Hawaiian Electric

CBRE Phase 2 Tranche 1 and LMI RFP O‘ahu, Maui, and Hawai‘i Islands Technical Training for Contracts

March 29, 2022

Hawaiian Electric

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Agenda

- Technical Requirements common to both Mid-Tier and Large Contracts for Oʻahu, Maui, and Hawaiʻi Island:
  - Net Energy Potential
  - Performance Metrics
  - DC Coupled Attachment
- Technical Requirements Specific to Mid-Tier Projects for Each Island
  - Hawaiʻi-Maui Project Specific Addendum (PSA) for the Mid-Tier SFC
  - Oʻahu Project Specific Addendum (PSA) for the Mid-Tier SFC
- Technical Requirements Specific to Large Projects for Each Island
  - Oʻahu Project Specific Addendum (PSA) for the Large RDG PPA
  - Hawaiʻi-Maui Project Specific Addendum (PSA) for the Large RDG PPA

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Net Energy Potential (NEP) in the RFP

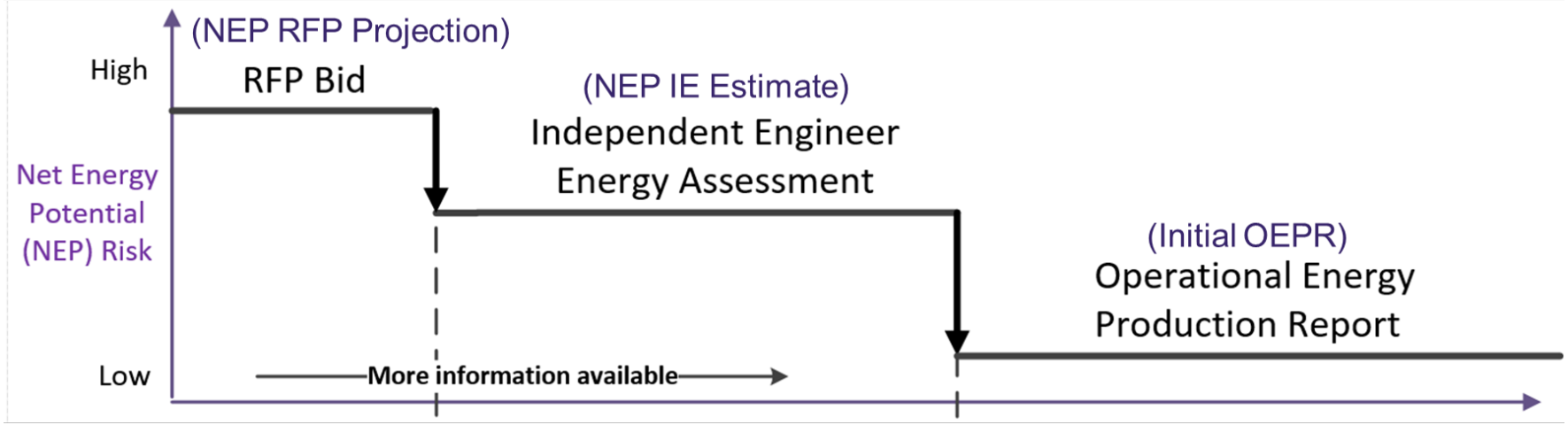
Section 3.10.1 of the RFP Body

- Proposals are required to provide a Net Energy Potential (“NEP”) RFP Projection for the Project.
- Represents the estimated annual net energy (in MWh) that could be produced by the Facility and delivered to the Point of Interconnection (“POI”) over a ten-year period with a probability of exceedance of 95%.
- Energy generated by the Facility in excess of Company dispatch but below the Facility’s Allowed Capacity that is stored in the Facility’s BESS component and can later be discharged to the POI considering the BESS Contract Capacity and Maximum Rated Output should be included in the NEP RFP Projection.
- Any energy in excess of what is allowed to be delivered to the POI and would exceed the BESS Contract Capacity shall be excluded from the Net Energy Potential.
- Energy delivered from the grid to charge the BESS should not be factored into the NEP RFP Projection.
- BESS round trip efficiency losses should be excluded from the NEP RFP Projection.
- NEP should consider auxiliary loads and electrical losses in developing the value relative to the POI.
- NEP RFP Projection will be used in the RFP evaluation process and therefore Proposers will be held to their provided value (PPA - Attachment J, SFC - Attachment B).

Net Energy Potential (NEP) in the PPA/SFC

- Attachment U of the Large RDG PPA and Attachment D of the Mid-Tier SFC
  - Constitutes an estimated single number with a P-Value of 95 for annual Net Energy that could be produced by the Facility based on the estimated long-term monthly and annual total of such production over a period of ten years excluding losses due to availability and Company Dispatch.
- Subject to adjustment from time to time
- NEP shall be calculated using, but not limited to:
  - Long-term resource data correlated with on-site measurements (if available)
  - Most current construction design and equipment specifications
  - Industry accepted energy simulation models
- Loss factors:
  - Include, but not be limited to, shading, electrical losses, and PV conversion
  - Exclude losses due to availability and Company Dispatch

PPA NEP Process Illustrated



- Final plant design
- Updated resource data

- Operational data

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Performance Metrics For AC Coupled

The following applies to **AC-Coupled PV+BESS Projects**

- PV generating facility metrics
  - **PV System Equivalent Availability Factor**
    - SFC - Attachment C, Section 1; PPA - Article 2.5
  - **Measured Performance Ratio**
    - SFC – Attachment C, Section 2; PPA - Article 2.6
- Battery Energy Storage System (BESS) metrics
  - **BESS Capacity Test**
    - SFC - Attachment C, Section 3; PPA - Article 2.7
    - SFC - Attachment H, Section 1; PPA - Attachment W
  - **BESS Annual Equivalent Availability Factor**
    - SFC – Attachment C, Section 4, PPA - Article 2.8
    - SFC – Attachment H Section 2, PPA - Attachment X
  - **BESS Annual Equivalent Forced Outage Factor**
    - SFC – Attachment C Section 5; PPA - Article 2.9
    - SFC – Attachment H Section 3; PPA - Attachment Y
  - **BESS Round Trip Efficiency Test**
    - SFC – Attachment C, Section 6; PPA - Article 2.10
    - SFC – Attachment H Section 1; PPA - Attachment W

PV System Equivalent Availability Factor

$$\text{PV System Equivalent Availability Factor} = 100\% \times \frac{AH - EDH}{PH}$$

- **Period Hours (PH)** is the total number of hours in the LD Period counting twenty-four (24) hours per day. In a normal year, PH = 8,760, and in a leap year PH = 8,784.
- **Available Hours (AH)** is the number of hours that the PV System is not on **Outage**. It is the sum of all **Service Hours (SH) + Reserve Shutdown Hours (RSH).**
- An "**Outage**" exists whenever the entire PV System is not online producing electric energy and is not in a Reserve Shutdown state.
- **Service Hours (SH)** is the number of hours during the LD Period the PV System is online and producing electric energy to meet Company Dispatch and/or to maintain the BESS State of Charge.
- **Reserve Shutdown Hours (RSH)** is the number of hours the PV System was available to the Company System but not providing electric energy or is offline at the Company's request for reasons other than Subscriber Organization/Seller-Attributable Non-Generation (SANG), or is offline due to insufficient irradiance levels based on the inverter manufacturer's minimum irradiance level for production. All hours between 7:00 pm and 6:00 am will be considered RSH. The PV System will be considered RSH in these hours, even if the system would otherwise be in an outage or derated state.

