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Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat

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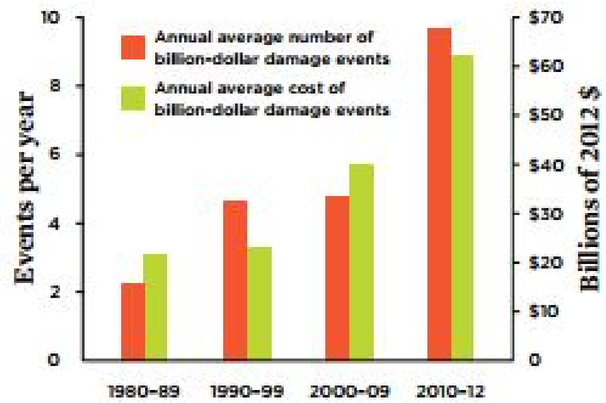
California Center for Sustainable Communities at UCLA

Background

- Climate change has increased the amount of extreme weather events
- Energy sector is especially vulnerable to increases in temperature and decreases in available water sources*+
  - Higher energy consumption levels to maintain thermal comfort
  - High air and water temperatures reduce efficiency of cooling for power plants
  - Oil and natural gas production requires significant amounts of water
  - Reduced efficiency for electricity transmission and distribution systems
  - Flooding and storm surges can damage energy infrastructure
  - Changes in water resources for hydro-power



Extreme weather events have become much more common as well as costly over the past three decades.

SOURCES: NOAA 2013A; WEISS AND WEIDMAN 2013A.

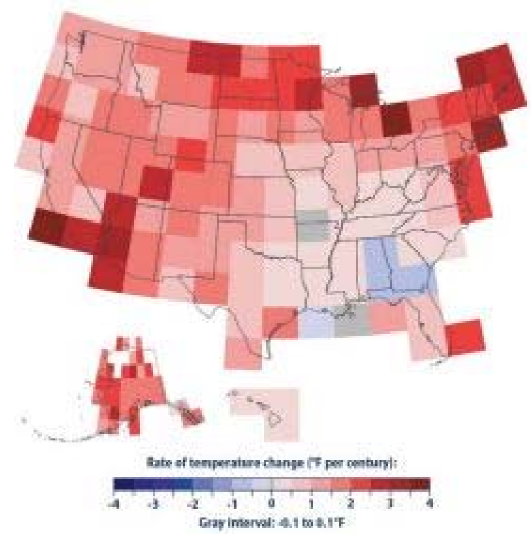


Figure 3. Rate of warming in the United States by region, 1901–2011

Source: EPA 2012a

*D.O.E., *U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather*, July 2013

+Union of Concerned Scientists, *How Climate Change Puts Our Electricity at Risk – and What We Can Do*, April 2014

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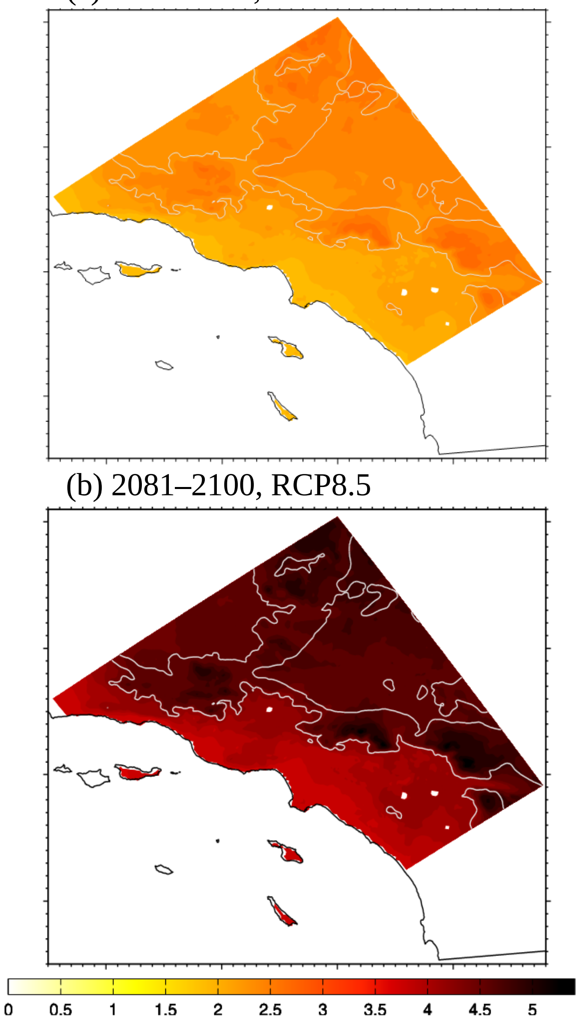
Future warming projections

