Agenda

• Transmission & Distribution (T&D) Value Study Recommendations
• Words to know
• What is the grid
• Overview of T&D Grid and Planning Process
• Power Flow on Grid – Yesterday vs Today
• Battery Storage & Energy Control Examples
• T&D Grid Impacts
• Illustrative Distribution Substation Transformer Loading & NEM PV Production
• Illustrative Service Transformer Loading & NEM PV Production
• Transmission & Distribution (T&D) Value Study Recommendations
NEM solar valuation -
Transmission & Distribution perspective

System Demand
- Benefit: Reduces daytime demand and may delay traditional system upgrades
- Cost: Capacity is still required to serve intermittency, evening load ramping, and immediately upon utility restoration

System Losses
- Benefit: Local generation reduces losses on distribution and transmission grid
- Cost: Excess generation increases losses at local level

Reliability & Resiliency
- Benefit: Customers can run critical loads using their PV/Storage system if isolated from the utility grid
- Neutral: Inverters will trip off line during system disturbance

Voltage/Power Quality
- Benefit: Local power quality support can be maintained with appropriate Smart Inverter settings
- Cost: Distribution system equipment wear & tear (voltage regulators, capacitors)
Words to know

- **American National Standards Institute (ANSI)** – Organization that oversees development of standards for products, services, processes and systems

- **ANSI C84.1** – American National Standard for Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)

- **California Public Utility Commission** – A government entity that regulates privately owned utility companies in California

- **Distribution Capacity** – The maximum loading an electrical equipment on the distribution grid can support during normal and emergency conditions measured in megavoltamperes (MVA) or kilovoltamperes (kVA)

- **Energy** – The amount of electricity produced by a generator, consumed by a customer, or stored by a battery over a specific period of time and measured in megawatt-hours (MWh) and kilowatt-hours (kWh)

- **Federal Energy Regulatory Commission (FERC)** – An agency that regulates the energy industry

- **Grid** – A network of transmission and distribution facilities that provide path for power to be transmitted from a generation source all the way to end users.

- **Native load** – The end-use customer connected loads (Air conditioner, appliances, electric vehicle charger, etc.)

- **North American Electric Reliability Corporation (NERC)** - A regulatory body that assures grid reliability and security

- **Power** – The output an electricity generator, demand resources or batteries deliver to a grid, measured in megawatts (MW) or kilowatts (kW)

- **System Demand** – The amount of power provided by SMUD to meet customer electricity use, including electricity travel losses, at a specific time measured in megawatts or kilowatts

- **System Losses** - Electricity has to be transmitted to consumers via extensive networks. The transmission over long distances creates power losses. The major part of the energy losses comes from Joule effect in transformers and power lines. The energy is lost as heat in the conductors.

- **Western Electricity Coordinating Council (WECC)** – An organization that has been delegated to assure grid reliability and security of the Western Interconnection’s Bulk Power System

January 9, 2020
What is the grid?

SMUD Electrical System

Transmission & Subtransmission

Primary Service
Secondary Service
Dedicated Service

Transmission

230,000 Volt Transmission Circuit
Transmission Tower
Transmission Switching Station
Oil Circuit Breaker
Transmission Tower

69,000 Volt Subtransmission Circuit

230,000 to 69,000 Volt Transformer & Oil Circuit Breaker

69,000 to 12,000/6,930 Volt Transformer

Large Industrial Customers

12,000/6,930 Volt Distribution Circuit

Commercial Customers

Network Transformer

12,000/6,930 Volts

Distribution Transformer

Small Industrial Customers

Schools

Overhead Transformer

120/240 Volts

Stores

Residential & Rural Customers

SMUD®
• Miles of Line
  - Transmission – 484 miles
  - Sub-transmission – 646 miles
  - Distribution – 9,692 miles
  - Secondary – 5,710 miles

• 20 Transmission Substations

• 187 Distribution Substations

• Total Photovoltaic (Installed PV Capacity)
  - NEM
    - Residential – 113 MW
    - Commercial – 97 MW
  - Utility Scale – 110 MW
Overview of Transmission & Distribution (T&D) Grid Planning Process

• Purpose
  - Ensure transmission and distribution system adequacy to meet load serving needs
  - Ensure compliance with North American Electric Reliability Corporation (NERC) reliability standards and other applicable industry standards

• Drivers
  - Safety
  - Reliability
  - Power Quality
  - Regulatory Compliance
  - Cost Effectiveness
Overview of Transmission & Distribution (T&D) Grid Planning Process (cont)

• Transmission Planning horizon covers 10 years (updated annually)

• Distribution Planning horizon covers 5 years (updated annually)

• Criteria
  - Serve load during peak conditions without exceeding equipment thermal ratings and voltage operating limits
    - Transformers
    - Wires
  - Locate substation facilities as close to the load center and in commercial/industrial parcels if possible
  - Coordinate capital investments with aging infrastructure replacements and other capital maintenance programs and initiatives

In depth analysis performed annually to ensure transmission and distribution grid comply with reliability standards and serve load safely, reliably and cost effectively
Power Flow on Grid - Yesterday vs Today

Before NEM

1-Way Power Flow

After NEM

2-Way Power Flow

Transmission Lines
Transmission Substations
Sub-transmission Lines
Distribution Substations
Distribution Lines
Service Transformer & Secondary

NEM customers

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Since we last talked on November 7th SMUD has…

- Launched Residential Smart Energy Optimizer Pilot Program *(Residential Customer Pilot)*
  - Enables customer owned systems to dispatch when resources are needed
  - Pilot will evaluate device response reliability and grid impact
  - Pilot Payment Structure: $500 upfront and $10/month

