

Energy and Civilization

University of California at Berkeley

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Administrator and CEO

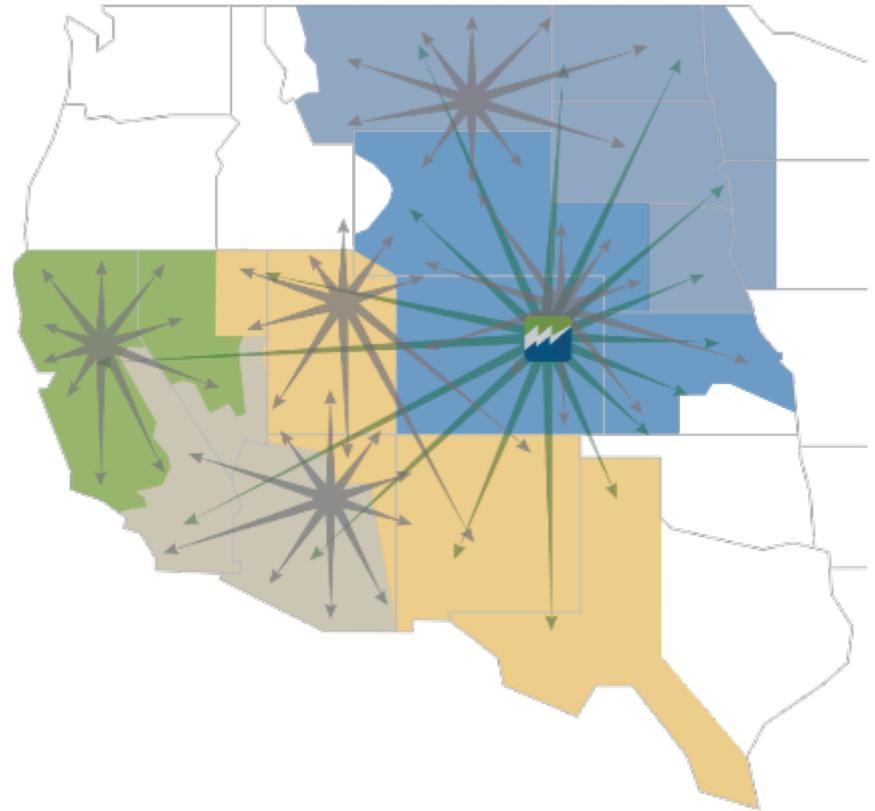
My perspective

- 30 years in electric industry (plus gas, oil and water)
- 8 years at Electric Power Research Institute
- Certified technology nerd
- Published author
- Utility, venture capital, private equity and consulting background
- A DOUG:
 - ✓ Dumb
 - ✓ Old
 - ✓ Utility
 - ✓ Guy



Who we are

- Serve 40 million Americans
- 15-state footprint
- 1.4 million square miles
- 49 offices
- ~700 customers
- Top-10 largest transmission utility in country



WAPA's services

- Firm electric
- Energy management and marketing
- Energy and resource planning
- Transmission
- Interconnection
- Ancillary



What we manage

- \$4.3 billion in assets
- 114,863 structures
- 17,231 miles of transmission line
- 322 substations
- 291 transformers
- 661 buildings
- 487 communication sites



