# SwRI Project Z

## Development of a Net Zero-Carbon Emission Microgrid on SwRI Campus

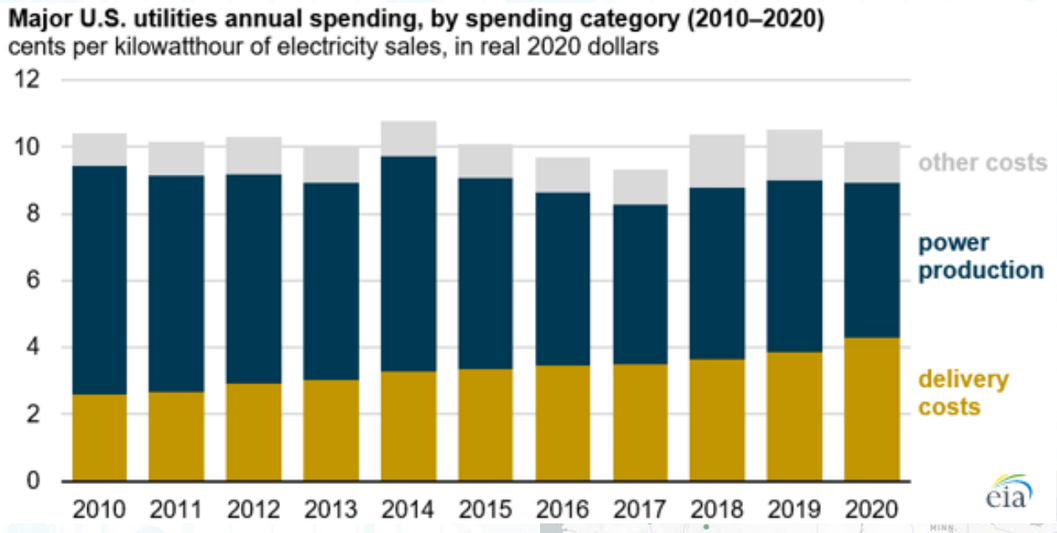
SOUTHWEST RESEARCH INSTITUTE®

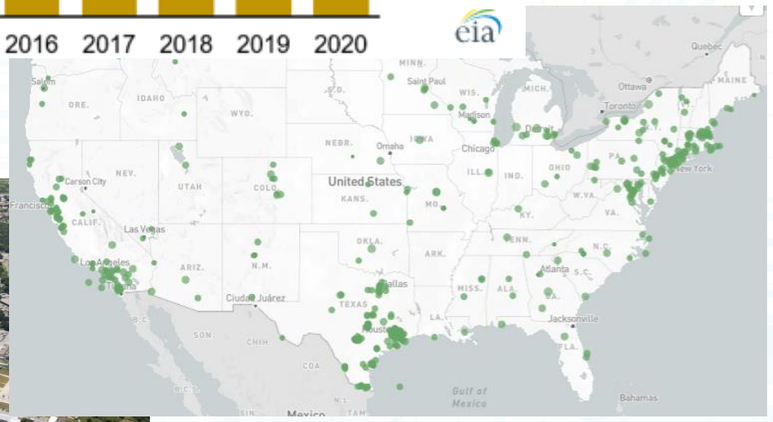
August 4, 2022

Joshua Schmitt
Senior Research Engineer

# Net-Zero Carbon Emission Power at the Microgrid Scale

- Utilities increase spending on transmission
- Microgrids
  - Typically can be "Islanded"
  - Capacity 100 kW-100 MW
  - Serve as a scale-up platform for utility scale
- DOE Database
  - 461 operational microgrids
  - 3.1 gigawatts of electricity
- SwRI pursuing onsite zero-carbon microgrid
  - 1,500 acres of land
  - 2.3 million sq. ft. of lab and office facilities
  - Over 2,800 employees



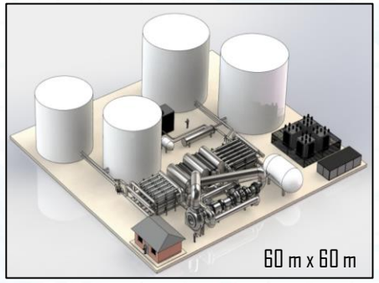

Source: EIA, "Major U.S. utilities spending more on electricity delivery, less on power production", November 2021
DOE, "U.S. Department of Energy Combined Heat and Power and Microgrid Installation Databases"

