HDR

Association of Women in Energy Conference

October 14, 2015

Distributed Generation Technologies

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01 The Basics of Distributed Generation

02 How is the Distributed Generation Market Changing

03 Technical Trends in Distributed Generation

01 The Basics of Distributed Generation

Distributed Generation

- DEFINITION (IEEE)
  - The generation of electricity by facilities that are sufficiently smaller than central generating plants so as to allow interconnection at nearly any point in the power system

(IEEE) Institute of Electrical and Electronics Engineers

Traditional Power Generation/Delivery Model

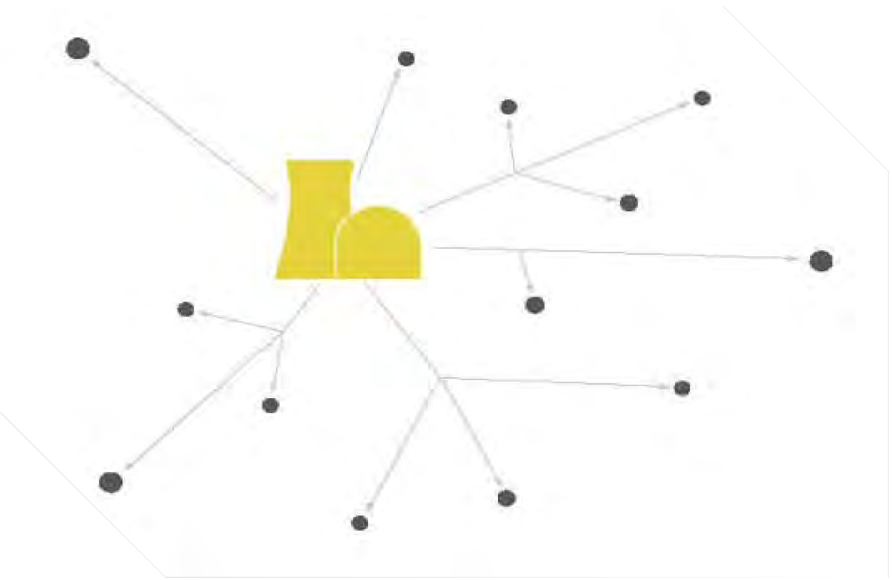
Generation ⟶ Transmission ⟶ Distribution/Residential ⟶ End User

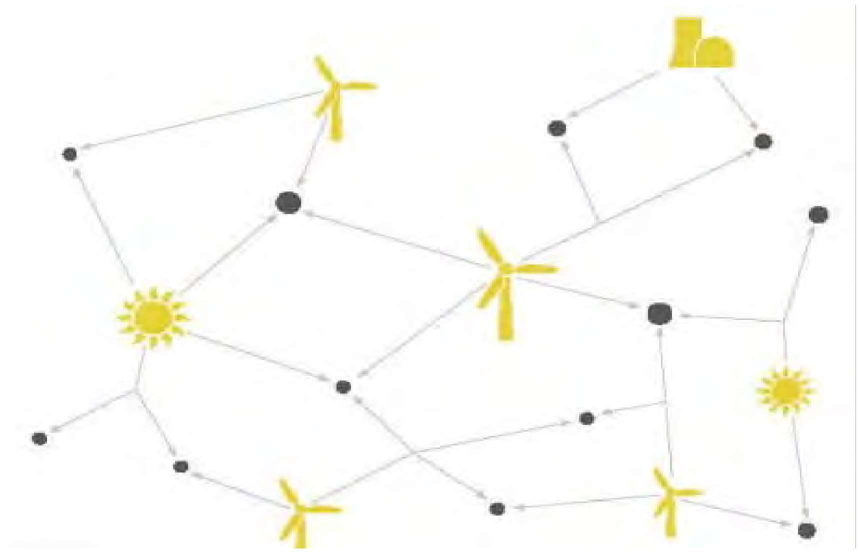
Distributed Power Generation/Delivery Model – Evolving

Generation ⟶ Transmission ⟷ Distribution/Residential ⟷ End User

The existing Power infrastructure has presented many challenges and opportunities

- Large centrally located generation
- Generation Locations are moving
- Load center demands are increasing





02 How is the Distributed Generation Market Changing

The existing state of our electrical distribution system is not acceptable

What areas of the business will see impacts from the DG evolution?

- Regulatory Compliance & Resiliency
- Fuels Planning
- Revenue/Cost Forecasting
- Demand Side Management
- Power Generation Planning/Supply
- Load Balancing
- Power Delivery/Grid Stability