Mission breakout

RELIABILITY

651
people

and

28
percent

of dollars invested
in maintenance
and related areas



DELIVERY

334
people

and

22
percent

of dollars dedicated
to power operations
and engineering areas



MARKETING

including purchase power
and wheeling

158
people

and

42
percent

of dollars committed
to power marketing areas



COST-BASED

and related services

298
people

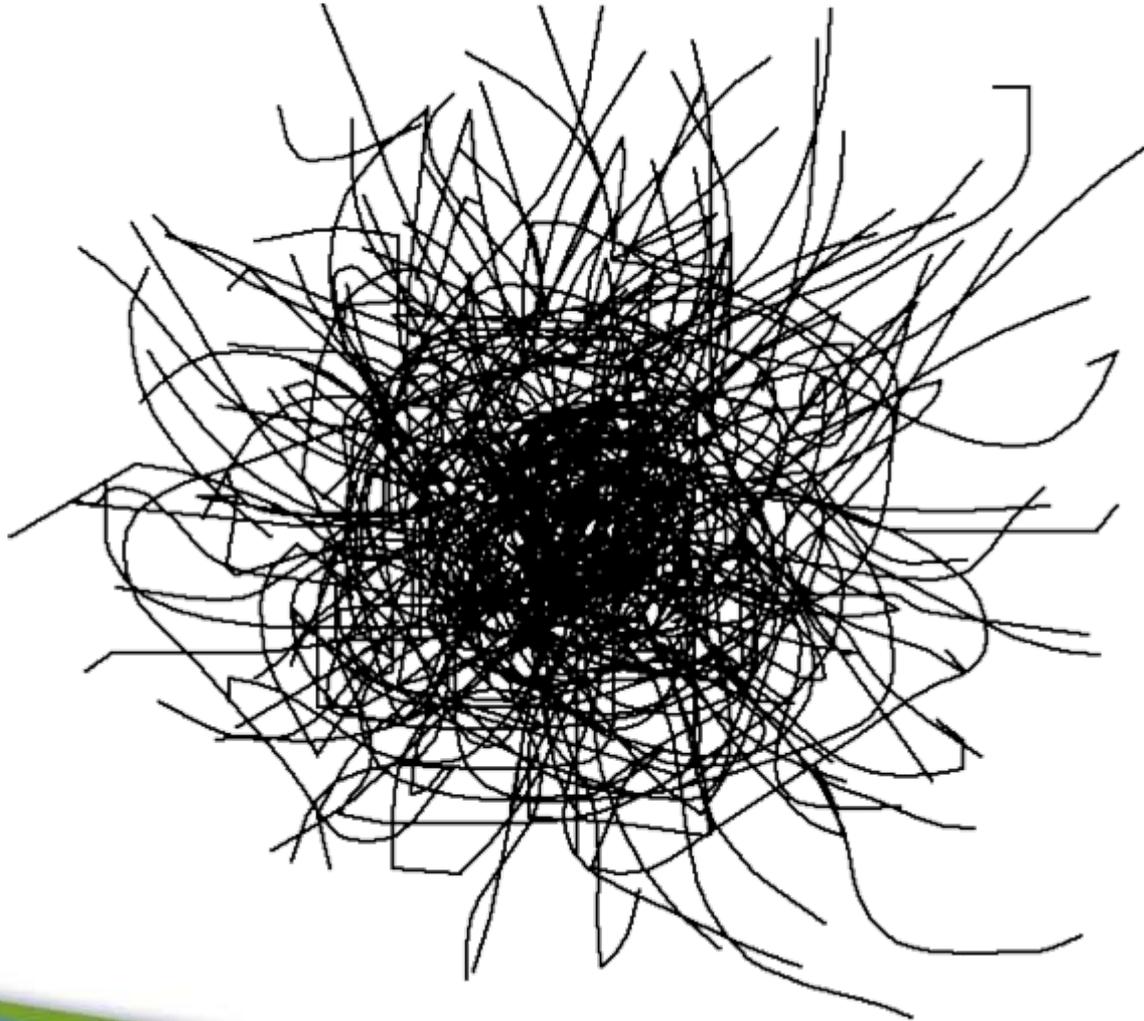
and

8
percent

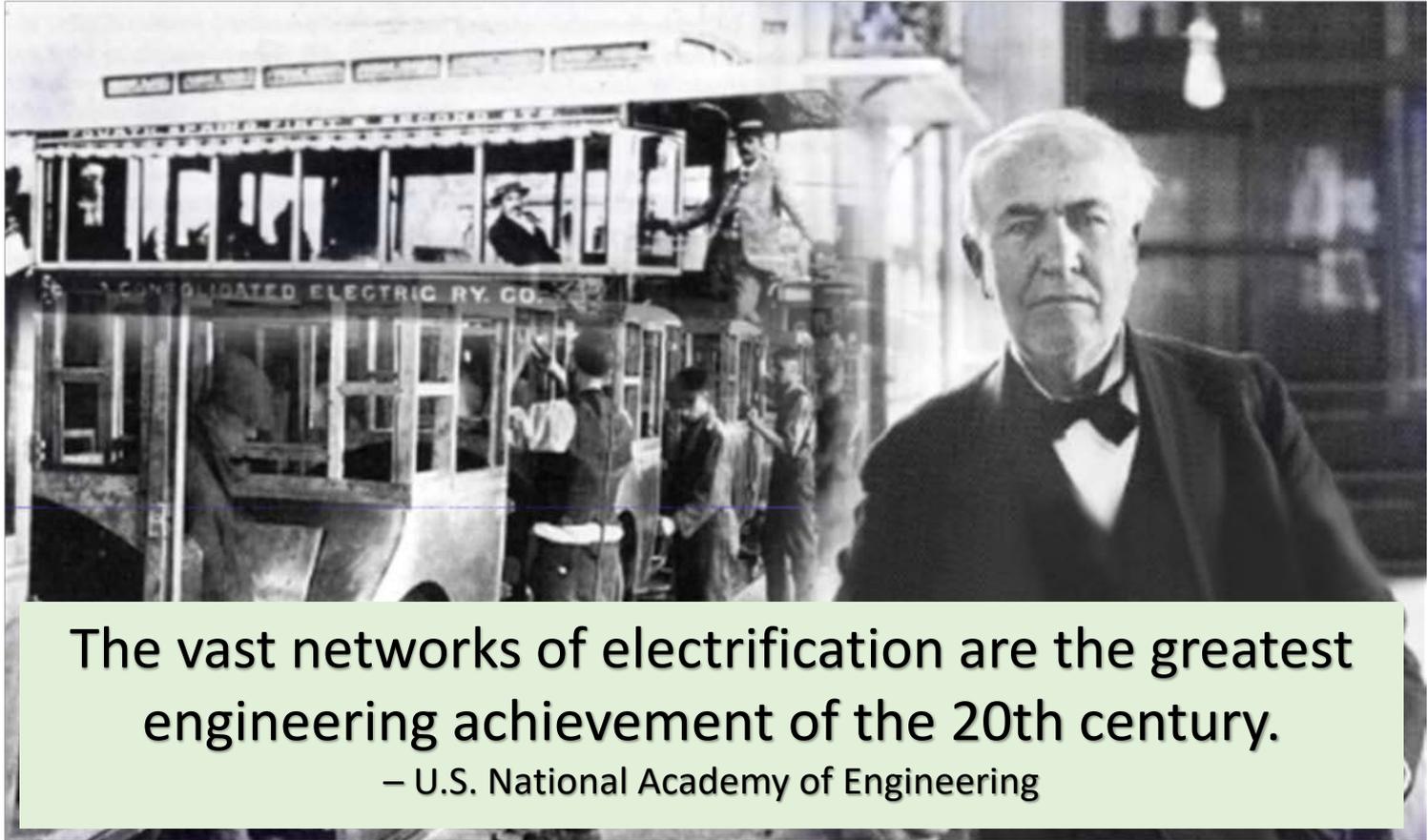
of dollars applied to
support the mission



Untangling giant hairball of electricity



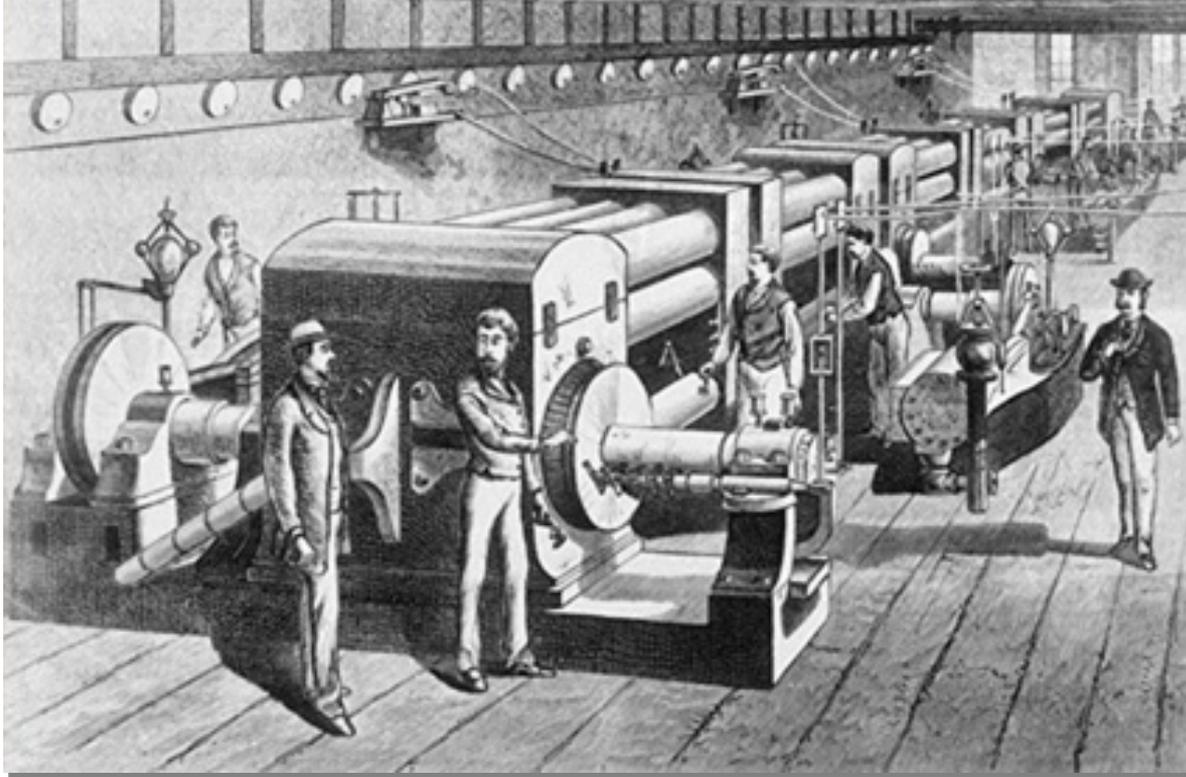
Do you recognize this man?