PV System Equivalent Availability Factor Cont…

$$\text{PV System Equivalent Availability Factor} = 100\% \times \frac{AH - EDH}{PH}$$

- **Equivalent Derated Hours (EDH) is the sum of ESADH, EPDH, and EUDH**.
  - For deratings due to PV System inverter unavailability, the equivalent full outage hour(s) are calculated by multiplying the actual duration of the derating (hours) by the number of inverters in the PV System unavailable and dividing by the total number of inverters in the PV System.
  - For deratings that do not impact the availability of an entire inverter or set of entire inverters, the equivalent full outage hour(s) are calculated by multiplying the actual duration of the derating (hours) by the size of the derating (in MW) divided by the Contract Capacity.
- **Equivalent Subscriber Organization/Seller-Attributable Derated Hours (ESADH):** A Subscriber Organization/Seller-Attributable Derating occurs when a derating exists due to **Subscriber Organization/Seller-Attributable Non-Generation (SANG).**
- **Equivalent Planned Derated Hours (EPDH)** includes Planned Deratings (PD) and Maintenance Deratings (D4).
- **Equivalent Unplanned Derated Hours (EUDH):** An Unplanned Derating (Forced Derating) occurs when the PV System experiences a derating that requires a reduction in availability before the end of the nearest following weekend.

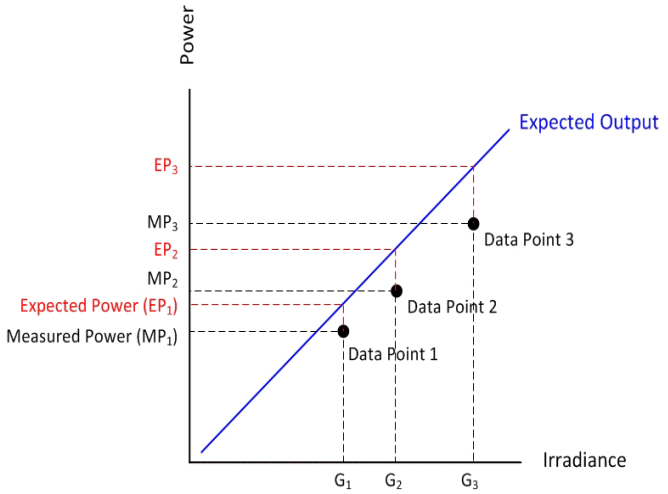
PV System Equivalent Availability Factor Cont…

PV System EAF Treatment of Force Majeure events on availability

- When an LD Period contains any hours in a month during which the PV System or a portion of the PV System is unavailable due to Force Majeure, then:
  - Such month shall be excluded from the LD Period
  - LD Period shall be extended back in time to include the next previous month during which there was no such unavailability of the PV System or a portion thereof due to Force Majeure
- See **PPA - Attachment J, SFC - Attachment B** for Force Majeure's directly proportional affect on the Lump Sum Payment

Measured Performance Ratio (MPR)

$$MPR_{corr} = \frac{\sum_i P_{AC\_i}}{\sum_i \left[P_{DC_{STC}} \left(\frac{G_{POA_i}}{G_{STC}} \right) \left(1 - \frac{\delta}{100} \left(T_{cell\_typ\_avg} - T_{cell\_i} \right) \right) \right]}$$



$$MPR_{corr} = \frac{\sum_i Measured\ Power\ Output\ of\ Facility}{\sum_i [(Expected\ Power\ Output\ of\ Facility)(Temperature\ correction\ factor)]}$$

Measured Performance Ratio (MPR) Cont…

- MPR is calculated only when during the entire 15-minute interval, the PV System output is allowed to convert all irradiance to AC power and the plane of array irradiance is not less than 600 W/m2.
- Data points that will be excluded are limited to data points where:

  (A) GPOA is below 600 W/m2;

  (B) GPOA is above the maximum threshold;

  (C) PV System is in Reserve Shutdown;

  (D) when the PV System has a Planned or Unplanned Derating;

  (E) PV System is not allowed to convert the full DC output to AC energy to deliver to the BESS and Point of Interconnection

  (F) there is a PV System Outage; or

  (G) BESS is discharging.

Measured Performance Ratio (MPR) Cont…

- Evaluated using available operational data that meet the criteria listed in the prior slide
- If there is insufficient operational data, a test may be scheduled
  - The test must obtain at least 16 valid data points to evaluate the MPR in a month that had insufficient data
- Performance is assessed against a Guaranteed Performance Ratio (GPR)
- GPR is determined as part of the NEP analyses (NEP IE Estimate, OEPRs)
  - Intent is to hold projects to the same level of performance estimated in the NEP IE Estimate/Initial OEPR/Subsequent OEPR
  - Defaulted to 0.85 if the NEP IE Estimate is not provided to the Company
- GPR is adjusted for degradation each month using a 0.005 degradation factor and appropriate time weighting post commercial operations for the month being evaluated

BESS Annual Equivalent Availability Factor

$$\text{Annual BESS Availability Factor Equivalent} = 100\% \times \frac{AH - EDH}{PH}$$

- The BESS EAF equation is equivalent to the PV System EAF but accounts for the BESS availability rather than the PV System availability.
- The variables are defined in the same way as described on slides 10 and 11 but with respect to the BESS; **EXCEPT**:
  - Reserve Shutdown Hours do not include any accounting for lack of irradiance or nighttime hours.
  - **Reserve Shutdown Hours (RSH)** is the number of hours the BESS is available but not charging or discharging electric energy or is offline at the Company's request for reasons other than SANG.

BESS Annual Forced Outage Factor

$$EFOF = 100\% \times \frac{(FOH + EUDH + ESADH)}{8760}$$

- **Equivalent Unplanned (Forced) Derated Hours (EUDH)** is calculated in the same way as was done for the BESS EAF (slides 16 and 11).
- **Equivalent Subscriber Organization/Seller Attributable Derated Hours (ESADH)** is calculated in the same way as was done for the BESS EAF (slides 15 and 10/11).
- **Forced Outage Hours (FOH)** = Sum of all hours the BESS experienced an Unplanned (Forced) Outage during the applicable BESS Measurement Period and the immediately preceding three (3) full BESS Measurement Periods.
- **Unplanned (Forced) Outage**: An outage that requires removal of the entire BESS from service before the end of the nearest following weekend that is not planned, including those caused by SANG.

BESS Capacity Test

$$BESS\ Capacity\ Ratio = \frac{Discharge\ Energy\ (MWh)}{BESS\ Contract\ Capacity\ (MWh)}$$

- The "BESS Capacity Ratio" shall be the number, expressed as a percentage, equal to the total "Discharge Energy" (MWh discharge) delivered to the Point of Interconnection to bring the BESS from its maximum State of Charge to a 0% State of Charge, divided by the BESS Contract Capacity.
- Measures the energy delivered to the POI when the battery is discharged continuously and following Company Dispatch to bring the BESS from its maximum state of charge to a 0% state of charge (BESS Capacity Test, paraphrased).
- The "BESS Capacity Performance Metric" shall be deemed to be satisfied where the BESS Capacity Ratio is not less than 100% for an applicable BESS Measurement Period, for any BESS Capacity Test performed in the period.
- The BESS Capacity Test can only be performed when the BESS is at its maximum State of Charge prior to the start of the BESS Capacity Test and during the BESS Capacity Test the Company Dispatch allows for continuous discharge of the BESS to 0% State of Charge with energy delivered to the Point of Interconnection.