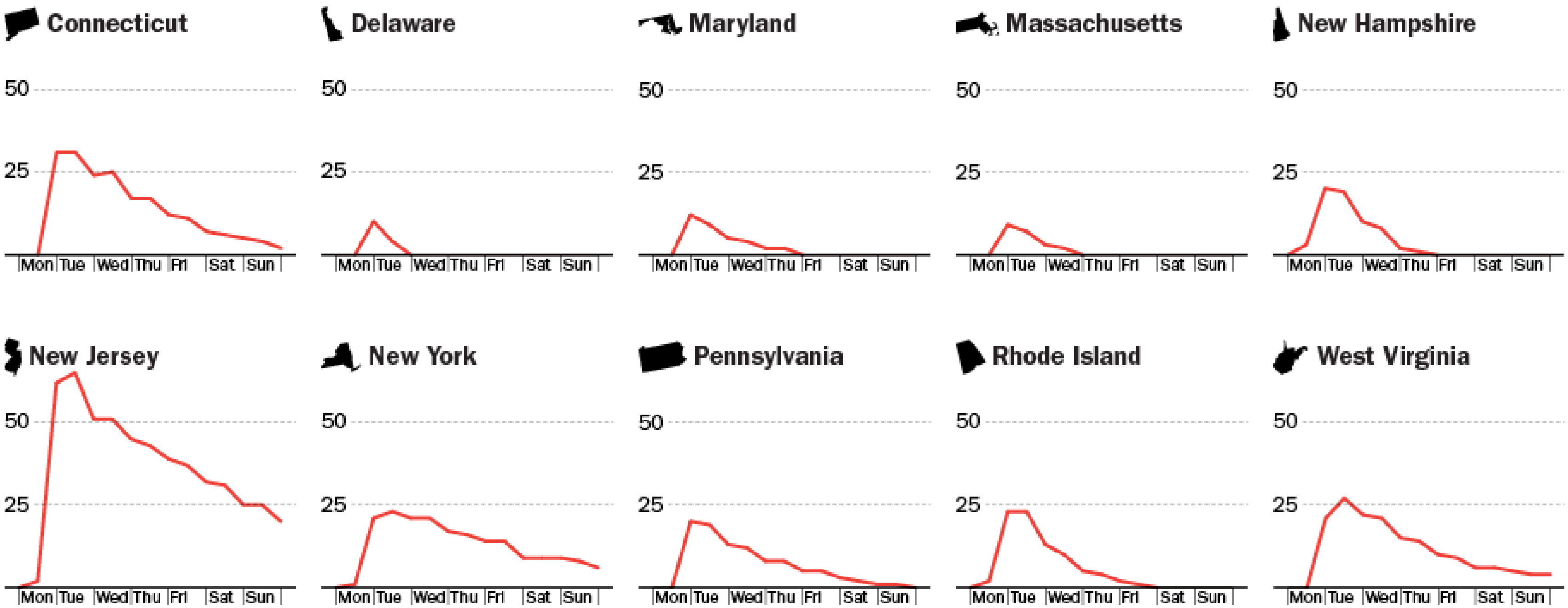
Customer Service

Regulatory Compliance & Resiliency

- Environmental Constraints
- NERC/FERC
- EPA
- PSC/PUC

East Coast Slowly Restores Power After Hurricane Sandy

The strong winds and heavy rains of Hurricane Sandy left more than 8 million people without power along the East Coast. Several states that anticipated massive outages, such as Maine, North Carolina, Ohio, Vermont and Virginia, were only minimally affected. Others, however, weren't so lucky. New Jersey was hit particularly hard, as was Connecticut. Power has been slow to return in these areas, with some expected to be in the dark for another week. Below are the 10 states affected most by outages and the rates at which they're recovering.



Source: United States Department of Energy/Note: Data current as of 10 a.m. on Nov. 5.

