Operational Challenges with High Inverter Penetration

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ADVANCED TECHNOLOGY
Transmission & Distribution Business Unit

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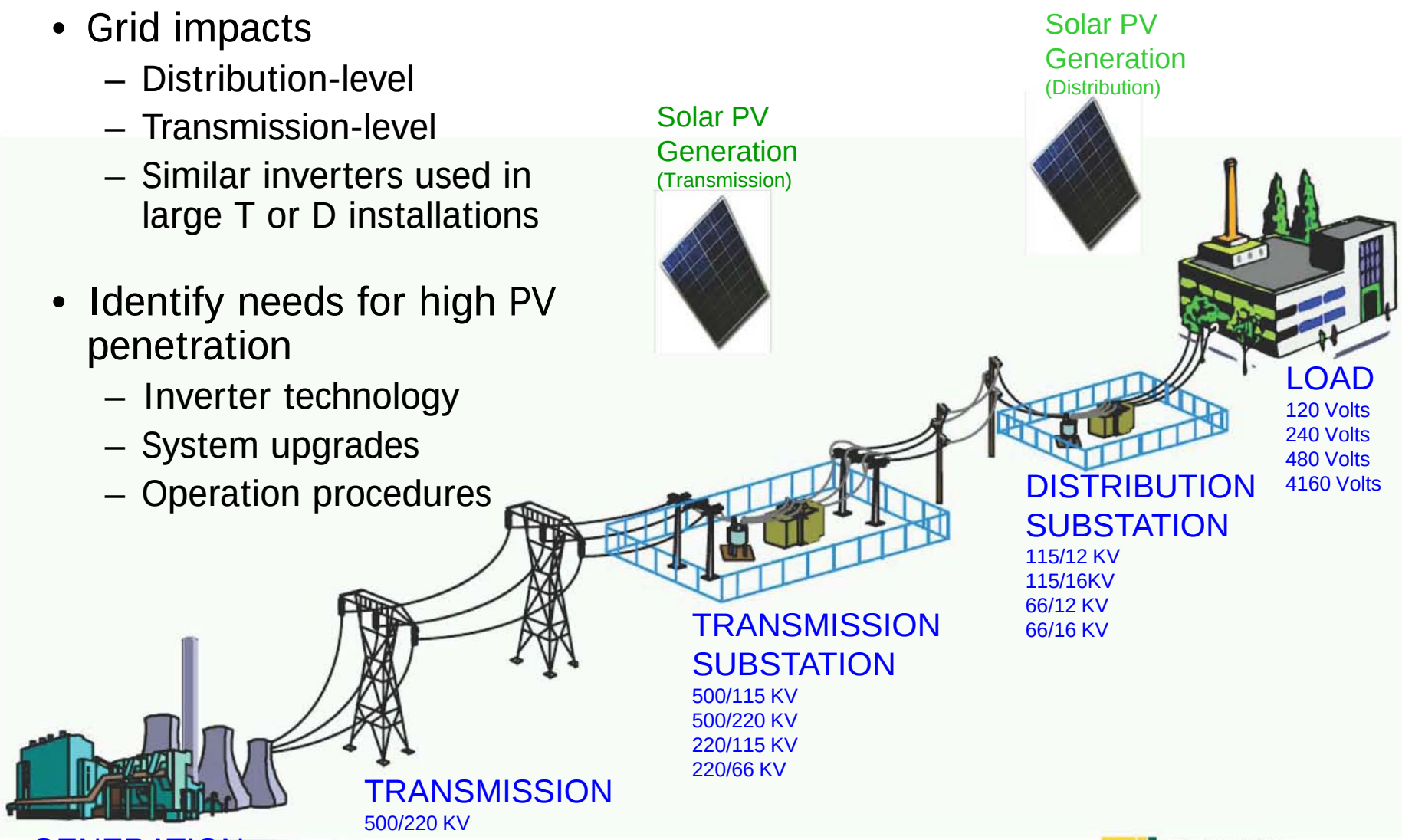
SCE PV Generation Studies

- Grid impacts
  - Distribution-level
  - Transmission-level
  - Similar inverters used in large T or D installations
- Identify needs for high PV penetration
  - Inverter technology
  - System upgrades
  - Operation procedures



Identified Grid Integration Questions

- Protection
  - Overall circuit protection coordination
  - Directional over-current relay capabilities for reverse current flow
  - Fault current effects on breaker ratings
  - Ground fault detection at the inverters
  - Subtransmission and transmission protection
- Engineering and Design
  - Voltage regulation
  - Transient over-voltage when islanded with little load
  - Lack of standard communications protocol
  - Harmonic issues on distribution circuits
  - Conductor and transformer sizing
- System Operation
  - Normal circuit switching impacts
  - Inverter monitoring
  - Low voltage ride through – LVRT/ System stability
  - Remote switching capability

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Protection Issues

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Solution Exists | Evaluating Best Solution | Technology/Standards Change

Engineering and Design Issues

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Solution Exists

Evaluating Best Solution

Technology/Standards Change

System Operation Issues

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Solution Exists

Evaluating Best Solution

Technology/Standards Change

Need to Improve Inverter Standards

- IEEE 1547
  - Developed with low penetration in mind
  - Does not allow some functions needed for high penetration:
    - Volt/VAR control
    - Low Voltage Ride Through
  - 1547.8 Recommended Practice to support high DG penetration
    - Will provide for advanced DG functionality
    - SCE taking an active role
- May also need to modify UL 1741 and CA Rule 21 to allow use of expanded inverter functionality

Contemplated Inverter Characteristics

- Help regulate voltage through VAR control
- Fast overvoltage protection when islanded
- Limited fault current contribution
- Potential for low voltage ride-through
- Low harmonic distortion of output current
- Curtail power level remotely
- Communicate in a standard manner
- Contribute to system stability (voltage/frequency damping

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