BESS Round Trip Efficiency (RTE) Test

$$BESS\ RTE\ Ratio(\%) = 100\% \times \frac{Discharge\ Energy\ (MWh\ @\ POI)}{Charge\ Energy\ (MWh\ @\ BESS\ AC\ Input)}$$

- Requires measurement of "Charging Energy" (MWh charge) at the BESS inverters' AC input to bring the BESS from a 0% State of Charge to a 100% State of Charge from the PV System (or grid, if grid charging is permitted) according to Company Dispatch,
- Followed by measurement at the Point of Interconnection of the "Discharge Energy" (MWh discharge) delivered to the grid to bring the BESS to a 0% State of Charge according to Company Dispatch.
- The RTE Performance Metric will be deemed to have been "passed" or "satisfied" to the extent the RTE Ratio is not less than the RTE Performance Metric.
- An "RTE Test" is when the Company coordinates Company Dispatch to demonstrate the charging/discharging requisite to satisfy the RTE Performance Metric.
- The RTE Test may be conducted concurrently with a BESS Capacity Test (Same "Discharge Energy").

BESS Tests

- BESS Tests are the BESS Capacity Test and BESS RTE Test
- Preferably Not Scheduled
  - Demonstrated through routine dispatch
- No fixed output or duration; must still follow dispatch
- Preferably operational data derived
- “Formal” test only if not proving satisfaction in operational data
  - Scheduled
  - Still conducted through dispatch
    - No fixed output or duration
  - Limited number of opportunities to request
  - Last “formal/scheduled” test result is counted, not the best test

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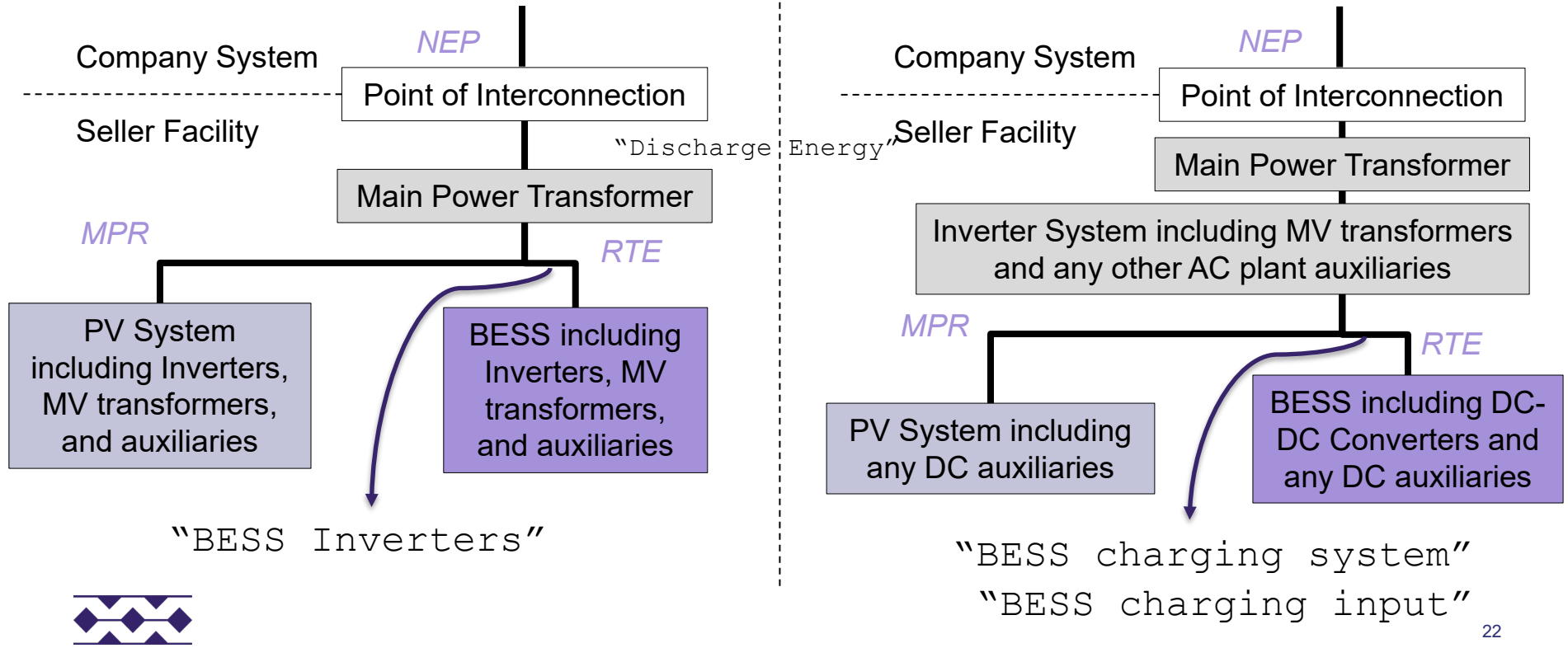
AC Coupled vs. DC Coupled



DC Coupled Attachment

Performance Metrics Modified

The following applies to **DC-Coupled PV+BESS Projects**

- For exact DC Coupled contract modifications see:
  - RFP - Appendix K-5 – Attachment DCC to the Project Specific Addendum for the Mid-Tier SFC: DC Coupled Storage
  - RFP - Appendix L-4 – Attachment DCC to the Project Specific Addendum for the RDG PPA: DC Coupled Storage
- PV generating facility metrics
  - **PV System Equivalent Availability Factor**
    - SFC - Attachment C, Section 1; PPA - Article 2.5
    - Each is modified by Section 6 of the respective DC Coupled Attachment
  - **Measured Performance Ratio**
    - SFC – Attachment C, Section 2; PPA - Article 2.6
    - Each is modified by Section 8 of the respective DC Coupled Attachment
- Battery Energy Storage System (BESS) metrics
  - **BESS Capacity Test**
    - SFC - Attachment C, Section 3; PPA - Article 2.7; remain unchanged from AC-Coupled version.
    - SFC - Attachment H, Section 1; PPA - Attachment W
      - SFC is modified by Section 12 of the DC Coupled Attachment
      - PPA is modified by Section 11 of the DC Coupled Attachment;

DC Coupled Attachment
Performance Metrics Modified (Cont.)

- Battery Energy Storage System (BESS) metrics (cont.)
  - **BESS Annual Equivalent Availability Factor**
    - SFC – Attachment C, Section 4; PPA - Article 2.8; remain unchanged from AC-Coupled version.
    - SFC – Attachment H, Section 2; PPA - Attachment X
      - Both are modified by Section 12 of their respective DC Coupled Attachment
  - **BESS Annual Equivalent Forced Outage Factor**
    - SFC – Attachment C, Section 5/Attachment H, Section 3; PPA - Article 2.9/Attachment Y; remain unchanged from AC-Coupled version
  - **BESS Round Trip Efficiency Test**
    - PPA - Article 2.10, SFC – Attachment C, Section 6; remain unchanged from AC-Coupled version.
    - PPA - Attachment W, SFC – Attachment H, Section 1
      - SFC is modified by Section 12 of the DC Coupled Attachment
      - PPA is modified by Section 11 of the DC Coupled Attachment

DC Coupled Attachment

Inverter System Equivalent Availability Factor

$$\text{Inverter System Equivalent Availability Factor} = 100\% \times \frac{AH - EDH}{PH}$$