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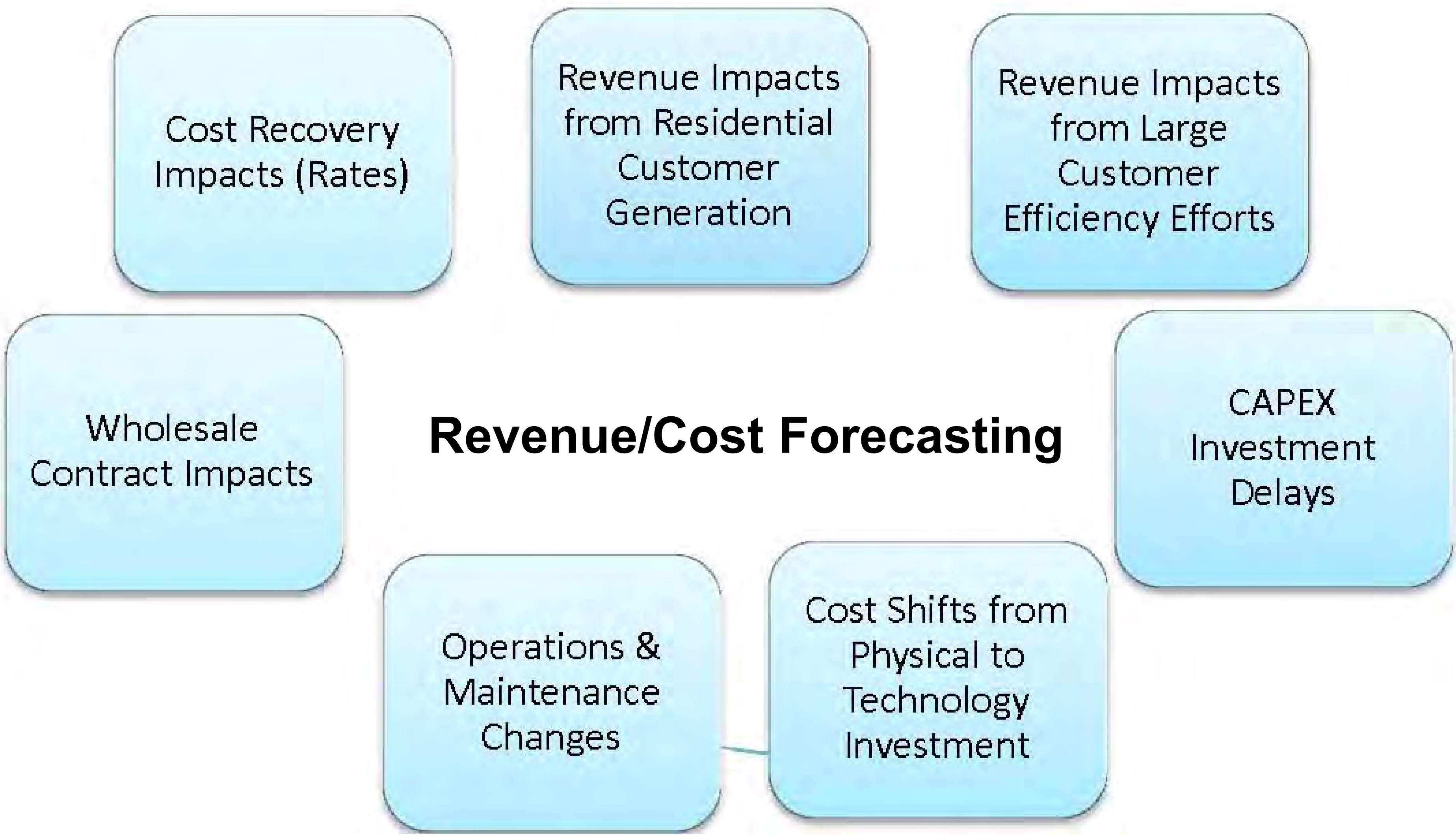
Fuels Planning

- Changes to long term use of coal, gas, etc.
- More smaller projects to negotiate contracts for rather than few, large ones.


Cost Recovery Impacts (Rates)
Revenue Impacts from Residential Customer Generation
Revenue Impacts from Large Customer Efficiency Efforts
Wholesale Contract Impacts
Revenue/Cost Forecasting
CAPEX Investment Delays
Operations & Maintenance Changes
Cost Shifts from Physical to Technology Investment

Demand Side Management

- Load reduction to delay the next large capital cost increase via:
  - Smart Metering
  - Use of Residential Scale Battery Systems
  - Utility Control of Residential Level Equipment (appliances, air conditioners, etc.)
  - Plug in Hybrid Vehicles/Fuel Cells

What are some DG Power Generation Options?

- Combustion Turbine
- Small Steam Turbine
- Solar PV Energy
- Geothermal source heat
- Wind & Micro wind
- Fuel Cells/Energy Storage
- Biogas

Load Balancing

- Large scale base load
- Distributed system modeling
  - Small scale variable renewables addition
  - Fast response energy storage
- Key node points for RTO transmission modeling integration tied to distributed model

Power Delivery/ Grid Stability

- With increase in DG, there are additional technical challenges to maintaining the grid. These can be mitigated using:
  - Energy Storage Systems
  - Smart Inverters
  - Reactive compensation (dynamic static compensators/ Synchronous Condensers/ Flywheels)
  - VARS Optimization at Substation level

03 Technology Trends in Distributed Generation

Trends in Distributed Generation

- Renewables + Combustion Turbine (Diesel or Gas) + flywheel
- Renewables + Storage (Load Shifting)
- Renewables + Storage (Demand Side Management)
- Renewables + Spinning Reserve for Grid Support (VARS)

Renewables + Flywheel + Combustion Turbine

- Issue: Variable generation associated with renewables and impact on grid. As renewable % increases, increased risks for power supply disruptions if no other modifications made to the grid.
- Solution: Supplement renewables with small scale combustion turbines (CTs) and flywheel backup. Quick start CTs can quickly start to fill the gap between demand and renewable generation during variable hours. Flywheel use supports the grid during switching between the renewable resource and the CTs.