The vast networks of electrification are the greatest engineering achievement of the 20th century.

– U.S. National Academy of Engineering

Dot-com era circa 1880: electricity

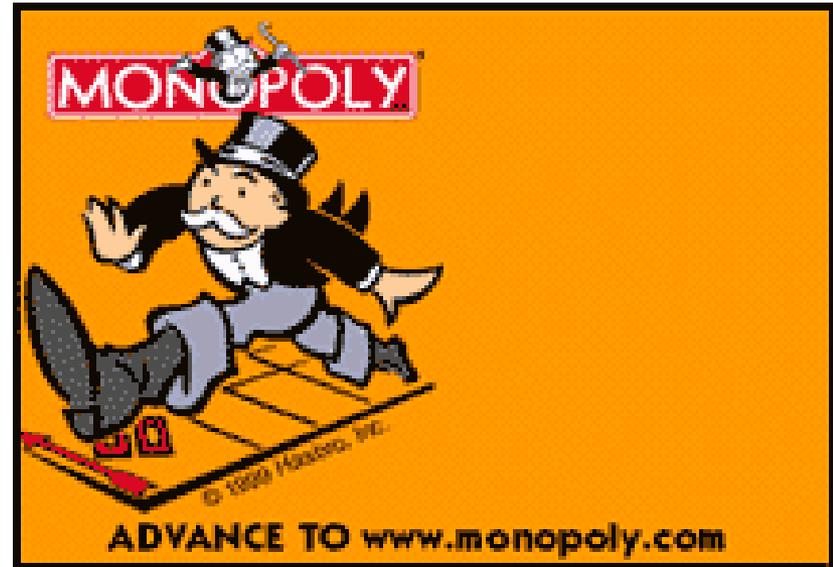


1882, First electric station built by
Edison on Pearl Street

Do you recognize this man?

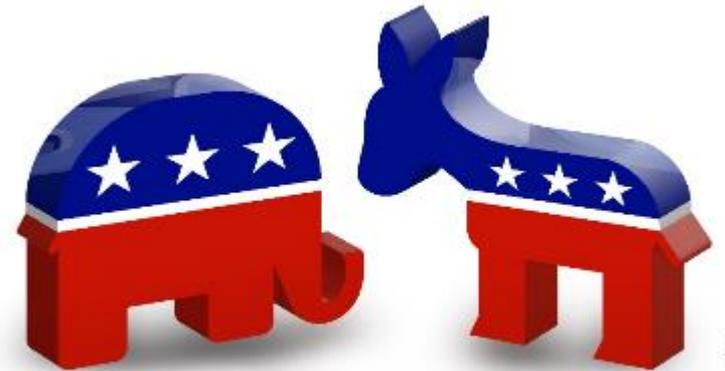
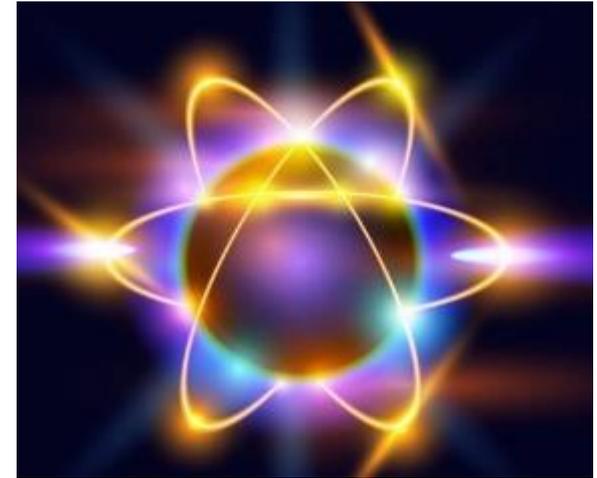


Samuel Insull,
aka the Monopoly Man



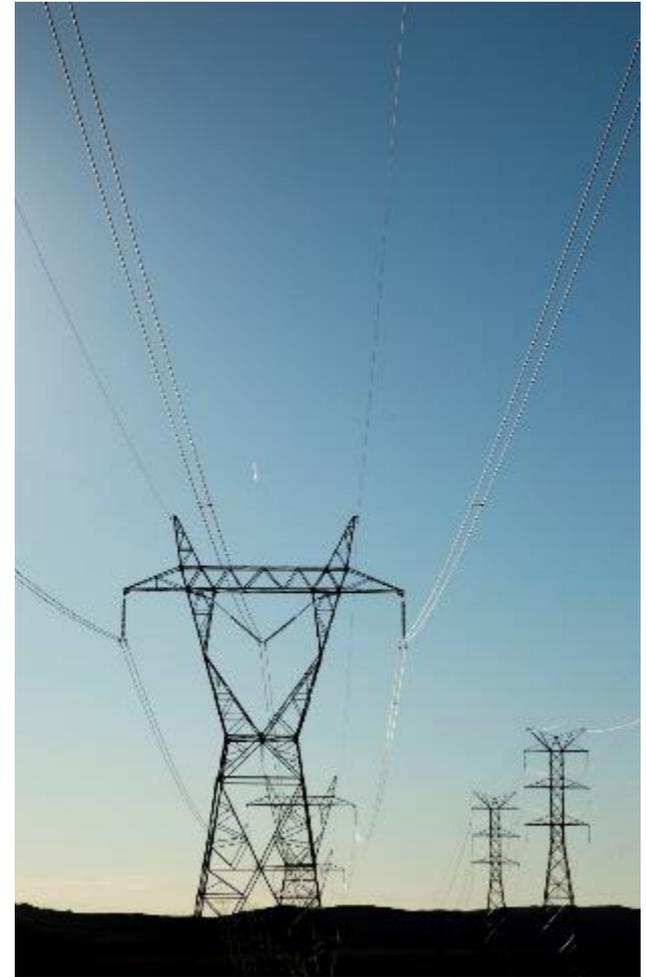
Basic rules of electricity

- Electrons are governed by the laws of physics
 - Flows to the point of least resistance
 - Always must be in supply and demand balance
 - No storage outside of fossil fuel, water and some chemical reactions
- Electricity is governed by the laws of politics



