The Changing Landscape of Electric Generation

Presented by Ram Sastry
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## Company Overview

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues (in billions)</td>
<td>$14.4</td>
</tr>
<tr>
<td>Net Income (in millions)</td>
<td>$1,211 ¹</td>
</tr>
<tr>
<td>Earnings Per Share</td>
<td>$2.53 ¹</td>
</tr>
<tr>
<td>Cash Dividends Per Share</td>
<td>$1.64</td>
</tr>
<tr>
<td>Service Territory</td>
<td>197,500 mi²</td>
</tr>
<tr>
<td>Transmission</td>
<td>39,000 miles</td>
</tr>
<tr>
<td>Distribution</td>
<td>215,800 miles</td>
</tr>
<tr>
<td>Generating Capacity</td>
<td>38,988 MW ²</td>
</tr>
<tr>
<td>Generating Stations</td>
<td>More than 80</td>
</tr>
<tr>
<td>Renewable Portfolio (hydro)</td>
<td>364 MW ³</td>
</tr>
<tr>
<td>Pumped Storage</td>
<td>586 MW</td>
</tr>
<tr>
<td>Renewable Portfolio (wind, solar)</td>
<td>1,406 MW ⁴</td>
</tr>
<tr>
<td>Total Kilowatt-hour Sales (in millions)</td>
<td>195,312</td>
</tr>
<tr>
<td>Total Assets (in billions)</td>
<td>$48.3</td>
</tr>
<tr>
<td>U.S. Customers (year-end, in thousands)</td>
<td>5,220</td>
</tr>
</tbody>
</table>

1. Generally Accepted Accounting Principles.
2. Represents nominal capacity; includes 270 MW of mothballed / decommissioned generation, AEP’s interest in Ohio Valley Electric Corp., purchased power agreements and renewables.
3. Excludes pumped storage; includes owned capacity and purchased power.
4. Regulated wind and solar capacity on line or under contract.

- AEP Ohio
- Appalachian Power
- Indiana Michigan Power
- Kentucky Power
- AEP Texas
- Public Service Company of Oklahoma (PSO)
- Southwestern Electric Power Company (SWEPCO)
## Current Initiatives at AEP

<table>
<thead>
<tr>
<th>Generation</th>
<th>Transmission</th>
<th>Distribution</th>
<th>Customers</th>
</tr>
</thead>
</table>
| - Environmental Projects  
  - Wind  
  - IGCC  
  - Carbon Capture & Storage | - I-765™  
  - Electric Transmission Texas JV  
  - Electric Transmission America JV  
  - AEP-ABB Alliance | - Distribution automation  
  - Self-healing distribution circuits  
  - Advanced metering  
  - Communications infrastructure  
  - Mobile workforce  
  - Internal energy efficiency  
  - Integration platform for advanced visualization and analytics  
  - Distributed generation and energy storage | - Customer programs and incentives  
  - Energy efficiency  
  - Direct load control  
  - Peak demand reduction  
  - Energy storage  
  - PHEVs |

Generation and transmission control systems  
gridSMART™: bridging the gap to provide integrated two-way communications & control across the electricity value chain  
Home energy automation
Electric companies use a diverse mix of fuels to generate electricity.

Centralized Coal Fired Generation

- As of May 20, 2011, out of the U.S. installed coal-fired power capacity totaling 316 gigawatts (GW) and 1,400 units; 8.9 GW (3 percent of the fleet) are committed to retiring by 2020, 5.9 GW of which are set to retire by 2015.

- Another 8.5 GW (3 percent of the fleet) have been proposed to retire by 2020, 5.0 GW of which by 2015.

- AEP’s compliance plan would permanently retire coal fired generation of 450 MW by Dec. 31 2011; an additional 165 MW by Dec 31, 2012; and an additional 5,241MW by Dec 31, 2014.

- An additional 1070 MW of coal fired generation will be refueled with natural gas.

