TEMA October Meeting

OCTOBER 2ND 2025

SANTA FE, NM

Speaker: Matt Higgins

- UNM Graduate 2007 “Sustainable Development”
- CEM – Certified Energy Manager
- CxA – Certified Commissioning Authority
- NABCEP PV Associate
- Instructor at UNM School of Architecture & Planning
- Lead Energy & Utility Consultant at Henderson Engineers
- Deep Retro-Commissioning, Planning, & Energy Analysis Experience

Meeting Agenda

Current Trends in Systems & Equipment

- Electrification
- Decarbonization
- Energy Storage
- Chiller Systems

Future of the Industry

- Solar PV Codes & Net-Zero Energy
- Resilience + Microgrids
- VPPs and Load Growth
- Long Duration Storage Technologies

Current Systems & Equipment Trends

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FACILITY ELECTRIFICATION

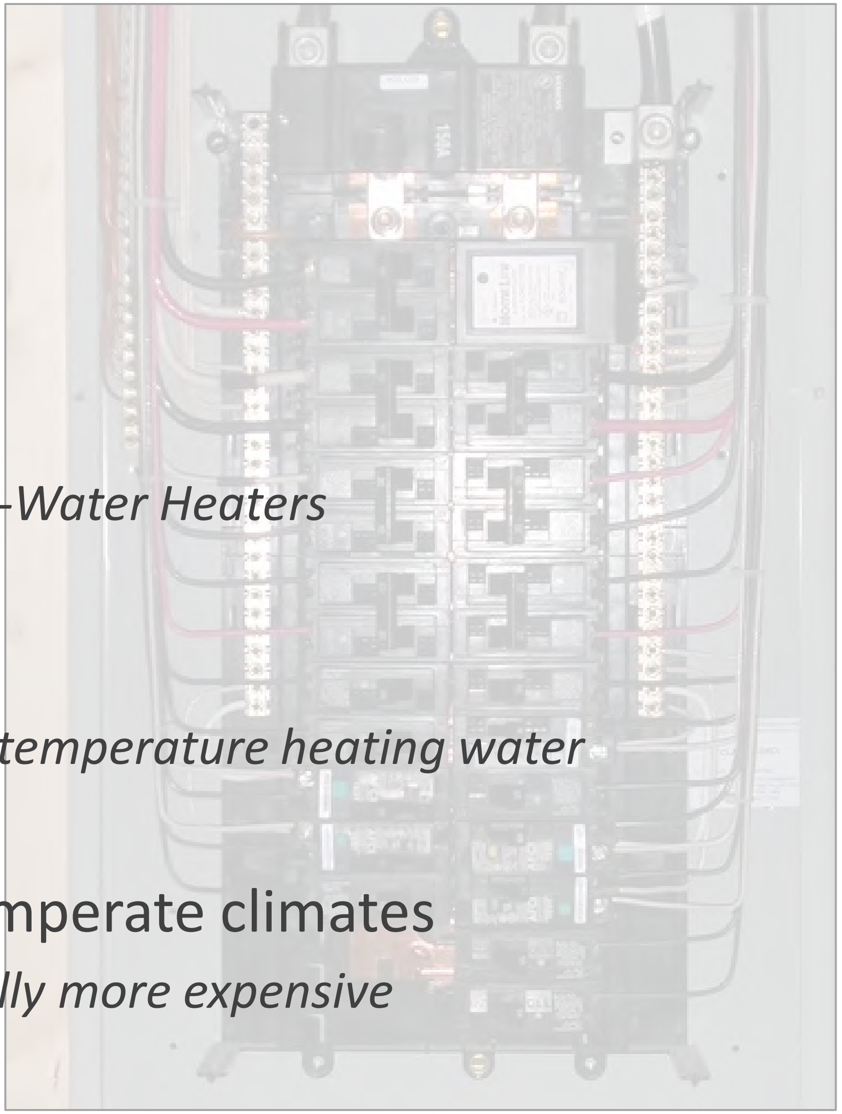
Assumes Two Things:

1. The electric grid will decarbonized by a milestone date
2. There is a Business Case:
   - All-electric buildings are easier to achieve net-zero energy use
   - All-electric buildings can be backed up with Solar PV + Batteries

New Mexico has a decarbonization goal of 2045

Governor signs landmark energy legislation, establishing New Mexico as a national leader in renewable transition efforts - Office of the Governor - Michelle Lujan Grisham

FACILITY ELECTRIFICATION



Converting Gas Equipment:

- Domestic hot water heating is easiest

  Primarily through widely-available Air-Source Heat-Pump Hot-Water Heaters

- Space Heating can be difficult in cold climates

  Especially hot water (boiler) systems, with coils sized for high-temperature heating water

- Cooking is typically the most difficult end-use in temperate climates

  Equipment availability depends on the appliance and is typically more expensive

FACILITY ELECTRIFICATION

Can trigger a Main Distribution Panel Upgrade

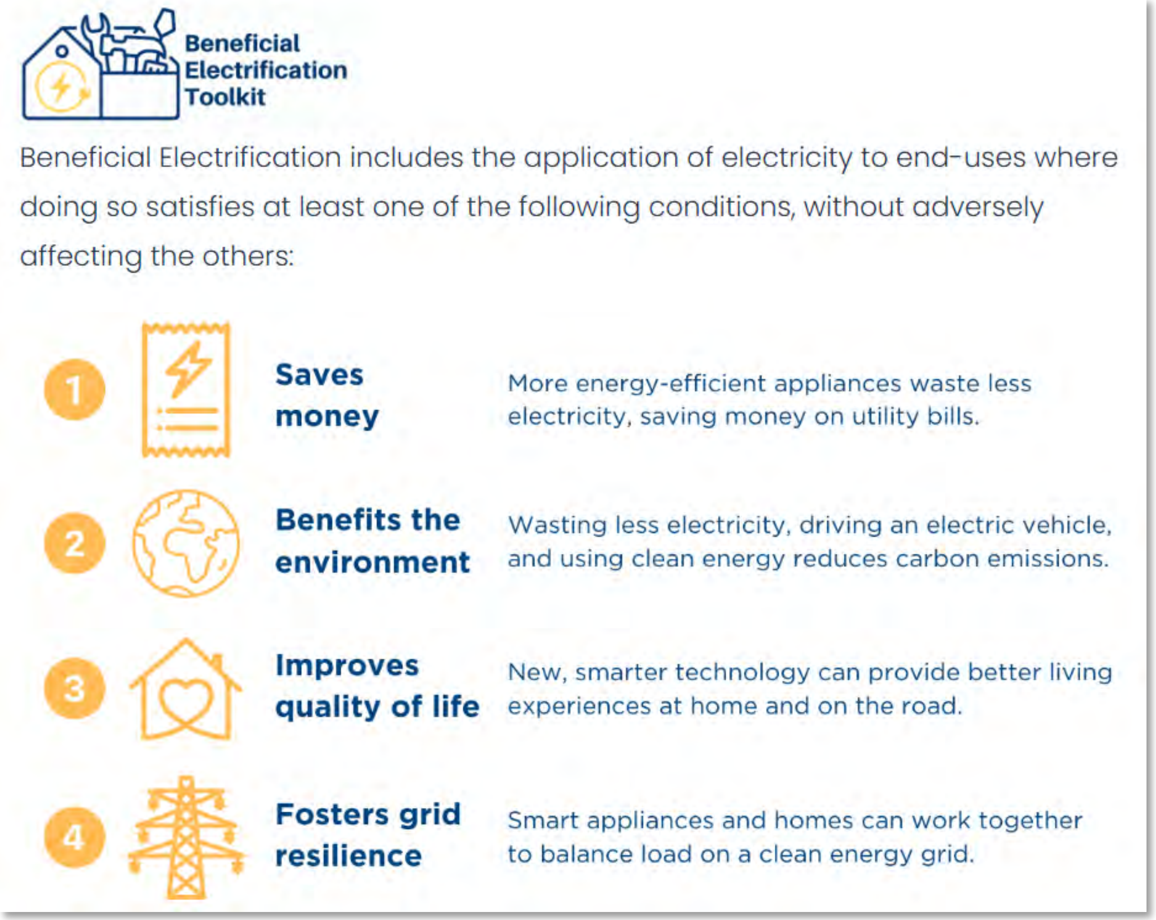
(Big service interruption impact!)

