Modernizing the California Electricity Grid -- Critical Public Policy Issues

Michael Sullivan, Senior Vice President

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My background
Biographical Information

- Lived in California since 1952 – except military and graduate school
- Grew up in San Diego and San Bernardino
- Served in US Army 101st and 82nd Airborne
- Viet Nam Veteran 1967 – 1968
- Graduated from UCR -- 1972 BA in Political Science
- Graduated from WSU – 1984 Ph.D. Sociology
- Lectured at Haas Business School in Berkeley 1984, 1987
- Founded Freeman, Sullivan & Co in 1984
- Chairman of FSC 1992-2013
- Expertise – utility investment planning, impacts of behavioral interventions, demand response, utility EE and DR program evaluation, market research and planning
Energy Expertise across the globe

600+ energy industry and software specialists, many recognized as industry experts

Global Offices

Headquarters

Planned 2014 Offices

Project Offices

Representative Offices

Modernizing the California Electricity Grid -- Critical Public Policy Issues
A diverse customer base

<table>
<thead>
<tr>
<th>Utilities</th>
<th>Energy Companies</th>
<th>Transmission &amp; Distribution</th>
<th>Financial &amp; Private Equity</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>CenterPoint Energy</td>
<td>Shell</td>
<td>National Grid</td>
<td>Citibank</td>
<td>World Bank</td>
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<tr>
<td>AEP American Electric Power</td>
<td>DuPont</td>
<td>California ISO</td>
<td>Morgan Stanley</td>
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<tr>
<td>ComEd</td>
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<td>ISO new england</td>
<td>Deutsche Bank</td>
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<td>Georgia Power</td>
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<td>ISO</td>
<td></td>
<td>European Bank for Reconstruction and Development</td>
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<td>TVA</td>
<td></td>
<td>Midwest ISO</td>
<td>HSBC</td>
<td>USAID</td>
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<tr>
<td>PGE</td>
<td>Exxon Mobil</td>
<td>ERCOT</td>
<td>Carlyle Group</td>
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<td>FirstEnergy</td>
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<tr>
<td>Dow</td>
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</tbody>
</table>

And many more…
Industry Challenges

Utility Services

• Managing complex regulatory and market requirements
• Improving planning and operations for transmission, distribution and demand management
• Managing energy efficiency and demand response requirements across load base
• Integrating renewable and distributed generation
Focused expertise

Nexant helps utilities embrace a customer-centric model that aligns grid operations, demand side programs and strategic planning to reduce costs, manage risk, improve customer engagement and achieve superior results.
Forces Driving Change
The California Electric Grid Today

Mostly centralized generation ~ 55,000 MW

- Natural gas fired thermal
- Nuclear thermal
- Hydroelectric
- Utility Scale Wind
- Utility Scale Solar
- Geothermal
- Imports

Small amounts of distributed renewable resources
- Rooftop solar
- wind
The California Electric Grid Today

- **Transmission and Distribution**
  - High voltage transmission lines – 500, 230 and 69 kV lines deliver power from central generation stations to distribution substations
  - Distribution transformers step down voltage to 12 kV and 4 kV
  - Secondary transformers step down voltage to residents and business
The California Electric Grid Today

Disruptive forces

- **Climate change policy is dramatically increasing penetration of renewables**
  - California Renewable portfolio standard – 33% renewable electricity by initiatives by California and US governments 2030 – state tax incentives encouraging renewables, instructions to utilities
  - EPA 111(d)
  - AB 32
  - Tax incentives
  - AB 1X -- Electric rate designs intended to foster conservation

- **Technological innovation also a strong driver**
  - Solar cell cost down from $10/watt to $3/watt since 2000
  - Smart meters deployed to most of California
  - Smart grid distribution system control technologies can dramatically reduce outage exposure and duration
  - PEVs are starting to penetrate automotive market
  - Battery storage costs are coming down
  - Internet of things
How these forces are affecting the design of the grid

Daily Load shape is changing from this:

To this:

The duck curve

Solar production centered on 12 PM significantly depresses net demand

Causes deep valley in production in the afternoon and steep ramp rate in the evening to meet new peak

Will cause significant changes in the way the system is operated

Investment in new fast ramping generators

DER
So What?

