Harnessing Electricity
Demand Flexibility

PSERC Summer School
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March 20, 2015 74% Solar Eclipse in Germany

- Solar output ramped down by 7 GW in 60 minutes
- Output ramped up by 13 GW in 60 minutes after eclipse
- Cloud cover fluctuations are smaller scale but can match similar rates of change

# Electric Vehicles

<table>
<thead>
<tr>
<th>Penetration Timeframe</th>
<th>&lt;10%</th>
<th>&gt;10%</th>
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</thead>
</table>
| **Daily load curve impact** | • Home charging after work: Load increase during evening  
• Work charging at beginning of work day: Load increase during morning | • More pronounced “Nessie” curve at end of day |
| **Minute by minute fluctuations** | • No major impact | • Load spikes when DC fast chargers heavily utilized |
| **Resulting load curve** | *When EV drivers come home in the evening and plug in their cars, they exacerbate the challenge of managing peak demand.* | [Image of load curve]

James Avery, SVP Power Supply, SDG&E

Electric Vehicles

- DC Fast Chargers (DCFC) Create Load Spikes
- DCFCs are critical for long distance driving in EVs
- Each unit can draw 50kW to 400kW at 240V
- As a result, demand from DCFCs can lead to substantial load spikes and drops on utility circuits
<table>
<thead>
<tr>
<th>Technical capability</th>
<th>Will EV Owners:</th>
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<tbody>
<tr>
<td>Dynamically publish daytime ToU pricing to EVs</td>
<td>Accept longer charging wait for saving $.50-$2 per charge?</td>
</tr>
<tr>
<td>Reduce charging load to manage through peak load</td>
<td>Accept longer charging wait to help manage load peaks?</td>
</tr>
<tr>
<td>Use car batteries as storage for the grid</td>
<td>Be ok with increased range anxiety after a utility discharge event?</td>
</tr>
<tr>
<td>Utilities fully control EV charge/discharge behavior</td>
<td>Be more accepting of utility control than regulators and the public in the case of HAN?</td>
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Home Battery Effect

- Charge and discharge as programmed
- No dependency on day or solar availability
- Installers program the battery based on the preference of the owner and economic consideration of rate structure at the time of installation
- Charge during off peak periods of Time of Use Plans
- Discharge during peak periods of Time of Use Plans
- Homeowner may not change the schedule at a later date
# Home Battery Effect

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<tr>
<td>Daily load curve impact</td>
<td>Discharge during on-peak 2-7pm when ToU credits are highest, in sync with solar</td>
<td>Same profile at higher penetration, leading to a more pronounced effect</td>
</tr>
<tr>
<td></td>
<td>Charge during off-peak 11pm – 7am when ToU rates are lowest</td>
<td></td>
</tr>
<tr>
<td>Minute by minute fluctuations</td>
<td>No substantial fluctuations</td>
<td>No substantial fluctuations</td>
</tr>
<tr>
<td>Resulting load curve</td>
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Right incentives can improve DER behavior

- Dynamic pricing

- As DER become a substantial part of the generation portfolio, they must become manageable like other power plants: technology, regulation and pricing contracts that allow grid operators to manage these assets are needed

- Legal and commercial frameworks required

- DER adoption will be widespread
  - *Opportunity to incentivize adoption in areas with best impact*

- EV charging, voltage violations lead to transformer overload

- Mitigate with voltage regulation, transformer upgrades, move to managed DER as soon as possible

- DER >> 10% results in 10-20% utility sales and peak load reduction, peak shift to evening
  - Flatter overall load curve possible by combining PV, storage, DR via smart tariffs
Modeling: DER are typically netted with load at the distribution bus for operations and planning. The challenge is to understand their variability and interactions with other resources. The electric industry has studied and incorporated the characteristics of conventional resources into the models that are used for planning and operations. To support the reliable integration of DER at higher levels, appropriate modeling methods will be necessary.

Ramping and Variability: Certain types of DER create significant ramps, such as morning and evening solar ramps that are different than historically experienced by the distribution system and the bulk power system (BPS). Coordination between BPS and distribution system for planning, installation, and operation of DER resources is a continuing need as the generation resource mix evolves on both transmission and distribution systems
**NERC DER Task Force**

**Reactive Power:** Currently, most DER are not required to provide reactive support to help control local voltage levels. Modern technologies, including inverters for new rooftop solar PV installations, should have the capability to support voltage and ride-through voltage excursions. Use of these capabilities will be increasingly important to support the reliability of both the transmission and distribution systems.

**System Protection:** DER are not coordinated with UFLS programs nor are they used to calculate the most severe single contingency and contingency reserve requirements. High levels of DER with inverters can also result in a decline in short circuit current, which can make it more difficult for protection devices to detect and clear system faults. Hence, the implications of DER as part of system protection must be taken into consideration while planning the BPS and distribution systems.

NERC DER Task Force

Visibility and Control: Many DER are passive in that they do not follow to a dispatch signal and are generally not visible to the system operator. The lack of visibility and control is not only a challenge for operations, but must also be accounted for in the planning of power systems. At higher penetration levels, DER capabilities related to visibility and control may become increasingly important.

Load and Generation Forecasting: Currently, DER are modeled as load modifiers for most load forecasting tools. However, given the number of DER installation applications and projections of future growth, it may become important to have sufficient information to support forecasting of DER power production separately from load, as well as to consider future DER deployment scenarios in the planning of both the distribution systems and the load/generation forecasting systems.

NERC DER Task Force

**Interconnection Requirements:** Interconnection requirements are evolving with increasing DER penetrations, and as a consequence of this, a number of DER classes with very different dynamic behaviors will exist in the BPS. It will be important to know this information, at least in an aggregate way, so that the dynamic characteristics can be modeled correctly for BPS planning.

**Reliability Standards:** NERC and industry must consider the existing standards, functional model, and related equipment standards in terms of accommodating the growing integration of DER while ensuring prudent planning and reliable operation of the BPS.