Consider Instead:

- Sizing for 80-90% Rule, leaving Gas in place till load reductions occur
- The last 10-20% of heating load is the most expensive and most difficult to electrify (i.e., for peak heating days)
  - This heating load occurs less than 5% of the year
  - This may be less of an issue with warming climate and fewer Heating Degree Days
- The newest NEC allows for an Energy Management System to manage loads, which can prevent panel upgrades

BENEFICIAL ELECTRIFICATION

1. Not just electric resistance space heating and hot-water
2. Start with Heat-Recovery, Load Reduction, and Energy Balancing
3. Make energy decisions for social equity and unburdening
4. Electrification paired with Decarbonization



LINK: Beneficial Electrification Toolkit

BENEFICIAL ELECTRIFICATION
GETs (Grid Enhancing Technologies)

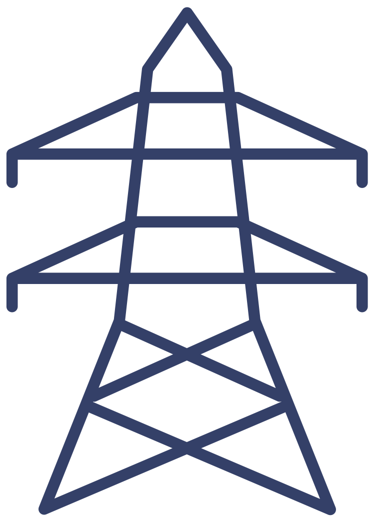
Hardware-Based

Dynamic Line Rating (DLR)
- Adjusts transmission line capacity in real time based on weather and environmental conditions.
- Can increase line capacity by 20–40%, sometimes up to 150% in optimal conditions.

Advanced Conductors
- High-temperature, low-sag (HTLS) conductors and carbon fiber core designs.
- Allow for higher current capacity and better thermal performance.

Power Flow Controllers
- Devices like FACTS (Flexible AC Transmission Systems) and Modular FACTS (M-FACTS).
- Optimize electricity routing and balance flows in real time.

Energy Storage Solutions
- Includes battery systems and pumped hydro.
- Helps balance supply and demand, reduce curtailment, and improve reliability.



BENEFICIAL ELECTRIFICATION

GETs (Grid Enhancing Technologies)

Software-Based GETs

Topology Optimization

Algorithms that reconfigure grid topology (e.g., switching lines or transformers at substations) to reduce congestion and improve efficiency.

Wide-Area Monitoring, Protection, and Control (WAMPAC)

Uses Phasor Measurement Units (PMUs) for real-time grid monitoring and control.

Measuring waveforms (voltage or current) to detect anomalies/outages.

Enhances situational awareness and operational decision-making.

Advanced Metering Infrastructure (AMI)

Enables better demand-side management and grid visibility.

Increasing grid capacity

Reducing congestion costs

Accelerating renewable energy integration

Deferring costly transmission upgrades

BENEFICIAL ELECTRIFICATION SYSTEMS

DOMESTIC HOT WATER HEATERS

VRF/VRV HEAT-PUMPS

“ELECTRIC” HEATING

DECARBONIZATION

Removing Carbon Emissions through three Carbon Tiers (largely Tier-1):

Tier 1 – Building Energy Use (Onsite Boilers/Furnaces/DHW/Cook)

Tier 2 – Energy Purchase (Source Emissions @ Power Plant)

Tier 3 – Operations, Vehicles, and Non-Building Use

Deprioritize (Less Effective) Offsets and REC's

Requires a degree of electrification for cost-effective end-uses

DECARBONIZATION

Design Process

- ✓ Rely on architects to reduce thermal loads (i.e. glazing, shading, insulation)
- ✓ Use an Energy Model to understand diversity of loads (i.e. peak vs. average)
- ✓ Understand where simultaneous heating/cooling occurs (VAV Reheat)
  - Both heat-recovery chillers and heat-pump chillers can fill a large portion of these loads
- ✓ Possibly leverage Thermal Storage (Ice Making at night) to allow daytime peak electrical loads to be driven by heat-pump heating – ASHP Chiller does both
- ✓ Rely on Ambient Loops (condenser water loops) to absorb waste heat and allow room-level heat-pumps to boost temperatures
  - Consider using waste-heat from wastewater or dedicated cooling units (CRAC's)

DECARBONIZATION

Retrofit Process

Rely on Heat-Pumps for Heating and Hot-Water

- May require new HVAC coils for lower temperature hot-water supply
- Cascading or High Temperature Heat-Pumps may overcome this

