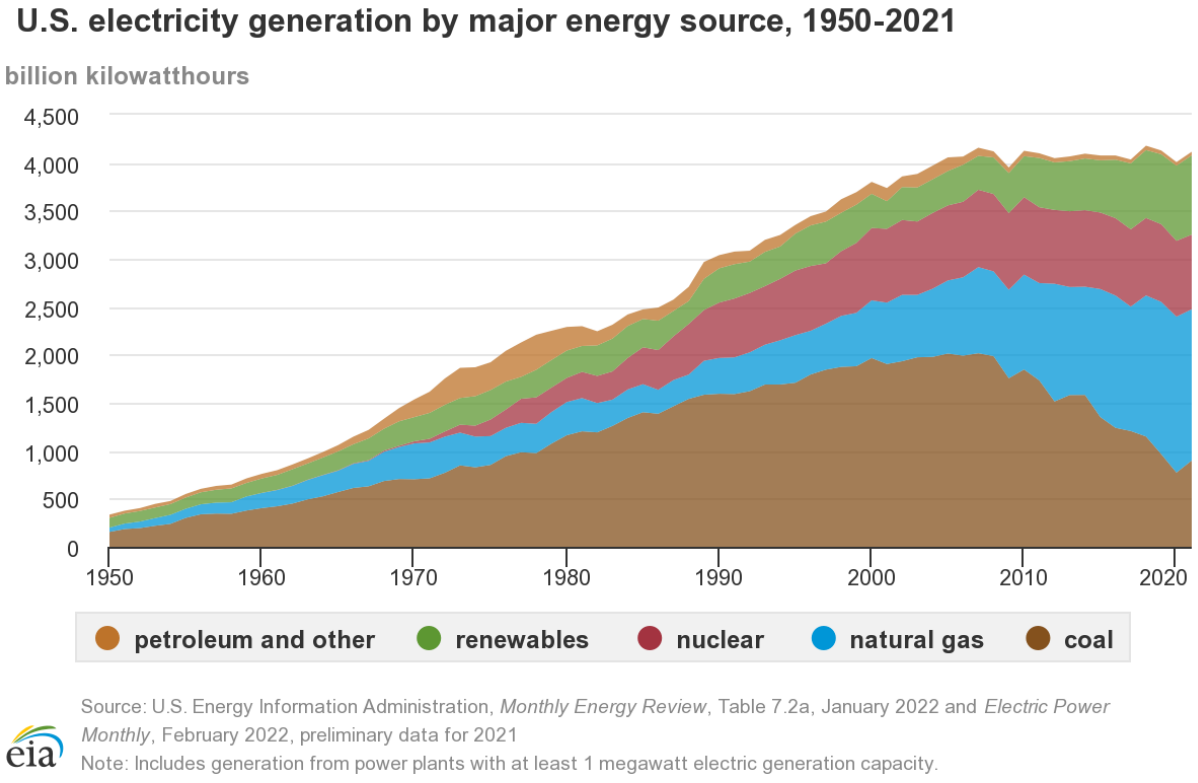
GENERATION – RENEWABLES, CONT.



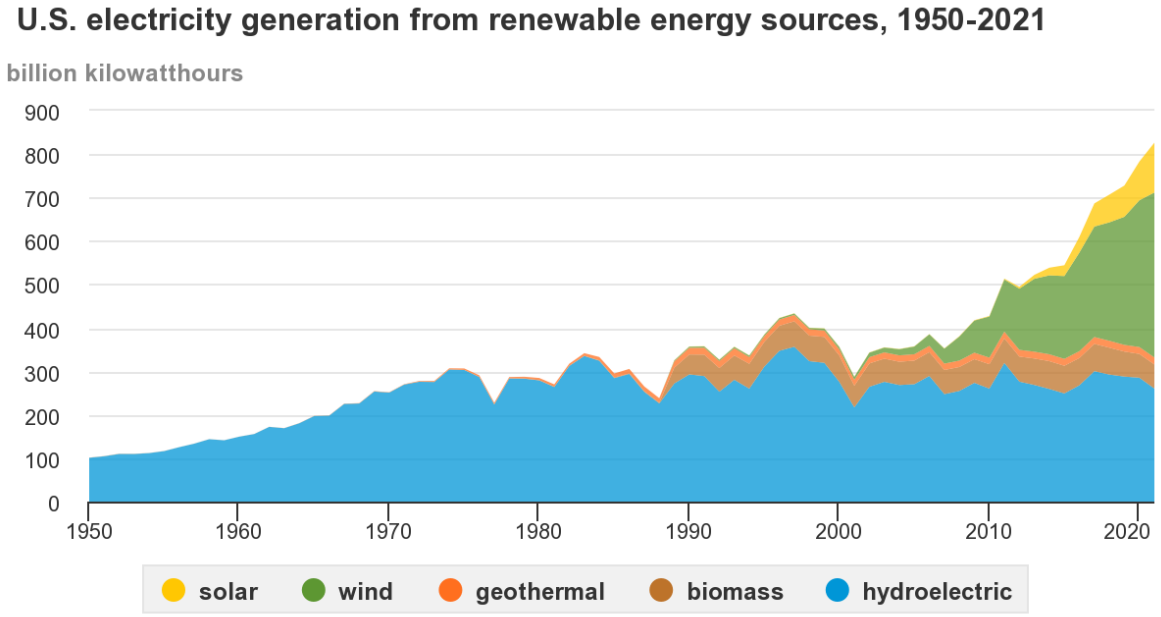
WAVE ENERGY

https://www.eia.gov/energyexplained/hydropower/wave-power.php

US ELECTRICTY GENERATION



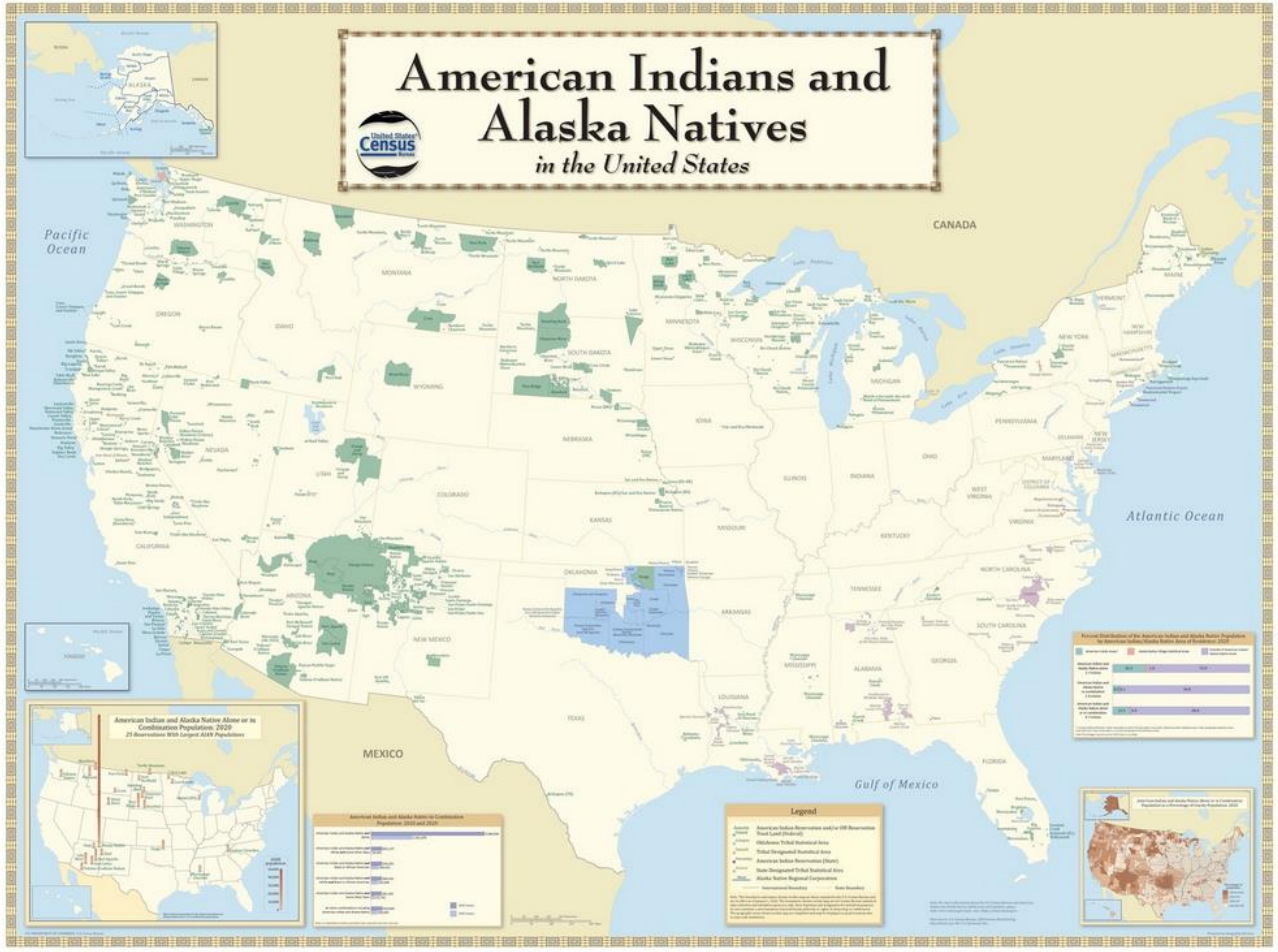
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 7.2a, January 2022 and *Electric Power Monthly*, February 2022, preliminary data for 2021
Note: Includes generation from power plants with at least 1 megawatt electric generation capacity.



Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 7.2a, January 2022 and *Electric Power Monthly*, February 2022, preliminary data for 2021
Note: Includes generation from power plants with at least 1 megawatt electric generation capacity. Hydroelectric is conventional hydropower.

- In 2021, ~ 61% US Utility-scale generation was produced from fossil fuels (coal, natural gas, and petroleum), ~19% was from nuclear energy, and ~20% was from renewable energy sources
- Energy Information Administration

574 FEDERALLY RECOGNIZED TRIBES IN THE U.S.



Alaska is divided into 13 regional Native Corporations (229 tribes)

- 326 Native American reservations in the US (most are in the 34 or lower 48 States)
- Known variously as Villages, Nations, Pueblos, Communities, Bands, Rancherias, etc.
- American Indian and Alaska Native or Native American terms may be used interchangeably as collective reference to tribal communities and peoples unless Tribal affiliation is specifically stated.
- There are also some state recognized tribes.
- Current population is 6.79 million (2.09%) of the entire U.S. population – U.S. Census Bureau

574 FEDERALLY RECOGNIZED TRIBES IN THE U.S.

Alaska is divided into 13 regional Native Corporations (229 tribes)

- Tribal sovereignty: tribes have their own government, traditions, culture, etc. and have a unique relationship with the federal and state governments.
- The tribal government exercise single-point of authority over their critical infrastructures and share common critical infrastructure modernization and protection concerns – Energy Sovereignty.

RENEWABLE ENERGY POTENTIAL ON TRIBAL LANDS

- Collective geographical area of all reservations is 56.2M acres, ~ size of the State of Idaho
- Range: 1.32 acres (Pit River Tribe CA) to 17M acres (Navajo Nation)
- Tribal lands comprise of about 5.8% of the land area in the conterminous U.S. land
- Utility-scale renewable energy potential is ~6.5% of total national potential – DOE Indian Energy

Red Mesa Tapaha 72 MW Solar Farm

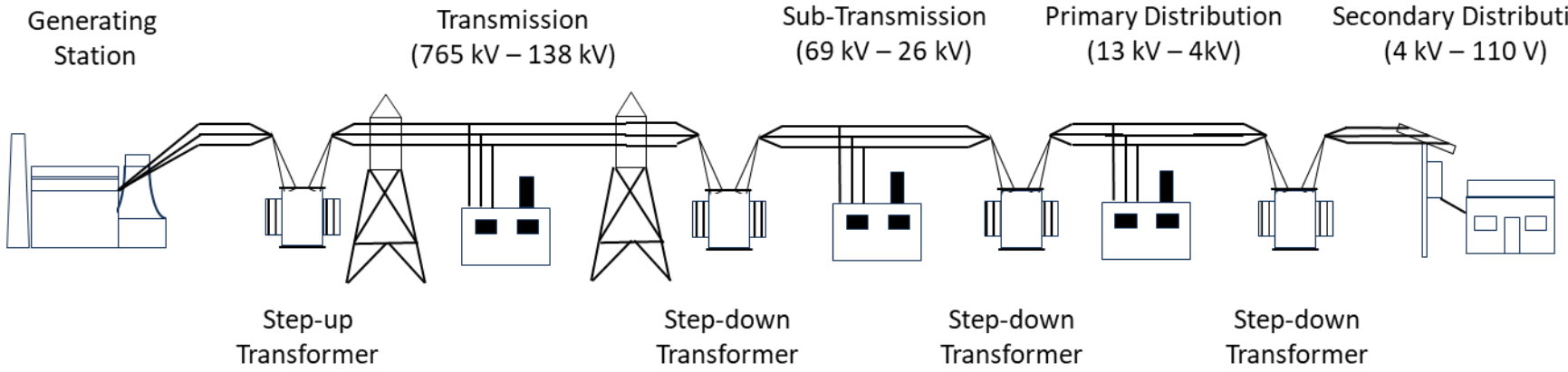
Red Mesa

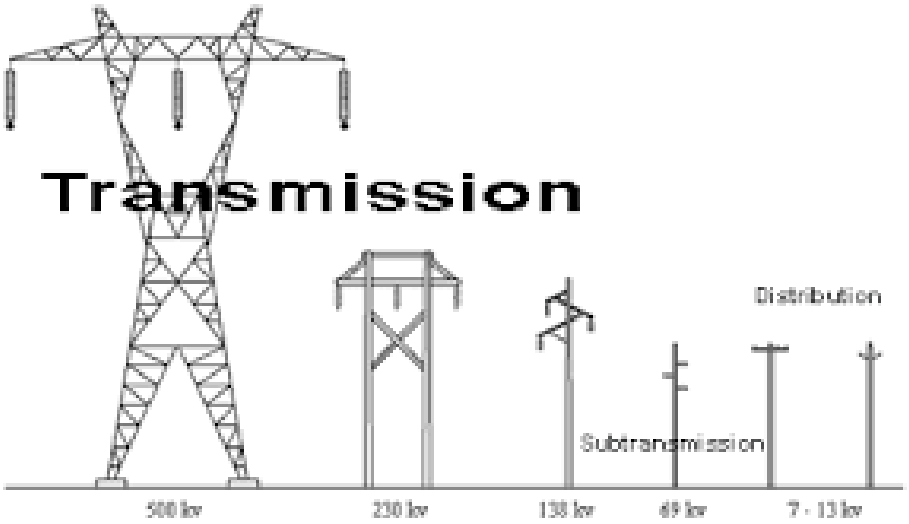
NAVAJO NATION

- Extends into the states of Utah, Arizona, and New Mexico
- Covers ~27,000 sq. mi (~size of West Virginia)
- 2010 U.S. Census: 332,129 enrolled tribal members
- About **37% of tribal members lack electricity** – Energy Information Admin.
- Homes without electricity can be greater than **40 miles from the electric grid** thus cost prohibitive to provide electricity
- **Navajo Tribal Utility Authority (NTUA)**, a non-profit distribution utility is addressing the lack of utility on the Navajo Nation

Remote home north of Kayenta AZ

ELECTRIC UTILITY TRANSMISSION SYSTEM





Transmission, Sub-transmission, Distribution Power Lines

https://www.eetimes.com/are-superconducting-power-lines-still-a-viable-option/

High Voltage Transformers

https://www.electricityforum.com/td/utility-transformers/high-voltage-transformers