- Global climate models were used to project temperature increases based on representative concentration pathway (RCP) scenarios*,+
  - 30+ CMIP5 global climate models and two RCPs were used
  - RCP 4.5: GHG emission reductions over 21st century ("mitigation")
  - RCP 8.5: Continued 21st century GHG emissions increases ("business as usual")
- Temperature projections were downscaled to 2 km by 2 km resolution for LA county for three time periods, 2021–2040, 2041–2060, and 2081–2100 *,+

(a) 2041–2060, RCP8.5

(b) 2081–2100, RCP8.5



Ensemble mean of downscaled annual-mean surface warming (°C) for (a) mid-century (2041–2060) and (b) end of century (2081–2100), under RCP8.5. White contours are plotted at 1000-m elevation.

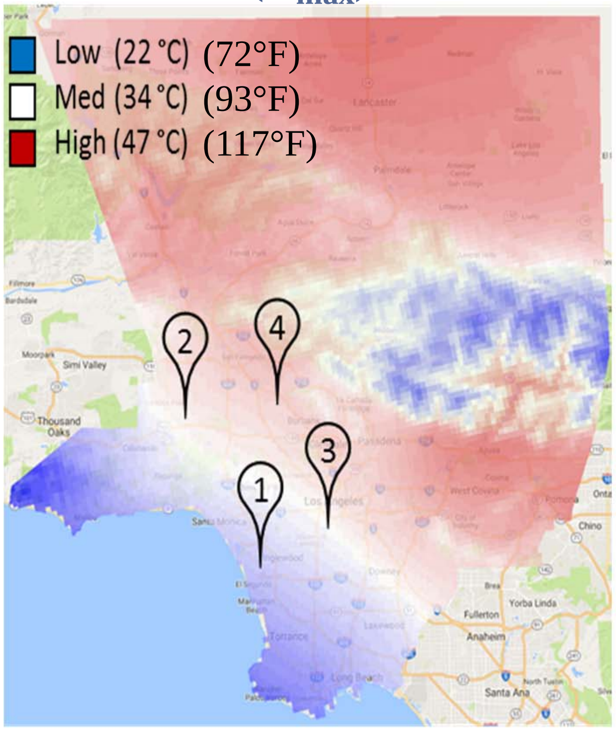
*D. Walton, F. Sun, A. Hall, S. Capps, *A Hybrid Dynamical-Statistical Downscaling Technique. Part I: Development and Validation of the Technique*, Journal of Climate, 2015

+F. Sun, D. Walton, A. Hall, *A Hybrid Dynamical-Statistical Downscaling Technique. Part II: End-of-Century Warming Projections Predict a New Climate State in the Los Angeles Region*, Journal of Climate, 2015c

Quantifying uncertainty in air temperatures

Differences between historical *T90* and T_{max} have been over 16°C (30°F).
As we develop better capabilities for predicting T_{max}, how can we better prepare for extremes?

2000-2016 mean daily maximum air temperature (T_{max})



Comparison of early century (2000-2016), and projected mid century (2021-2060), and late century (2061-2099) daily maximum air temperatures.