Renewables + Flywheel + Combustion Turbine

- Well suited for Industrial or heavy power users as well as for grid balancing
- Gas least cost traditional generation and consistent generation
- Wind/Solar least cost renewable generation but variable generation
- Flywheel transitions from variable renewable to quick start turbine
- Utility Issues
  - Small gas traditionally not base load – peaking load and /intermediate load
  - Gas price volatility – Past \$2-\$12/MMBTU
  - Renewables – Gas price hedge
  - Renewable and Carbon Reduction
- Together
  - Reliable and Renewable
  - Low & no emissions – SOx, Nox, mercury, CH2
  - Relatively easy to permit

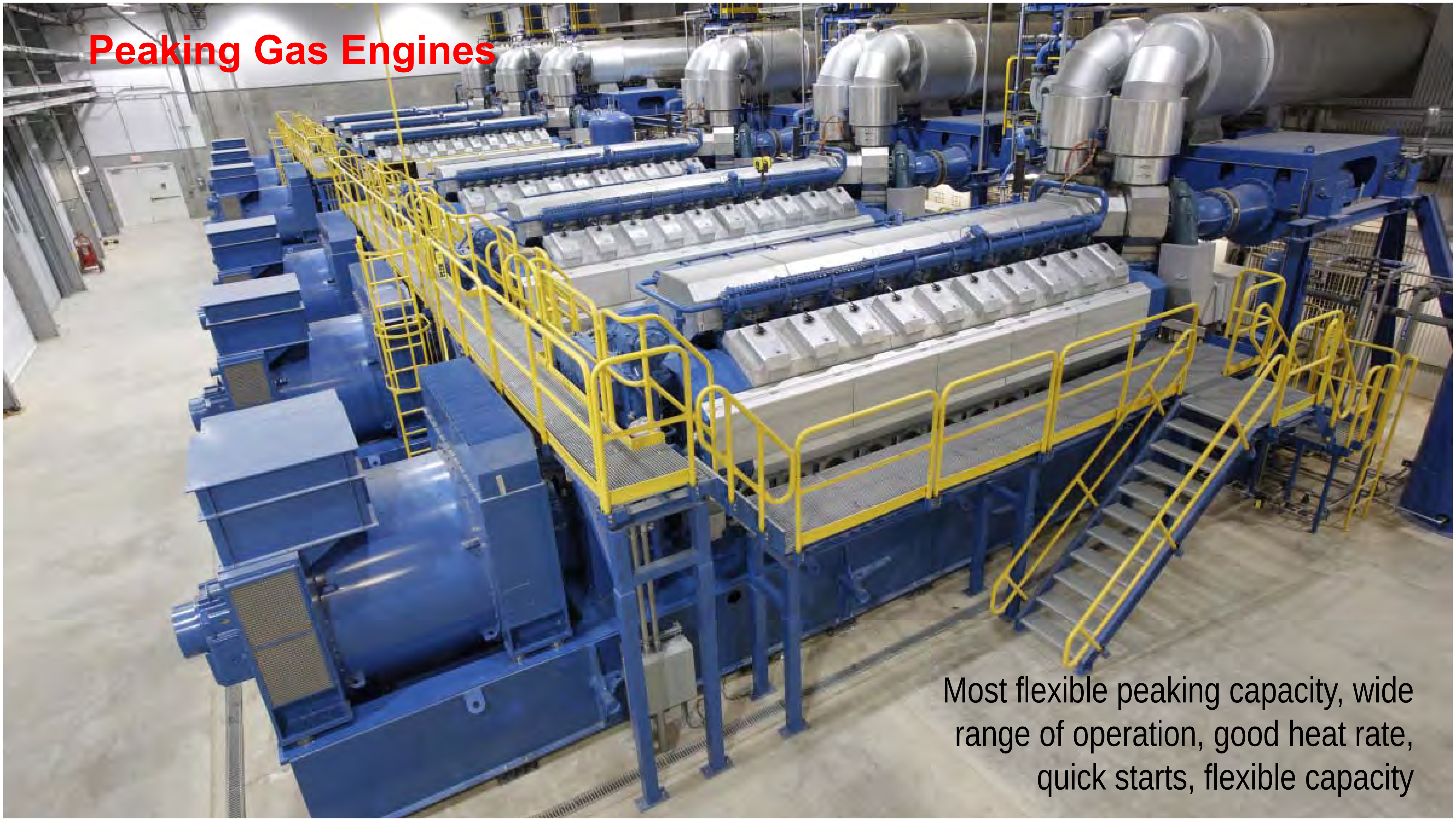
Gas and Renewable Power Generation

Wind/Solar