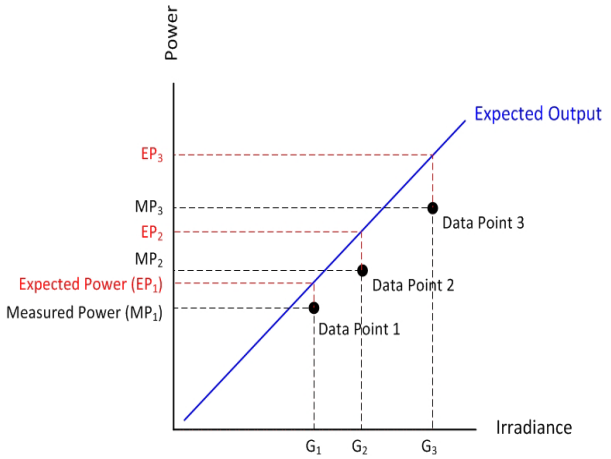
- Essentially replaces the PV System Inverter Availability accounting in an AC coupled system with the shared inverter availability accounting in a DC coupled system.
- In order to treat the DC coupled system equally to the AC coupled system in EAF accounting, the RSH definition still accounts for unavailability due to lack of resource, but **Outages or Deratings that occur during those periods that impact the BESS availability are to be accounted for in the BESS EAF**.
- **Reserve Shutdown Hours (RSH)** is the number of hours the PV System was available to the Company System but not providing electric energy or is offline at the Company's request for reasons other than Subscriber Organization/Seller-Attributable Non-Generation (SANG), or is offline due to insufficient irradiance levels based on the inverter manufacturer's minimum irradiance level for production. All hours between 7:00 pm and 6:00 am will be considered RSH. The PV System will be considered RSH in these hours, even if the system would otherwise be in an outage or derated state. A BESS Outage or Derating can exist due to an Inverter System Outage or Derating during Inverter System Reserve Shutdown Hours and the effect of such Inverter System Outage or Derating on the BESS Availability shall be included when calculating the BESS Annual Equivalent Availability Factor in accordance with Attachment H (BESS Annual Equivalent Availability Factor).

DC Coupled Attachment

Measured Performance Ratio (MPR)

- The Measured Performance Ratio ("MPR") is modified in the DC coupled Attachment to identify one measurement of power will be at the DC charging interface to the BESS.

$$MPR_{corr} = \frac{\sum_i P_{AC\_i} + \sum_i P_{DC\_i}}{\sum_i \left[P_{DC_{STC}} \left(\frac{G_{POA_i}}{G_{STC}} \right) \left(1 - \frac{\delta}{100} \left(T_{cell\_typ\_avg} - T_{cell\_i} \right) \right) \right]}$$



$$MPR_{corr} = \frac{\sum_i Measured\ Power\ Output\ of\ Facility}{\sum_i [(Expected\ Power\ Output\ of\ Facility)(Temperature\ correction\ factor)]}$$

DC Coupled Attachment

BESS Annual Equivalent Availability Factor

$$\text{BESS Annual Equivalent Availability Factor} = 100\% \times \frac{AH - EPDH - EUDH}{PH}$$

- The AC coupled BESS EAF equation is modified for the DC Coupled design to account for SANG directly in the EUDH term and therefore the EDH and ESADH terms are no longer used
  - This modification is needed to include periods that are SANG that would otherwise be Inverter System RSH. For comparison SANG could be adequately accounted for separately during those hours in an AC coupled system
- Variables are defined very similarly as the AC Coupled Terms (Slide 14) EXCEPT as modified to account for:
  - If the Inverter System is in Reserve Shutdown but would have otherwise been on Outage or Derated the Inverter System Outage or Derating is counted as a BESS Outage or derating during the Inverter System RSH.

DC Coupled Attachment

BESS Annual Forced Outage Factor

Remains Unchanged from the AC-Coupled version

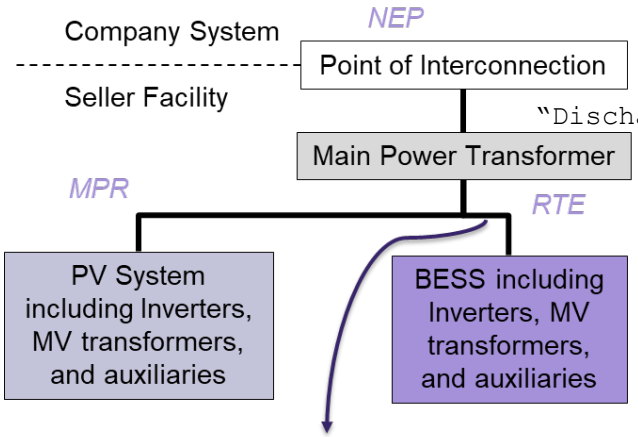
$$EFOF = 100\% \times \frac{(FOH + EUDH + ESADH)}{8760}$$

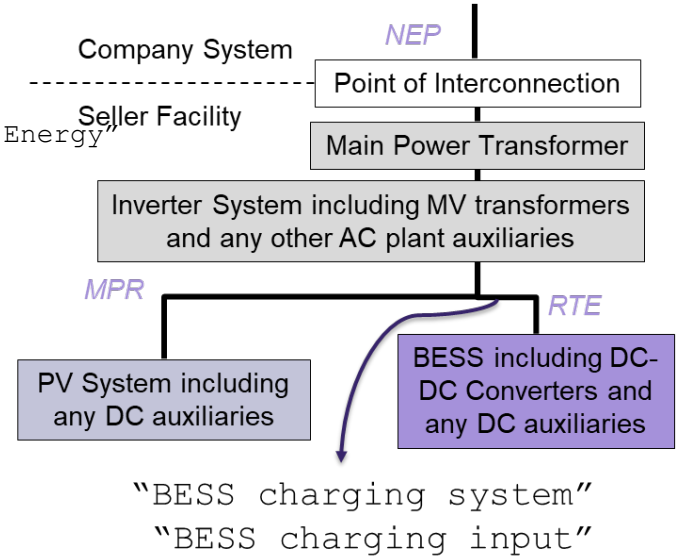
- **Equivalent Unplanned (Forced) Derated Hours (EUDH)** is calculated as described on slide 24 (inclusive of SANG derations)
- ~~**Equivalent Subscriber Organization/Seller Attributable Derated Hours (ESADH)** is calculated in in the same way as was done for the BESS EAF (slides 16 and 11).~~
  - Does not exist for BESS in DC coupled contract = 0

DC Coupled Attachment

BESS Tests

- The DCC BESS Tests remain largely unchanged from the AC coupled versions (slides 16,17,18)
- Only change as is done in the MPR is the moving of the measurement point between the PV system and the BESS to the DC side of the plant