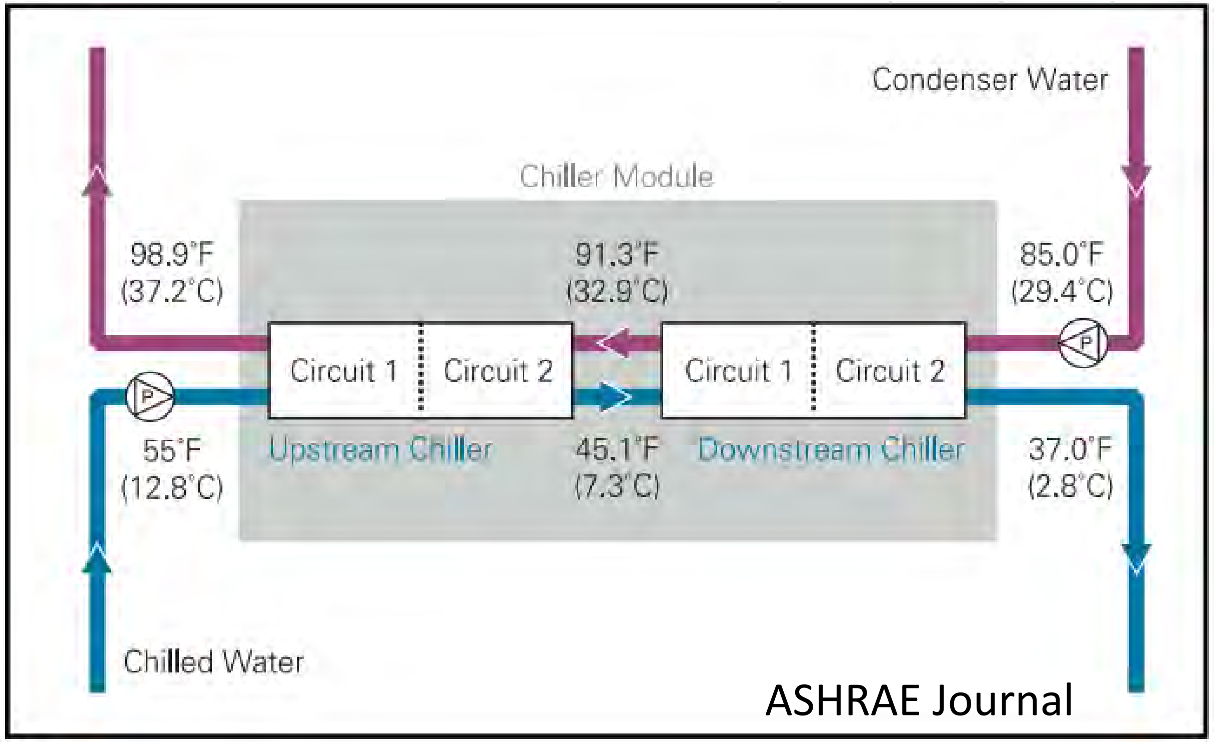
Lower Cost Routes

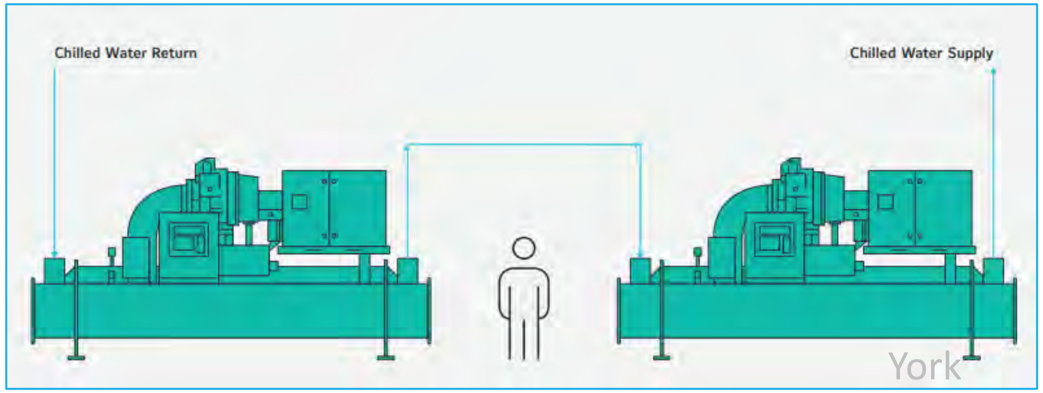
- Preserving natural gas equipment for peaks (<10% of the year)
- Using a Power Management Control System (EMCS)
- Using the 80% Rule (electrify all but 80%, with 20% from load reduction)

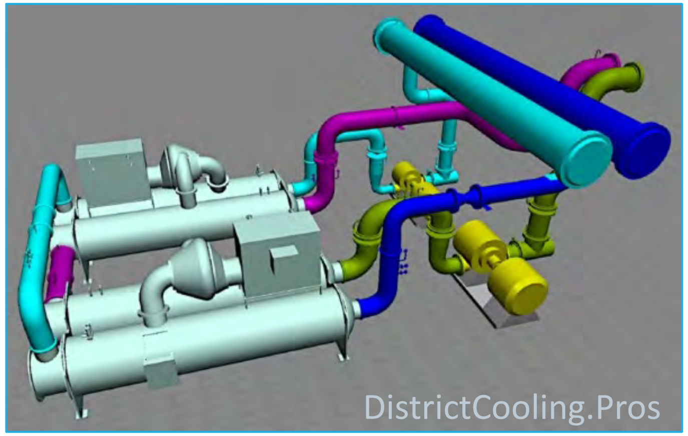
CHILLER SYSTEMS: HEAT-PUMPS

- Produces low temperature heat for loops served by condensing boilers (120deg F. LWT)
- Can pair with ice-storage (storing ice at night, off-peak) and produce heat during the day
- Multiple machines can be installed in parallel to meet large loads
- Air-Cooled unit placed outdoors

CHILLER SYSTEMS: Series Counter-Flow



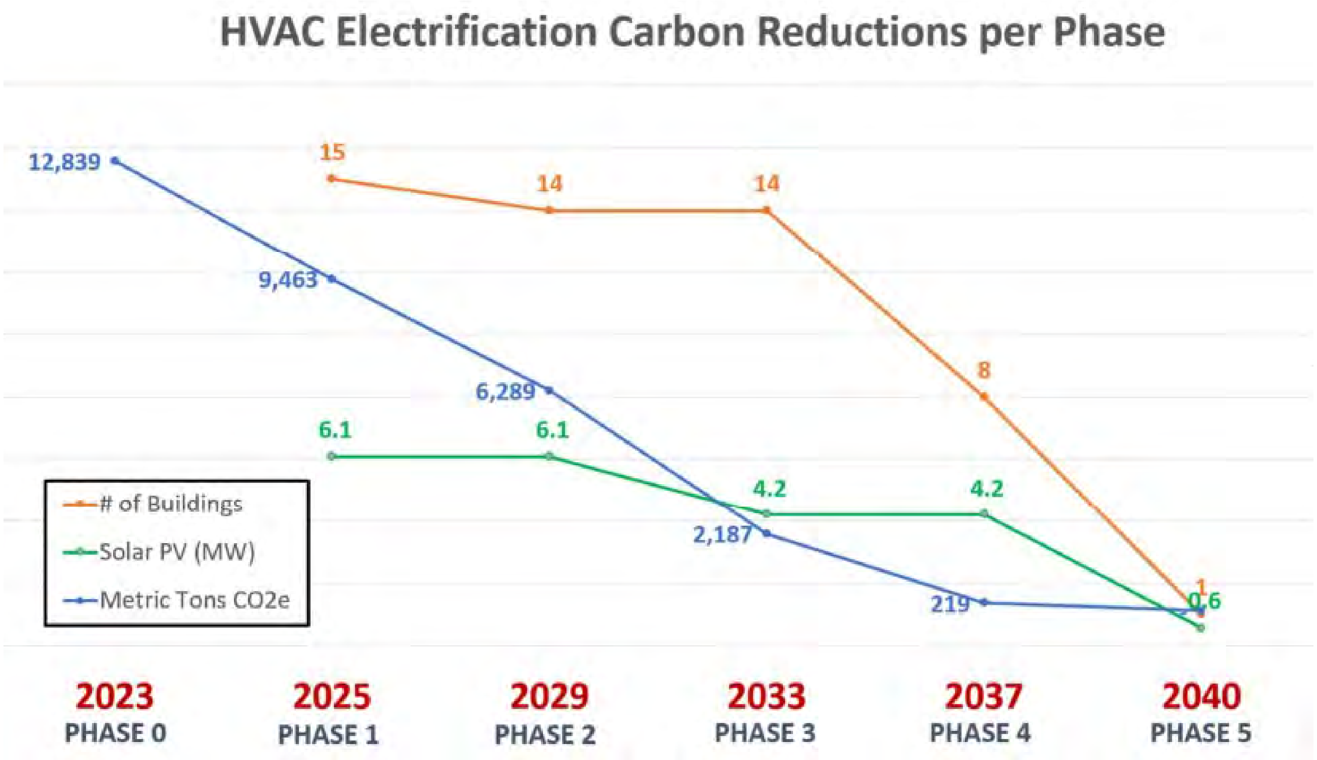




CHILLER SYSTEMS: Heat-Recovery

							
MODEL	**AquaSnap® 30MP Chiller**	**AquaForce® 30HXC Chiller**	**AquaForce® 30HXC Modified Chiller**	**AquaForce® 30HXA Chiller**	**AquaForce® 30XW Chiller**	**AquaEdge® 19DV Chiller**	**AquaSnap® 30RB Chiller**
Cooling Medium	Water-Cooled	Water-Cooled	Water-Cooled	Water-Cooled (Condenser from Finger Lakes)	Water-Cooled	Water-Cooled	Air-Cooled
Max Temp (°F)	140°*	110°	120°	135°	140°	120°	131°
Capacity (Tons)	16-71	75-265	75-265	75-265	325-400	500-800	60-300
Control Algorithm	Controls to leaving chilled water temperature	Controls to leaving chilled water temperature or leaving hot water temperature	Controls to leaving chilled water temperature or leaving hot water temperature	Controls to leaving chilled water temperature or leaving hot water temperature	Controls to leaving chilled water temperature or leaving hot water temperature	Controls to leaving chilled water temperature	Controls to entering hot water temperature