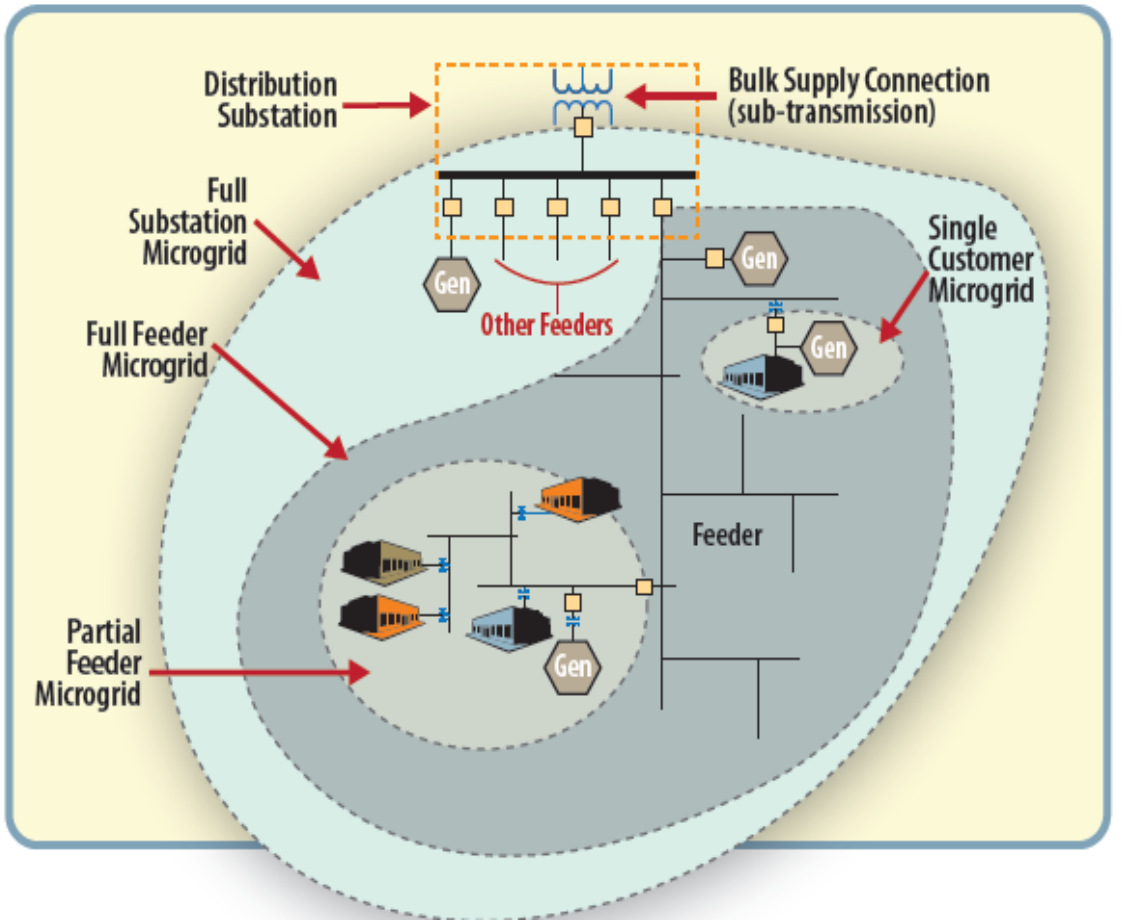
Distribution Transformers

https://www.gevernova.com/grid-solutions/hvmv_equipment/catalog/distribution_transformers.htm

SO WHAT IS A "MICROGRID"?

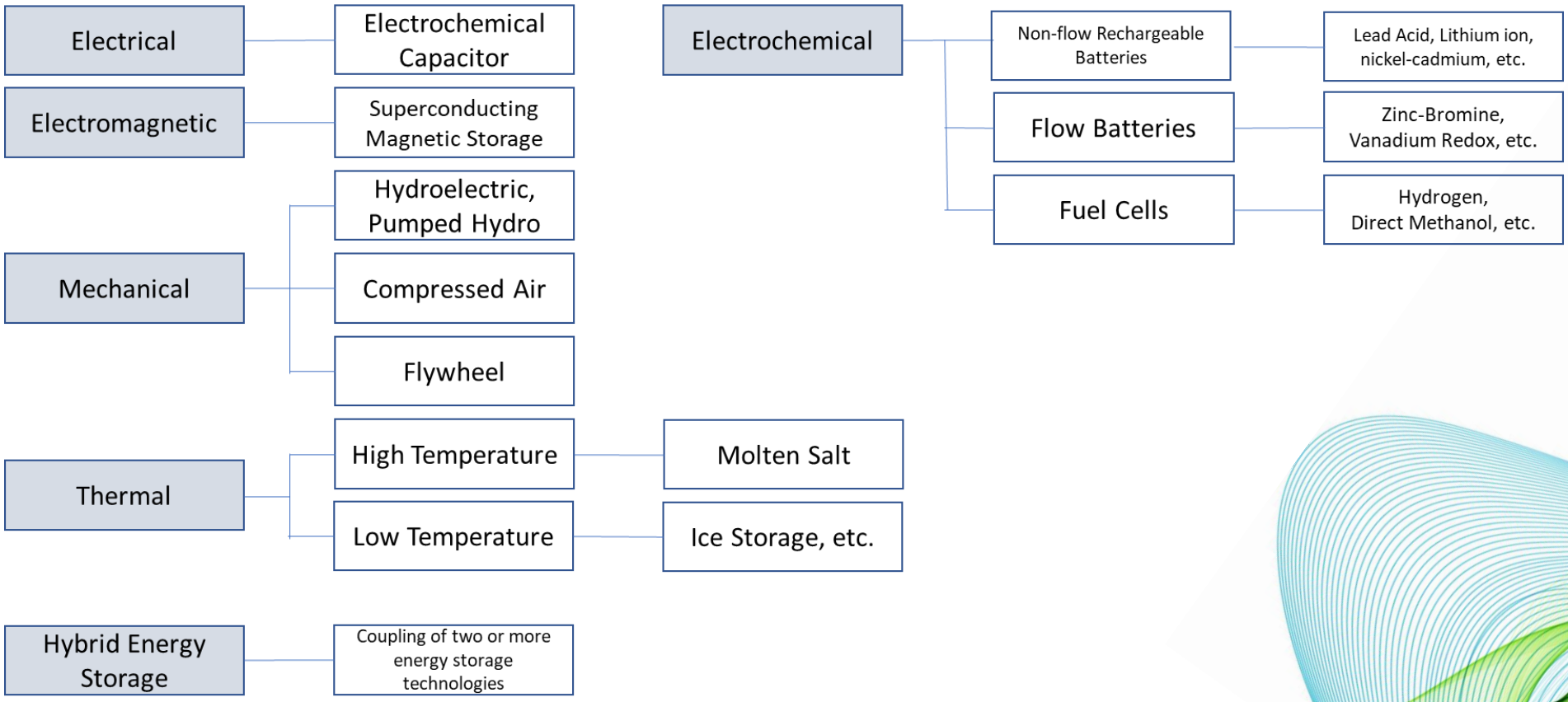
DEFINITION

- A microgrid is a small power system that has the ability to operate connected to the larger grid, or by itself in stand-alone mode.
- Microgrids may be small, powering only a few buildings; or large, powering entire neighborhoods, college campuses, or military bases.
- Many microgrids today are formed around the existing combined-heat-and-power plants ("steam plants") on college campuses or industrial facilities.
- However, increasingly, microgrids are being based on energy storage systems combined with renewable energy sources (solar, wind, small hydro), usually backed up by a fossil fuel-powered generator.