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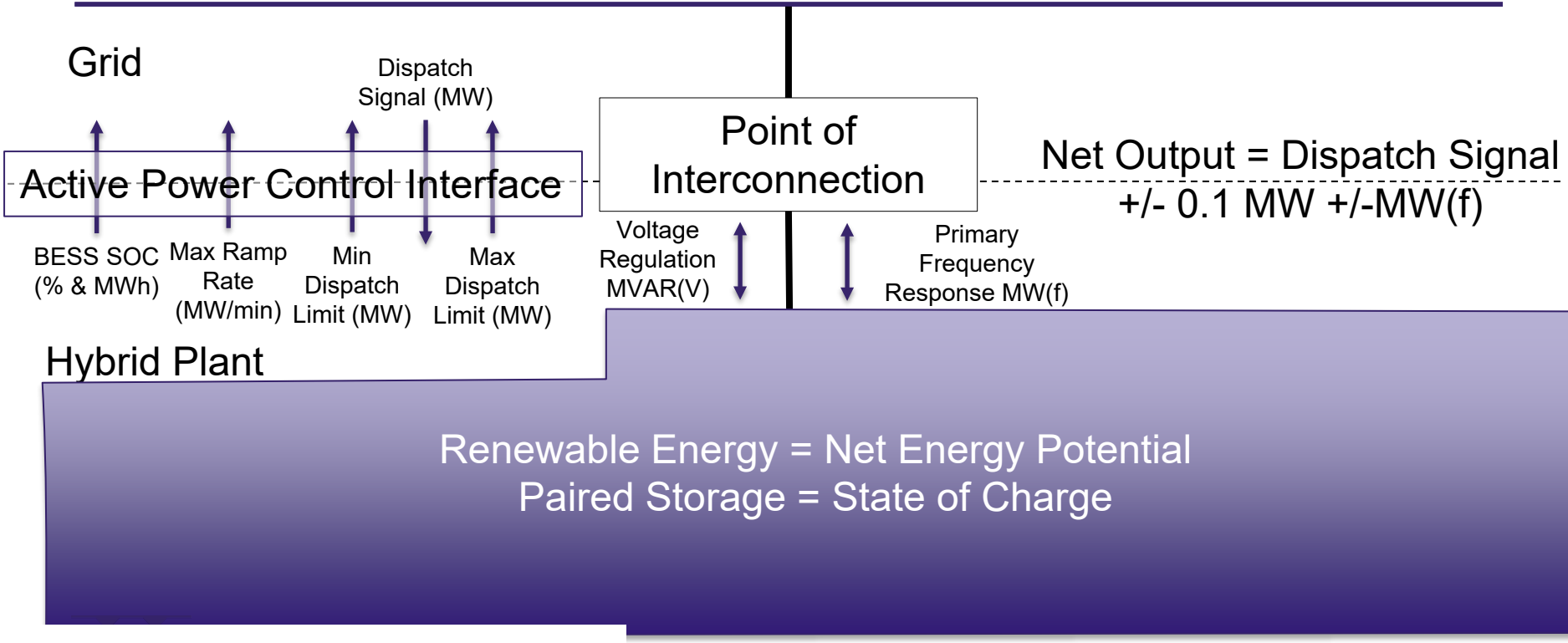
Hawai‘i-Maui Project Specific Addendum (PSA) for the Mid-Tier SFC

- Appendix K-1 of the RFP
  - Used to modify the base SFC with the requirements specific to Maui and Hawai‘i Islands
  - Attachment F - Facility Owned by Subscriber Organization
    - Contains the technical requirements specific to the Facility
  - Exhibit F-1: captures the Facility equipment parameters including but not limited to:
    - Contract Capacity, Installed Nameplate Capacity, Net Nameplate Capacity, and Allowed Capacity
  - Exhibits F-7 and F-8: General Testing Criteria (CSAT & AT)

Hawai‘i-Maui Mid-Tier PSA Technical Highlights

- Attachment F:
  - Section 1.B.3.e - Subscriber Organization's equipment also shall provide at a minimum:
    - Telemetry and control of various analog quantities, binary statuses, and control parameters.
    - Provision for Loss of Telemetry and Control
  - Section 1.B.3.h – Determination of Power Possible based on resource modeling and equipment availability
  - Section 1.G. – Active Power Control Interface (APCI)
  - Section 1.G.11. – Active Power - Frequency Response (DROOP)
  - Section 3 – Performance Standards
  - Section 4.A. – Disconnection Events
  - Section 6 – Modeling (source code requirements)
  - Section 7 – Testing Requirements
  - Section 8 - Data and Forecasting (data requirements for performance metric enforcement)
  - Section 9 - Technology Specific Requirements (inverter and BESS considerations)

“A Picture is worth 1000 words”



Hawai‘i-Maui Mid-Tier PSA Technical Highlights

- Attachment F, Section 3 – Performance Standards (Section 2 numbering error needs to be fixed)
  a. PROVISIONS FOR DISTRIBUTION CONNECTION Rule 14H. The Facility shall follow the performance standards of Rule 14H Appendix I and the additional provisions set forth below in Section 3.B. (Reactive Power Control) through Section 3.J. (Unintentional Islanding). To the extent any of those additional provisions conflict with Rule 14H, the provisions of this Contract shall control.
  b. Voltage Ride Through – ensures equipment remains connected and operating during voltage transient. No “momentary cessation” or tripping even when “may trip” unless there is eminent risk of equipment damage.
  c. Undervoltage Ride-Through – minimum requirements
  d. Overvoltage Ride-Through – minimum requirements
  e. Fault Ride-Through – requirement for staying connected during transients
  f. Grid Forming Capability – [As Applicable] Area of development in industry and has been informed by latest industry work on the topic.
  g. Black Start Capability – [As Applicable] Can be “self starting” mitigation to MPT energization OR for microgrid applications.
  h. Control System and Auxiliary Equipment – requirement for staying operational during transients
  i. Frequency Response – Ensures Section 1.G.11. – Active Power - Frequency Response (DROOP)
  j. Unintentional Islanding – requires IEEE-1547 unintentional islanding performance

Hawai‘i-Maui Mid-Tier PSA Technical Highlights

- Attachment F, Section 9.D – Battery Energy Storage Systems
  - For Facilities with variable energy and paired storage: The BESS shall directly charge storage from the variable resource when the Company Active Power Dispatch is less than the available resource energy.
  - No more than [___] % of the BESS energy capacity can be charged from the grid prior to the fifth (5th) anniversary of the Commercial Operations Date. Thereafter, 100% of the BESS energy capacity can be charged from the grid. [Gets adjusted appropriately for any grid charging provisions or lack there of]
  - The BESS will not be required to discharge more energy than available relative to the available state of charge.
  - For storage used primarily for energy shifting, the BESS shall be designed for an average annual use of 365 cycle(s).

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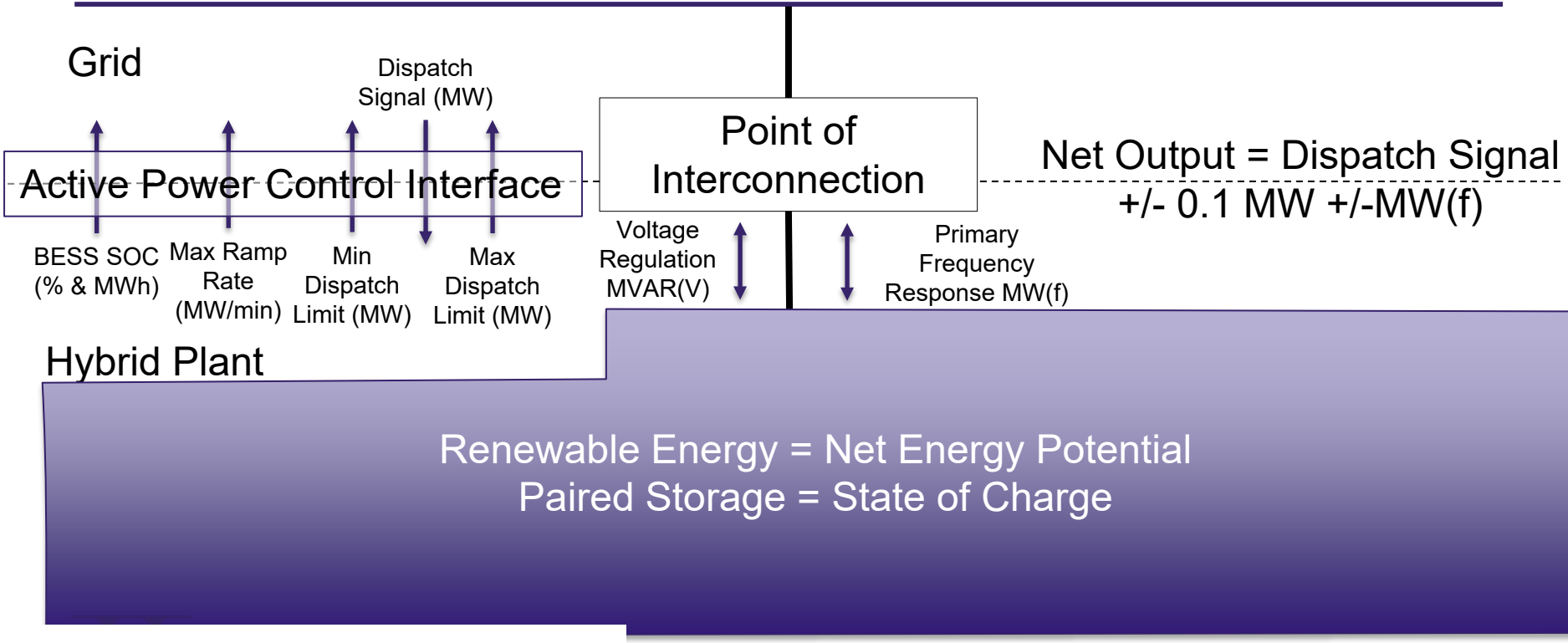
O‘ahu Project Specific Addendum (PSA) for the Mid-Tier SFC