Energy Transition Planning



[Master Plan | New Mexico State University]

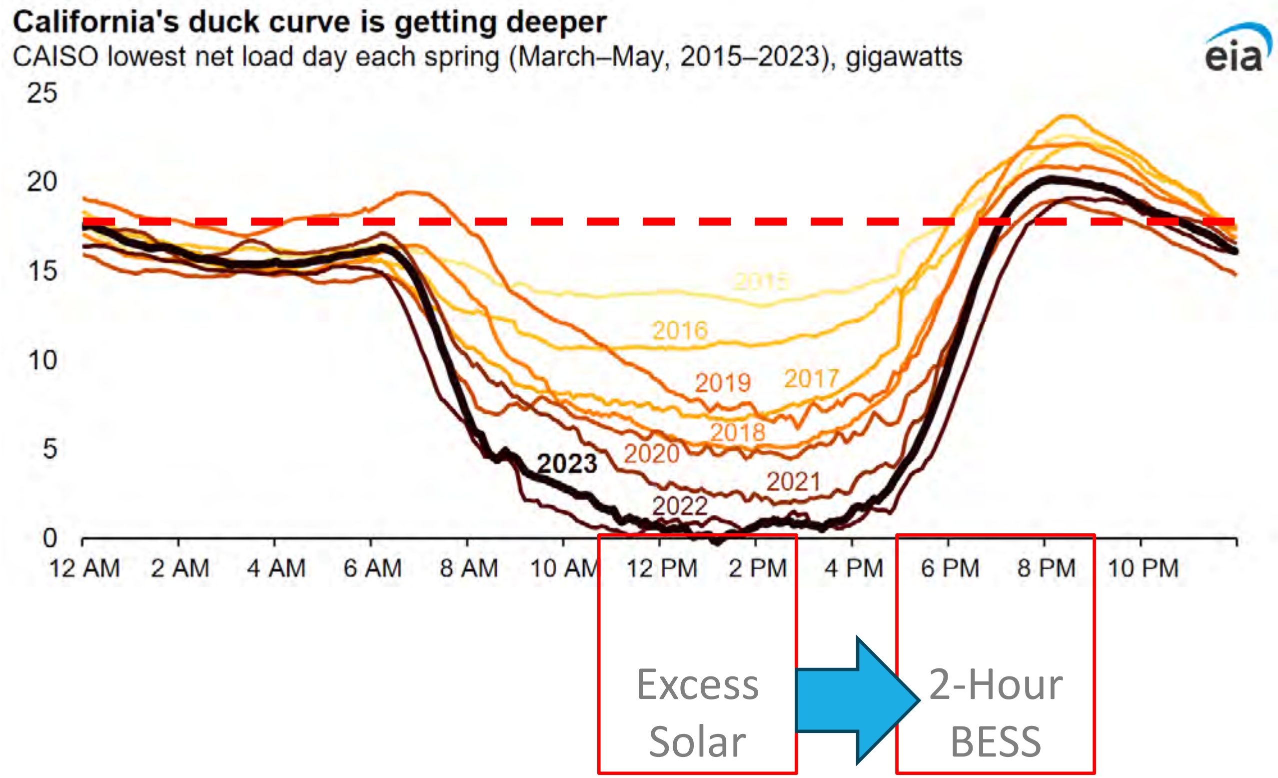
10-Year Plan (2028-2033)

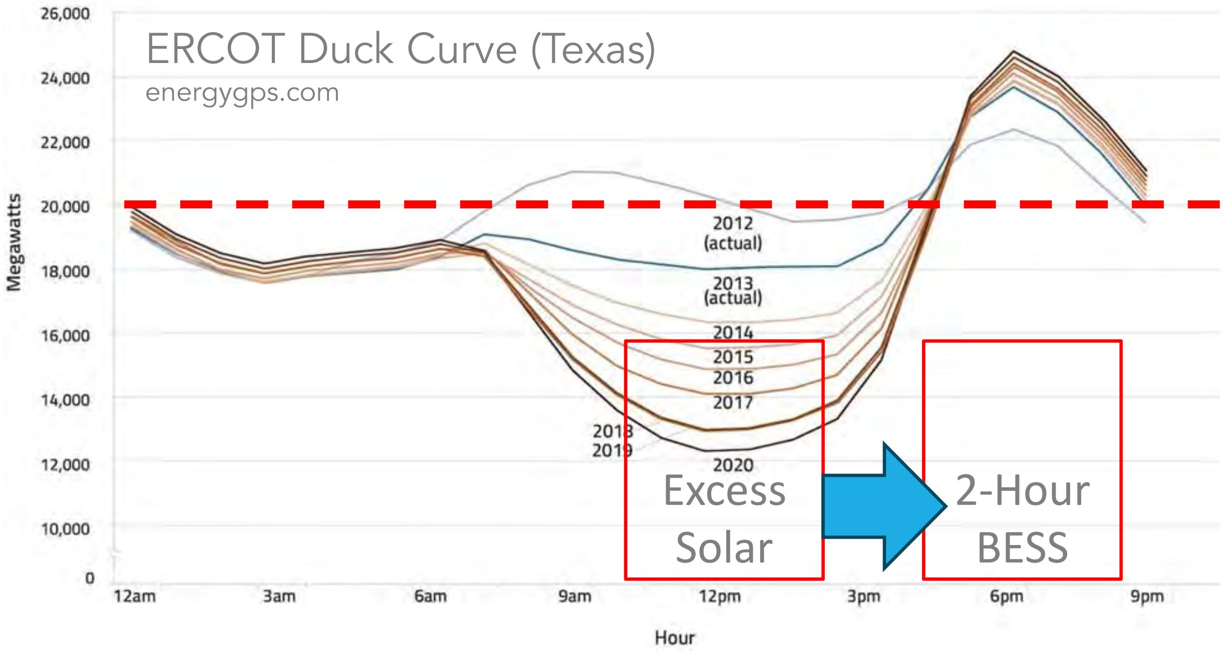
- Complete implementation of 24 kV electrical loop.
- Complete individual building-level upgrades in preparation for all-electric systems.
- Continue energy conservation measures in existing facilities.
- Implement second phase of steam system decommissioning. Migrate other utilities out of tunnel systems or repair tunnels if needed to contain other utilities (CHW, IT, electrical).
- Migrate select buildings to fully electric systems.
- Design and install additional photovoltaic and storage systems on campus.
- Complete phase-out of natural gas in existing buildings and replace with electrified heat sources.
- Design and install additional photovoltaic systems on campus.
- Invest in virtual power plant infrastructure when purchasing Electric Vehicles (bi-directional)
- Implement wider Micro-Grid Capabilities (for Islanding), incorporating Direct Current Systems
- Explore, study, and implement new district thermal energy systems at Arrowhead, dorm, family housing, athletics, core classroom, and research districts. Refer to Section 3 for additional discussion on these potential systems.