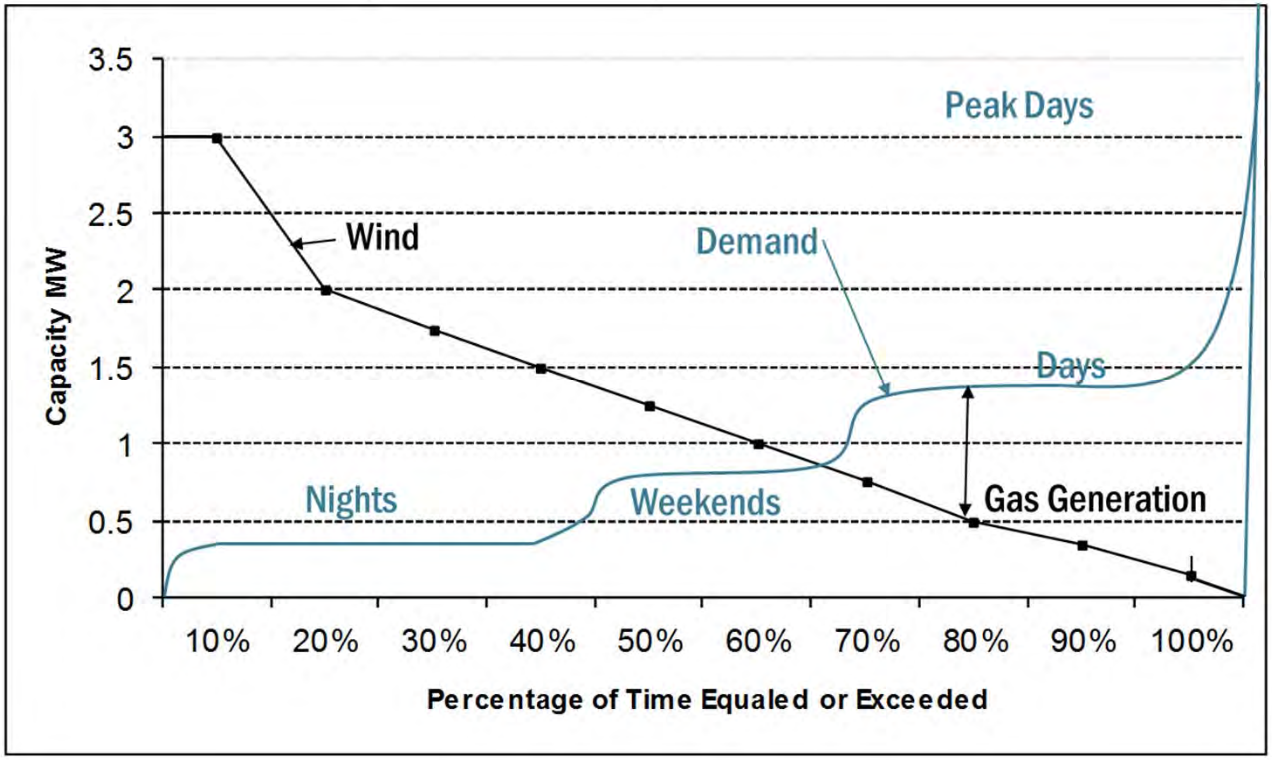
- Renewable
- Clean generation
- Variable Efficiency
- Variable Capacity
- Significant Capital Cost
  –$2 M/MW range
- Unlimited fuel availability
- Relatively easy to permit
- Relatively quick to build – 1-2 years

Gas

- Fossil
- Clean combustion
- High efficiency
- Dependable Capacity
- Moderate Capital Cost
  - $0.4-2.0 M/MW range
- Good fuel availability
- Relatively easy to permit
- Relatively quick to build – 1-3 years


Peaking Gas Engines
Most flexible peaking capacity, wide range of operation, good heat rate, quick starts, flexible capacity

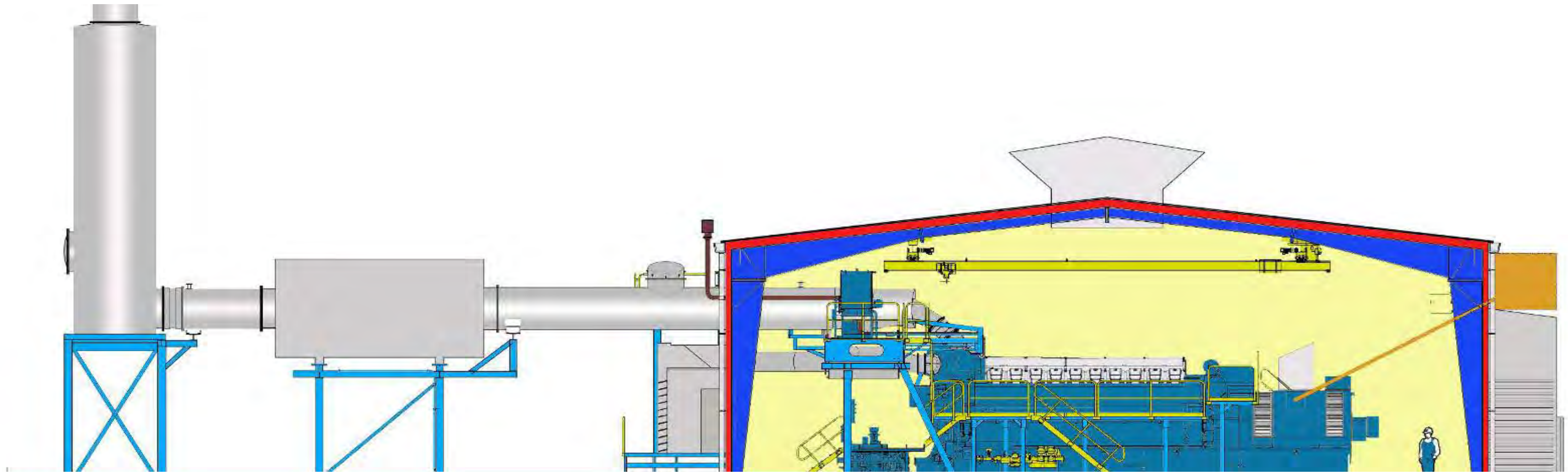
Renewables, Demand, and CT Generation



Wind = Negative Demand (worst case assumption)

Why use?