ELECTRIC ENERGY STORAGE

Electrical energy storage: energy generated at one time can be used at another time through storage – DOE Energy Storage Handbook



POWER CONVERSION SYSTEM

Converts one form of energy to another

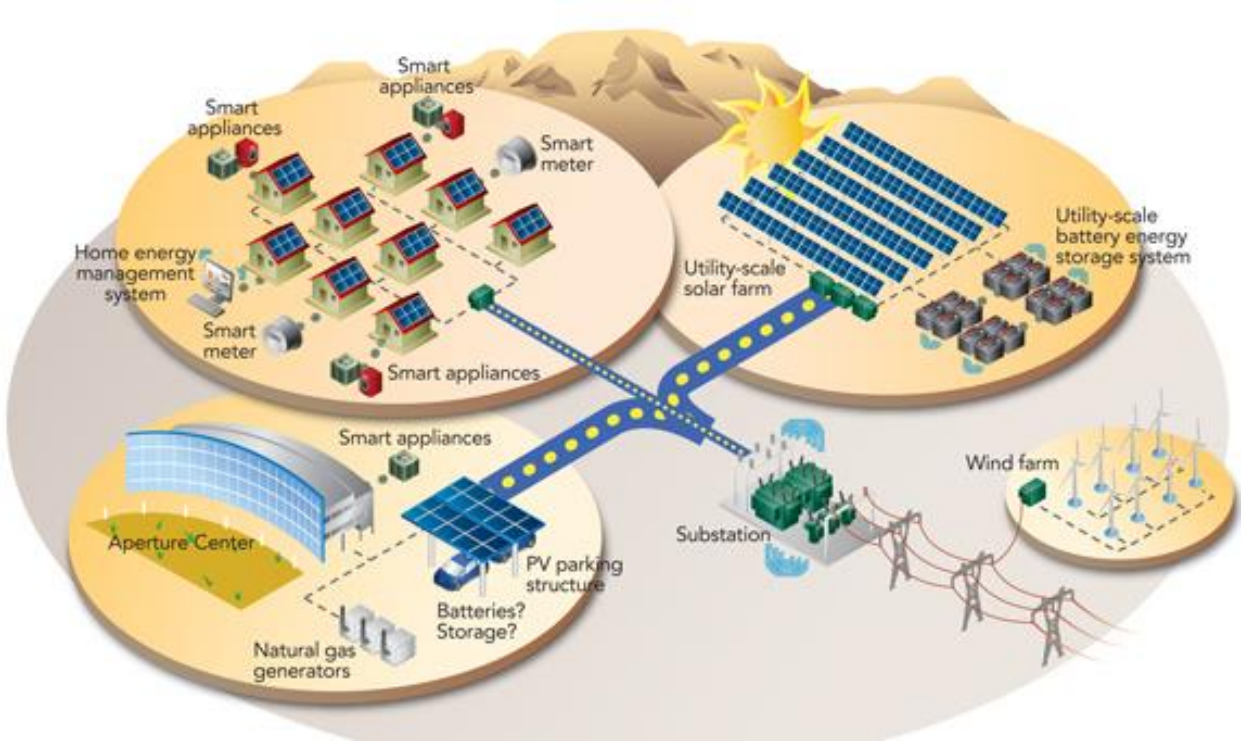
Energy Storage Technology → Power Conversion System → Electric Utility or Electric Load

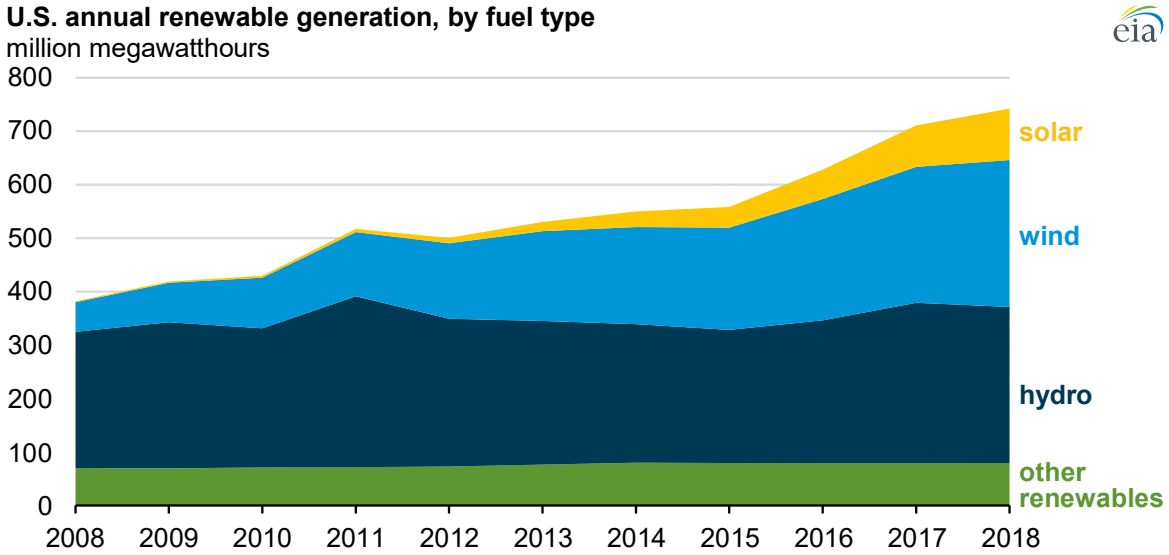
CONSUMER ELECTRONICS

ELECTRIC VEHICLES

RENEWABLES PLUS STORAGE

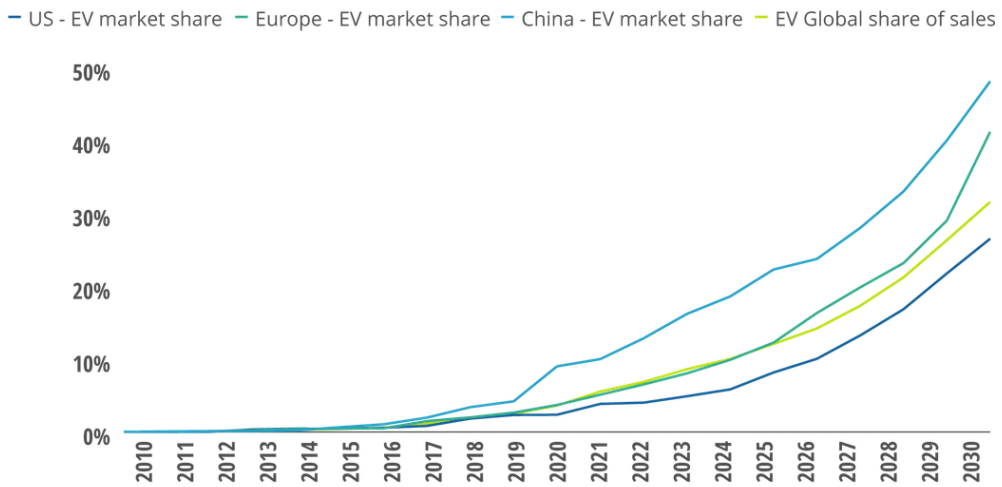
RENEWABLES AND ENERGY STORAGE





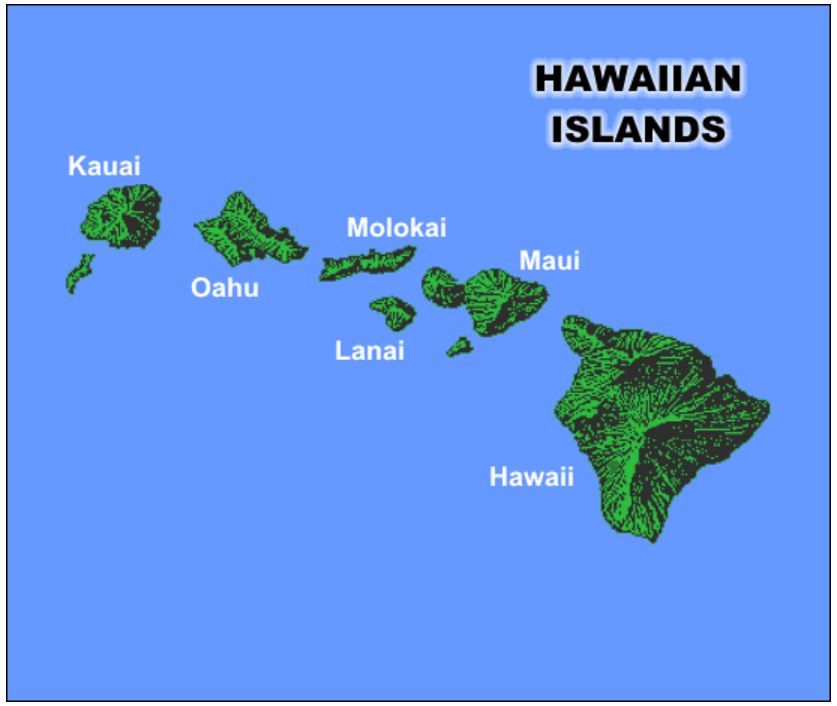
- Renewable generation and the growth of electric vehicles are accelerating grid modernization and the need for energy storage at various points on the grid.