2040 Plan (2030-2040)

- Implement third, fourth, and fifth phases of steam system decommissioning.
- Migrate final buildings to fully electric systems.
- Design and install additional photovoltaic and storage systems on campus.
- Fully decommission and end use of use of natural gas turbine on campus.
- Fully decommission and end use of use of natural gas steam boilers on campus.
- Continue energy conservation measures in existing facilities.
- Study and implement carbon sequestration and carbon capture systems on campus.
- Expand district thermal energy systems.
- If present, study and implement hydrogen usage on campus.
- Achieve planned carbon neutrality of consumed utilities by 2040.

SOLAR PV + STORAGE





Battery Energy Storage Systems (BESS)

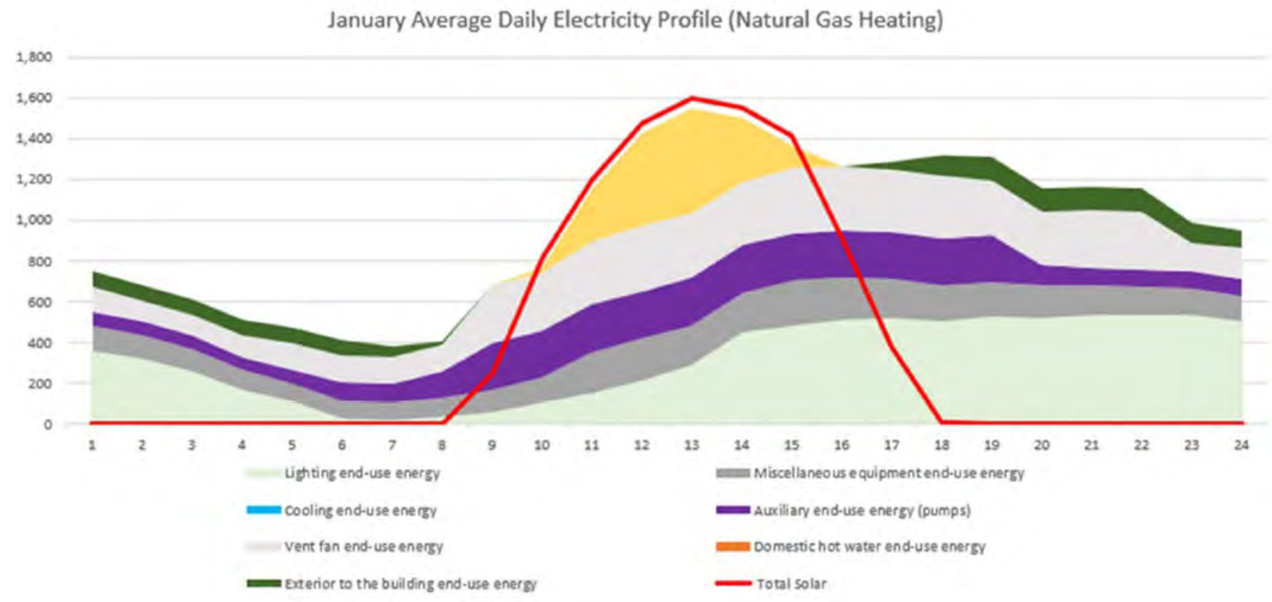
- Energy Discharge for 2-4 Hours
- Typically used for Energy Arbitrage (Cost Savings)

  More use cases now → load smoothing, frequency regulation, and resilience
- Predominantly Lithium-Ion Chemistry (LFP and Sodium)
- Charge with Solar (DC) or Stand-Alone Grid-Power (AC)
- Retains Federal Tax Credits with OBBBA
- Saves both Energy Costs and Demand Charges (good payback)
- 1 MW of Solar = 5 MWh of BESS in one 40’ Conex
  - *~$400/kWh First Cost and 15-Year Life with ~$100/kWh recycling*

Battery Energy Storage Systems (BESS)

ENERGY ARBITRAGE

- Demand Charges & Load-Shifting (Standalone Energy Storage)
- Much like Thermal Energy Storage Systems (Chilled-Water or Ice)
- Moving generation to when it is needed – the “on-peak” window



Example from Canadian Solar Corporation

Future of the Industry

HENDERSON
ENGINEERS

EMBODIED CARBON

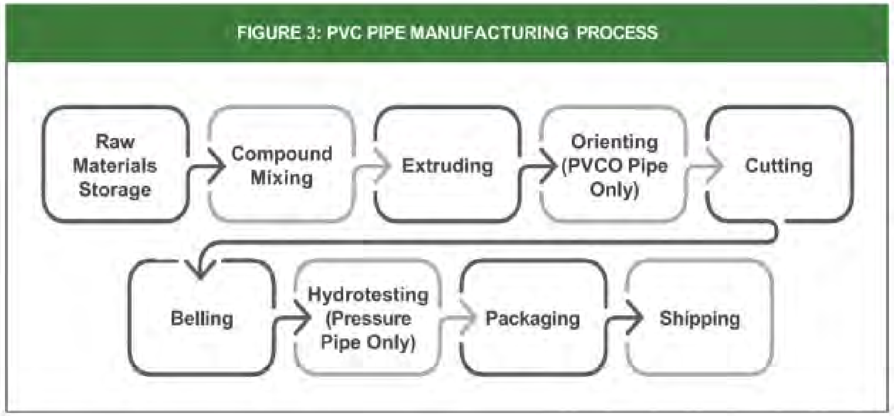
MEP 2040
Committing to Zero

A critical factor in addressing climate change, representing total greenhouse gas emissions associated with:

- Production
- Transportation
- Installation
- Maintenance
- Disposal

TABLE 1: SUMMARY OF EMBODIED CARBON AND ENERGY

Product	Embodied Carbon A1-A3	Embodied Energy A1-A3
	kg CO_2 eq / 1,000 ft	MJ / 1,000 ft
8" DR 18 AWWA C900	9.10E+03	2.64E+05
8" DR 25 AWWA C900	6.70E+03	1.95E+05
24" DR 25 AWWA C900	5.89E+04	1.69E+06
8" PC 235 AWWAC909	6.38E+03	1.79E+05
24" PS 46 (Profile) ASTM F794 / AASHTO M304	3.19E+04	9.34E+05
8" PS 46 (Profile) ASTM F794	2.67E+03	7.71E+04
8" DR 35 ASTM D3034	4.31E+03	1.18E+05
24" PS 46 ASTM F679	3.06E+04	8.88E+05



nsfsustainability.org

Building materials, systems, vehicles, consumables, etc.

Solar PV Readiness
IECC 2021

APPENDIX CB SOLAR READY ZONE COMMERCIAL

CB103.3 Solar-ready zone area.