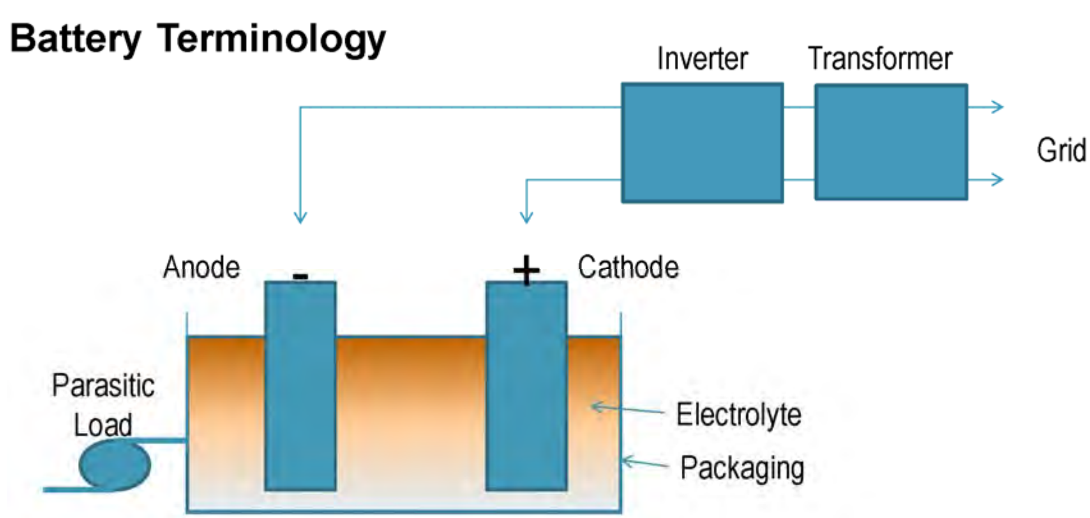
- Wind/Solar – provide renewable energy to extent possible to minimize fuel costs.
- Gas – supports wind/solar as needed to continue to provide revenues at lower cost that cycling more expensive generation (coal, large gas plants, etc.)
- Flywheel – provides grid support for instantaneous power and reactive power during transitions between renewables and turbine generation
- Increases – Capacity factor compared to renewables alone
- Provides – Potential for additional revenues by using lower cost generation overall.

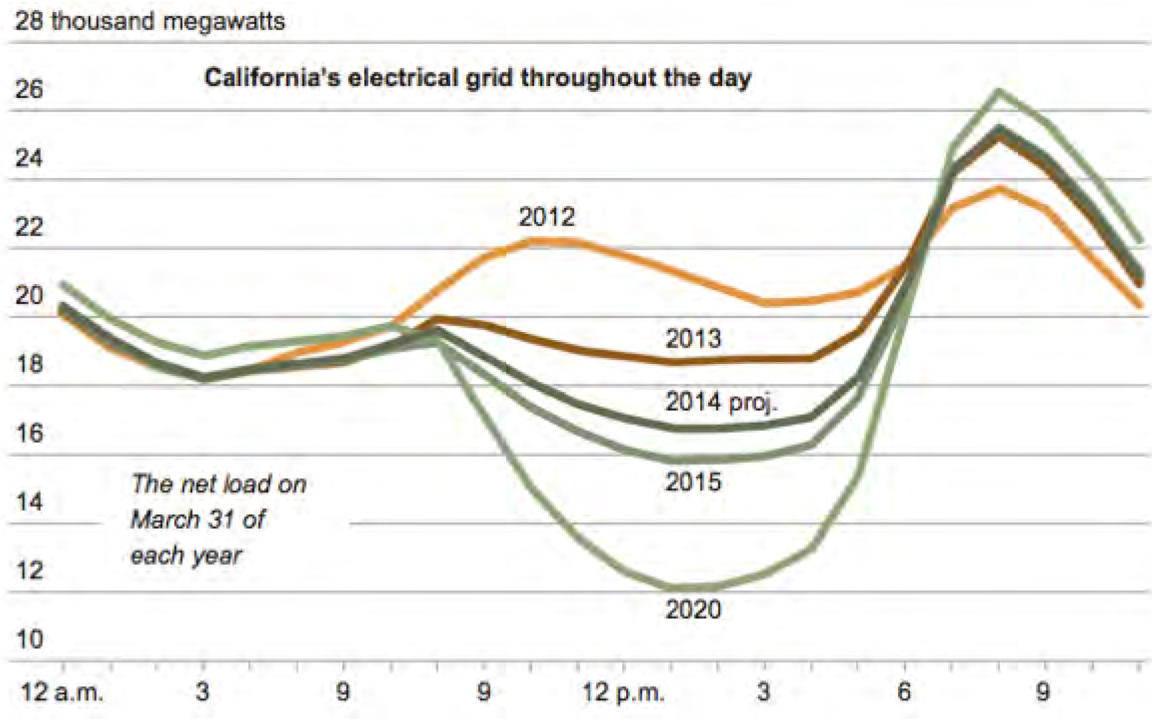


Renewables + Storage (Load Shifting)

- Issue: Power supply and grid stability issues as solar generation tails off and traditional generation ramps back up. As solar % increases, the timing of load generation does not match up with timing of maximum demand. This increases risks for power supply disruptions if back up generation sources can start soon enough to maintain grid stability.