- First customer enrollment into the SMUD Energy StorageShares Pilot Program *(Commercial Customer Pilot)*
  - Aligns customer investment in technology with grid needs
  - Avoids increased GHG emissions from demand charge reduction
  - Considers locational impact of technology adoption

- Released an RFP for a 4MW energy storage system
  - Will provide infrastructure support for the Hedge Substation
  - Planned market participation (CAISO / Energy Imbalance Market)
  - Evaluation of stacked value streams

- Completed Installation of our 60kW Second Life Battery Project
  - Located at SMUD’s PV canopy parking lot
  - Supporting 175kW DC fast charger, Level 1&2 Electric Vehicle Storage Equipment (EVSE's) and ~65kW of PV
  - Coordinated operation of all technologies reducing the burden on service infrastructure
This graph shows an **individual commercial customer load profile** for 1 day. The curve contains 96 data points taken at 15-minute intervals. Recording data at 15-minute intervals is standard for commercial customers.
This graph is an overlay of data from 9 similar commercial customer loads for a 24 hour day. Each line shows the utility meter readings for an individual customer.
Adding the 9 individual customer loads together shows the load that SMUD serves for these customers. Lowest consumption occurs overnight with increased consumption during the daytime.
The impact of battery control was evaluated under 2 scenarios. Scenario 1 assumes installation of batteries by individual customers and operation based on individual demand charge reduction. Scenario 2 considers the installation of a smaller battery system to reduce peak demand of the aggregated load.

**Scenario 1: Individual Optimization**

9 Individual Systems Installed: Each sized at 60kW // 120kWh  
Total Batteries installed: 540kW // 1080kWh  
Estimated Total Battery Cost: $600,000 to $1,000,000

**Scenario 2: Aggregated Optimization**

1 System Installed: 200kW // 400kWh  
Estimated Total Battery Cost: $200,000 to $400,000
Under scenario 1, individual operation of each of the 9 battery systems decreases the peak of the aggregated load. Peak reduction varies over the 24 hour period because individual customer loads do not always peak at the same time.

Scenario 1: Individual Optimization
Total Storage: 540 kW // 1080 kWh
Under scenario 2, aggregated operation of the battery systems also decreases the peak of the aggregated load. Peak reduction is more stable over the 24 hour period because the battery is not responding to changes at the individual customer level, but rather changes in the aggregated load.

Scenario 2: Aggregated Optimization
Total Storage: 200 kW // 400 kWh
This example shows the power of the utility model and how working together brings the best outcomes (financially & environmentally) for all parties and maximizes every dollar we spend to benefit all our customers.
Location Matters For Distributed Energy Resources

A few guiding questions for integration with distributed energy resources:
• How do we make the best use of the assets we have?
• How can we increase the useful life of the assets we invest in?
• How do we provide the right solution to the right place at the right time?

*Representative Example. Not based on actual location needs.
NEM / Grid Operating Environments

- **Optimal Sunny Conditions**
- **Cloudy / Smoky Conditions**
- **Grid Disturbances / Outages**
- **Evening Peak Load Conditions**
Rooftop solar reduces system net demand during normal daytime operating condition.
Load must be served under ALL conditions (cloudy or smoky day, evening). System must be designed to meet demand also when rooftop solar is not producing.
## Grid Impacts from PV on System Demand

<table>
<thead>
<tr>
<th>System Demand</th>
<th>Solar</th>
<th>Solar + Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEM Customer</strong></td>
<td>Benefit</td>
<td>Benefit</td>
</tr>
<tr>
<td><strong>Utility Distribution</strong></td>
<td><strong>Benefit</strong> – Reduces System Demand during normal day time operating conditions</td>
<td><strong>Benefit</strong> – Reduces System Demand during peak periods</td>
</tr>
<tr>
<td><strong>Grid</strong></td>
<td>Neutral - Does not contribute during non-solar producing periods</td>
<td><strong>Cost</strong> – Uncontrolled battery storage charging could increase System Demand</td>
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Rooftop solar reduces system losses but as excess generation flows upstream, then losses occur at local level.
Grid Impacts from PV on System Losses

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<tr>
<td><strong>Utility Distribution Grid</strong></td>
<td><strong>Benefit – Reduces System / Line Losses</strong></td>
<td><strong>Benefit – Reduces System Line Losses</strong></td>
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<td></td>
<td><strong>Cost – Excess generation causes System Losses at local level</strong></td>
<td><strong>Added Benefit – Shared control of the inverter can avoid load pockets</strong></td>
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Rooftop solar with Smart Inverter technology is capable to support voltage regulation at local level.
Grid Impacts from PV on Voltage Regulation

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| **Utility Distribution Grid** | **Benefit** – If applicable Smart Inverter technology functions are enabled it will provide voltage regulation support at local level.  
**Cost** – If not enabled, additional voltage support is required from SMUD to support all customers (i.e., capacitor banks, voltage regulators). | **Benefit** – If applicable Smart Inverter technology functions are enabled it will provide voltage regulation support at local level.  
Storage can provide additional benefit by absorbing excess PV generation. |
Rooftop solar will go off line in the event of a utility service outage.
## Grid Impacts from PV on Reliability & Resiliency

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Key Takeaway: Transformer capacity still required to address native load
Key Takeaway:
PV generation can become intermittent due to clouds or smoke
Key Takeaway:
Capacity still required to address native load
### NEM solar valuation - Transmission & Distribution perspective

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Questions
Illustrative Service Transformer Loading & NEM PV Production (5/11/19, 5/16/19, 1/7/20)

Distribution Service 75kVA Transformer Loading and NEM Generation

- Service Transformer Net Load
- NEM PV Gen
- Native Load

- 5/11/19 – Clear day
- 5/16/19 – Cloudy day
- 1/7/20 – Foggy day

January 9, 2020