Source: IHS CERA

Three – six percent of coal-fired centralized generation will be retired by 2020 creating an opportunity for cost competitive new generation technologies.
AEP’s renewable generating capacity is expected to almost double by 2020.
# Life-Cycle Cost of Electricity

## (Levelized) Life-Cycle Cost of Electricity (LCOE) in $ per MWh (2009 $ and 30 year life)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Install Cost per kW</th>
<th>LCOE per MWh</th>
<th>Heat Rate (Efficiency %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-Supercritical Pulverized Coal</td>
<td>$3,100</td>
<td>$104</td>
<td>8,750 (38 – 40)</td>
</tr>
<tr>
<td>Natural Gas Combined Cycle</td>
<td>$1,250</td>
<td>$91</td>
<td>6,700 (50 – 52)</td>
</tr>
<tr>
<td>Nuclear</td>
<td>$7,500</td>
<td>$119</td>
<td>10,500 (32.5)</td>
</tr>
<tr>
<td>Wind</td>
<td>$2,100</td>
<td>$145</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Solar PV</td>
<td>$4,500</td>
<td>$300</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Solid Oxide Fuel Cell</td>
<td>$3,500 - $7,500</td>
<td>$120</td>
<td>7,500 (50 – 60)</td>
</tr>
</tbody>
</table>

To effectively compete with incumbent centralized generation, new generation technologies need to have a LCOE less than or equal to $100/MWh.
Progression of Technologies

Crawl:
- Technologies must prove that they are reliable (80 – 90% capacity utilization)
  - Distributed generation opportunities

Walk:
- Technologies must prove that they are reliable and scalable
  - Hybridization such as combining a high-temperature fuel cell with a traditional gas turbine

Run:
- Technologies must prove that they are reliable, scalable, affordable and sustainable
  - Central generation fuel cell deployment with coal gasification

Reliability is the most important factor for a utility when considering a generating technology and then cost.
Why utilize distributed generation applications first?

Advantages

- Limited reliability risk
- Relatively small footprint compared to renewables or central
- Little to no permitting required
- Quick time to power
- Modular design
- Public policy – incentives, tax credits, cost sharing, etc.
- Plug & play with existing T&D infrastructure
- Potential solution for uninterruptible power/critical power
- Applicable for Purchase Power Agreements (PPA)
- Limited staff

*Distributed Generation helps limit risk by enabling scalable deployment and requiring little to no permitting.*
Fuel Cell

Benefits:

- Environmentally friendly – hydrogen produces zero emissions besides water vapor
- Size – individual fuel cells are the size of a cocktail napkin - 1MW units are typically the size of a 1-2 large parking spaces
- Easily sited due to minimal space requirements, little/no permitting requirements and no noise
- More efficient than other renewables (45% - 65%) Fuel cells can run off virtually any feedstock – natural gas, biogas, ethanol, methane, landfill gas

Disadvantages:

- Technology is expensive
- Technology not fully developed and few products are available
Environmental Impacts:
- Fuel cells emit 800lb/MWh CO2 output (this is typically 60%-75% cleaner than central gen) and have negligible levels of NOx or SOx.

Potential Applications:
- Institutions – colleges & universities, hospitals, nursing homes, prisons, military bases requiring backup power
- Commercial – data centers and other buildings with high power quality requirements and grocery stores or others requiring backup power
- Residential – widely used in Japan as sole source of power - units are about the size of a traditional AC unit

Fuel cells can power an extraordinary range of applications, from battery replacements in consumer electronics to backup and remote power generation to auxiliary power units to combined heat and power systems and high efficiency base load electrical generation.
# Fuel Cell Technologies