- Solution: Storage can be used to extend the time used for traditional generation ramp up each day to allow existing infrastructure to be utilized while still capturing the economic benefit of renewables.

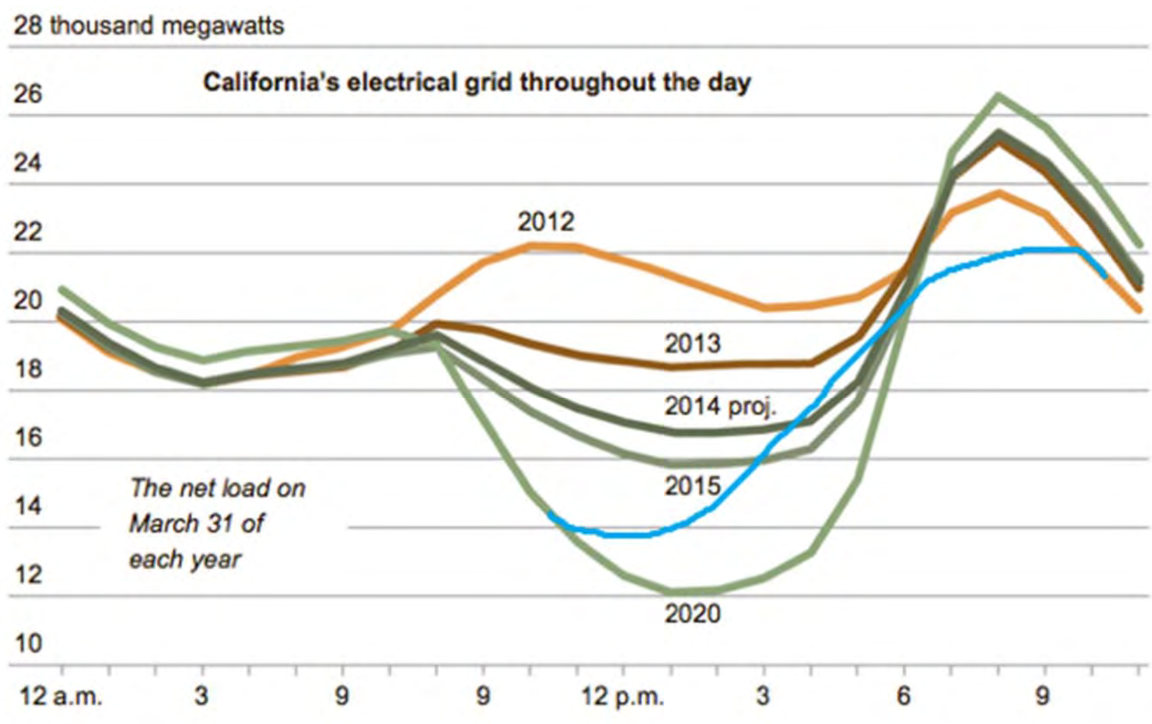




Source: CalISO

Renewables + Storage (Load Shifting)

What does the current load curve look like?



Source: CalISO

Renewables + Storage (Load Shifting)

What does the curve look like with energy storage added?

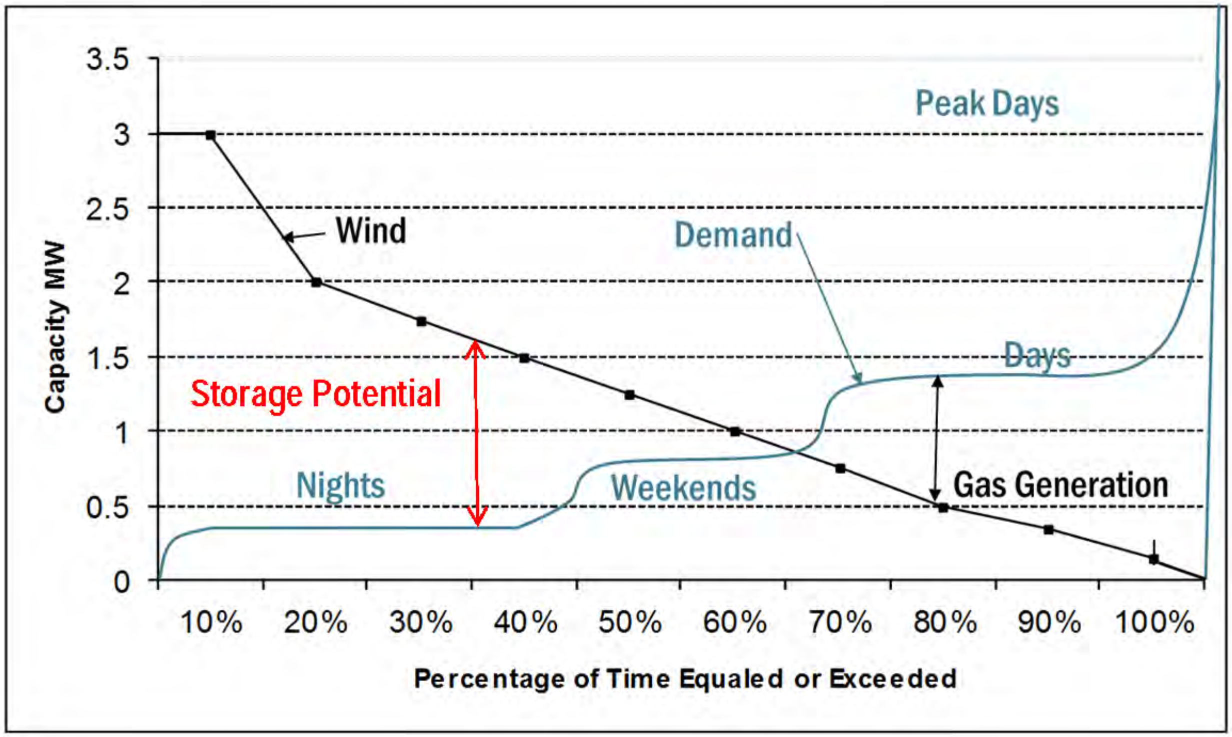
Why use?