- Appendix K-1 of the RFP
  - Used to modify the base SFC with the requirements specific to O‘ahu
  - Attachment F - Facility Owned by Subscriber Organization
    - Contains the technical requirements specific to the Facility
  - Exhibit F-1: captures the Facility equipment parameters including but not limited to:
    - Contract Capacity and Allowed Capacity
  - Exhibits F-7 and F-8: General Testing Criteria (CSAT & AT)

O‘ahu Mid-Tier PSA Technical Highlights

- Attachment F:
  - Section 1.B.3.e - Subscriber Organization's equipment also shall provide at a minimum:
    - Telemetry and control of various analog quantities, binary statuses, and control parameters.
    - Provision for Loss of Telemetry and Control
  - Section 1.B.3.h – Determination of Power Possible based on resource modeling and equipment availability
  - Section 1.G. – Active Power Control Interface (APCI)
  - Section 3 – Performance Standards
  - Section 4.A. – Disconnection Events
  - Section 6 – Modeling (source code requirements)
  - Section 7 – Testing Requirements
  - Section 8 - Data and Forecasting (data requirements for performance metric enforcement)
  - Section 9 - Technology Specific Requirements (inverter and BESS considerations)

“A Picture is worth 1000 words”



O‘ahu Mid-Tier PSA Technical Highlights

- Attachment F, Section 3 – Performance Standards
- Separate provisions for Distribution Interconnection vs. Sub-Transmission Interconnection
- PROVISIONS FOR DISTRIBUTION CONNECTION
    a. Rule 14H. The Facility shall follow the performance standards of Rule 14H Appendix I and the additional provisions set forth below in Section 3.B. (Reactive Power Control) through Section 3.J. (Unintentional Islanding). To the extent any of those additional provisions conflict with Rule 14H, the provisions of this Contract shall control.
    b. Voltage Ride Through – ensures equipment remains connected and operating during under and over voltage transient. Largely aligned to latest version of Rule 14H and most recent version of IEEE-1547.
    c. Fault Ride-Through – requirement for restoring output after system transients if it had ceased power output
    d. Voltage Phase Angle Change Ride-Through
        a. 30 degree minimum requirement
        b. PLL synchronism requirement
    e. Rate of Change of Frequency (“ROCOF”) – minimum requirement to ridethrough as significant a ROCOF as 5Hz/s
    f. Grid Forming Capability – [As Applicable] Area of development in industry and has been informed by latest industry work on the topic.
    g. Black Start Capability – [As Applicable] Can be “self starting” mitigation to MPT energization OR for microgrid applications
    h. Ramp Rates – Specified requirements for each type of expected ramp
    i. Primary Frequency Response – DROOP characteristic requirements
    j. Unintentional Islanding – requires IEEE-1547 unintentional islanding performance

Oʻahu Mid-Tier PSA Technical Highlights

- Attachment F, Section 3 – Performance Standards
- Separate provisions for Distribution Interconnection vs. Sub-Transmission Interconnection
- PROVISIONS FOR SUB-TRANSMISSION CONNECTION (Same as Large Oʻahu PSA)
  - (a) Reactive Power Control – Describe requirement to regulate voltage at the POI
  - (b) Reactive Amount- Capability established by the Facility Power Curve (+IRS)
    - Also describes expected small signal and large signal response
  - (c) Ramp Rates – Specified requirements for each type of expected ramp
  - (d) Ride Through Requirements – ensures equipment remains connected and operating during voltage and frequency transient. No “momentary cessation” or tripping even when “may trip” unless there is eminent risk of equipment damage
  - (e) Undervoltage Ride-Through – minimum requirements
  - (f) Overvoltage Ride-Through – minimum requirements
  - (g) Transient Stability Ride-Through – requirement for staying connected during transients
  - (h) Voltage Phase Angle Change Ride-Through - 30 degree minimum requirement; PLL synchronism requirement

Oʻahu Mid-Tier PSA Technical Highlights

- PROVISIONS FOR SUB-TRANSMISSION CONNECTION (continuing from item h) (Same as Large Oʻahu PSA)

  (i) Underfrequency Ride-Through – minimum requirements

  (j) Overfrequency Ride-Through – minimum requirements

  (k) Voltage Flicker– Describes voltage flicker limits

  (l) Harmonics – establishes the total harmonic distortion limits

  (m) Primary Frequency Response – Specified requirements for response to frequency deviations

  (n) Grid Forming Capability – [As Applicable] Area of development in industry and has been informed by latest industry work on the topic.

  (o) Black Start Capability – [As Applicable] Can be “self starting” mitigation to MPT energization OR for microgrid applications

  (q) Rate of Change of Frequency (“ROCOF”) – minimum requirement to ridethrough as significant a ROCOF as 5Hz/s

O‘ahu Mid-Tier PSA Technical Highlights

- Attachment F, Section 9.D – Battery Energy Storage Systems
  - For Facilities with variable energy and paired storage: The BESS shall directly charge storage from the variable resource when the Company Active Power Dispatch is less than the available resource energy.
  - No more than [___] % of the BESS energy capacity can be charged from the grid prior to the fifth (5th) anniversary of the Commercial Operations Date. Thereafter, 100% of the BESS energy capacity can be charged from the grid. [Gets adjusted appropriately for any grid charging provisions or lack there of]
  - For Contract Years that are non-leap years, the BESS shall be discharged no more than BESS Contract Capacity x 365, MWh in each Contract Year. For Contract Years that are leap years, the BESS shall be discharged no more than BESS Contract Capacity x 366, MWh in each Contract Year.
  - The BESS will not be required to discharge more energy than available relative to the available state of charge.