<table>
<thead>
<tr>
<th>Type</th>
<th>Electrolyte</th>
<th>Temp (°C)</th>
<th>Applications</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton Exchange Membrane</td>
<td>Hydrated Polymer</td>
<td>80</td>
<td>C&amp;I, Residential,</td>
<td>Solid electrolyte, Low temperature, High power</td>
<td>Extensive fuel processing, Expensive catalyst,</td>
</tr>
<tr>
<td>(PEMFC)</td>
<td></td>
<td></td>
<td>Transportation, Portable</td>
<td>density</td>
<td>Sensitive to fuel impurities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkaline (AFC)</td>
<td>Aqueous solution in a solid</td>
<td>65-220</td>
<td>Military, space</td>
<td>High performance</td>
<td>Expensive CO₂ removal from fuel &amp; air</td>
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<tr>
<td></td>
<td>matrix</td>
<td></td>
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<tr>
<td>Phosphoric Acid (PAFC)</td>
<td>Liquid acid in a solid</td>
<td>205</td>
<td>Electric utility, C&amp;I</td>
<td>Tolerates fuel impurities, Commercially available</td>
<td>Expensive catalyst, Low power density</td>
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</tr>
<tr>
<td>Molten Carbonate (MCFC)</td>
<td>Liquid metal solution in</td>
<td>650</td>
<td>Electric utility, C&amp;I</td>
<td>High cogen efficiency, Fuel flexibility, Low</td>
<td>High temperature (component failure)</td>
</tr>
<tr>
<td></td>
<td>a solid matrix</td>
<td></td>
<td></td>
<td>power density</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inexpensive catalyst, Commercially available</td>
<td></td>
</tr>
<tr>
<td>Solid Oxide (SOFC)</td>
<td>Ceramic</td>
<td>600-1000</td>
<td>Electric utility, Transportation, Residential, Portable power</td>
<td>Solid electrolyte, High cogen efficiency, Fuel flexibility, Inexpensive catalyst, Commercially available</td>
<td>High temperature (component failure)</td>
</tr>
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Potential Opportunities for DG within AEP

Why would utilities consider DG?

- Less risk than traditional central generation
  - Less capital
    - Improves ability to finance
    - Limits rate recovery exposure
  - Limited permitting risk – quicker time to power
- Avoided construction of transmission and distribution for stand alone or small loads
- Deferred investment in substations
- Meets Renewable Portfolio Standards (RPS) in many jurisdictions
- Peak shaving/peak shifting opportunities
- Standby/spinning reserve capacity
- Islanding – system reliability
- Power Quality – potential solution for uninterruptible power/critical power
- Environmental concerns – little to no permitting

DG applications that enable us to avoid/delay a large capital expenditure are prime candidates.
Why isn’t small scale distributed generation widely adopted today?

- High initial capital cost & ongoing cost/kWh
- Lack of clarity on interconnection and local environmental rules
- No guarantee that primary fuel prices will remain low
- Limited system life (typical life for fuel cell stack is 3 - 5 years)
- Reliability concerns for some technologies
- Limited commercial availability of some technologies
- Limited incentives, which are then spread across all customers creating potential backlash
- Uncertain economy – DG not at the top of the list of investments for commercial customers

The primary barrier to widespread deployment of DG today is the cost, and it is coming down as technologies mature and become more commercially available.
Distributed Generation provides utilities with a number of potential business models including . . .

- Traditional ownership of generation and ability to use to support traditional loads or to meet Renewable Portfolio Standards (RPS) requirements
- “Green Power” rate applications
- “Premium Power” rate applications
- Consumer ownership of asset with utility utilizing a purchase power agreement (PPA) to meet RPS requirements

* Distributed Generation provides utilities with increased flexibility in meeting RPS requirements and providing rate options to consumers.*
Rolls-Royce Solid Oxide Fuel Cell

Rolls-Royce Fuel Cell Systems
1 MW SOFC Test & Evaluation Program
5 kW lab scale system built and demonstrated

15 kW pilot scale system built

- Initial system demonstrations complete
- Positive net power in August 2009

250 kW demonstration system field test

- Installation @ Utility site – 1Q 2010
- Shakedown and system testing – 2-4Q 2010
- Installation at launch customer site – 1QQ 2011

- Fully automated, unattended operation
- Long-term durability demonstration

Scale up to 5 - 8 MW system underway with demonstration project initiated in 2011
Key Take Aways

For new generation technologies to be competitive at replacing traditional central generation they must…

- Proven Reliability
- Scalable
- Sustainable
- Economical

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…provide reliable large scale power…

- Established, validated track record at large scale capacities
- Operate independent of the grid

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….at a competitive cost.

- Readily available economical fuel source
- Low public policy risk (incentives, tax credits, cost sharing, cost shifting)
- Limited Siting/permitting
- Quick/easy/scalable projects, timely completion