# What Does SwRI's Site Require?

- Two parallel full-size energy systems for redundancy and research flexibility
- SwRI application mirrors "grid of the future" dynamics including baseload and variable power sources
- All components commercially procurable for reliable electricity
- Multiple options for pilot-scale research
  - Carbon capture/utilization technologies
  - Electric-to-electric energy storage
  - Hydrogen production, storage, and use
  - Air separation and oxy-combustion
  - Battery usage/degradation

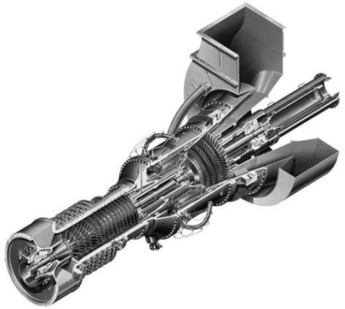
Onsite Solar PV

+




Long-Duration Storage (pumped thermal, oxygen, hydrogen)

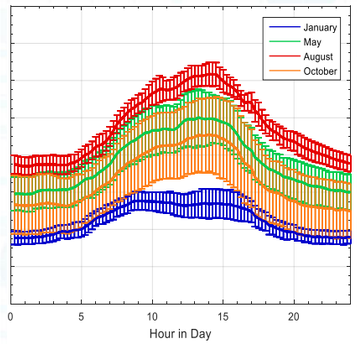
Batteries for frequency regulation, fast dispatch <30 min