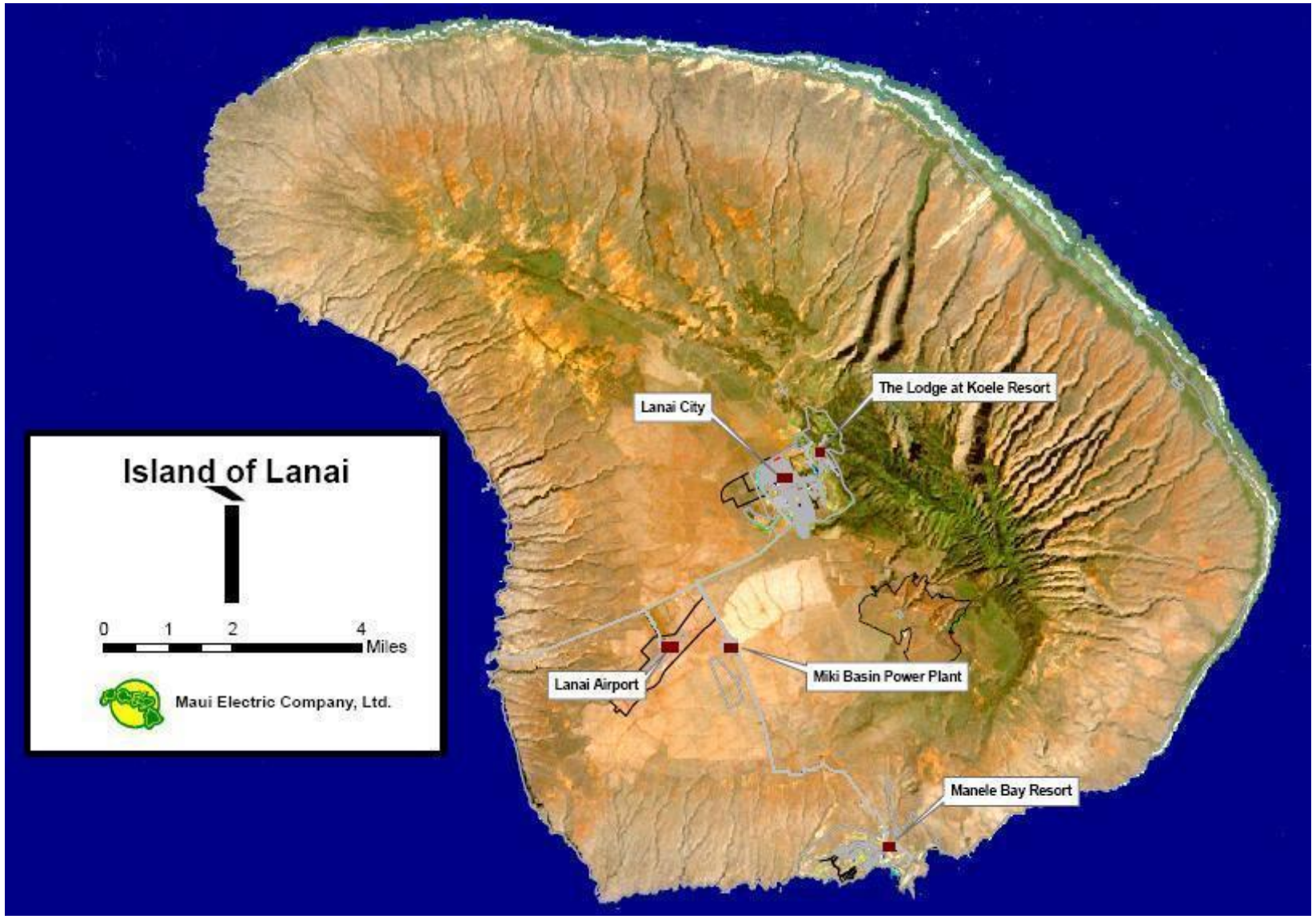
- Energy storage is needed to shift renewable generation, add inertia to the grid, and compensate, locally, for the additional peak demand brought by EV charging stations.



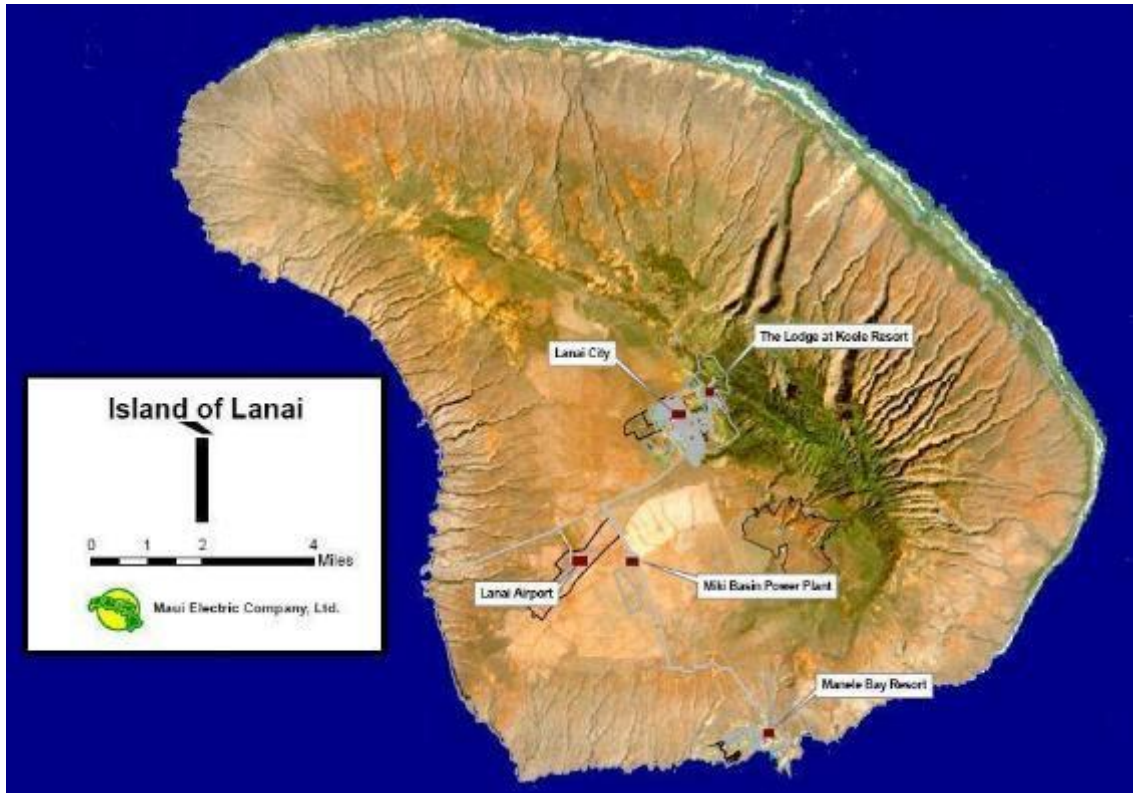
Source: Deloitte analysis, IHS Markit, EV-Volumes.com[17]

