Virginia Solar Pathways Project Training Session
Module II: Generation Overview

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Solar Pathways Project

Goal:
To Develop a Common Foundation of Technical & Regulatory Understanding
Utility Overview

Generation

- Power Plant Generates Electricity
- Transmission Lines Carry Electricity Long Distances
- Distribution Lines Carry Electricity To Houses
- Transformer Steps Up Voltage For Transmission
- Neighborhood Transformer Steps Down Voltage
- Transformers On Poles Step Down Electricity Before It Enters Houses
Generation & Utility-Scale Solar
Generation System Planning

Why is Utility and Regional Generation System Planning Needed?

**Produces** electricity for customers utilizing existing power plants balancing real-time load with current generation output

**Forecasts** load in the near and long-term including a reserve margin to ensure reliability

**Plans** future generation resources to meet customers’ projected capacity and energy requirements on an instantaneous basis
Generation Resources
Power Plants

*Produce electrical energy that is delivered to customers using many different types of fuel*

**Generation Unit** – single turbine or generator

**Power Plant** – multiple generation units in one facility
Dispatchable Generator Capacity

Baseload Resource
- Minimum (or base load) of the system
- Produces electricity and runs continuously

Intermediate Resource
- Less than base load, greater than peak load
- Used during transition between baseload and peak requirements

Peaking Resource
- Meets requirements during highest load periods
Generation Options

Most common resources used to generate electricity:

Steam & Air:
- Nuclear
- Coal
- Gas
- Oil

Renewables:
- Solar
- Hydro
- Pumped Storage*
- Biomass
- Wind

*Not included in the formal definition of renewable energy
Combustion Turbine (CT)

One generator produces energy using an internal combustion engine, similar to a jet engine, fueled by gas or oil.
Steam Turbine
Hydro

A dam is opened allowing for rapid changes in power output using the force of the river current
Pumped Storage

- Stored water in upper reservoir is released to turn turbines and generate electricity during periods of high demand.
- Water is pumped back to the upper reservoir during periods of low demand.
Wind

The flow of the wind current spins the turbine.
Utility-Scale Solar PV

Cells in a solar panel use the energy of photons to dislodge electrons from their atomic bonds.
Solar Fixed Vs. Horizontal Tracker

Fixed –
- Does Not Move
- Less Upfront Capital Costs
- Less Energy Output

Horizontal Tracker –
- Moves to Orient Toward Sun
- More Upfront Capital Costs
- More Energy Output

Graph showing average daily insolation for different solar tracking systems at a latitude of 40°N.
# Generation Resource Comparison

<table>
<thead>
<tr>
<th>Resource</th>
<th>Capital Costs</th>
<th>Fuel Costs ($/MWh)</th>
<th>Capacity Factor</th>
<th>Dispatchable</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>$</td>
<td>High</td>
<td>~20%</td>
<td>Yes</td>
<td>Peak</td>
</tr>
<tr>
<td>CC</td>
<td>$</td>
<td>Moderate</td>
<td>~70%</td>
<td>Yes</td>
<td>Baseload/Intermediate</td>
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<tr>
<td>Utility-Scale Solar</td>
<td>$$</td>
<td>None</td>
<td>~20%</td>
<td>No</td>
<td>Intermittent</td>
</tr>
<tr>
<td>Onshore Wind</td>
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<td>None</td>
<td>~40%</td>
<td>No</td>
<td>Intermittent</td>
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<tr>
<td>Coal</td>
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<td>~70%</td>
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<td>Baseload/Intermediate</td>
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<tr>
<td>Biomass</td>
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<td>Moderate</td>
<td>~90%</td>
<td>Yes</td>
<td>Baseload</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>$$$$</td>
<td>None</td>
<td>~40%</td>
<td>No</td>
<td>Intermittent</td>
</tr>
<tr>
<td>Nuclear</td>
<td>$$$$</td>
<td>Low</td>
<td>~90%</td>
<td>No</td>
<td>Baseload</td>
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</tbody>
</table>
Dispatchable Screening Curve

2014 IRP Screening Curve

- $/kW-YEAR vs. Capacity Factor
- Graph showing cost per kW-year against capacity factor for various fuel types:
  - FUEL CELL
  - BIOMASS
  - NUCLEAR
  - IGCC
  - 3X1 CC
  - CT
  - Coal
Fuel Diversity Advantages

- Improves reliability
- Reduces reliance on one fuel source reducing price shocks
- Variety of technologies, costs, and availability

2013 Actual Capacity Mix

2013 Actual Energy Mix
PJM Market
**PJM**

- Regional Transmission Organization (RTO) that is part of the Eastern Interconnection
- Coordinates movement of wholesale electricity across 13 states
- Neutral, independent party that helps ensure grid reliability utilizing long-range planning procedures

**PJM does:**
- Direct operation of the transmission system
- Remain profit neutral
- Maintain independence from PJM members
- Coordinate maintenance of grid facilities

**PJM does not:**
- Own any transmission or generation assets
- Function as a publicly traded company
- Take ownership of the energy on the system
- Perform the actual maintenance on generators or transmission systems (e.g. repair power lines)
- Serve, directly, any end use (retail) customers
PJM

Capacity Market
- Ensures long-term reliability to meet forecasted demand
- Uses Reliability Pricing Model (RPM)
- New PJM Capacity Rules
- Forecasting & Reliability of Solar

