Steve Collier
Director, Smart Grid Strategies
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PEARL STREET STATION
255 – 257 Pearl Street
Manhattan, New York
September 4, 1882

c coal fired steam turbines
6 100 kW jumbo dynamos
27 tons each
139,000 btu/kWh
110 Volts DC
100,000 ft of wiring

82 electric customers
400 light bulbs ($1 ea)
50¢ / kWh
Steam customers
district heating
• Traditional Power Grid:

One-way flow of electricity
Regulated Monopolies

- **Cost-plus regulation** sets price at per unit explicit costs plus a mark-up for implicit costs

- Used for electricity, telephone and cable
  - Policies vary by state

- Disadvantages
  - High administrative cost
  - Reduced incentive for cost-saving innovation
  - Price is greater than marginal cost

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“...the current electric power delivery system infrastructure...will be unable to ensure a reliable, cost-effective, secure, and environmentally sustainable supply of electricity for the next two decades...Much of the electricity supply and delivery infrastructure is nearing the end of its useful life.”
ERODING LEGACY FOUNDATIONS
AGING INFRASTRUCTURE
The State of the Electric Utility 2015 survey revealed that aging infrastructure is what troubles industry players most.
In the U.S., the average system age is 40 to 60 years old. At the moment, 25 percent of America’s power assets are of an age in which condition is a concern.
Declining Reliability / Security
According to federal data, the U.S. electric grid loses power 285 percent more often than in 1984, when the data collection effort on blackouts began. That’s costing American businesses as much as $150 billion per year, the DOE reported, with weather-related disruptions costing the most per event.

“If each one of these [blackouts] costs tens of hundreds of millions, up to billions, of dollars in economic losses per event,” said Massoud Amin, director of the Technological Leadership Institute at the University of Minnesota, who has analyzed U.S. power grid data since it became available in the '80s.
New Threats
Rising Costs & Prices
(constant 100 would mean electricity prices rising at same rate as other prices)
Price of Residential Electricity

Source: US Department of Energy
Long-run average cost

Diseconomies of scale

Constant returns to scale

Economies of scale

Cost per unit

Output per period
Preference • Price • Market • Operational • Regulatory • Construction
Vicious Cycle from Disruptive Forces

Behavior Change

Energy Efficiency (EE/DR)

Technology Innovation (DER)

Lost Revenues

Rate Increase Required

Customer Assessment

DER

The threat of the "utility death spiral" is pushing companies to rethink their rate structures, often with controversial consequences. Credit: Edison Electric Institute’s "Disruptive Challenges"
Diminishing Growth In Electric Energy Consumption
ENERGY

ECONOMY & CONSERVATION

Conservation
By stopping wastage and using appliances properly.

Efficiency
By buying efficient appliances.

Both Save Energy and Money

✓ Reduce consumption or stop wastage to save energy.

✓ Same output for lesser energy.
DER may reach 33% of Installed US Capacity by 2020

Effectively all incremental growth in capacity will come from customers

**US Resource Capacity**

- **Backup Generation:** 240 GW
- **CHP:** 122 GW
- **Demand Response:** 90 GW
- **Solar PV:** 40 GW
- **Other DG:** 15 GW
- **Dist. Storage:** 3 GW

**Potential DER Total:** 500 GW

Sources: EIA, EPA, DOE, FERC, Carnegie Mellon, GlobalData
Nearly half of utility-scale capacity installed in 2017 came from renewables

Source: U.S. Energy Information Administration, Form EIA-860M, Preliminary Monthly Electric Generator Inventory
Netting all additions and retirements

Renewables accounted for ~95% !!!
Eroding Monopoly
FORMAL Deregulation

Electric Competition
DEFACTO DEREGULATION

ELECTRIC COMPETITION
Conservation & Energy Efficiency
Energy Management Systems become Non-Utility Virtual Power Plants
The Cost of Electricity
EV Lithium-Ion Battery Pack Price
($/KWh)

EV lithium-ion battery pack prices will have fallen 77% between 2010 and 2018.

- Observed values, BNEF EV Lithium-Ion battery price index
- Reported future value, major manufacturers

Note: Forecast range based on a learning rate of 14-20%. EV cost parity is calculated on an unsubsidised total cost of ownership (TCO) basis. Date range reflects cross over with different vehicle classes in the US.

Source: Bloomberg New Energy Finance, EV lithium-ion battery price index
Annual electricity output by the major generating technologies, 2016-40, thousand TWh.
“Wind and solar are set to surge to almost “50 by 50” – 50% of world generation by 2050 – on the back of precipitous reductions in cost, and the advent of cheaper and cheaper batteries that will enable electricity to be stored and discharged to meet shifts in demand and supply. Coal shrinks to just 11% of global electricity generation by 2050.”

• https://about.bnef.com/new-energy-outlook/
Solar With Batteries Cheaper Than Gas in Parts of U.S. Southwest

Toward a network of networks.

**Today: One-way power system**
- Large, centrally located generation facilities
- Designed for one-way energy flow
- Utility controlled
- Technologically inflexible
- Simple market structures and transactions
- Highly regulated (rate base) and pass through

**Emerging: The energy cloud**
- Distributed energy resources
- Multiple inputs and users, supporting two-way energy flows
- Digitalization of the electric-mechanical infrastructure: smart grid and behind-the-meter energy management systems
- Flexible, dynamic, and resilient
- Complex market structures and transactions
- Regulation changing rapidly around renewables, distributed generation (solar, microgrids, storage), net metering, etc.
### Emerging utility models

Utilities need to adopt a new structure to serve the customer.

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<th><strong>Services &amp; solutions</strong></th>
<th><strong>Transactive commodity exchange</strong></th>
<th><strong>System operation and planning</strong></th>
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<td>Static web/mobile service experience</td>
<td>Flat tariff structure based on rate</td>
<td>Traditional planning to accommodate central station generation</td>
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<tr>
<td>Electric service support, program enrollment</td>
<td>No sensitivity to location or temporal value of service</td>
<td>Static long-term planning process</td>
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<td>Structured platform enables transactions across traditional services and P2P scenarios</td>
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<td>Dynamic/personalized customer experience</td>
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<td>Full real-time exchanges (either bilateral or through a commodity exchange — e.g., D-LMP)</td>
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<td>Real-time power-quality assessment and reliability monitoring</td>
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<td>Connected distributed architecture</td>
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<td>Mass market DER integration with traditional infra.</td>
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<td>Two-way power flows</td>
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<td>Fully transparent System-Centric infrastructure</td>
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CHANGE OF DA IMPORTANCE IN NEXT 3 TO 5 YEARS

- **INCREASE**: 90%
- **NO CHANGE**: 8%
- **DECREASE**: 2%
Distribution System Operator
Energy As A Service

Energy Efficiency
- Optimization
- Retrofit
- Maintenance

Energy Resources
- Supply
- Generation
- Storage

Energy Financing
- Balance Sheet
- Partnerships
- Guarantees

Energy Insights
- Data Aggregation
- Monitoring
- Analysis
Transactive Energy Markets
(Block Chain / Cryptocurrency)
NEW BUSINESS MODELS

LET GO OF COST-PLUS MONOPOLY MINDSET

COMPETE FOR CUSTOMERS

YOUR CUSTOMERS DID NOT SIGN
THE LONG-TERM, ALL-REQUIREMENTS
WHOLESALE POWER PURCHASE AGREEMENT!
Trying to ensure full cost recovery with declining sales is not a sustainable tactic in a competitive market.

Business viability depends upon cutting costs, adding value, and new revenue sources.