Agenda

- Technical Requirements common to both Mid-Tier and Large Projects for Oʻahu, Maui, and Hawaiʻi Island:
  - Net Energy Potential
  - Performance Metrics
  - DC Coupled Attachment
- Technical Requirements Specific to Mid-Tier Projects for Each Island
  - Hawaiʻi-Maui Project Specific Addendum (PSA) for the Mid-Tier SFC
  - Oʻahu Project Specific Addendum (PSA) for the Mid-Tier SFC
- Technical Requirements Specific to Large Projects for Each Island
  - Oʻahu Project Specific Addendum (PSA) for the Large RDG PPA
  - Hawaiʻi-Maui Project Specific Addendum (PSA) for the Large RDG PPA

O‘ahu Project Specific Addendum (PSA) for the Large RDG PPA

- Appendix L-1 of the RFP
  - Used to modify the base RDG PPA with the requirements specific to O‘ahu
  - Attachment A: captures the Facility equipment parameters including but not limited to:
    - Contract Capacity and Allowed Capacity
  - Attachment B: Facility Owned by Seller
    - Contains the technical requirements specific to the Facility
  - Attachment O: Control System Acceptance Test (CSAT) Criteria
  - Attachment N: Acceptance Test (AT) General Criteria

O‘ahu Large RDG PPA PSA Technical Highlights

- Attachment B:
  - Section 1.(b).(iii).E - Subscriber Organization's equipment also shall provide at a minimum:
    - Telemetry and control of various analog quantities, and binary statuses and control parameters.
    - Provision for Loss of Telemetry and Control
  - Section 1.(b).(iii).H – Determination of Power Possible based on resource modeling and equipment availability
  - Section 1.(g). – Active Power Control Interface (APCI)
  - Section 3 – Performance Standards
  - Section 4.(a). – Disconnection Events
  - Section 6 – Modeling (source code requirements)
  - Section 7 – Testing Requirements
  - Section 8 - Data and Forecasting (data requirements for performance metric enforcement)
  - Section 9 - Technology Specific Requirements (data requirements for performance metric enforcement)

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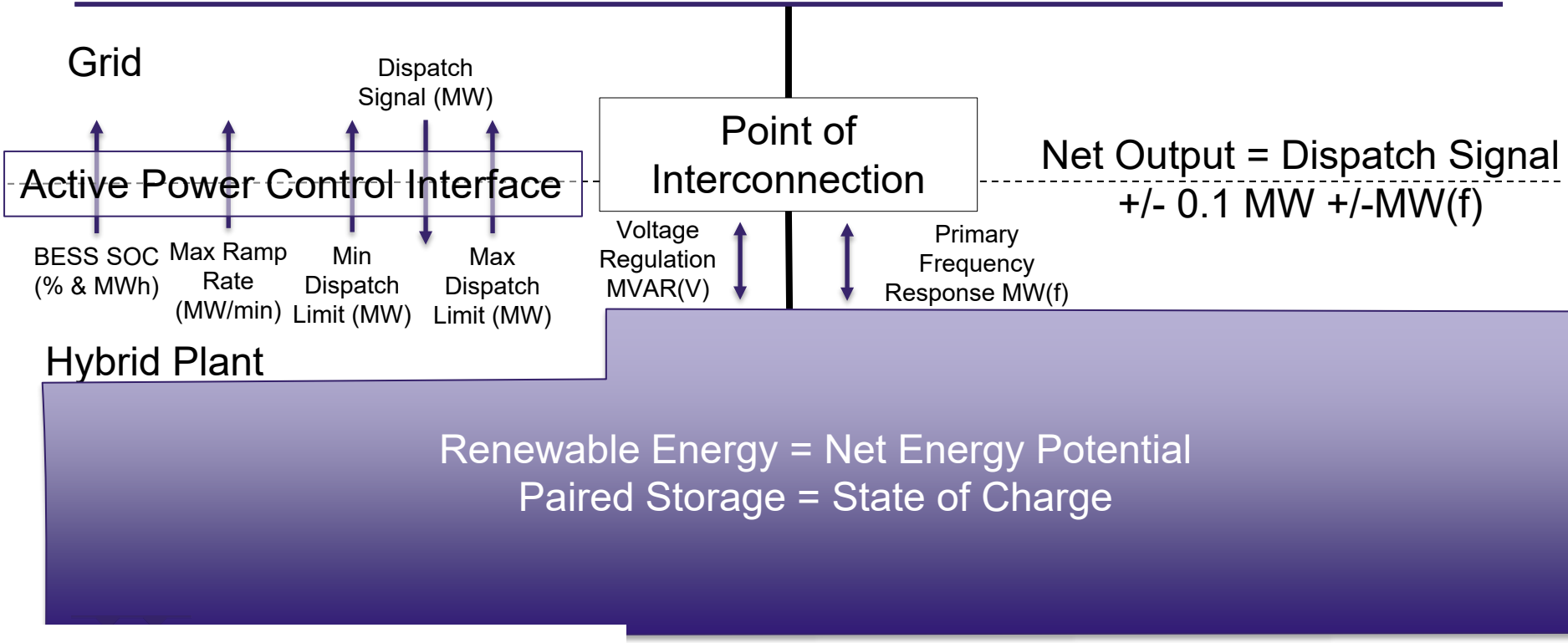

O‘ahu Large RDG PPA PSA Technical Highlights

- Attachment B, Section 3 – Performance Standards
  - (a) Reactive Power Control – Describe requirement to regulate voltage at the POI
  - (b) Reactive Amount- Capability established by the Facility Power Curve (+IRS)
    - Also describes expected small signal and large signal response
  - (c) Ramp Rates – Specified requirements for each type of expected ramp
  - (d) Ride Through Requirements – ensures equipment remains connected and operating during voltage and frequency transient. No “momentary cessation” or tripping even when “may trip” unless there is eminent risk of equipment damage
  - (e) Undervoltage Ride-Through – minimum requirements
  - (f) Overvoltage Ride-Through – minimum requirements
  - (g) Transient Stability Ride-Through – requirement for staying connected during transients
  - (h) Voltage Phase Angle Change Ride-Through - 30 degree minimum requirement; PLL synchronism requirement

Oʻahu Large RDG PPA PSA Technical Highlights

- PROVISIONS FOR SUB-TRANSMISSION CONNECTION (continuing from item h) (Same as Large Oʻahu PSA)

  (i) Underfrequency Ride-Through – minimum requirements

  (j) Overfrequency Ride-Through – minimum requirements

  (k) Voltage Flicker– Describes voltage flicker limits

  (l) Harmonics – establishes the total harmonic distortion limits

  (m) Primary Frequency Response – Specified requirements for response to frequency deviations

  (n) Grid Forming Capability – [As Applicable] Area of development in industry and has been informed by latest industry work on the topic.

  (o) Black Start Capability – [As Applicable] Can be “self starting” mitigation to MPT energization OR for microgrid applications

  (q) Rate of Change of Frequency (“ROCOF”) – minimum requirement to ridethrough as significant a ROCOF as 5Hz/s

O‘ahu Large RDG PPA PSA Technical Highlights

- Attachment F, Section 9.D – Battery Energy Storage Systems
  - For Facilities with variable energy and paired storage: The BESS shall directly charge storage from the variable resource when the Company Active Power Dispatch is less than the available resource energy.
  - No more than [___] % of the BESS energy capacity can be charged from the grid prior to the fifth (5th) anniversary of the Commercial Operations Date. Thereafter, 100% of the BESS energy capacity can be charged from the grid. [Gets adjusted appropriately for any grid charging provisions or lack there of]
  - For Contract Years that are non-leap years, the BESS shall be discharged no more than BESS Contract Capacity x 365, MWh in each Contract Year. For Contract Years that are leap years, the BESS shall be discharged no more than BESS Contract Capacity x 366, MWh in each Contract Year.
  - The BESS will not be required to discharge more energy than available relative to the available state of charge.

