Electric Perspectives

Hillhouse Club
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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
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
Untangling giant hairball of electricity
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
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
# California wildfires 5-year overview

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres Burned</th>
<th>Number of Fires</th>
<th>Loss of Life</th>
<th>Structures Damaged or Destroyed</th>
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<td>2019</td>
<td>259,823</td>
<td>7,860</td>
<td>3</td>
<td>732</td>
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<td>2018</td>
<td>1,963,101</td>
<td>7,639</td>
<td>100</td>
<td>24,226</td>
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<td>2017</td>
<td>1,548,429</td>
<td>9,270</td>
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<td>2016</td>
<td>669,534</td>
<td>6,954</td>
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<td>1,274</td>
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<tr>
<td>2015</td>
<td>880,899</td>
<td>8,283</td>
<td>7</td>
<td>3,159</td>
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</tbody>
</table>
Importance of vegetation management

Before

After
ROW reclamation

• Removing incompatible species
• Promoting low-growing, fire-resistant plant communities
WAPA’s wildfire mitigation plan

- Prevent, combat and respond to wildfires
- Minimize probability of being the origin or contributing source
- Communication protocols regarding potential de-energization of lines
- Details operation and maintenance procedures to mitigate wildfires
Re-investing in assets & managing grid

5-YEAR REINVESTMENT TOTAL

- Improvements & Replacements, 45,150,000
- Preventative Maintenance & Repairs, 16,686,000
- Vegetation, Roads & Remote Sensing, 16,220,000
2018 Carr Fire
Impact on WAPA
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)

253 MW Peak Reduction

Demand After 763 MW Solar

Hourly Solar DE Production (MW)

Hour Ending
California duck curve

California Independent System Operator Duck Curve

Net Load - March 31

Ramp need ~13,000 MW in three hours

Overgeneration risk

Western Area Power Administration

Energy and Civilization - 22
Fundamental change

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

Electric sector generation mix over time by technology and scenario

Source: Electric Power Research Institute

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CAISO’s expected resource shortage

Projected shortfalls at 7 p.m.:
- 2020 = 2,300 MW
- 2021 = 4,400 MW
- 2022 = 4,700 MW

1 Assumes no transmission outages or other significant events affecting availability of generation
Change is upon us

NEW WIND-PENETRATION RECORD

71.3% AT 3:15 A.M. FEB. 3, 2020

Energy and Civilization - 26
USVI Solar Farm post hurricane
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

- Fixed rates
- Energy charge adjustment
- Critical peak pricing
- Time of use
- Real-time pricing

UTILITY RISK

Fixed rates annual adjustment

CUSTOMER RISK
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

Emissions free
- Wind
- Solar
- Biomass/gas
- Geothermal
- Hydropower
- Nuclear
Societal changes
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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