+

Gas Turbine(s) 24/7 capability

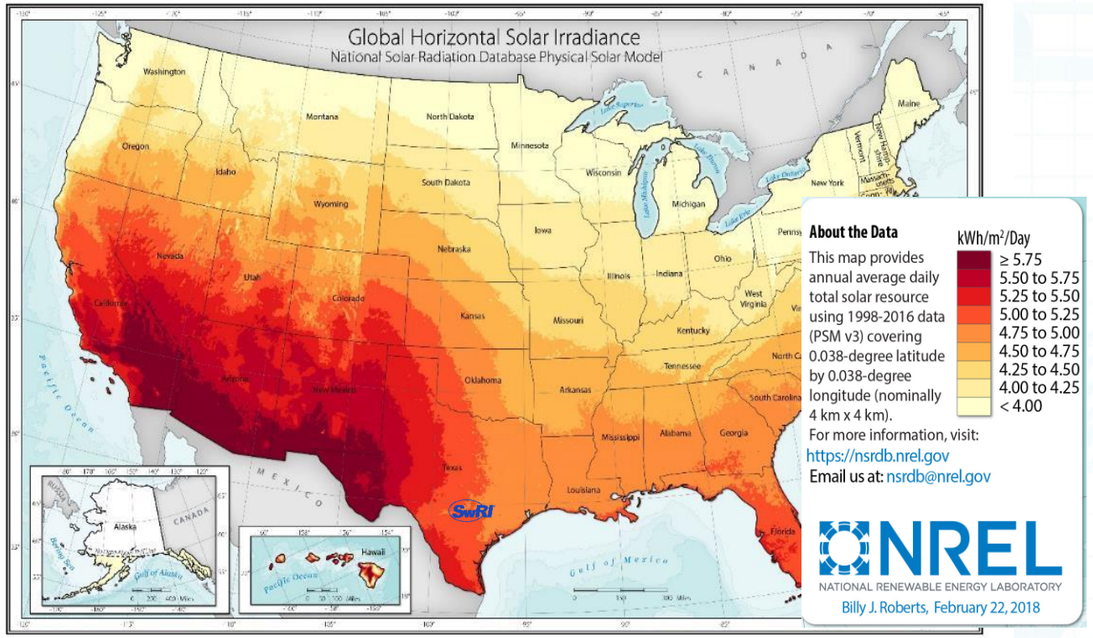
Carbon Capture & Utilization

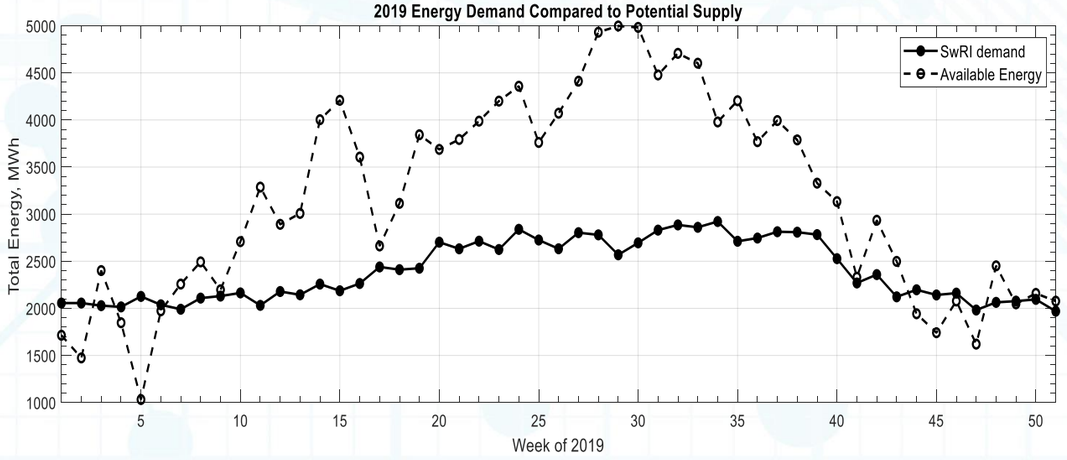



SwRI Load: 22 MW peak, 10 MW min

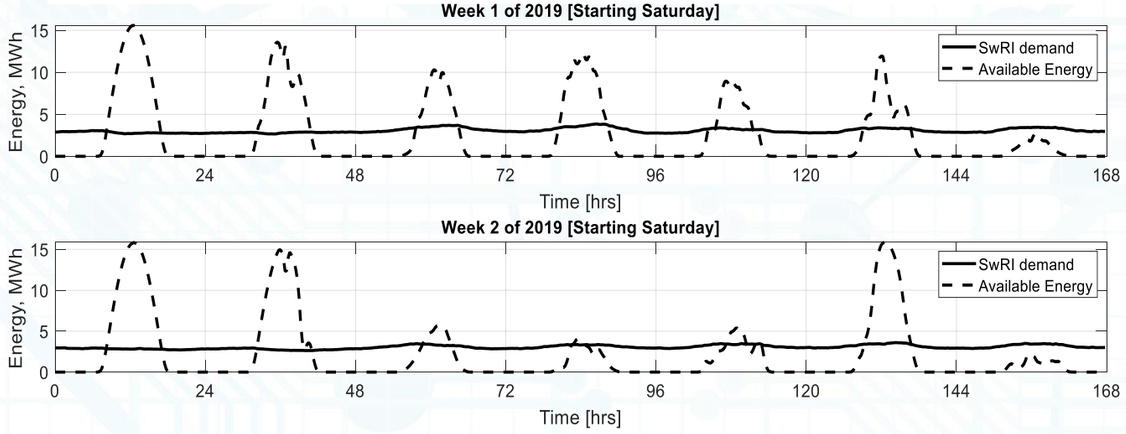
# What Resources are Available?

- Examined feasibility of solar PV, wind and solar thermal
- Solar is more abundant than wind
- Best use of land determined to be Solar PV
- Risk for solar in winter energy production