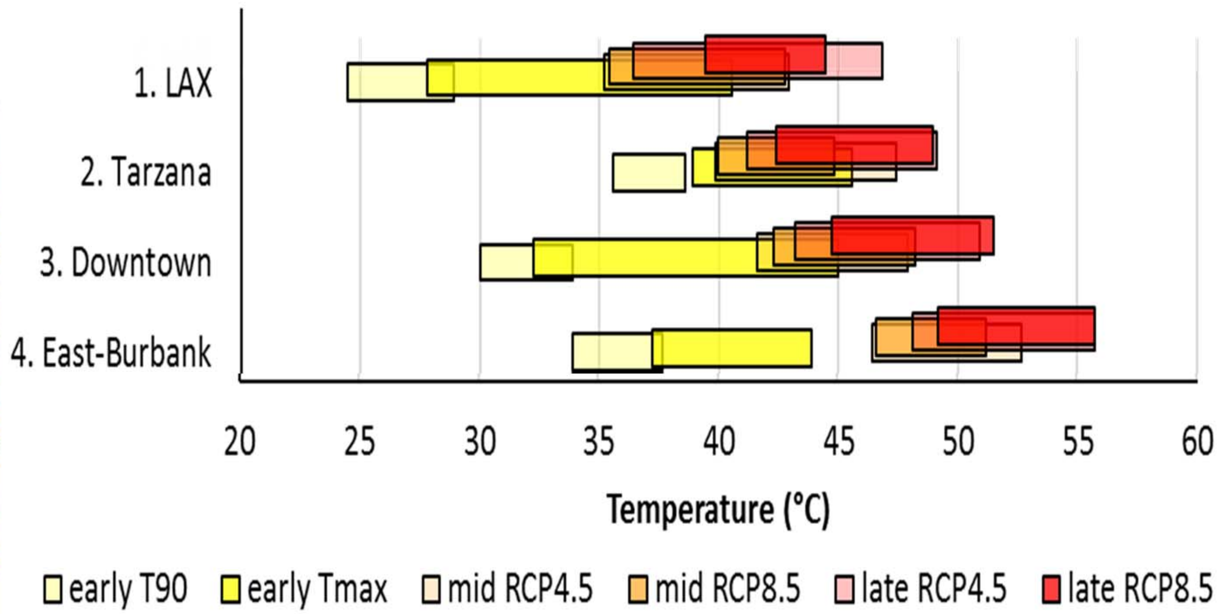


Figure Source: D Burillo, M Chester, B Ruddell, N Johnson, Electricity demand planning forecasts should consider climate non-stationarity to maintain reserve margins during heat waves, In Preparation.

Temperatures effects on peak demand

Physics-based structural equation model (SEM) outperforms previous straight-line methods.
Considered 3.4 million buildings in county lines, all generators, and efficiency losses (as derating) in natural gas plants.

- Peak demand as a function of air temperature
  - AC usage is the primary driver in increasing peak demand
  - Once all ACs are effectively “on” during a peak hour in an extreme heat event, peak demand continues to increase with higher temperatures at a slower rate
  - Accounting for the saturation of active AC units results is a better reflection of peak demand than the straight line approach