The total solar-ready zone area shall be not less than 40 percent of the roof area calculated as the horizontally projected gross roof area less the area covered by skylights, occupied roof decks, vegetative roof areas and mandatory access or set back areas as required by the *International Fire Code*. The solar-ready zone shall be a single area or smaller, separated sub-zone areas. Each sub-zone shall be not less than 5 feet (1524 mm) in width in the narrowest dimension.

CB103.4 Obstructions.

Solar ready zones shall be free from obstructions, including pipes, vents, ducts, HVAC equipment, skylights and roof-mounted equipment.

CB103.5 Roof loads and documentation.

A collateral dead load of not less than 5 pounds per square foot (5 psf) (24.41 kg/m^2) shall be included in the gravity and lateral design calculations for the solar-ready zone. The structural design loads for roof dead load and roof live load shall be indicated on the construction documents.

CB103.6 Interconnection pathway.

Construction documents shall indicate pathways for routing of conduit or piping from the solar-ready zone to the electrical service panel and electrical energy storage system area or service hot water system.

CB103.7 Electrical energy storage system-ready area. INSIGHTS

The floor area of the electrical energy storage system-ready area shall be not less than 2 feet (610 mm) in one dimension and 4 feet (1219 mm) in another dimension, and located in accordance with Section 1207 of the *International Fire Code*. The location and layout diagram of the electrical energy storage system-ready area shall be indicated on the construction documents.

> INSIGHTS (1)

CB103.8 Electrical service reserved space.

The main electrical service panel shall have a reserved space to allow installation of a dual-pole circuit breaker for future solar electric and a dual-pole circuit breaker for future electrical energy storage system installation. These spaces shall be labeled "For Future Solar Electric and Storage." The reserved spaces shall be positioned at the end of the panel that is opposite from the panel supply conductor connection.

Virtual Power Plants (VPP's)

System of **distributed** energy resources working together to balance energy supply **and** demand (flexible capacity) on a large scale using:

- ✓ Rooftop solar panels
- ✓ Battery energy storage
- ✓ Electric vehicle chargers
- ✓ Smart water heaters

Usually run by local utility companies who oversee demand/DER balancing.

Solar Power World · 6d

North American VPP market reaches 37.5 GW of flexible capacity

The virtual power plant (VPP) market grew rapidly over the last year, reaching 37.5 GW of behind-the-meter flexible capacity, ...

CBC · 16d · on MSN

These homes generate power for the grid — and residents don't worry about blackouts

When there's a blackout, the power stays on at Rebecca Calder's house. That's because her home is equipped with a battery for ...

pv magazine USA · 12d

California's virtual power plant program helped prevent blackouts and reliance on fossil fuels. Now its future is in jeopardy.

Gov. Newsom pushed off making a decision over the fate of a program to prevent California's blackouts and lower costs, but ...

P3's + Alternative Financing

- Utility Company Cost Sharing
- Developer Lead Projects on Public Property
- Energy Service Performance Contracts (ESPC)
- Energy as a Service (EAS) Contracting
- Solar & Storage Power Purchase Agreements (PPA)
- Thermal Energy Networks (TEN) and Cost-Share

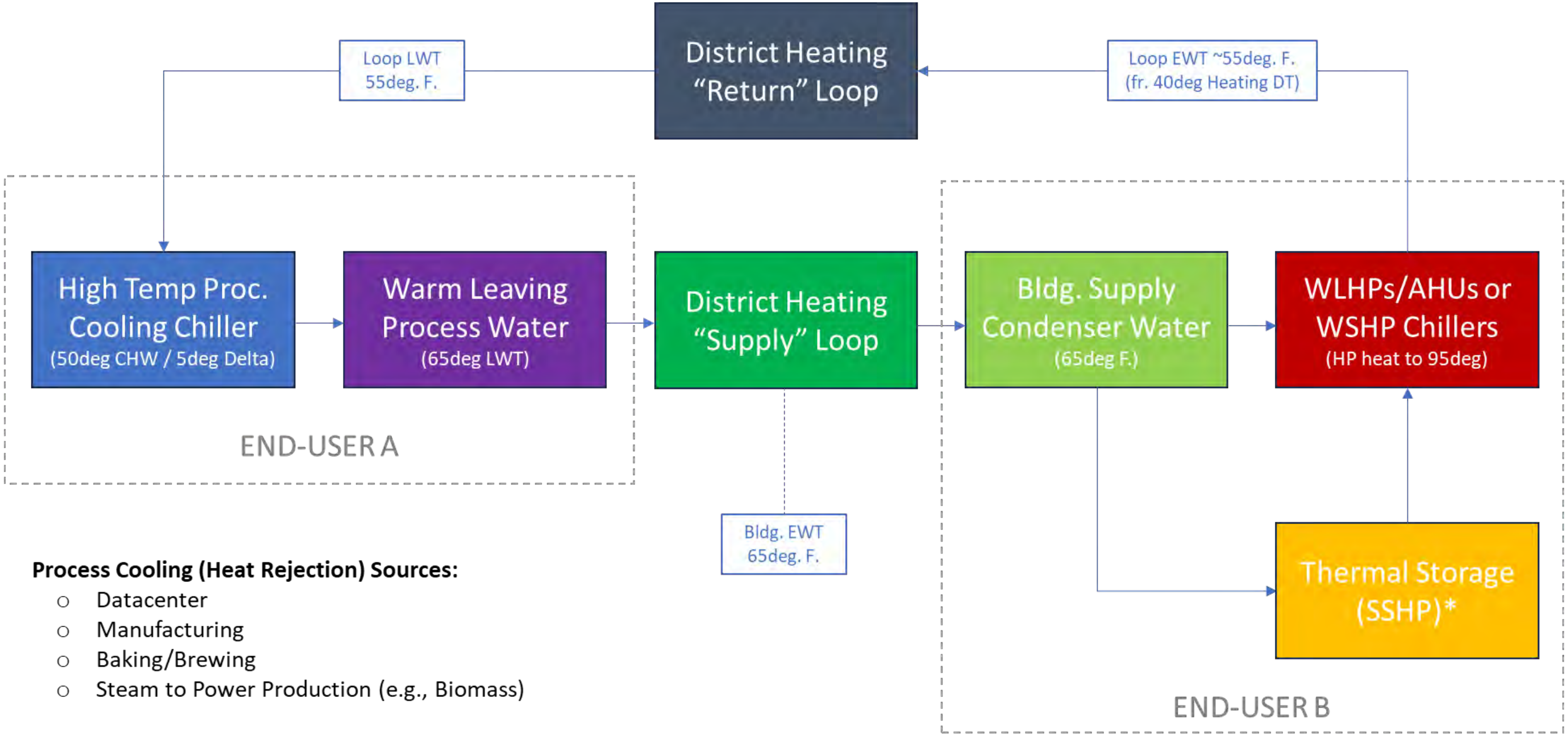
P3 – Public Private Partnership (with mutuality in benefit)

NM STATE
BE BOLD. Shape the Future.
New Mexico State University
NEWSROOM

The site consists of:

- 10,000 solar panels
- 3-MW solar PV array
- 1-MW / 4-MWh BESS
- 4-Hour Discharge

Thermal Energy Networks (TEN's)



Process Cooling (Heat Rejection) Sources:

- Datacenter
- Manufacturing
- Baking/Brewing
- Steam to Power Production (e.g., Biomass)