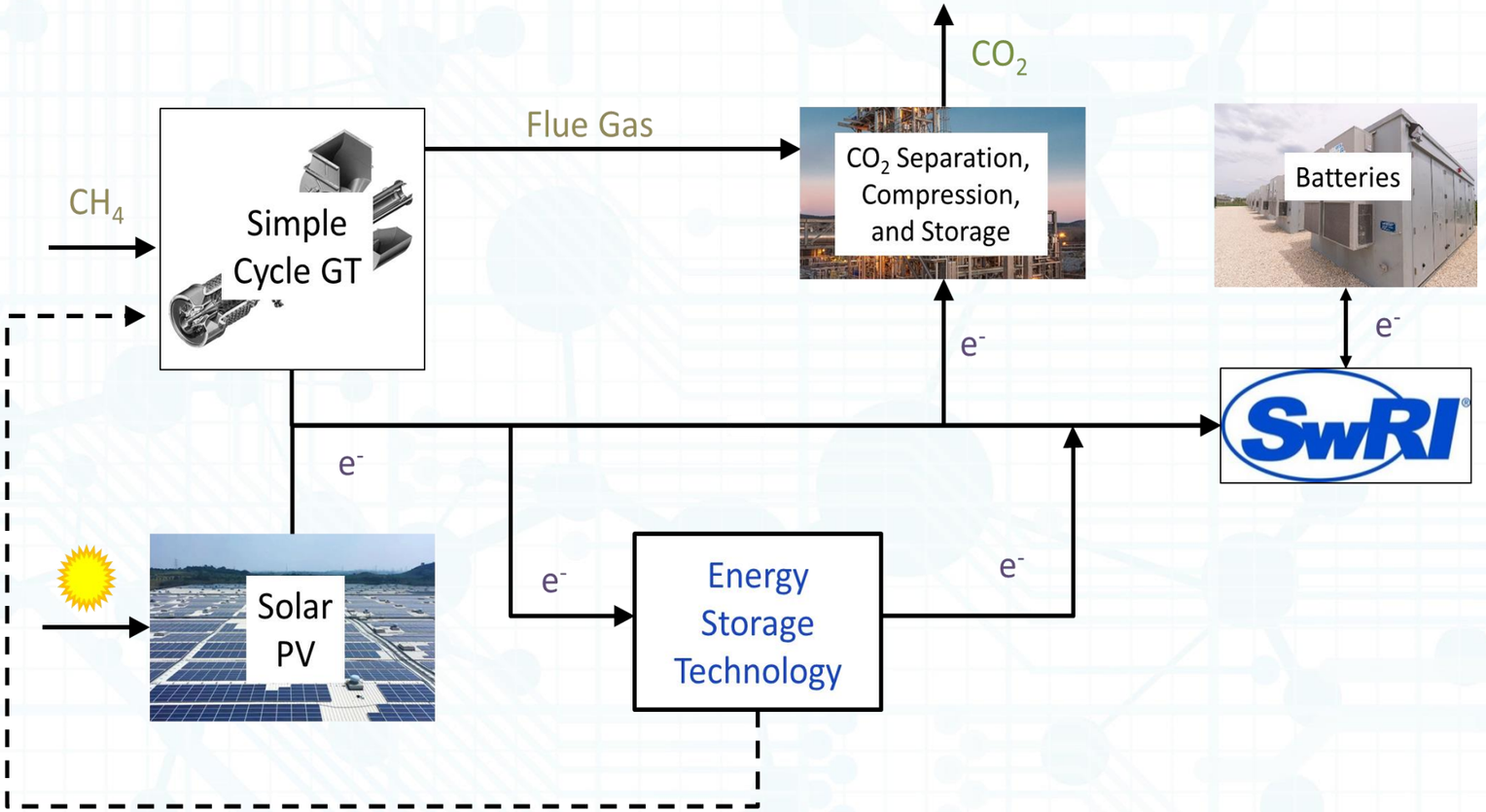




*18.7 MW AC PV Plant Example (140 Acres)



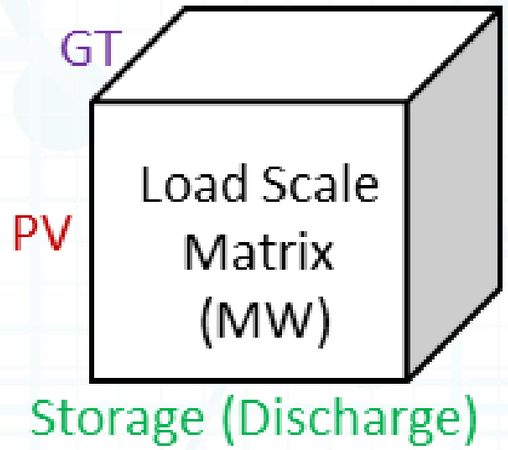
# Configuration and Technologies Examined