- Allows for continued use of existing, utility scale generation for greater revenue capture
- Allows for integration of solar into the distributed system with minimum impact on the larger transmission system
- Delays CAPEX expenditures of new quick start turbines
- Reduces OPEX costs of forcing existing generation from quick starts it was not designed for and cannot do
- Prevents grid instability as loads increase

Renewables + Storage (Demand Side Management)

- Well suited for constrained environments where there is limited to zero ability to increase system capacity during peak periods
- Allows Utility or service provider to access the stored power located in customers home/commercial scale energy storage devices to provide power to the distributed network during peak load periods.
  - Home battery
  - Fuel Cells from Electric Vehicles

Renewables, Demand, and Storage Potential



Wind = Negative Demand (worst case assumption)

Renewables + VARS Support (Grid Stability)

- Issue: With the decommissioning of large fossil facilities and the increased % of renewables installed at the distribution level that does not create reactive power, transmission and distribution grids face instability issues with a lack of steady VARS generation.

  - Utilities deliver both Active (kW) and Reactive Power (VARS) to the grid. VARS is used to maintain line voltage in order to deliver KW in the required voltage in the transmission and distribution systems.

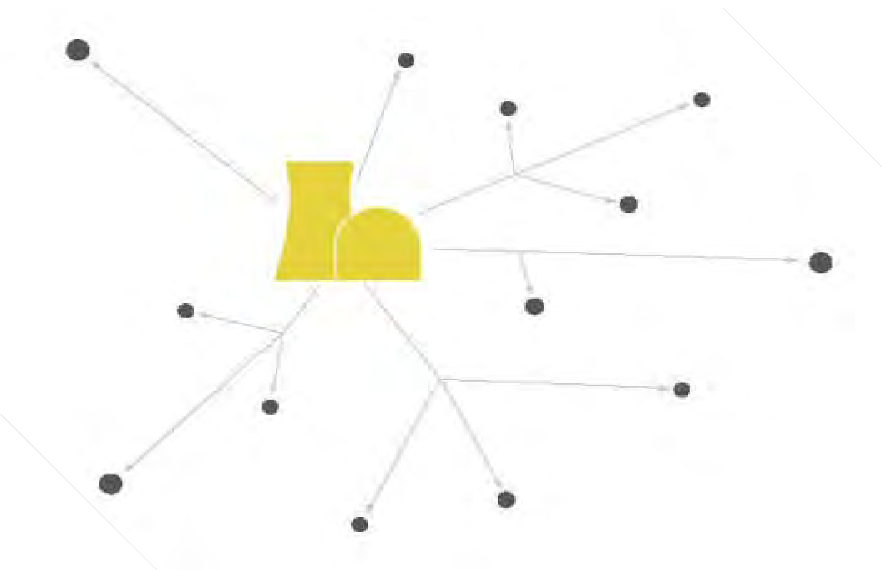
- Solution: As renewable generation increases on the distribution system, the use of smart inverters or other technologies that can produce and accept VARS will be necessary to maintain system voltages.

VARS support technologies

- Smart inverters
  - Inverters paired with solar PV which can generate and accept VARS from distributed grid.
- Synchronous Condensors
  - Starting to see generators being repurposed from fossil generation (Kw and VARS) to VARS management. Utility Scale
  - Spinning rotor with electromagnetic and mechanical inertia – flywheel
  - Application at Distributed level paired with renewables

The existing Power Market will be impacted by Distributed Generation in the future

- Distribution Generation Trends including renewables, small combustion turbines, energy storage, demand side management and grid stability will all play a role in the changing power market in years to come.
- Trends will impact revenues, costs, resiliency efforts, regulatory discussions and long term utility operations.



Questions?

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