The changes that are emerging are an existential threat to the current utility business model

• The HECO story

• California utilities are not far behind

What to do?
PV Penetration Estimation and Deployment Status

- The U.S. installed 976 MW of PV in the Q2 of 2013
  - 24% increase from Q1
PV in Pacific Gas & Electric (PG&E)

- **PG&E (California)**
  - 5.2M accounts; peak load: 20,000 MW
  - Total PV installation: 802 MW
    - 79,000 installations
    - ~30% of US total
    - PG&E serves ~5% of US population
    - Over 17,000 interconnections in 2012
  - Feeder-level penetration is generally low compared to max demand
  - High concentrations of PV exist
    - Localized areas (i.e., on individual transformers)
PV in Southern California Edison (SCE)

- SCE (California)
  - 5 millions accounts
  - Peak load: 21,996 MW
  - 50,000 sq. miles service territory
  - Total PV installation: 534 MW
    - Residential: 199 MW
    - Comm. & Ind.: 259 MW
    - Agricultural: 13 MW
    - Utility Owned: 63 MW
How these forces are affecting the design of the grid

To accommodate DER the design of the grid has to change from a one directional flow to a network in which “prosumers” are able to extract and inject power on to the grid from distribution points.
All Eyes Are On The New York REV Proceeding

NY regulators have ordered utilities to modernize their grids by changing design of the utility distribution platform from that of distributing power form central plants to one that is power distribution in a network that is built to take maximum advantage of distributed energy resources

• DER is
  • Solar
  • Combined Heat and Power
  • Wind
  • Energy Efficiency
  • Demand Response
  • Storage
## Other REV like proceedings

<table>
<thead>
<tr>
<th>State</th>
<th>Name</th>
<th>Commission</th>
<th>Docket</th>
<th>Year (status)</th>
<th>Intervening Parties</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN</td>
<td>In the Matter of Establishing a Distributed Solar Value Methodology Proposal</td>
<td>MN PUC</td>
<td>E-999/M-14-65</td>
<td>2014 (closed)</td>
<td>ELPC, Fresh Energy, IREC, ILSR, IWLA, SunEdison, <strong>Vote Solar</strong></td>
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<tr>
<td>FL</td>
<td>Commission review of numeric conservation goals (Duke Energy Florida, Inc.)</td>
<td>FPSC</td>
<td>130200</td>
<td>2013 (active)</td>
<td>Sierra Club, SACE, Earthjustice, EDF, TASC, SEEA, FSEIA</td>
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<tr>
<td>GA</td>
<td>Petition to Establish the Value of Solar Energy</td>
<td>GPSC</td>
<td>38619</td>
<td>2014 (active)</td>
<td>GSEIA, GIPL, SACE, Sierra Club</td>
</tr>
<tr>
<td>CO</td>
<td>Renewable Distributed Generation &amp; Net Metering</td>
<td>Co. PUC</td>
<td>14M-0235E</td>
<td>2014 (active)</td>
<td>TASC, COSEIA, SEIA, IREC, WRA, <strong>Vote Solar</strong>, Sierra Club</td>
</tr>
<tr>
<td>CA</td>
<td>Order Instituting Rulemaking Regarding Policies, Procedures and Rules for Development of Distribution Resources Plans</td>
<td>CPUC</td>
<td>14-08-013 (R1408013)</td>
<td>2014 (active)</td>
<td>EDF, Vote Solar, CSEIA, IREC, CESA, NRDC, SolarCity (a TASC member), MCE</td>
</tr>
<tr>
<td>NC</td>
<td>Biennial Determination of Avoided Cost Rates for Electric Utility Purchases from Qualifying Facilities</td>
<td>NCUC</td>
<td>E-100 Sub 140</td>
<td>2014 (active)</td>
<td>EDF, Sierra Club, NRDC, NCSEA, NC WARN, SACE, TASC</td>
</tr>
<tr>
<td>AZ</td>
<td>In the matter of the Commission’s Investigation of Value and Cost of Distributed Generation.</td>
<td>ACC</td>
<td>E-000000J-14-0023</td>
<td>2014 (active)</td>
<td>TASC, SEIA, Vote Solar, IREC, WRA, NRDC, EEI</td>
</tr>
</tbody>
</table>
An example of the changes that have to be made -- PV Integration & Impacts
Background

- PV converts sunlight into electricity
  - Observed as early as 1839
  - Bell Labs introduced the first solar PV in 1954
- Four largest markets for PV: Germany, Japan, Spain, and USA
- PV as Distributed Generation (DG) is rapidly growing
  - Renewable Portfolio Standards (RPS) requirements in USA (e.g. California RPS goal is 33% by 2020)
  - Incentives are in place
Stand-alone PV-DG

- 10 W - 10 kW off-grid units or systems
- Applications include:
  - Backup power
  - Water pumping
  - Swimming pools
  - Security
  - Communications
  - Lighting
  - Traffic
  - More …
Grid Connected Residential PV System