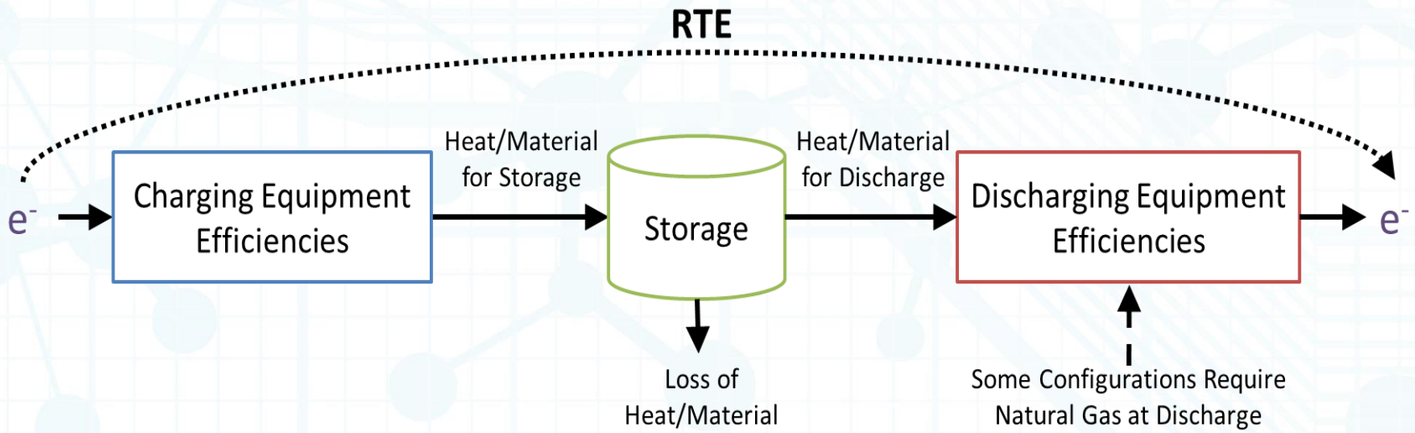
- Two gas turbine platforms
- Nine energy storage technologies
  - Pumped Thermal Energy Storage
  - Electrolyzer Hydrogen with Fuel Cell
  - Electrolyzer Hydrogen with SCGT Combustion
  - Electrolyzer Hydrogen to E-Fuel
  - Liquid Air Combined Cycle
  - Electrified Sensible Heat for SCGT
  - Atmospheric Oxy-combustion
  - Gas Turbine with High Exhaust Recirculation
  - $sCO_2$ Oxy-combustion
- Eighteen configurations analyzed



# Analytical Modeling Approach

- Data set with range of system sizes from 0-25MW
- Operating scenarios where Fossil+CCS or PV+Storage are given priority to meet load
- Generate operating profile for all cases
- Calculate LCOE from literature estimate of CAPEX and model predictions of OPEX
- About 22,000 cases generated