Energy Market
- Coordinates the buying, selling, and delivery of wholesale energy
- Uses Locational Marginal Pricing (LMP)

Ancillary Services
Dispatch

**Dispatch** – the order in which a power system meets customer demand for electricity

**Dispatch Cost** – average incremental operating cost for the next available capacity segment
Locational Marginal Pricing (LMP)

PJM Energy Market

- Reflects the value of energy at the specified location and time that it is delivered
- Mechanism for using market-based prices to manage transmission congestion
- Prices determined by the bids submitted by market participants
- Marginal cost of supplying the next incremental electric demand at a specified location
Reliability Pricing Model (RPM)

PJM Capacity Market –

- Ensures adequate development of new generating capacity at a reasonable cost
- Solicits capacity offers 1-3 years into the future via a Base Residual Auction (BRA)
- Determines amount of capacity DVP is required to build or buy to meet future reserve margins
Ancillary Services

Frequency Regulation –
- Provides the continuous balancing of generation and load

Synchronized Reserve –
- Balances generation and load after the loss of generation

Reactive Services –
- Maintains transmission voltages within acceptable limits
Integrated Resource Plan (IRP)

Forecast of a utility’s load obligations and its plan to meet those obligations by supply-side and demand-side resources over the next 15-years to promote reasonable prices, reliable service, energy independence, and environmental responsibility.

Regulatory Requirements
- Virginia
- North Carolina
Supply-Side vs. Demand-Side

Supply-Side –
- Conventional Generation Resources
- Renewable Generation Resources
- Non-Utility Generation
- Wholesale & Purchased Power

Demand-Side –
- Demand-Side Management (DSM)
- Energy Efficiency
- Demand Response
Long-Term System Planning Process

- Financial
- Load Forecast
- Environmental Compliance
- Fuel Prices
- Emission Prices
- New & Existing Unit Data
  - Heat Rate
  - Capacity
  - Installed Cost
  - O&M Costs
2014 IRP Fuel Diversity Plan

- Market Purchases
- Proposed and Future DSM
- Generation Under Development
- Approved DSM
- Generation Under Construction
- Existing Generation

Note: 1) Accounts for unit retirements and rating changes to existing units in the Plan, and reflects summer ratings.
2) See 2014 Integrated Resource Plan, Section 4.2.2.
2014 IRP Plan Overview

Base (Least Cost) Plan
- Gas currently remains the least cost generation option

Fuel Diversity Plan
- Continue reasonable development of fuel diverse generation options
- Increased solar, onshore wind, new nuclear, and gas

EPA Greenhouse Gas (GHG) Plan
- One way of meeting the proposed CO2 Regulation by including Additional Renewables
- Greatly increased solar, onshore wind, new nuclear and gas
Proposed Clean Power Plan

- Environmental Protection Agency (EPA) Greenhouse Gas (GHG) Regulation via Rule 111(d) for Existing Plants
- Requires significant reductions in carbon emissions via ambitious carbon intensity reduction targets in Virginia of approximately 38%
- CO2 intensity target for Virginia averaging 884 lb/MWh for 2020 – 2029 and 810 lb/MWh for 2030 and beyond
- Final Rule Expected Summer 2015
Solar Considerations

- Fuel Diversity
- Emissions Free Operations
- Scalable
- Located Near Load & Congestion
- No Fuel Cost

- Intermittent
- Integration Costs
- Low Capacity Factor
- Generation Vs. Peak Demand
- Limited Capacity Value
Utility-Scale Solar Development
Example: New Utility-Scale Solar

What process would the Company follow to develop a 100 MW Utility-Scale Solar Facility?
Need & Development

Step 1: Determine the Need
- Integrated Resource Plan
- Strategist Modeling

Step 2: Identify Sites
- Site Selection Process
- Interconnection Requests & Costs
- Engineering, Procurement, & Construction (EPC) Contractor Selection
- Finalize Costs & Technology
Strategist Modeling

Step 3: Model Cost/Benefit Analysis

- Assumptions, Finalized Costs, & Technology Modeled
- Considerations Include:
  - Capital Costs & Financing
  - RECs
  - Revenue Requirements
  - Fixed and Variable Operations & Maintenance (O&M) Expenses
  - Fuel Costs
  - PJM Market
Regulatory Proceeding

Step 4: Obtain Required Permits & Approvals

- Local Permits & Approvals
- Environmental Permitting
- Virginia State Corporation Commission (SCC) Approval for a Certificate of Public Convenience and Necessity (CPCN) & Rider
  - Application, Testimony, & Public Hearing
  - Discovery
- Provide Cost Justification
  - Strategist Modeling Results & Cost/Benefit Analysis
  - Rates
Development & In-Service

Step 5: EPC Contractor Notice To Proceed
- After all approvals received

Step 6: Construction of New Resource
- Construction Term of Approximately 8 Months
- Commercial Operation Date (COD) Determined
Solar Pathways Project
Study #1: Solar PV Integration

Investigate Impacts of Solar PV on:
- Ancillary Services
- Generation production costs
- T&D Losses
- Power Flows

Determine Critical Levels of PV:
- Material increase of System costs or
- Significant changes required to DVP energy system

Optimal Locations for Solar PV Installation
Questions?