Civilization, renewable energy, WAPA and the grid

University of California at Berkeley
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What is WAPA?

One of four power marketing administrations within the Department of Energy whose role is to market and transmit wholesale electricity from multi-use water projects.
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
My perspective

• 30 years in electric industry (plus gas, oil and water)
• Eight 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
Untangling giant hairball of electricity
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
Dot-com era circa 1880: electricity

- Industry began in support of other enterprises
  - Industrial
  - Telegraph, telephone
  - Street cars
- Wild West of the east coast
  - 20 companies providing service in NYC
  - 18 deaths in 1889
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
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
- Decreased hydropower production
- More customer-side resources
- Changing markets
- Security
Industry changes

"I welcome change as long as nothing is altered or different."
Who won the movie format battle?

Betamax

VHS
Neither!

• Apple redefined the market
• Identified a megatrend

Personalized entertainment
The Janus Conundrum

Choice of Capital Investment

Reliance on the Past
- Repair, replace, rebuild
- Status quo, current opportunity optimized
- System limited to yesterday's technology
- Reduced returns, limited upside, exposure to competition

Reliance on the Future
- Invest in new generation of technology
- New business opportunities
- System expansion
- Competitive advantage

© Mark A. Gabriel, *Visions for a Sustainable Energy Future*
The challenge of system ops

“Typical” 500 MW peaking utility

<table>
<thead>
<tr>
<th>100 MW</th>
<th>Spot Market, peakers, renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MW</td>
<td>Mid-term contracts or market positions</td>
</tr>
<tr>
<td></td>
<td>Natural gas</td>
</tr>
<tr>
<td>250 MW</td>
<td>Base load generation</td>
</tr>
<tr>
<td></td>
<td>Coal/nuclear/hydro/natural gas</td>
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</tbody>
</table>
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
The Solar/Peak Conundrum (even in Arizona)

Hourly Electric System Demand (MW)

Hourly Solar DE Production (MW)

253 MW Peak Reduction

763 MW Solar

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Eclipse operations

• Replacement energy came from the following:
  • Interties (~3,200 MW)
  • Hydro (~800 MW)
  • Thermal (~1,600 MW)
  • EIM transfers (~350 MW)
• No manual intervention during the eclipse
Megatrend: Carbon/Capacity Conflict

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

California Independent System Operator Duck Curve

Net Load - March 31

Ramp need ~13,000 MW in three hours

Overgeneration risk
Fundamental change

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

Wind-Penetration Record
54.22% at 00:55
On March 19, 2017
Oahe generation 2015

April 9th Comparison for Oahe Generation

4-second data for hours ending 1 - 24

2015
Oahe generation 2016
Oahe generation 2017

April 9th Comparison for Oahe Generation

MWs

4-second data for hours ending 1 - 24

2015 2016 2017
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
And over in Germany...

• Energiewende to eliminate coal and nuclear as a social policy
• Wholesale prices down steadily while consumers bear the impact: 40 cents/kWh
• Blown up the utility business
• 800-900 DSOs
• 4 TSOs (owned by foreign entities)
• 1.8 million generators
• Reliant on assets of other countries
Destiny of intelligent infrastructure

- $50 billion will be spent in next 5 years in T&D
- How smart grid will change load profile is critical
- The enabler for energy efficiency and demand response
- How customers interact with the system is key
My unpopular Smart Grid theory

• 80% of the benefits of intelligent infrastructure will initially accrue to the utility
• Consumer participation will be initially low
• Hype will hurt the efforts
• Utilities will move to smart grid because it makes sense
• Utilities will not get significant benefits unless they make major process changes
Choice vs. risk

UTILITY RISK

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

CUSTOMER RISK

Critical peak pricing
Home tech drives smart grid benefits

4.92 billion wireless devices globally / 66% penetration

Source: Hootsuite, January 2017
### Water-energy nexus

<table>
<thead>
<tr>
<th>Project</th>
<th>Annual H$_2$O need (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genesis Solar</td>
<td>536 million</td>
</tr>
<tr>
<td>Mojave Solar</td>
<td>705 million</td>
</tr>
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Economic challenge

How can we manage in a Twitter–centric world?
Radical thoughts...

- kWh is dead
- All-you-can-eat electricity
- Time-of-purchase rates
  NOT time-of-use rates
- Utility is the network provider
- Markets replace IRPs
Key takeaways

The industry is changing at a rapid pace. There are no indications of it slowing. We need the best and the brightest to stay ahead and remain competitive.
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