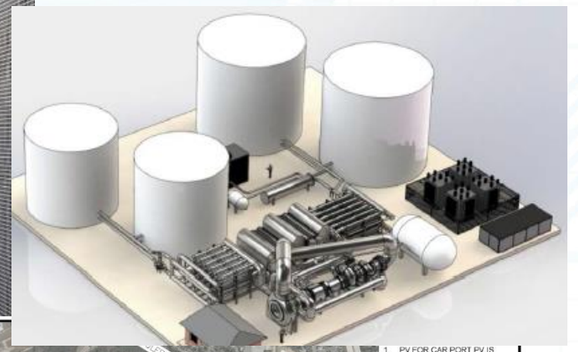


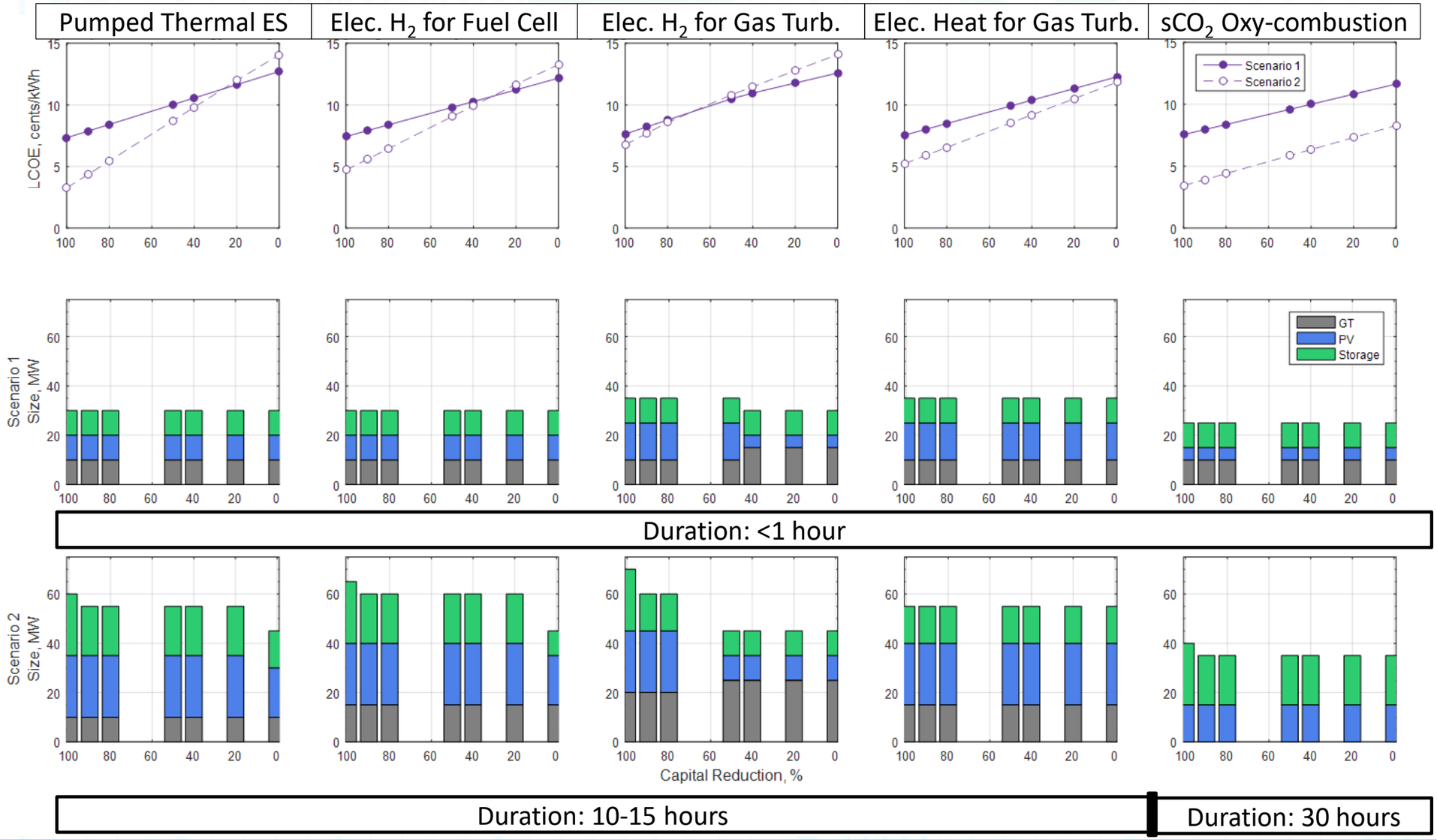

- Storage performance from electric-to-electric RTE
- Monthly balance approach
  - Sizing of charging
  - Storage duration

# Minimizing LCOE and Capital Incentives

- Analyzed large set of data and selected lowest LCOE for each configuration
  - 30 year time period
  - Estimates of cost/usage growth
- Study of campus distribution network and land availability
- Examined capital reduction incentives
  - 45Q carbon capture credit
  - Energy storage credits
  - Proposed microgrid credits
  - Research Pilots and Demonstrations