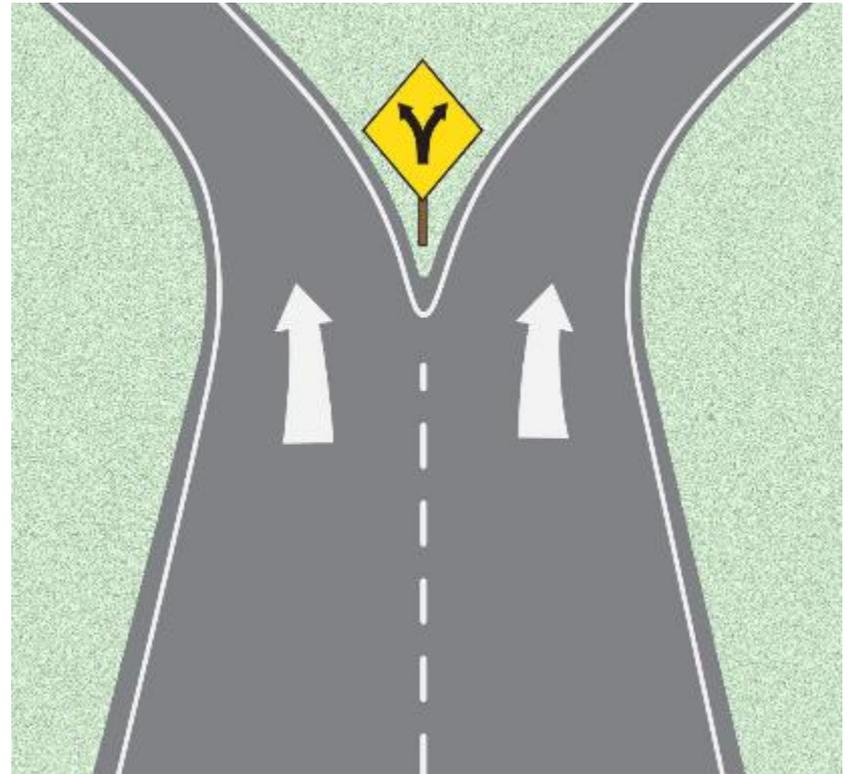
Build it bigger

- The U.S. power supply network is the largest most complex machine ever created
- Engages enterprise involving:
 - 5,000 corporate entities
 - Several forms of ownership and levels of regulatory oversight
 - Some 100 million customers
- Attempts to satisfy conflicting economic, social political and environmental objectives
- Complexity is increasing driving need for more system intelligence



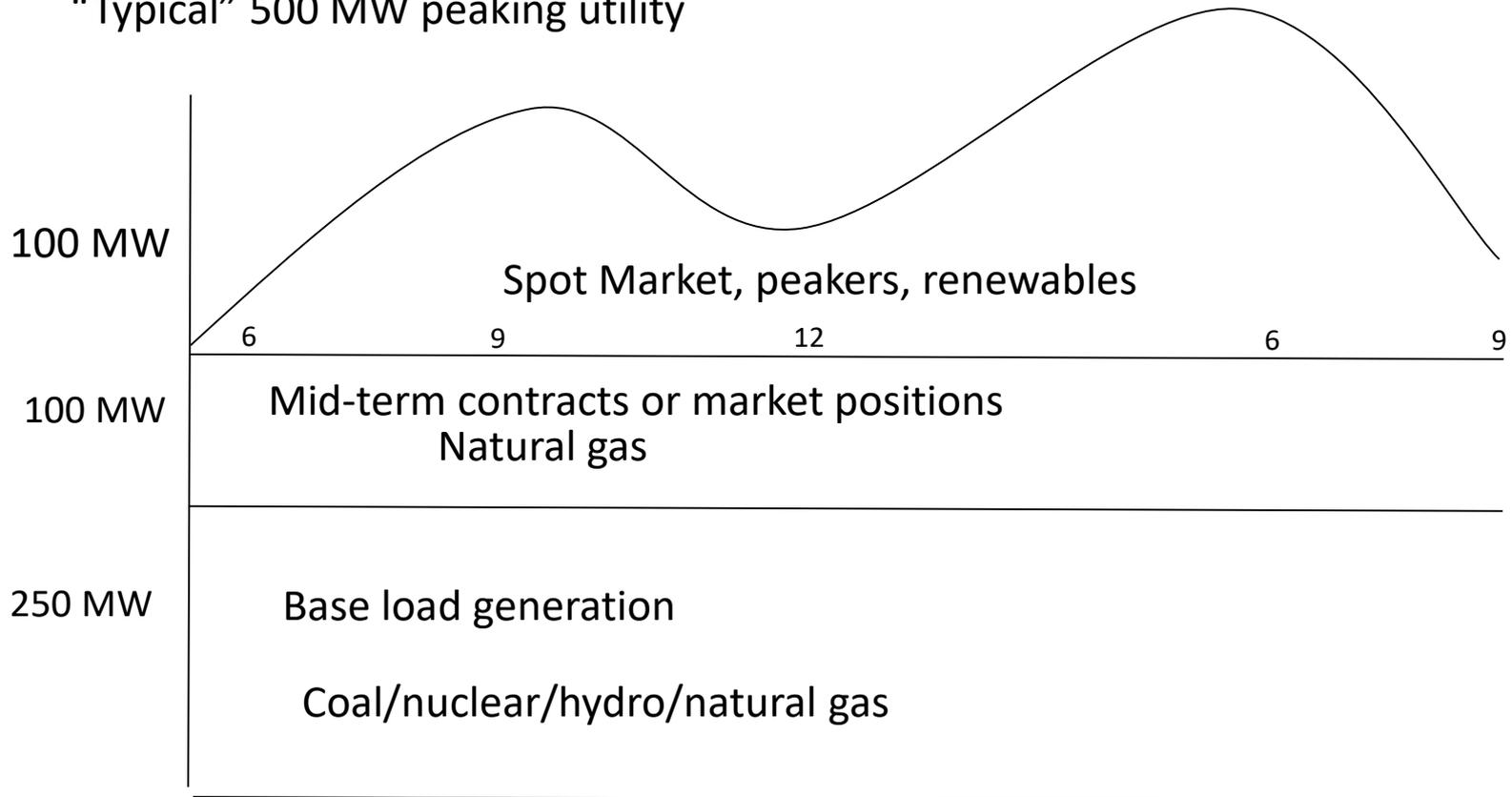
Challenges in the energy frontier

- Aging Infrastructure
- Increased regulation
- Intermittent resources
- Varying hydropower production
- More customer-side resources
- Changing markets
- Security