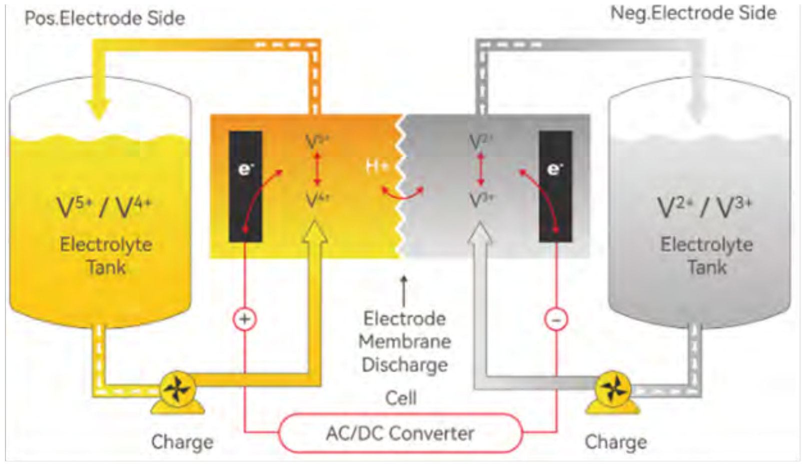
*SSHP: Storage Source Heat-Pump

LONG DURATION STORAGE

- Energy Discharge for >8 or >10 Hours (for resilience and decarbonizing industry)
- Many pilot sites are deployed globally, but few are available off-the-shelf
- Industry is familiar with Pumped Hydro & CAES

Customizable Solutions | ESS, Inc.

40' Conex x 9' Wide with Maintenance Clearance = 1,000 sqft per 500 kWh

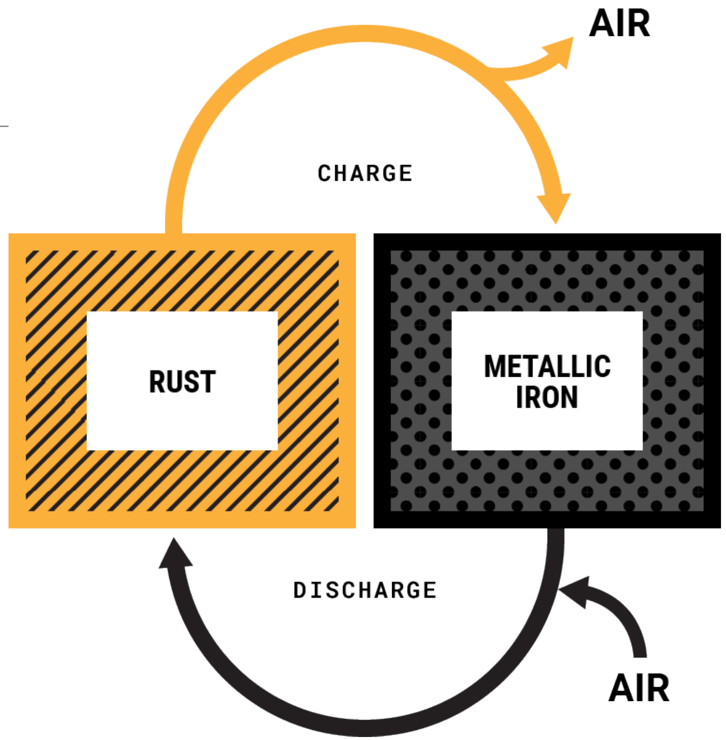


https://www.wontai.cn

Non-Flammable Long-Duration Storage (8-Hour Discharge)

LONG DURATION STORAGE

- Form Energy (Reversable Iron Oxidation)
- ESS, Inc. (Vanadium Redox Flow)
- Compressed CO2 (Hydrostore)
- Gravity Systems (Energy Vault)
- Modular Pumped Hydro
- Thermoelectric (Antora)
- Hydrogen Electrolyzer + Fuel-Cell → H_2O to H_2 (Plug Power)

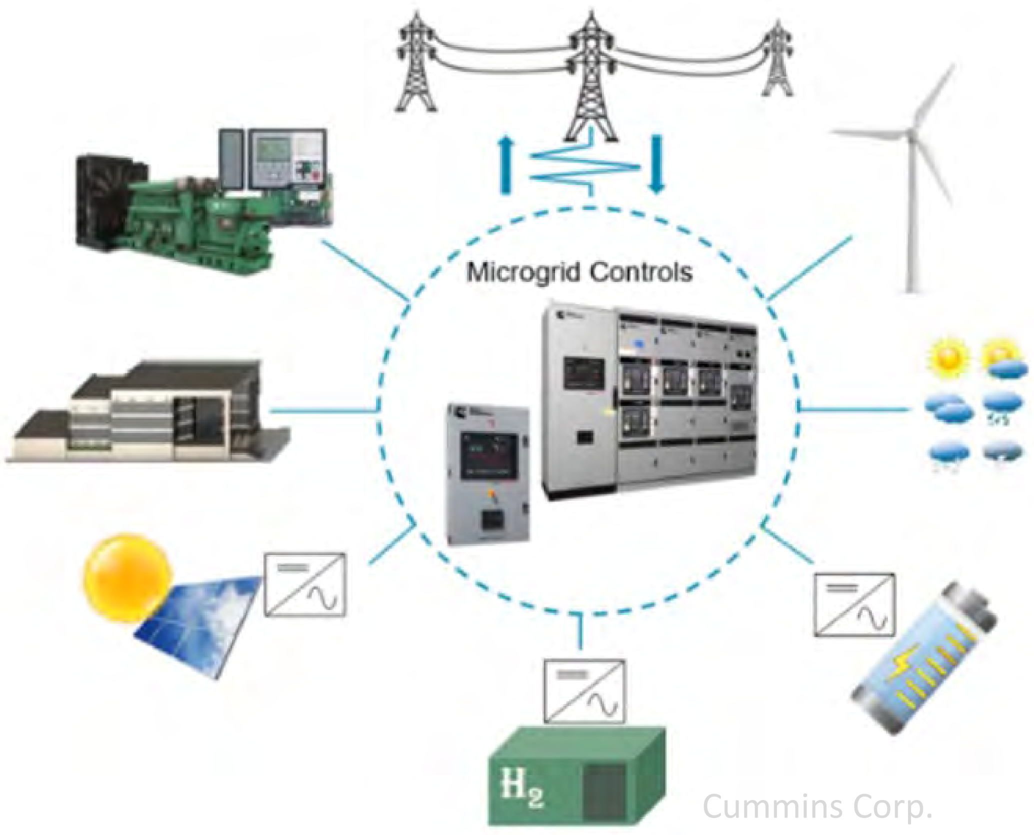


Battery Technology | Form Energy

RESILIENCE + MICROGRIDS

Generally defined as two or more Networked DER's, often storage with generation.