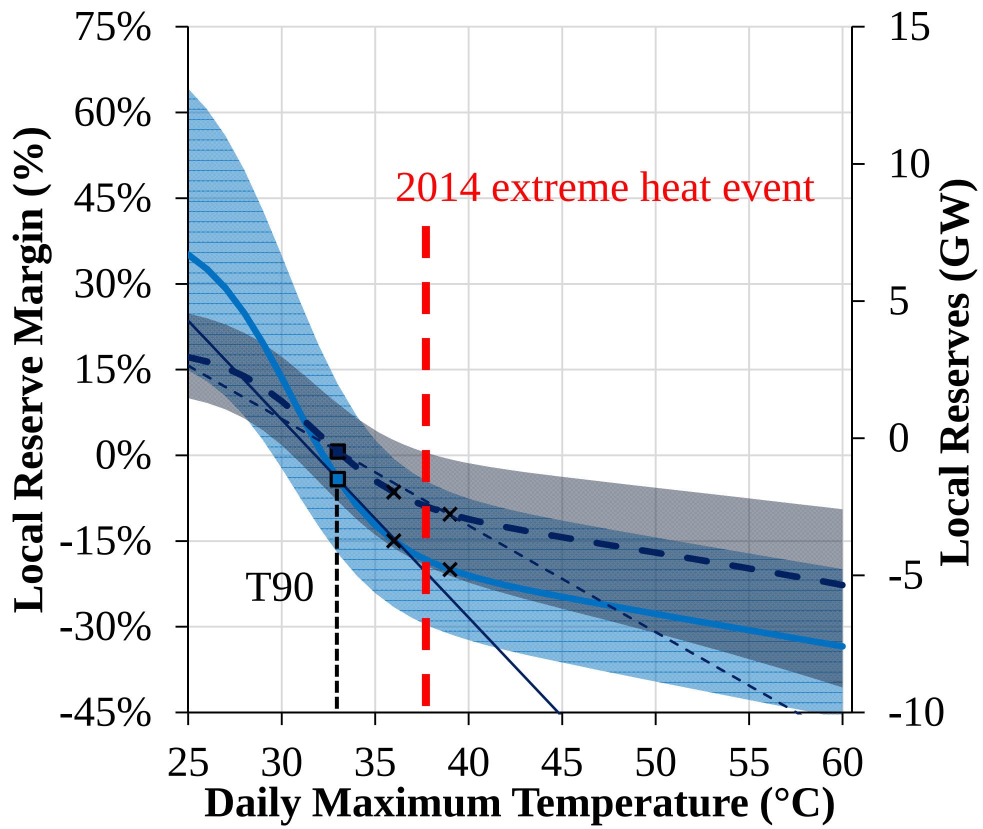
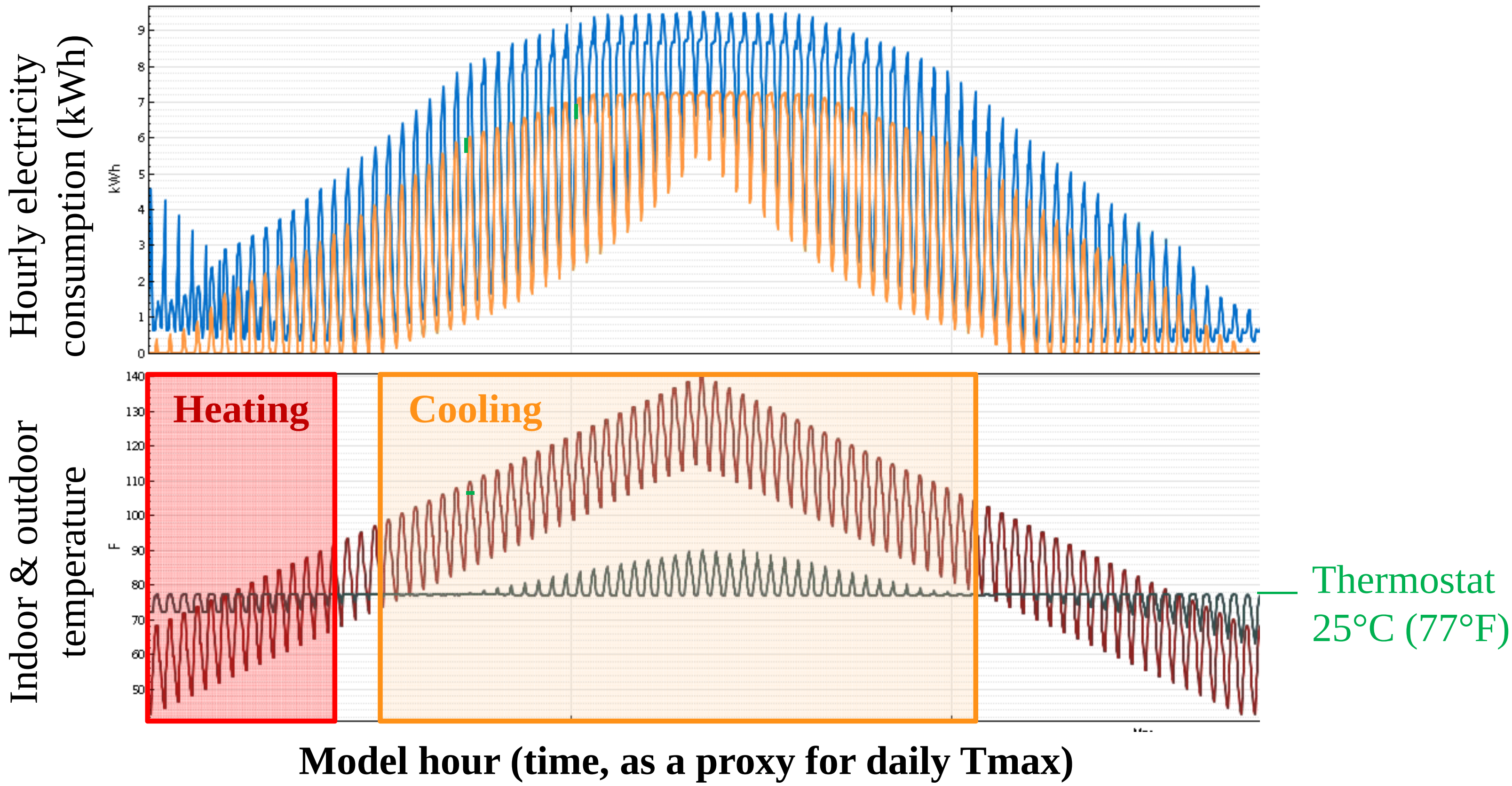