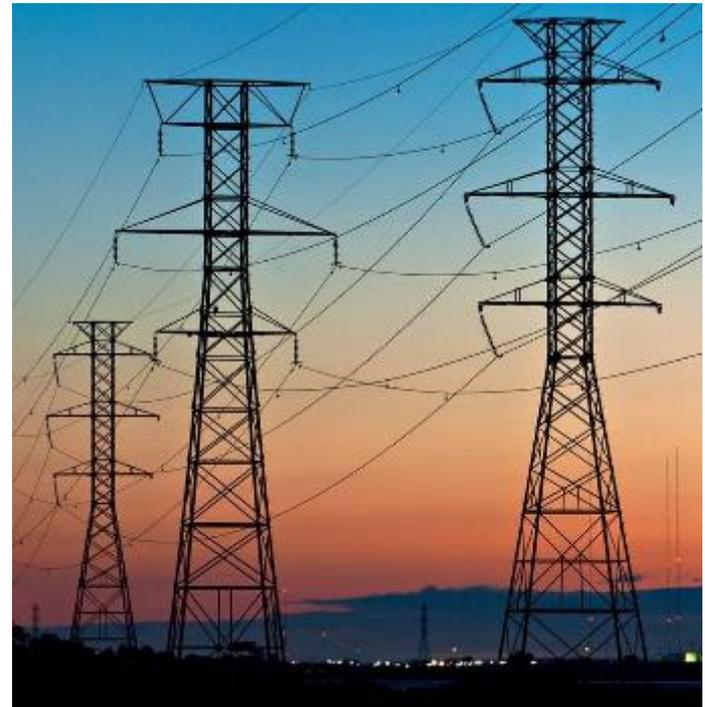
Challenge of system operations

“Typical” 500 MW peaking utility



Key concepts

- Utilities *make* money on assets
- Utilities *collect* money based on kWhs used
- Utilities may also act as tax collectors for states, municipalities and counties
- In many states (California) there is no benefit to utilities selling more electricity



Megatrend: Carbon/Capacity Conflict

We are on track for the “t***n w***k”
of regulations vs. carbon et al.



California is ground zero for the carbon/capacity conflict

- IMHO, there is plenty of blame to go around
- Improper incentives lead to poor choices
- Crushed energy prices constrain capital
- Keeping the lights on is a physics & engineering challenge, not a political decision



*Paradise, CA, destruction from 2018 Camp Fire
Courtesy of NBC News*

Importance of vegetation management



Before



After

Carbon constraints/capacity conflict

- Demand for new power sources will outstrip capacity
- Demand for clean energy will outstrip the capacity
- Public perception contrasts with the reality of the system
- Renewables are being promoted the only answer
- Cost of renewables creates financial challenges



Developed world
demand dead?
Developing world
demand galloping!