- 2–10 kW system with net utility metering
- Deliver DC power to a power conditioning unit or inverter that converts DC to AC
- Roof-mounted, ground mounted, or Building Integrated PV (BIPV)
Grid Connected Utility PV System

- Higher power directly connected to grid 2 – 10 MW
- Interconnecting to distribution system
- PV system supply power to the grid through large inverters
- Collector system voltage 400 V step up to > 4 kV
- Commercial building roof-mounted or ground mounted
## Potential Benefit Stream

<table>
<thead>
<tr>
<th>Category</th>
<th>Impact</th>
<th>RMI study</th>
<th>MN VOST</th>
<th>Consistent range (excluding outliers)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fuel / gen cost</td>
<td>2.5 to 10.5</td>
<td>4.05</td>
<td>4 to 7 cents</td>
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<tr>
<td></td>
<td>O&amp;M costs (Fixed + variable)</td>
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<td>0.28</td>
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<td></td>
<td>Fuel price hedge</td>
<td>0.4 to 3.8</td>
<td>NA</td>
<td>inconsistent</td>
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<tr>
<td></td>
<td>Market price response</td>
<td>0.8 to 4.5</td>
<td>NA</td>
<td>inconsistent</td>
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<tr>
<td><strong>Capacity</strong></td>
<td>Generation capacity</td>
<td>1 to 11</td>
<td>2.37</td>
<td>1 to 2 cents</td>
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<tr>
<td></td>
<td>Ancillary services / costs</td>
<td>-0.4 to 1.5</td>
<td>0.17</td>
<td>inconsistent</td>
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<td></td>
<td>T&amp;D capacity</td>
<td>0.1 to 8.5</td>
<td>2.46</td>
<td>0 to 1.5 cents</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>Emissions (Carbon + Criteria pollutants)</td>
<td>0.0365 to 3.9</td>
<td>2.87</td>
<td>1.5 to 2.5 cents</td>
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<tr>
<td></td>
<td>Water</td>
<td>0.1</td>
<td>NA</td>
<td>inconsistent</td>
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<tr>
<td><strong>Social</strong></td>
<td>Resiliency</td>
<td>1 to 2.25</td>
<td>NA</td>
<td>inconsistent</td>
</tr>
<tr>
<td></td>
<td>Economic development</td>
<td>1 to 4.5</td>
<td>NA</td>
<td>inconsistent</td>
</tr>
</tbody>
</table>
PV integration issues

- Example of Solar PV intermittency
PV integration issues continued (continued)

- Feeder voltage chart without and with PV

Without PV

![Voltage Profile (PU)](image1)

With PV

![Voltage Profile (PU)](image2)
Integration - Costs

- **Voltage control**
  - Multiple generation sources using different equipment – producing electricity with different characteristics (voltage, frequency, etc. – Noisy power)
  - Intermittency – clouds, diurnal

- **Protection**
  - Potential reverse power flow
  - Short-circuit current contribution
  - Coordination with PV inverters, anti-islanding logic

- **System operation and automation**
  - Switching impacts
  - Interoperability of inverters of from various manufactures

- **Power quality**
  - Potential harmonic issues; resonance phenomenon

- **Monitoring and control**
Critical Public Policy Issue

- Utilities are going to have to make significant investments to modernize the grid while their revenues from the current cost recovery model are declining
  - A significant fraction of the fixed cost of the grid is being recovered through variable energy charges – which are declining as customers generate their own power
  - Current rate designs required under AB 1X are producing a death spiral
  - AB 327 may help – but will it be enough
  - The problem is that more than half of the cost of power delivery is a fixed cost and only a tiny fraction of that is recovered through fixed charges – maybe 10%
  - Electric rates should be restructured so that:
    - Fixed costs are recovered from customers in proportion to their share of total costs
    - Variable costs vary with the actual cost of service delivery
    - Hidden taxes on electricity use are mitigated (income transfer and societal benefit costs)
Critical Public Policy Issue

- NOT SO FAST!!!
  - Consumer’s advocates object to changes
  - Environmental lobby objects
  - Solar industry lobby objects
  - Ratepayer lobby objects

- We are stuck in a political quagmire that industry doesn’t seem to be able to get out of

- Efforts to explain the coming crisis are viewed as self serving

- Policy makers do not understand the seriousness of the situation

- A focused vision of the future of grid modernization is badly needed and is underway at the CPUC – but it is a political bomb so time will tell whether a coherent solution will emerge

- Stay tuned
Questions/Discussion