Figure Source: D Burillo, M Chester, B Ruddell, N Johnson, Electricity demand planning forecasts should consider climate non-stationarity to maintain reserve margins during heat waves, In Preparation.

Modeling temperature effects on electricity consumption

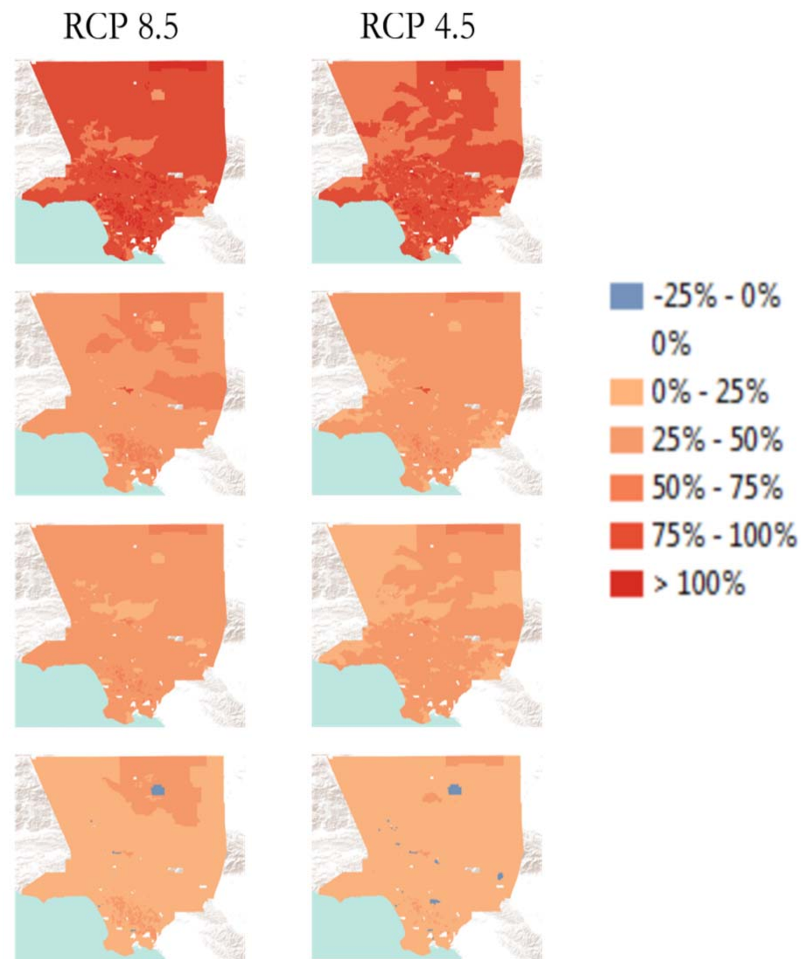
We are using 51 and 48 residential and commercial building prototypes to simulate hourly electricity consumption in all 3.4 million buildings in Los Angeles County. Critical factors include: building type, and age (proxy for insulation & appliance efficiencies).



Total E (kWh)
E for cooling (kWh)
Outdoor Drybulb (°F or °C)
Living Space Indoor Temperature (°F or °C)

Next steps

- Building modeling found that in some cases, new buildings consume more energy than older buildings under extreme heat events
  - We will need to further investigate the causes of this
- Spatial projections of peak demand will be produced for LA County
  - They include different climate, population growth, and energy efficiency scenarios



Estimated results for changes in peak electricity demand based on climate, population growth, and energy efficiency scenarios

Spatial Map Source: J Reyna and M Chester, Expected 2017, Energy Efficiency to Reduce Residential Electricity and Natural Gas Use Under Climate Change, Nature Communications, In Press.