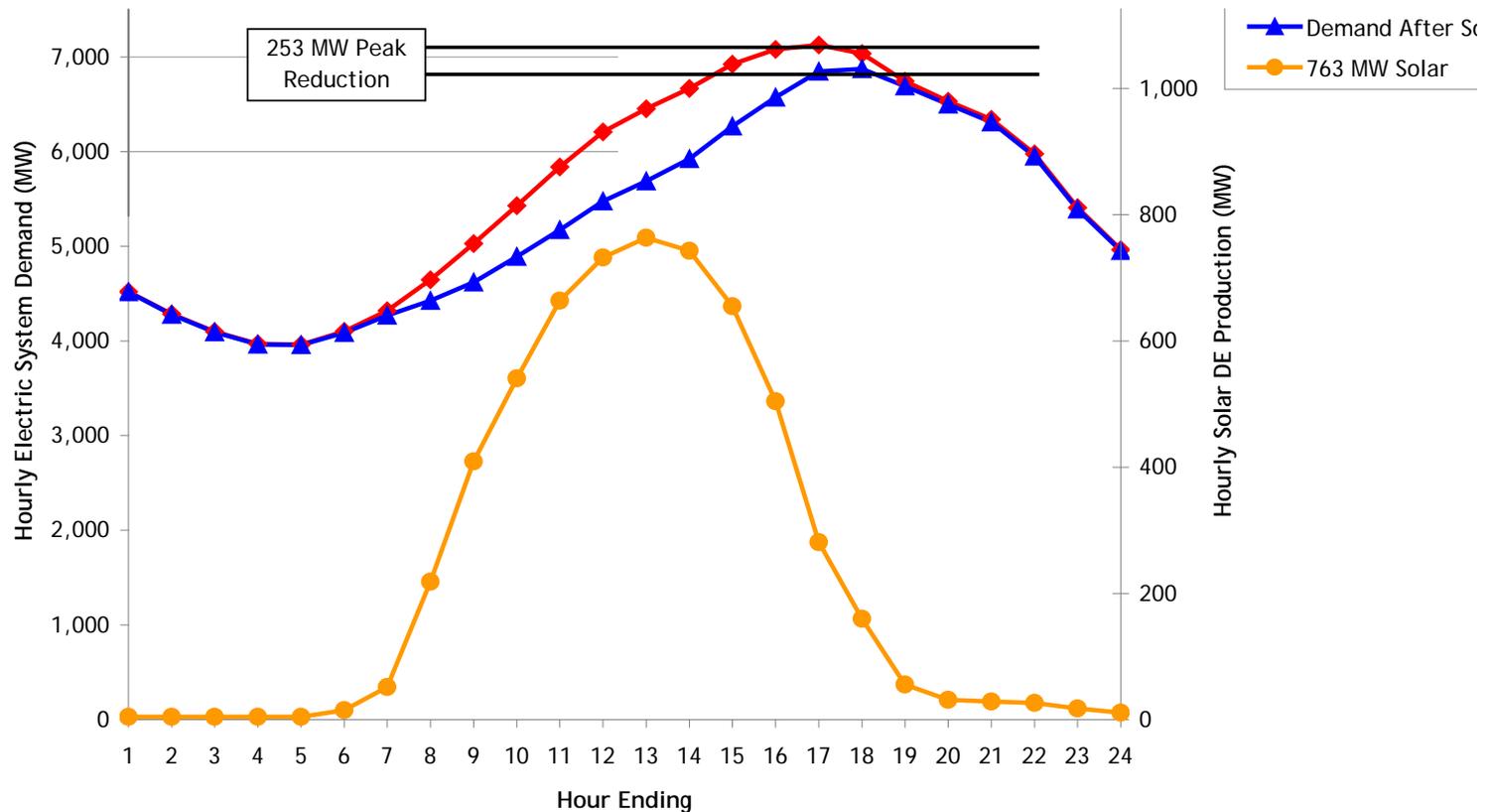
Energy vs capacity



The physics barrier is real

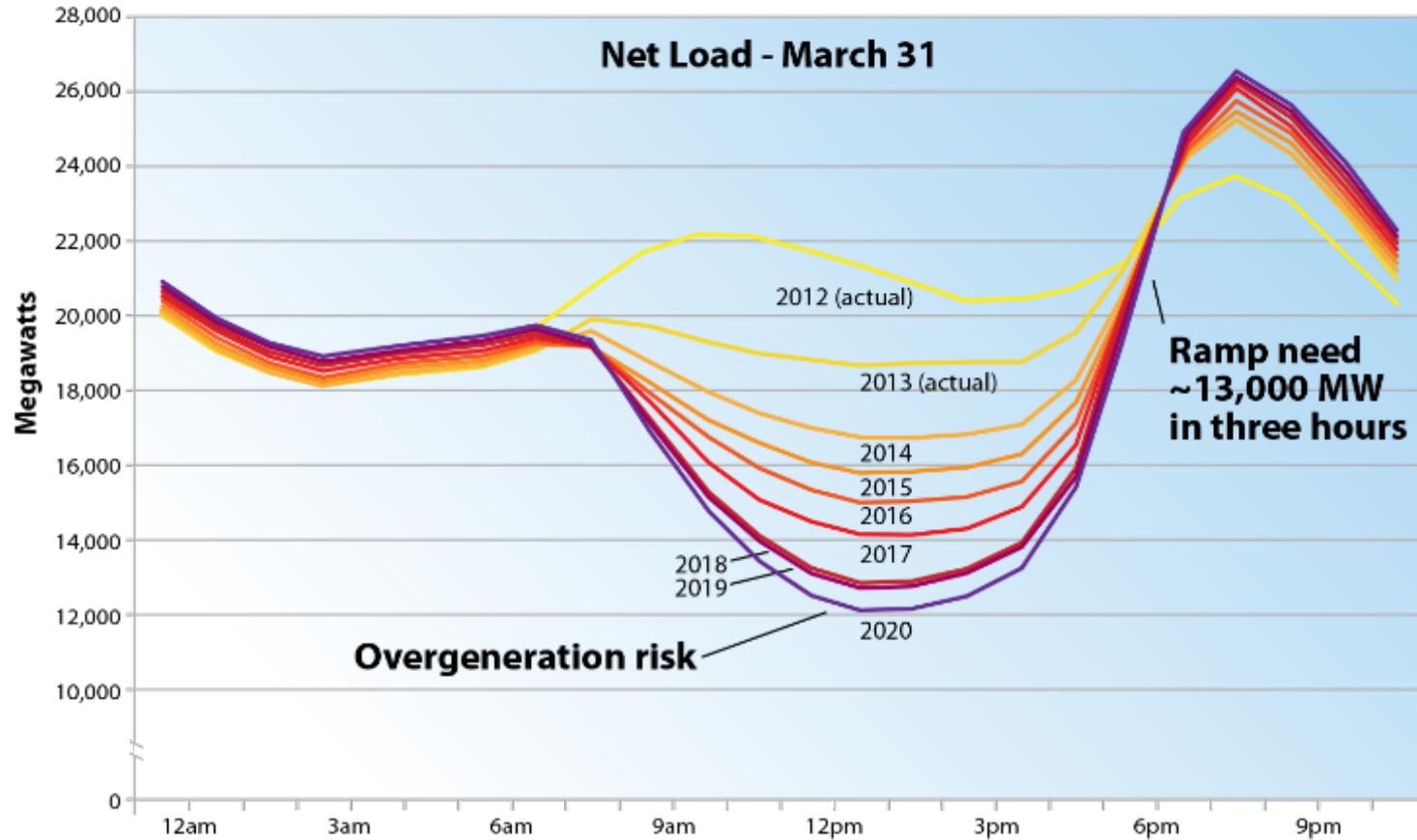
The Solar/Peak Conundrum

(even in Arizona)