ISLAND OF LANAI EXAMPLE



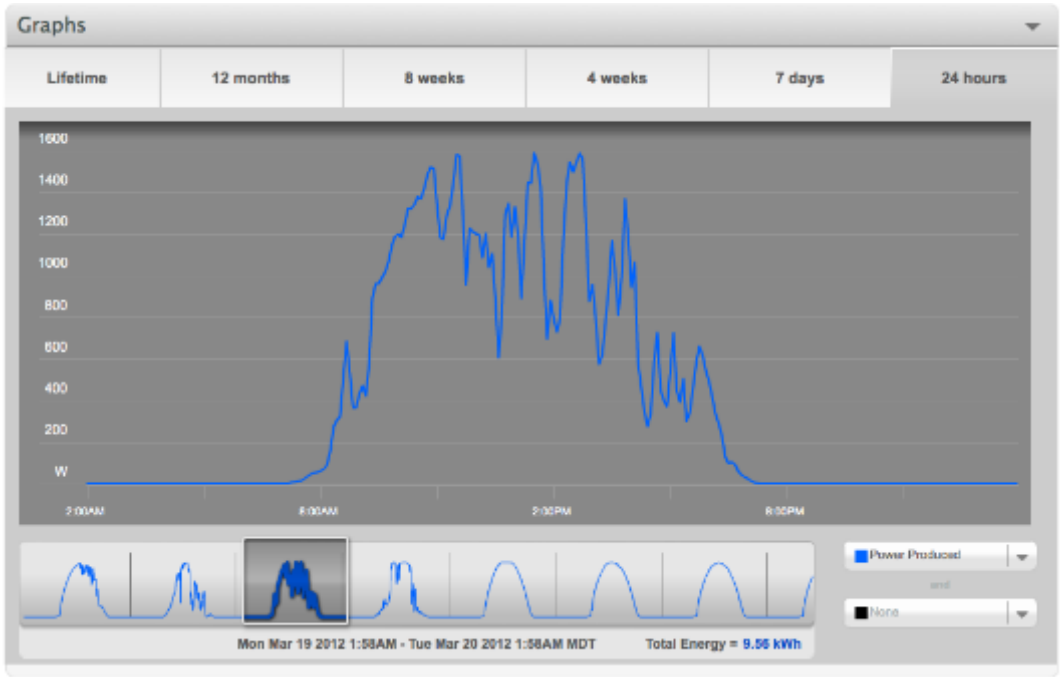


ISLAND OF LANAI EXAMPLE

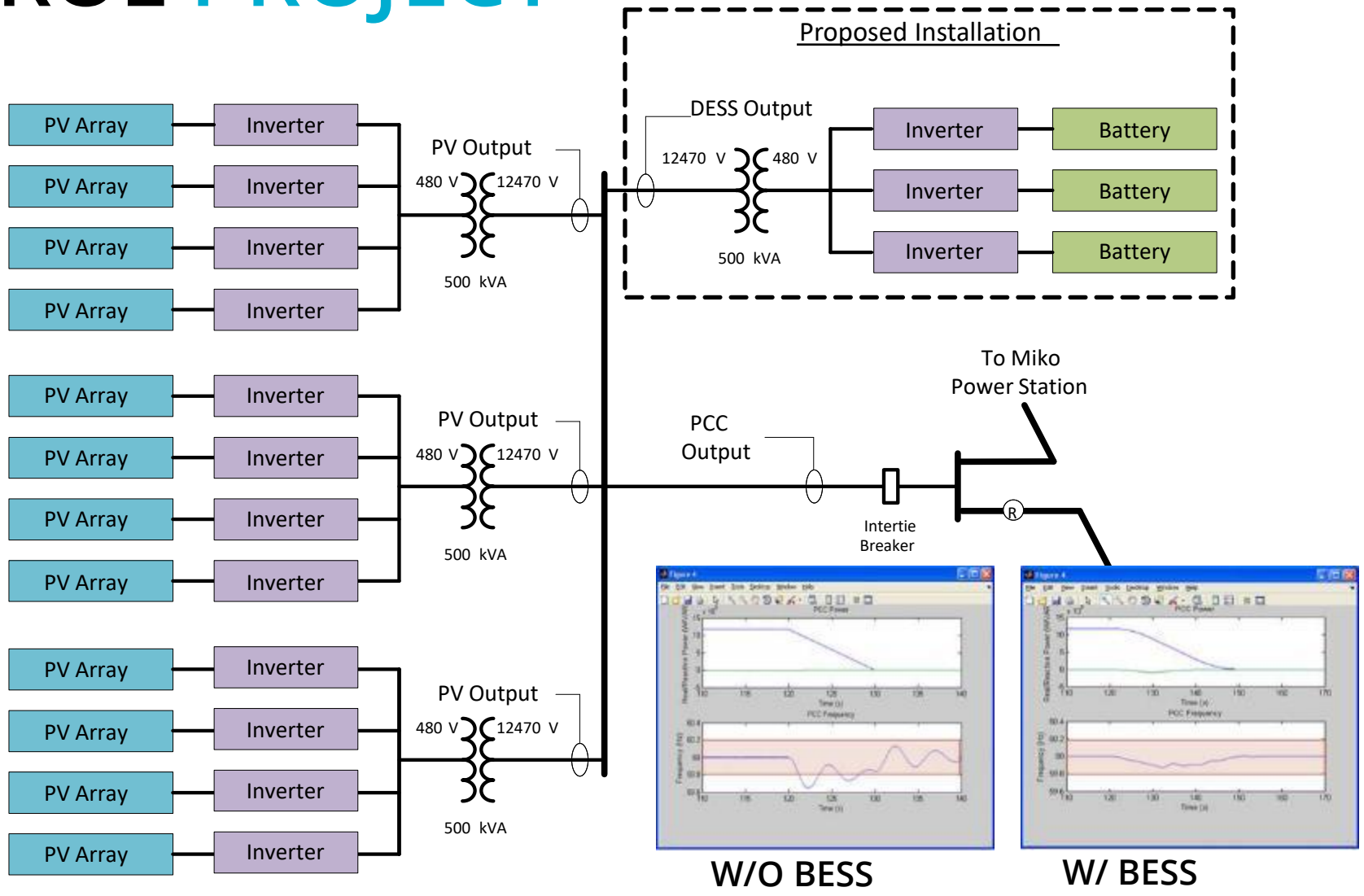


(6) 1.0 MW EMD Diesel Generators
(2) 2.2 MW Caterpillar Diesel

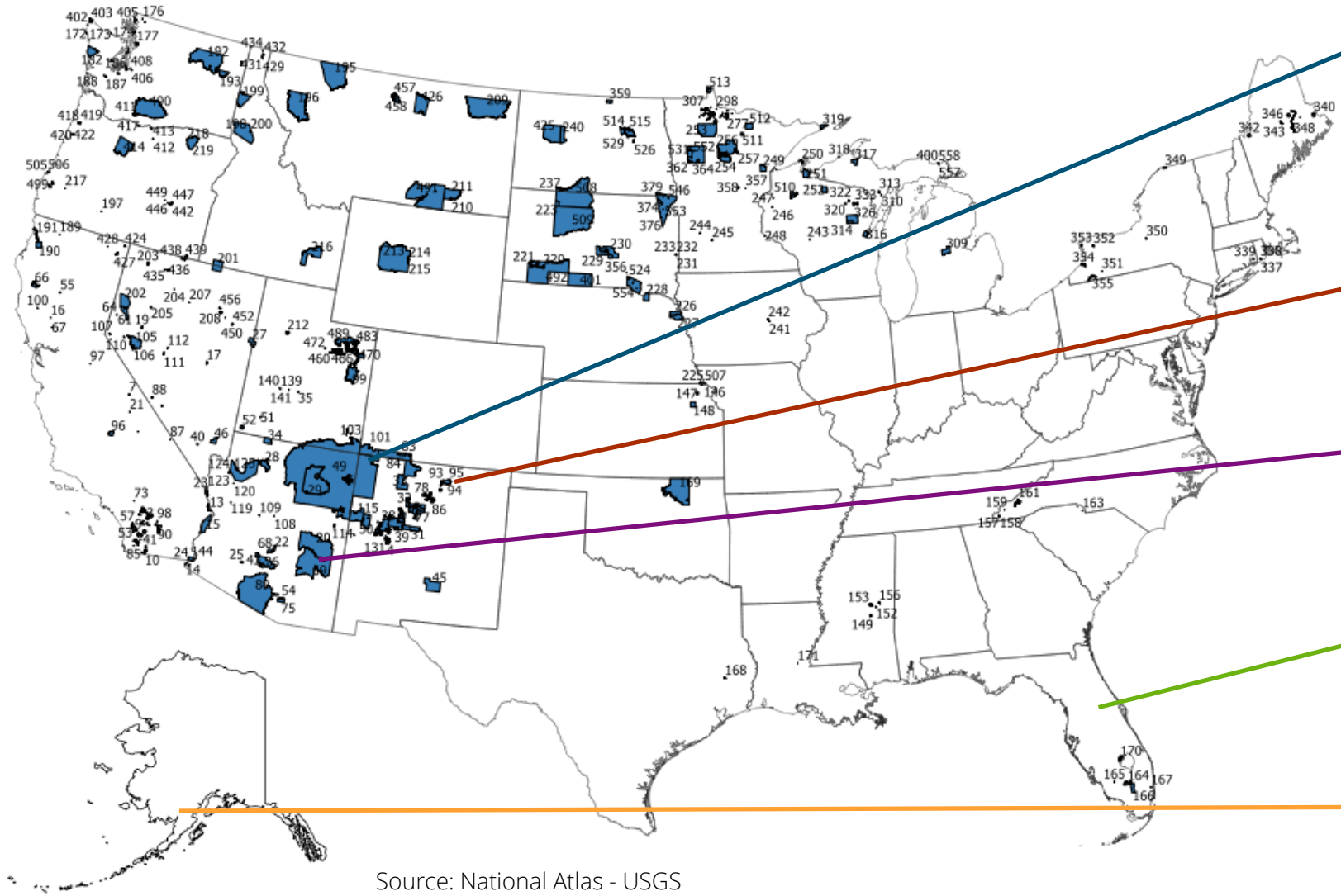
1.2 MW PV Plant



LANAI GRID ENERGY STORAGE CONTROL PROJECT



DOE OE ENERGY STORAGE TRIBAL ENERGY PROJECTS



Source: National Atlas - USGS

Navajo Nation, Navajo Tribal Utility Authority (NTUA), Urban Electric Power, Georgia Tech Project

Picuris Pueblo Energy Storage Microgrid Project

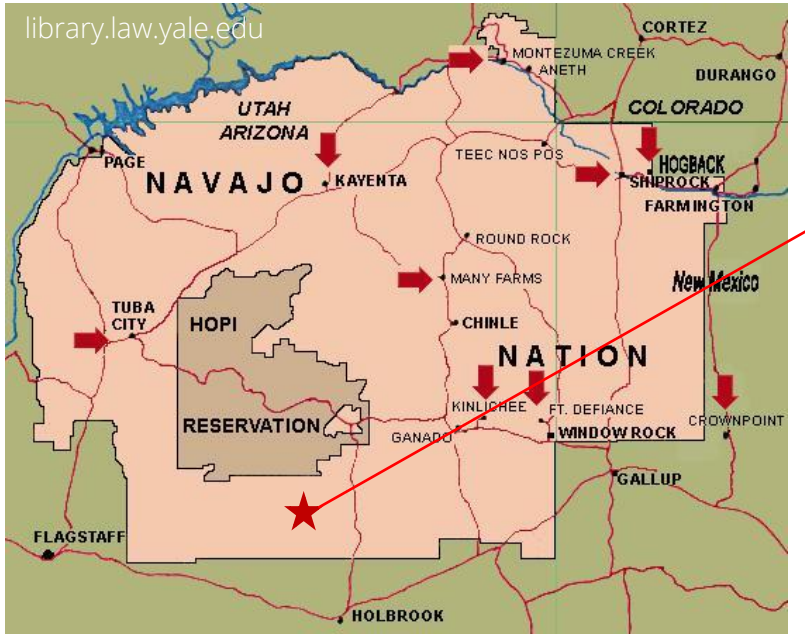
San Carlos Apache Tribe Energy Storage Microgrid Project

Seminole Tribe of Florida Energy Storage Microgrid Project

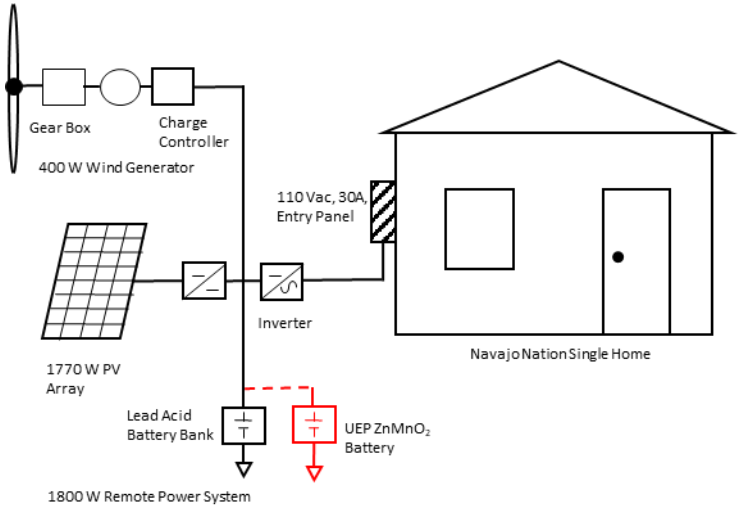
Alaskan Village of Levelock Energy Storage Microgrid Project

ENERGY STORAGE BENEFITS TO THE NAVAJO NATION

- **PROBLEM STATEMENT:**
  - Many residents are off-grid due to expense of installing electrical infrastructure to their homes
  - Traditional lead acid batteries have proven to work but come at a cost with replacing every 3-5 years
- **APPROACH:**
  - Procure batteries that are comparable in size to existing lead acid system of 13 kWh capacity
  - Install and monitor performance over a few years
  - Evaluate UEP Zn-MnO_2 technology compared to traditional lead acid batteries
- **PROJECT IMPACT:**
  - Tribe will have access to alternative batteries that have better performance, is safer, and more environmentally friendly since UEP technology does not contain lead
  - Enhanced understanding of new battery technology and associated power electronic controls resulting in a more consistent delivery of off-grid power