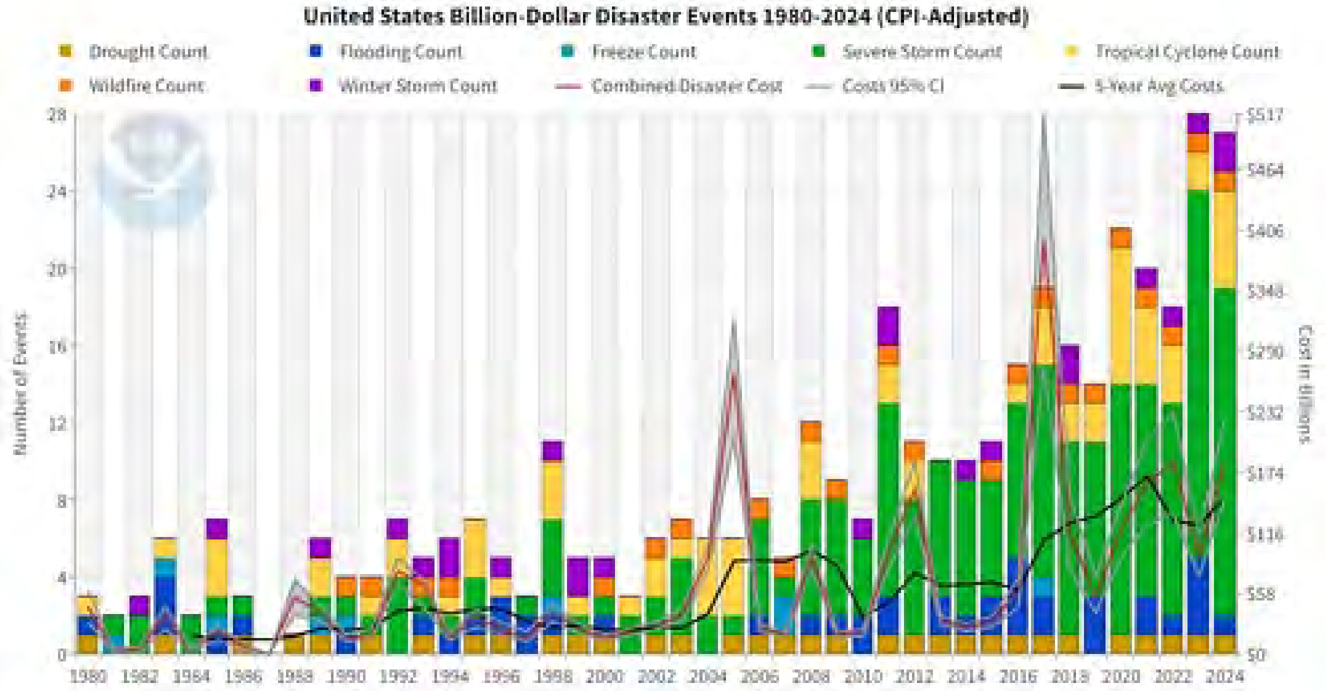
- **Designed for:**
  - Continuity of Operations
  - Passive Survivability
  - Performing Energy Arbitrage
- **Requires:**
  - Grid-Forming Capable Inverters
  - Microgrid Controls Integration



Cummins Corp.

RESILIENCE PLANNING + MITIGATION

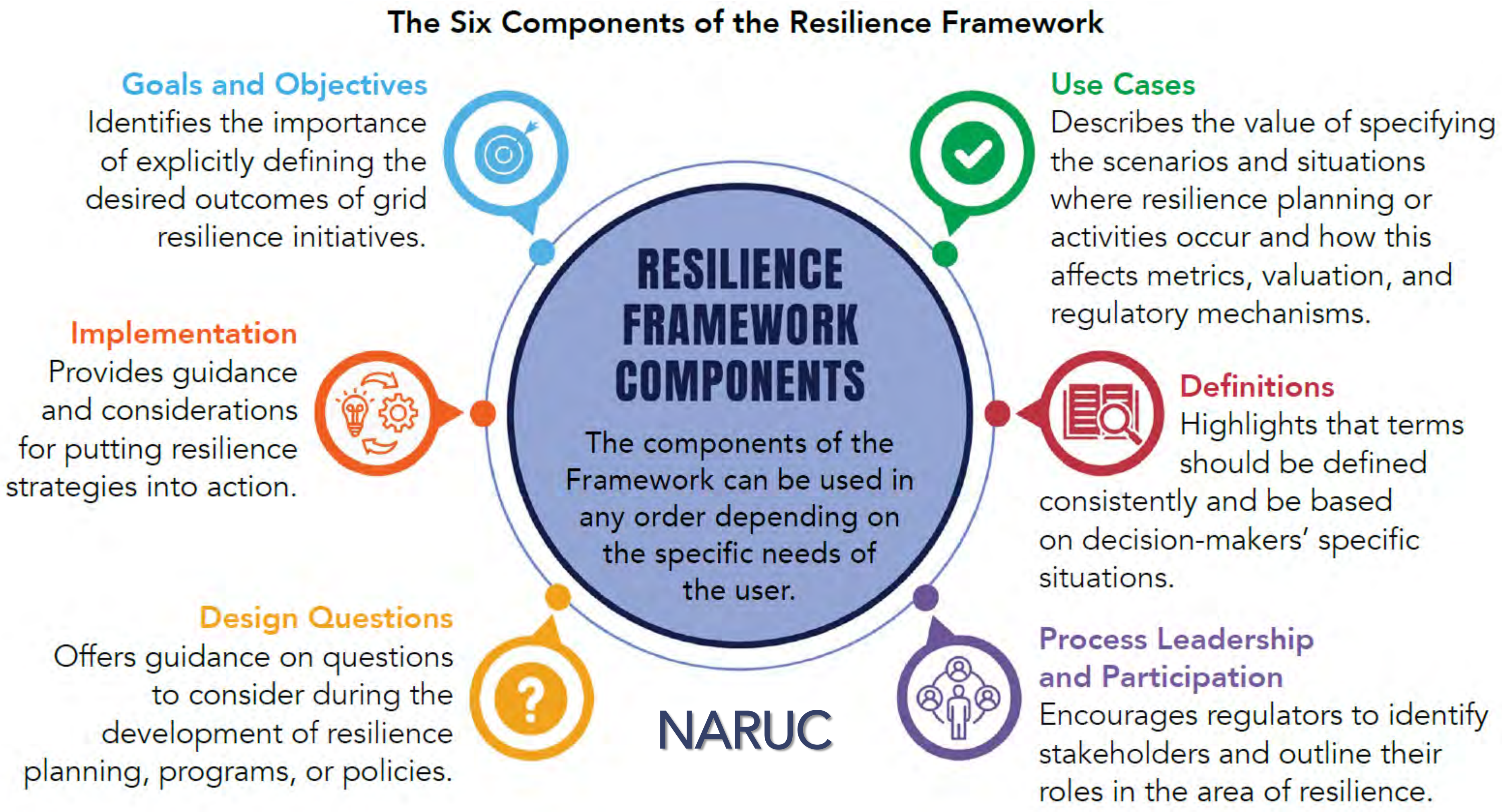
https://pubs.naruc.org/pub/1037E2EB-D1FE-747C-C0DD-2A78CF3ECDE3



U.S. Billion-dollar Weather and Climate Disasters, 1980 - present (NCEI Accession 0209268)

Grid Hardening Measures | Grid Enhancing Technologies (GETs)

RESILIENCE + MITIGATION MEASURES



LOAD GROWTH ON AN AGING GRID

- Fleet and Consumer EV Charging
- Vehicle to Grid (V2G) Bi-Directional Charging
- Rapid Cross-Sector Electrification from:
  - Warming Environment and more Air-Conditioning
  - Industry & Manufacturing
- Winter Peaking with Heat-Pumps
- AI Data Centers (special tariffs and interconnection rules)

electrek.co

Thank You

Matt Higgins

Lead Energy & Utility Consultant

CEM, CxA, HBDP, LEED-AP (BD+C), NABCEP PVA

Matt.Higgins@HendersonEngineers.com

(505) 507-4717 cell
(913) 742-5615 office

HENDERSON ENGINEERS