**Single-Meter Solar + Storage Export Limit Scheme - Operational Narrative**

### Controls Layer

The first layer of protection under this scheme is an active curtailment function deployed by a plant-level controller. The plant controller will continuously monitor both the PV system kW output and the ES system kW out. If the cumulative kW output of both systems approaches the designated export limit (within a specified bandwidth), the plant controller will curtail the energy storage system. This operation will be performed autonomously and continuously throughout the discharge cycle of the ESS.

For example:

- **PV AC nameplate:** 4950kW
- **ES AC nameplate:** 3300kW
- **Export limit:** 4950kW

If at t=1, the PV kW output is 4000kW, the ESS output will be limited to 950kW (minus a specified buffer).

If at t=2, the PV kW output is 4500kW, the ESS output will be limited to 450kW (minus a specified buffer).

If at t=3, the PV kW output is 1000kW, the ESS output will be limited to 3950kW (i.e. the ES will not be limited).

### Utility-Grade Relay and Revenue Grade Meter- Layer

In addition to the plant-level controls, the energy storage system will include a second layer of export limitation, enforced by a trip function within a SEL-651R installed with the G&W Viper recloser. The recloser will be tripped if the plant controller fails to effectively curtail the energy storage system, such that the designated export limit is enforced. The SEL-735 (labelled ‘A’ in the drawings below) will take current and voltage readings from current transformers and voltage transformers on the customer primary metering pole. The measurement points for both the current and voltage readings are upstream of the combined output of the ESS and PV system, therefore, the SEL-735 will register the combined kW output of both systems. Refer to the meter/control section for the excellent accuracies of the device and instrument transformers.

If the measured kW output exceeds the designated export limit, a digital signal will be sent to the SEL-651R via optic cable. Given a pre-defined time delay– the recloser (common to both PV and Storage) will be...
tripped, disconnecting both the ES and PV systems. The digital signal will be transmitted within 4ms by mirrored bits protocol.

**Metering/Control Accuracies:**

Please see following pages for SEL-735 metering and control accuracies per datasheet 20180208.

Per the datasheet, accuracy for power elements, the voltage, current, and power accuracy is +/-0.06% at unity power factor. If a system is curtailed for export at a limit of 4950kW, the accuracy in power export curtailment is

Please see the following pages for the accuracy of the meter CT and PT below.
Per the CT datasheet (custom made for Borrego), the accuracy for current measurement is 0.15%.

Per the PT datasheet (shown below), the accuracy for voltage measurement is 0.3%.

In the below calculation, we showing the total possible inaccuracy (the worst case) of the SEL-735 in series with the instrument transformers:

\[
\text{Primary Set Point (Watts) = Secondary Set Point (Watts)} \times \frac{\text{PT Ratio} \times \text{CT Ratio}}{\text{PT Ratio} + \text{CT Ratio}}
\]

\[
\frac{4,950,000 \text{ W}}{63.5 + 80} = 974.41 \text{ W}
\]

If we perform the calculation with ‘worst case’ CT and PT inaccuracies, read by SEL-735 (inaccuracy of 0.06%):

Expected Secondary Voltage
\[
\frac{13,800 \text{ v}}{63.5} = 217.32 \text{v}
\]

Secondary Voltage with 0.3% error
\[
217.32 \text{v} \times 1.003 = 217.97 \text{v}
\]

Worst Case Secondary Voltage (read by SEL-735)
\[
217.97 \text{v} \times 1.0066 = 218.1 \text{v}
\]

Expected Secondary Current
\[
\frac{358.7 \text{ A}}{80} = 4.484 \text{ A}
\]

Secondary Current with 0.15% error
\[
4.484 \times 1.0015 = 4.49 \text{ A}
\]

Worst Case Secondary Current (read by SEL-735):
\[
4.49 \times 1.0015 = 4.493 \text{ A}
\]
Actual Power (in worst scenario):
4.493 A * 218.1 V = 979.85 W

Power Calculation by SEL-735 (in the worst case scenario):
974.41 W

As shown in the line above, the system could possibly be exporting 979.85W (secondary) while the meter is still only reading 974.41W. This 979.85 W, on the primary side would be:

\[
979.85 \times 63.5 \times 80 = 4,977,671.3 \text{ W}
\]

\[
\frac{(4,977,671.3 \text{ W} - 4,950,000 \text{ W})}{4,950,000 \text{ W}} \times 100 = 0.56\% \text{ Inaccuracy}
\]

To be safe the set point in our SEL-735 should reflect this possible error and will be set at:

4,922,483.32 W

Therefore, a worst case 0.56% inaccuracy would produce a 4,950,000 W export.
SEL-735 Data Sheet: This is the overall accuracy of the meter’s voltage, current, and power measurements
Voltage Transformer Type: VEF 15-09

<table>
<thead>
<tr>
<th>Primary Voltage (V)</th>
<th>Winding Ratio</th>
<th>Catalog Number</th>
<th>IEEE Accuracy Class, 60HZ</th>
<th>Thermal Rating (VA)</th>
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</thead>
<tbody>
<tr>
<td>2400/4160 GY*</td>
<td>20:1</td>
<td>121531009 395000</td>
<td>0.3 WXY</td>
<td>1000</td>
</tr>
<tr>
<td>4200/7280 GY*</td>
<td>35:1</td>
<td>121531009 395001</td>
<td>0.3 WXY</td>
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<tr>
<td>4800/8320 GY*</td>
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<td>121531009 395002</td>
<td>0.3 WXY</td>
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<tr>
<td>7200/12470 GY</td>
<td>60:1</td>
<td>121531009 395003</td>
<td>0.3 WXY</td>
<td>1000</td>
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<tr>
<td>7620/13200 GY</td>
<td>63.5:1</td>
<td>121531009 395004</td>
<td>0.3 WXY</td>
<td>1000</td>
</tr>
<tr>
<td>7970/13800 GY</td>
<td>66.42:1</td>
<td>121531009 395005</td>
<td>0.3 WXY</td>
<td>1000</td>
</tr>
<tr>
<td>8400/14400 GY</td>
<td>70:1</td>
<td>121531009 395006</td>
<td>0.3 WXY</td>
<td>1000</td>
</tr>
</tbody>
</table>

PT datasheet: This (0.3%) is the overall accuracy of the voltage measurements
SEL-651R datasheet: This is the overall accuracy on the power export limit (32) function in the SEL-651R-2
**Relay Failsafe Protection requirements**

Currently National Grid requires DC power supply and relay failure protection in the 651 relays, which has been programmed logically in the relay. Borrego’s single line shows the Equivalent 74 elements schematic which has been accepted by NGRID in the past. Please see the schematic below.