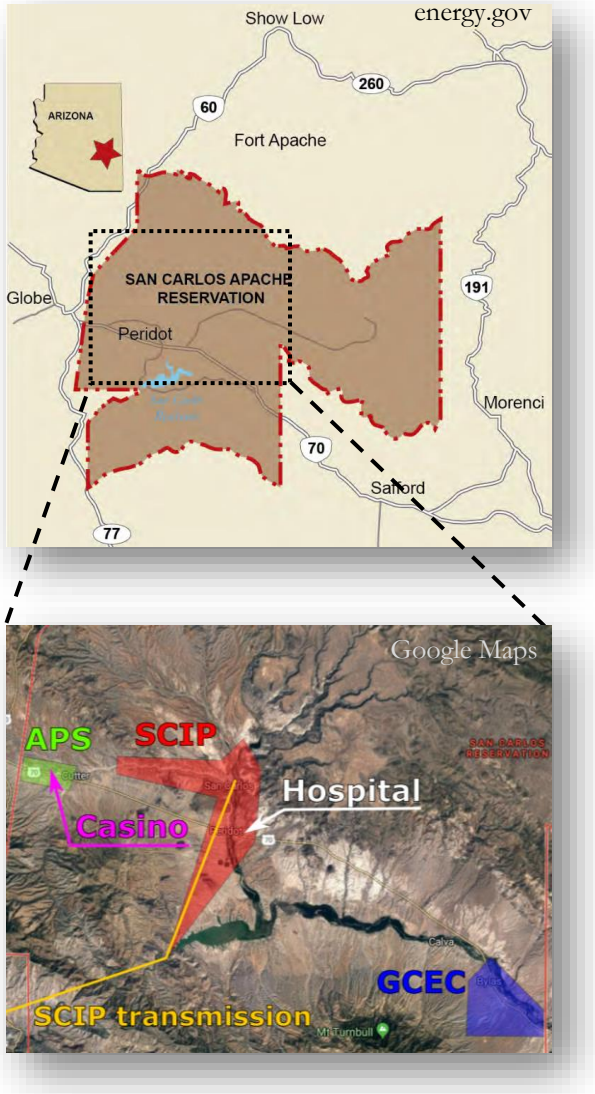


UEP Batteries

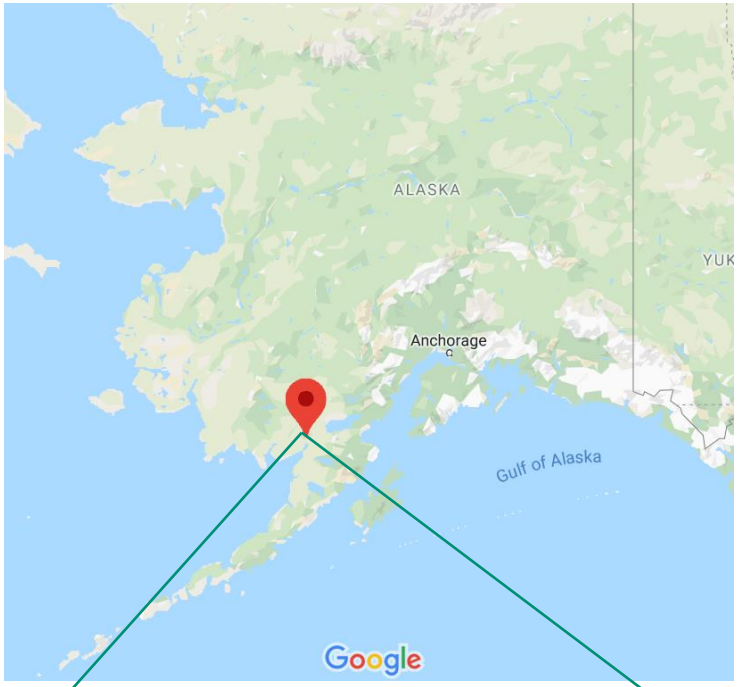


ENERGY STORAGE BENEFITS TO SAN CARLOS APACHE TRIBE

- **San Carlos Apache Tribe Facts:**
  - Tribal members: ~17.000
  - Area: 1.8 million acres (about the size of the State of Delaware)
  - Limited power generation and transmission assets – poor system reliability
- **Problem Statement:**
  - Tribal members report over 100 power outages per year
  - Some solar PV projects under way to decrease the tribe's energy dependency:
    - 2 - 3MW solar PV plant co-located with San Carlos Healthcare Hospital Community PV project
  - Tribe looking into deploying and energy storage system to decrease energy costs and improve reliability of critical loads



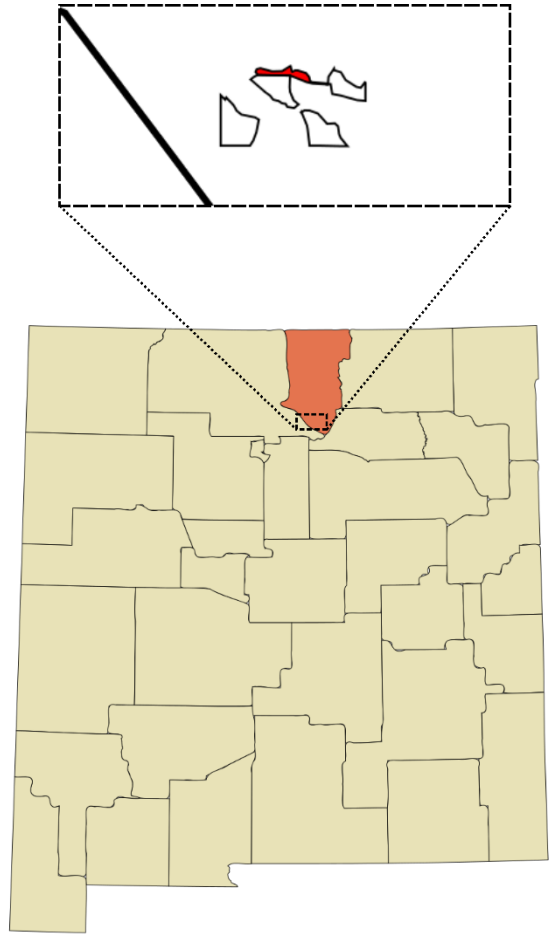
ENERGY STORAGE BENEFITS TO THE LEVELOCK VILLAGE OF ALASKA



- **Alaskan Village of Levelock Facts:**
  - Tribal members: over 70 enrolled members
  - Area: 7,744 acres
- **Problem Statement:**
  - The tribe currently powered by three diesel generators (1-100kW and 2-67kW)
  - Tribe is embarking on a microgrid with energy storage due to high fuel cost ($3.84/gal – 2019 cost), high electricity cost (85¢/kWh) and high emissions from the generators
- **How is Sandia Supporting the Levelock project?**
  - Performed pre-microgrid baseline analysis – install meters on three diesel generators and analyze load profile, fuel usage, resiliency, and cost of operation for approximately 5 to 6 months.
  - Estimate benefits of energy storage to the Village from multiple revenue streams, including i) reliability, ii) fuel cost-savings, iii) reduction in operation and maintenance, and iv) extension of generator life.

ENERGY STORAGE BENEFITS TO PICURIS PUEBLO

- **Picuris Pueblo Facts:**
  - Tribal members: ~300 enrolled members
  - Small area: 256 acres
  - Located in Sangre de Cristo Mountains, Taos County, Northern New Mexico
- **Background Information:**
  - High rates of electricity
  - 1 MW solar PV operational since Jan. 2018, funded though DoE grant and loan
  - Tribe has a PPA to sell power to the local utility, Kit Carson Electric Co-op
  - Revenue from PPA pays back loan and subsidizes tribal members' electric bills
  - Funding secured for another project, a microgrid with 1 MW solar
    - Provide electricity directly into tribal buildings, homes and economic development buildings
- **How Sandia is Supporting Picuris Pueblo?**
  - Evaluate alternative electrical service scenarios, including tribe's energy independence
  - Evaluation of different solutions to couple large scale energy storage and solar
  - Analysis of reduction of electricity costs with energy storage and solar power
  - Provide a report to the tribe to support decision making process



ENERGY STORAGE BENEFITS TO SEMINOLE TRIBE OF FLORIDA

- **Seminole Tribe of Florida Facts:**
  - Tribal members: 4,244 enrolled members
  - Area: nearly 100,000 acres of land within the boarders of FL
  - 5 Seminole Indian Reservation in Florida as well as a tribal trust land in Fort Pierce
  - Tribe provides services to members at the municipal and county level
- **Problem Statement:**
  - Grid instability caused by weather-related events
    - 100 Outages per year
    - 20 hours per week using diesel generation
    - Tribe is developing energy resiliency capacity
    - Installing 973kW of PV and 3,300kWh of Energy Storage across 8 facilities
- **How is Sandia Supporting Seminole Tribe of Florida?**
  - Assist in the RFI and RFP development and selection of vendor
  - Review commissioning plan
  - Evaluate solar plus storage over years of operation

		125%	4 hours
Big Cypress	**kW Max Demand (12 mo)**	**Minimum Battery Peak Power, kW**	**Minimum Battery Capacity, kWh**
Big Cypress Frank Billie Field Office	138.9	**180.0**	**320**
Big Cypress Senior Center	83.9	**110.0**	**150**
Big Cypress Public Safety Complex	140.3	**180.0**	**400**
Big Cypress Health Clinic	201.9	**260.0**	**640**
Brighton			
Brighton Health Clinic	70.8	**90.0**	**150**
Brighton Administration Building	179.6	**230.0**	**570**
Brighton Public Safety Building	286.7	**360.0**	**740**
Brighton Veterans Building	140.2	**180.0**	**350**
1242 kW Demand		**1590** kW Batteries	**3320** kWh Batteries

NAVAJO NATION RENEWABLE ENERGY DEPLOYMENT BARRIERS

Some Barriers identified by NTUA (Derrick Terry, Renewable Energy Specialist)

- Funding and financing
- Permitting and clearances (archeological sites, endangered plants and species, etc..)
- Grazing permits and homesite leases
- Remote location
- Partnership
- Customers
- Education

TRIBAL STUDENTS

2019 Summer Interns

- DOE Indian Energy Summer Internship Program
- Minority Serving Institute Tribal Colleges & Universities Program

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Ahéhee' (Thank You!)

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