IEEE VOLT VAR TASK FORCE
Basic C84.1 Considerations for Distributed Resources

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Special Thanks to Hawaii Electric, Kenneth Fong, and Reid Udea
Feeder voltage challenge

• Traditional C84.1 allocation of voltage range
  – All MV feeders had voltage drop
  – All secondary and services have voltage drop
  – All internal building wiring had voltage drop

• Add many small distributed resources
  – Some MV feeders may have a little voltage rise
  – Some secondary and service combinations have voltage \textit{RISE} and drop
  – Branch circuit to distributed resource has voltage \textit{RISE}

• Do we need to rethink C84.1?
Existing ANSI C84.1 Range A

Transformer from HV to MV

Apply voltage regulation here

MV distribution
4.16 kV, 12.47 kV,
24 kV, 34.5 kV
Pole mounted capacitors and
Regulators maintain voltage

Allocate 7.5% drop
Range A = +5% to – 2.5%
126 to 117 volts at MV

Allocate 2.5% drop
Range A = +5% to – 5%
126 to 114 volts at meter

Allocate 5% drop
Range A = +5% to – 10%
125 \text{Note} \, 1 \text{ to } 108 \text{ volts}

Some utilities “reallocated” this line

Note 1: Assumes 1 volt drop somewhere

LV distribution
secondary and service

LV building wiring systems
Some recent experiences

• High density rooftop solar
• Many, if not all homes on a single distribution transformer have PV
• Attempts to be net zero cause as much backflow as forward flow
• A few reports of larger demand than before due to sense of can use as much as you want
• High service voltages during sunlight hours
HECO Voltage Criteria to Accommodate DG PV and 100% RE Future

Secondary Voltage Drop/Rise Criteria: 2.5%

Primary Voltage Criteria: +/-2.5%

Substation Transformer

Service Transformer

Primary Distribution System (12kV)

(Other customers)
HECO Voltage Criteria to Accommodate DG PV and 100% RE Future

- **Tariff**
  - Voltage: ±5%
  - @ Customer Service Entrance (Secondary)

- **Primary Voltage Criteria to accommodate DG PV and 100% RE Future**
  - Previous Criteria: +/-5% for all times
  - Current Criteria
    - +/-2.5% for daytime
    - +5%/-2.5% for evening
  - Changed to accommodate Secondary Voltage drop/rise criteria
    - +2.5% Voltage Rise during Daytime for Customers with PV
    - -2.5% Voltage Drop for all times of day
Some comments from HECO

• Secondary voltage rise is a major concern and driving factor.
• HECO started requiring 95% lead (consuming vars) for all rooftop solar effective 1/1/2016 to counteract high voltage on the secondary
• Use of R and possibly X compensation is increasing on substation transformers to lower bus voltage at light loads.
• HECO is considering future volt var requirements rather than immediately installing capacitors to compensate for the additional var load. (Waiting on effects of 95%)
• Search web for Hawaiian Electric Power Supply Improvement Plans for more information.
## Possible Suggestions to C84

<table>
<thead>
<tr>
<th>Location</th>
<th>Existing</th>
<th>To Consider</th>
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</thead>
<tbody>
<tr>
<td>MV systems voltage drop</td>
<td>7.5%</td>
<td>5%</td>
</tr>
<tr>
<td>MV voltage range</td>
<td>105 – 97.5 % (126-118 Volts)</td>
<td>102.5 – 97.5 % (123-118 Volts) (daytime only?)</td>
</tr>
<tr>
<td>MV-LV secondary and service to meter</td>
<td>2.5%</td>
<td>+ or – 2.5%</td>
</tr>
<tr>
<td>LV range at meter</td>
<td>105-95 % (126-114 Volts)</td>
<td>105-95 % (126-114 Volts)</td>
</tr>
<tr>
<td>Combined drop in branch and feeder inside building</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Voltage range for equipment terminals</td>
<td>105-90 % (126-108 Volts)</td>
<td>105-90 % (126-108 Volts)</td>
</tr>
<tr>
<td>Combined drop for feeder to DG</td>
<td>None</td>
<td>-3%</td>
</tr>
<tr>
<td>Preferred operating range for DG</td>
<td>105-90 (126-108 Volts)</td>
<td>108-90% (130-108 Volts)</td>
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</tbody>
</table>
Open Discussion

- Questions
- Is it time to broaden the discussion to North America?
- Should this be in 1885?
- Should C84 take this under consideration?