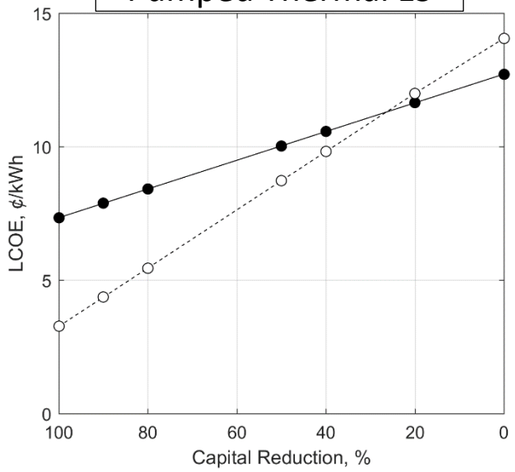


# Lowest LCOE for Select Configurations

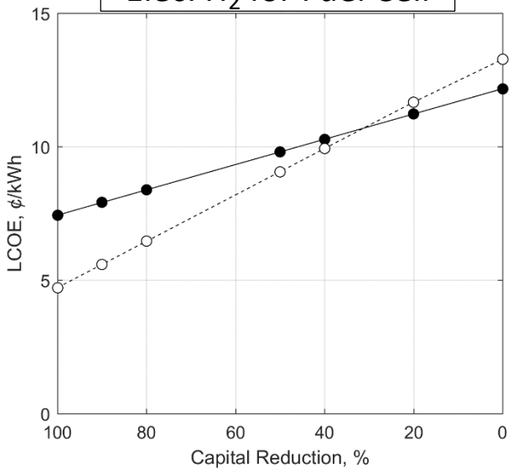


# LCOE vs Capital Cost Reduction

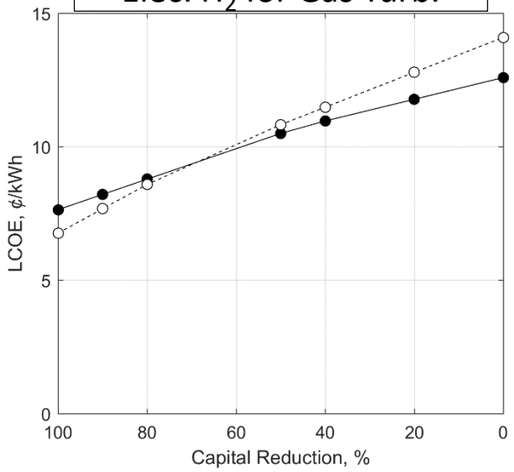
Pumped Thermal ES



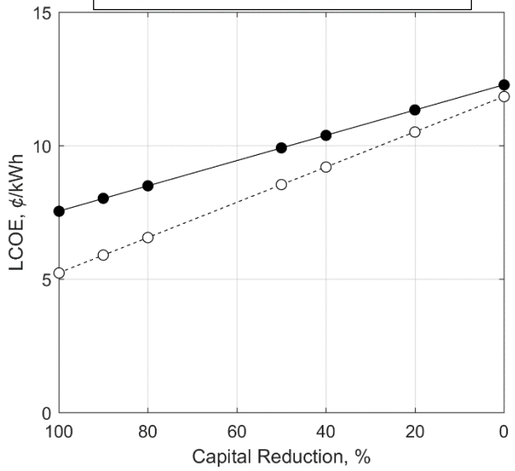

Elec. $H_2$ for Fuel Cell



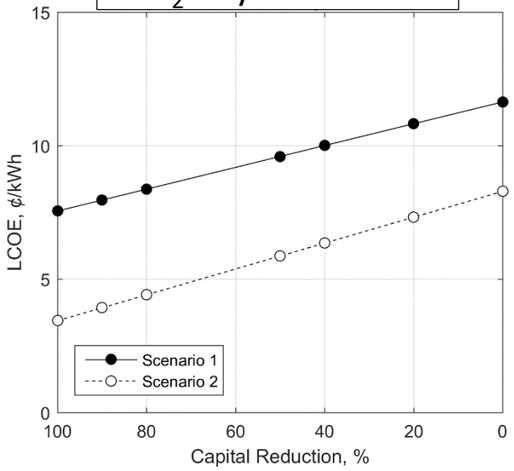

Elec. $H_2$ for Gas Turb.




Elec. Heat for Gas Turb.




$sCO_2$ Oxy-combustion



# Conclusion

- Southwest Research Institute is developing a net-zero carbon emission electric generation facility
- Microgrid provides an interesting test case for energy storage that can provide performance data for grid applications
- A variety of configurations were analyzed for their LCOE
- Microgrid installations provide scale-up platforms for energy storage
  - Should be paired with reductions in CAPEX/tax credits to be adopted

# Thank You