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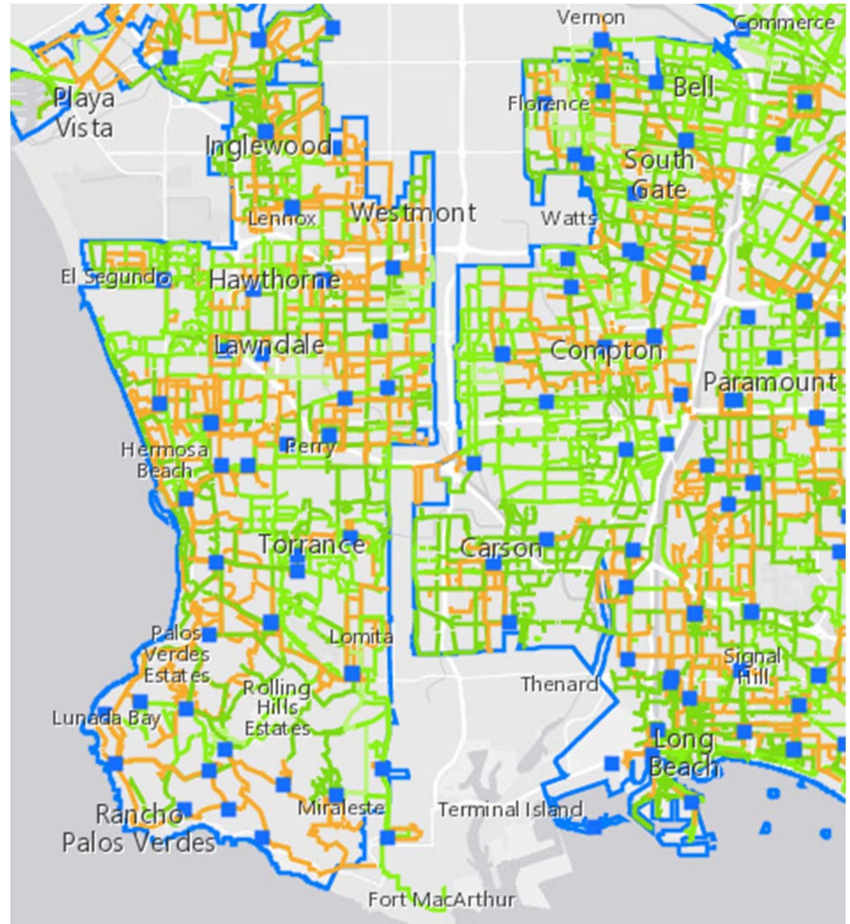
Potential application of analysis on the grid

- Understanding the impacts extreme heat has on the grid
  - How will the existing grid handle the increases in electricity demand due to higher temperatures?
  - What areas are more likely to experience strain during a high heat event?
- Planning to make the grid more resilient
  - What technical and policy solutions can be identified to make the grid more resilient to high heat events?



The DERiM map showcases the remaining availability for circuits in SCE territory

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Policy considerations

- Reduce peak load and load variances (per capita)
  - Incentivize multi-unit housing & transit oriented development
  - High building albedo, thermal insulation, shade, energy efficient appliances
  - Thermal storage AC systems
  - High-level utility incentives for load smoothness/consistency (let them innovate the details!)
- Prevent automatic outages in aging infrastructure & potential cascading outages
  - Identify circuits for distributed energy resources to relieve congestion
  - Develop standards for “dispatchable” distributed energy resources

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Further thoughts for consideration

- “Hard lines” are necessary to define parameters for engineering research legislation and markets.
- Other climate uncertainty issues exist related to air temperature that can affect power reliability
- When considering climate and energy for the sake of power reliability, we must understand the maximums. Some statistics are not relevant.
- It is important to evaluate trade-offs with other goals before implementation: power quality, security, water use, land use, emissions, hardware service life, and economics.