Agenda

- Technical Requirements common to both Mid-Tier and Large Projects for Oʻahu, Maui, and Hawaiʻi Island:
  - Net Energy Potential
  - Performance Metrics
  - DC Coupled Attachment
- Technical Requirements Specific to Mid-Tier Projects for Each Island
  - Hawaiʻi-Maui Project Specific Addendum (PSA) for the Mid-Tier SFC
  - Oʻahu Project Specific Addendum (PSA) for the Mid-Tier SFC
- Technical Requirements Specific to Large Projects for Each Island
  - Oʻahu Project Specific Addendum (PSA) for the Large RDG PPA
  - Hawaiʻi-Maui Project Specific Addendum (PSA) for the Large RDG PPA

Hawai‘i-Maui Project Specific Addendum (PSA) for the Large RDG PPA

- Appendix L-2 of the RFP
  - Used to modify the base RDG PPA with the requirements specific to Maui and Hawai‘i Islands
  - Attachment A: captures the Facility equipment parameters including but not limited to:
    - Contract Capacity, Installed Nameplate Capacity, Net Nameplate Capacity, and Allowed Capacity
  - Attachment B: Facility Owned by Seller
    - Contains the technical requirements specific to the Facility
  - Attachment O: Control System Acceptance Test (CSAT) Criteria
  - Attachment N: Acceptance Test (AT) General Criteria

Hawai‘i-Maui Large RDG PPA PSA Technical Highlights

- Attachment B:
  - Section 1.(b).(iii).E - Subscriber Organization's equipment also shall provide at a minimum:
    - Telemetry and control of various analog quantities, and binary statuses and control parameters.
    - Provision for Loss of Telemetry and Control
  - Section 1.(b).(iii).H – Determination of Power Possible based on resource modeling and equipment availability
  - Section 1.(g). – Active Power Control Interface (APCI)
  - Section 1.(g).(xi). – Active Power - Frequency Response (DROOP)
  - Section 3 – Performance Standards
  - Section 4.(a). – Disconnection Events
  - Section 6 – Modeling (source code requirements)
  - Section 7 – Testing Requirements
  - Section 8 - Data and Forecasting (data requirements for performance metric enforcement)
  - Section 9 - Technology Specific Requirements (data requirements for performance metric enforcement)

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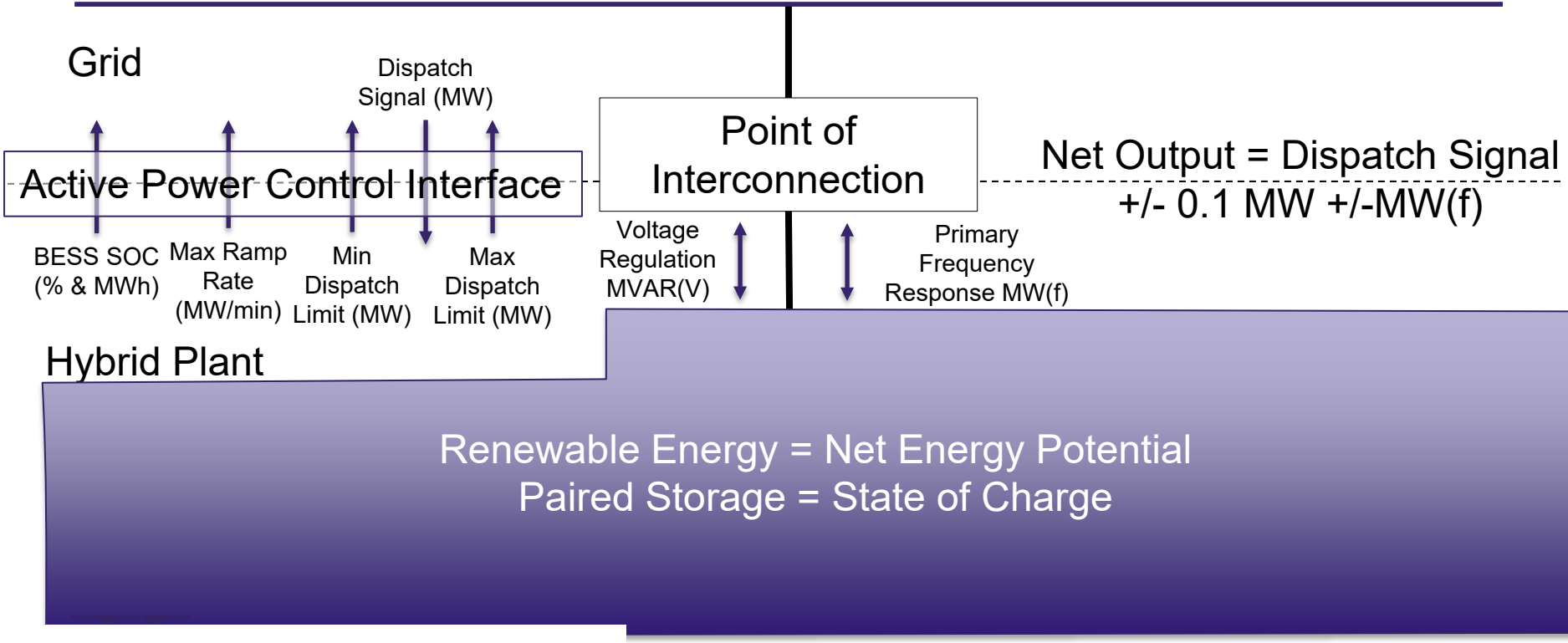

Hawai‘i-Maui Large RDG PPA PSA Technical Highlights

- Attachment B, Section 3 – Performance Standards
  - (a) Reactive Power Control – Describe requirement to regulate voltage at the POI
  - (b) Reactive Power Characteristics - Capability established by the Facility Power Curve (+IRS)
    - Also describes expected small signal and large signal response
  - (c) Ramp Rates – Limits ramp rate to 2MW/min or less for “uncontrolled” ramps
  - (d) Ride Through – ensures equipment remains connected and operating during voltage and frequency transient. No “momentary cessation” or tripping even when “may trip” unless there is eminent risk of equipment damage
  - (e) Undervoltage Ride-Through – minimum requirements
  - (f) Overvoltage Ride-Through – minimum requirements
  - (g) Transient Stability Ride-Through – requirement for staying connected during transients
  - (i) Underfrequency Ride-Through – minimum requirements
  - (j) Overfrequency Ride-Through – minimum requirements
  - (k) Successive Faults – Ensures ride-through capability for event close in time due to reclosing into faults

Hawai‘i-Maui Large RDG PPA PSA Technical Highlights

- Attachment B, Section 3 – Performance Standards (continued from item k)
  - (l) Rate of Change of Frequency (ROCOF) – Prevents tripping on ROCOF
  - (m) Phase Angle Shift Ride-Through – Ensures IBR remains synchronized through phase angle shifts
  - (n) DC Protection – requires protection coordination of the DC side
  - (o) Voltage Flicker – Limits flicker to within standard limits
  - (p) Harmonics – limits harmonics to within standard limits
  - (q) Grid Forming Capability – Area of development in industry and has been informed by latest industry work on the topic.
  - (r) Black Start Capability – Can be “self starting” mitigation to MPT energization OR for microgrid applications
  - (s) Generator Step-Up Transformer Impedance – IRS fills in with designed GSU impedance
  - (t) Control System and Auxiliary Equipment – requirement for staying operational during transients
  - (u) Frequency Response – Ensures Section 1.G.11. – Active Power - Frequency Response (DROOP)
  - (v) Unintentional Islanding – requires IEEE-1547 unintentional islanding performance

Hawai‘i-Maui Large RDG PPA PSA Technical Highlights

- Attachment B, Section 9.D – Battery Energy Storage Systems
  - For Facilities with variable energy and paired storage: The BESS shall directly charge storage from the variable resource when the Company Active Power Dispatch is less than the available resource energy.
  - No more than [___] % of the BESS energy capacity can be charged from the grid prior to the fifth (5th) anniversary of the Commercial Operations Date. Thereafter, 100% of the BESS energy capacity can be charged from the grid. [Gets adjusted appropriately for any grid charging provisions or lack there of]
  - The BESS will not be required to discharge more energy than available relative to the available state of charge.
  - For storage used primarily for energy shifting, the BESS shall be designed for an average annual use of 365 cycle(s).

Mahalo for your time.

Any questions?

Chat or CBRERFP@HawaiianElectric.com