California duck curve

California Independent System Operator Duck Curve

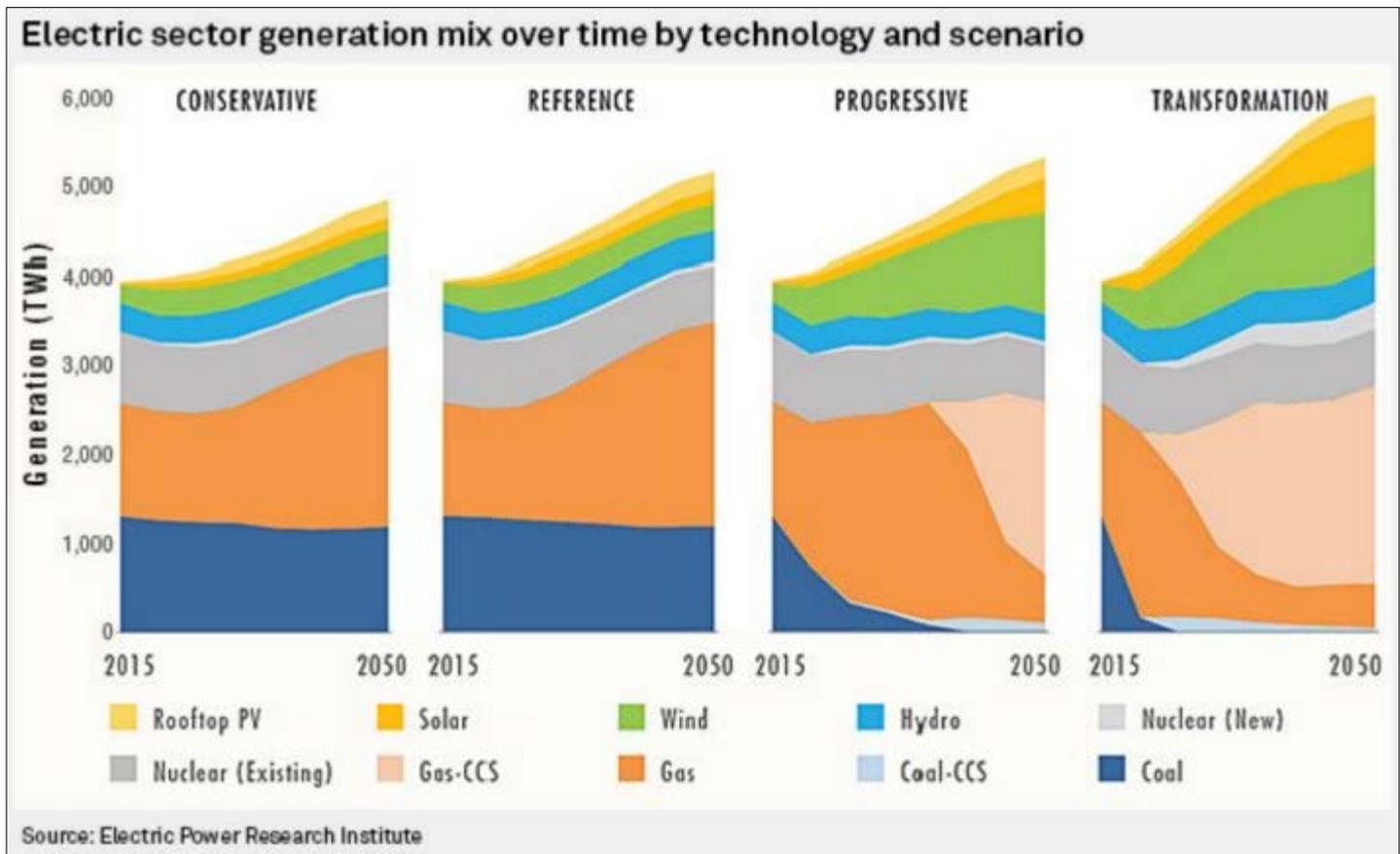


Fundamental change

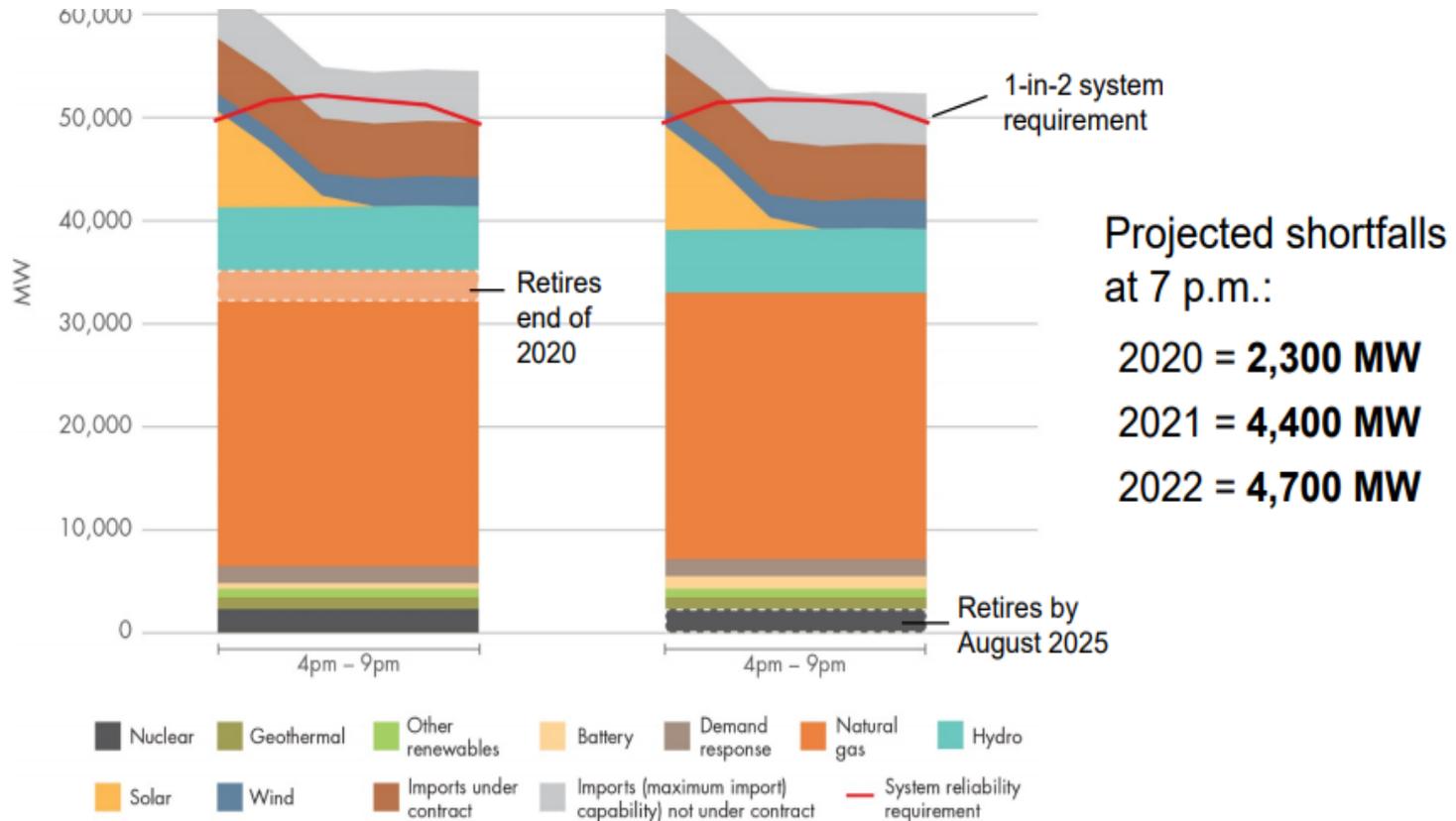
The challenge for the utility of today is not only what is real but what is perceived as real.



Generation mix



CAISO's expected resource shortage



¹ Assumes no transmission outages or other significant events affecting availability of generation

Change is upon us

WIND PEAK

17,595.1 MW AT 8:42 P.M. ON OCT. 17, 2019

WIND PENETRATION

68.78% AT 1:37 A.M. ON OCT. 18, 2019

RENEWABLE PENETRATION

76.94% AT 3:01 A.M. ON OCT. 18, 2019



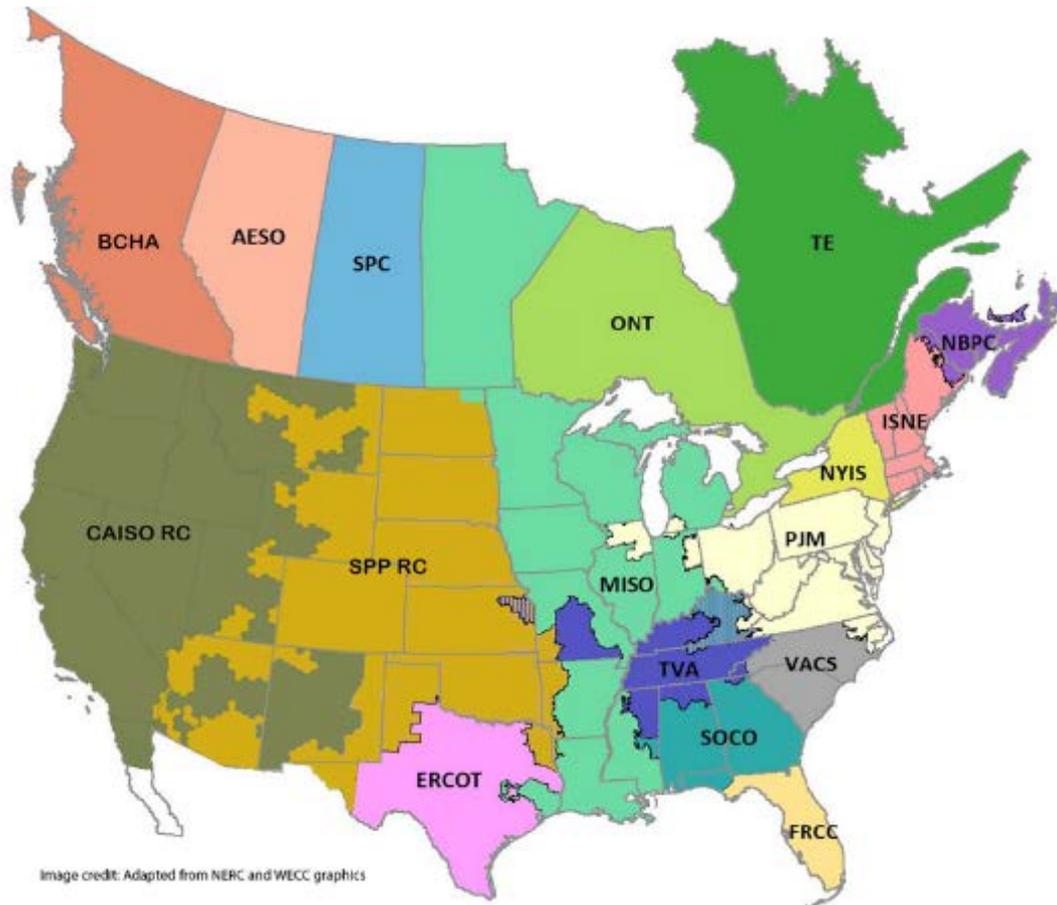
USVI Solar Farm post hurricane



Energy imbalance objectives

- Ensure reliable delivery of our hydropower while adjusting to a changing energy mix
- Respond to customer feedback requesting WAPA lead organized market discussions
- Address WAPA balancing authority area constraints
- Facilitate integration of renewable resources
- Enable participants who want to optimize their resources to participate in markets

Reliability Coordinator transition



NERC Reliability Coordinators

Expected as of Dec. 3, 2019

- Alberta Electric System Operator
- Electric Reliability Council of Texas
- Florida Reliability Coordinating Council
- Hydro Quebec TransEnergy
- ISO New England, Inc.
- Midcontinent ISO
- New Brunswick Power Corporation
- New York Independent System Operator
- Ontario Independent Electricity System Operator
- Peak Reliability
- PJM Interconnection
- Saskatchewan Power Corporation
- Southern Company Services, Inc.
- Southwest Power Pool
- BAs receive RC services from SPP or TVA
- Tennessee Valley Authority
- BAs receive RC services from TVA or MISO
- VACAR South

Image credit: Adapted from NERC and WECC graphics

Advanced Small Modular Reactors (SMRs)

- DOE generation priority
- Black-start capability
- Baseload resource
- Self-contained “island-mode” power



Contrasting world views

- Reality of system ops generally ignored
- Sky is falling?
- Sky is not falling?
- Reliability hangs in balance
- Surge in demand may lead to significant shortages
- Timing of regulations affect regions differently
- Belief, not engineering, leads the way



Choice vs. risk



Dinosaurs to Avatars



Connected world



Distributed generation

- Generation at point of consumption
- Increase dispatch and accessibility
- Retail driven
- Risks:
 - Diseconomies of scale
 - Strand existing assets



Home tech drives smart grid benefits

4.92 billion wireless devices globally / 66% penetration

Source: Hootsuite, January 2017



Storage scale

- WAPA has 10,000 MW of nameplate capacity
- 1 tractor trailer = 1 MW of storage
- Battery life = 4 hours
- Need 60,000 trailers to replace WAPA's hydro capacity



EV trip: New York to Florida

- 40 gallons of gasoline
- 286 pounds of coal
- 2,500 cubic feet of natural gas
- 7 days of 10-kW rooftop array
- 33 minutes of giant offshore wind turbine



Renewable vs carbon free

Renewable

- Wind
- Solar
- Biomass/gas
- Geothermal

Carbon free

- Wind
- Solar
- Biomass/gas
- Geothermal
- Hydropower
- Nuclear

Societal changes



The future nexus



U.S. and World Populations

	United States	World
Median household income	\$61,372	\$9,733
No internet access	24%	45%
Renters	36.6%	33.1%



Water-energy nexus

Project	Annual H ₂ O need (gallons)
Genesis Solar	536 million
Mojave Solar	705 million

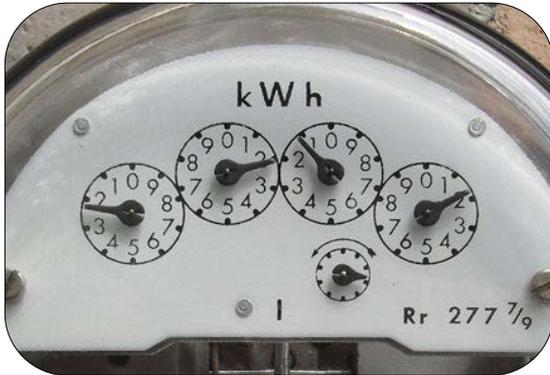


Economic challenge

How can we manage in a Twitter–centric world?



Radical thoughts



The kilowatt-hour
is dead



Time-of-purchase
vs. time-of-use



All-you-can-eat
energy

Key takeaways

The industry is changing at a rapid pace.
There is no microgrid without a macrogrid.
100% carbon free versus 100% renewable.
We need the best and the brightest to stay ahead
and remain competitive.



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