Hawaiian Electric

IGP Technical Advisory Panel

April 28, 2022

Agenda

- Present draft results of the probabilistic resource adequacy testing for O‘ahu’s proposed renewable firm RFP

Assumptions and Test Cases

Stochastic Assumptions

- 250 samples – based on a balance of LOLE convergence and reasonable run time (less than a day)
  - 50 outage draws x 5 years of PV and wind patterns (2015 – 2019)
- Test year is based on a specific future procurement year to confirm the reliability need
  - Year 2029 for O‘ahu was selected based on when proxy renewable firm resources are added
- Outage draws are weighted more heavily because of concerns with continued reliability of the aging thermal generating fleet
  - Future stochastic assumptions will vary as variable renewable resources are added through future IGP cycles/procurements, additional weather years may be added and outage draws reduced

Planning Assumptions

- Thermal Units
  - 50 outage draws
- PV
  - 5 years of NREL data (2015 - 2019) from NREL Resource Potential study
- Onshore Wind
  - 5 years of historical data (2015 - 2019)
- Offshore Wind
  - 5 years of NREL data from NREL-BOEM Offshore Wind study
- DER
  - 5 years of monthly historical capacity factor data (2015-2019)
- Capacity needs identified using the August 2021 IGP inputs and assumptions including:
  - Sales forecast
  - Assumptions to no longer dispatch certain existing firm generating units
  - Considerations for developable resource potential from the NREL Alt-1 and Land Constrained scenarios

Resource Adequacy Test Cases

- Existing
  - Existing system in 2021, no units removed from service
- Base
  - RESOLVE resource plan without any future firm generation in 2029, without Kalaeloa* and AES Coal, without 371 MW of utility-owned fossil fuel steam generation capacity
- Base_200
  - Base case with 4x50 MW SCCT added in 2029
- Base_300
  - Base case with 6x50 MW SCCT added in 2029
- Base_399
  - Base case with 6x50 MW SCCT and 11x9 MW ICE added in 2029
- Base_480
  - Base case with 6x50 MW SCCT and 9x20 MW Biomass added in 2029

*Kalaeloa's Amended and Restated Power Purchase Agreement application is currently before the Commission to extend Kalaeloa's contract term by 10-15 years. This scenario assesses grid needs upon the eventual expiration of any Kalaeloa extension (independent of the year that may occur)

Test Case Resources

Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11-9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9-20 MW Biomass

Resource (MW)	Existing (2021)	Existing (2029)	Base	Base_200	Base_300	Base_399	Base_480
Existing Firm	1,729	1,247 (-482)	970 (-759)	970 (-759)	970 (-759)	970 (-759)	970 (-759)
Existing PV	188	188 (0)	188 (0)	188 (0)	188 (0)	188 (0)	188 (0)
Existing Wind	123	123 (0)	123 (0)	123 (0)	123 (0)	123 (0)	123 (0)
CBRE (including Ph 2)		185	185	185	185	185	185
Stage 1 • Hoohana / Millilani / Waiawa / West Oahu		139.5	139.5	139.5	139.5	139.5	139.5
Stage 2 • Barbers Point / Kupono / Mountain View / Waiawa Ph 2		94	94	94	94	94	94
Future PV			0	0	0	0	0
Future Wind			163	163	163	163	163
Future Firm Units			0	200 MW - 4-50 MW SCCT	300 MW - 6-50 MW SCCT	399 MW - 6-50 MW SCCT - 11-9 MW ICE	480 MW - 6-50 MW SCCT - 9-20 MW ICE
Total Gen Capacity	**2,040**	**1,977**	**1,863**	**2,163**	**2,163**	**2,262**	**2,343**
Stage 1 BESS		139.5 MW / 558 MWh	139.5 MW / 558 MWh	139.5 MW / 558 MWh	139.5 MW / 558 MWh	139.5 MW / 558 MWh	139.5 MW / 558 MWh
Stage 2 BESS (including Kapolei BESS)		279 MW / 1,068 MWh	279 MW / 1,068 MWh	279 MW / 1,068 MWh	279 MW / 1,068 MWh	279 MW / 1,068 MWh	279 MW / 1,068 MWh
Future BESS			287 MW / 539 MWh	287 MW / 539 MWh	287 MW / 539 MWh	287 MW / 539 MWh	287 MW / 539 MWh
Total BESS Capacity	**0 MW / 0 MWh**	**418 MW / 1,626 MWh**	**705 MW / 2,165 MWh**	**705 MW / 2,165 MWh**	**705 MW / 2,165 MWh**	**705 MW / 2,165 MWh**	**705 MW / 2,165 MWh**

Reliability Indices

- Probabilistic RA examined the following reliability metrics:
  - LOLE
  - LOLH
  - LOLEv
  - EUE

Probabilistic Results

Base_200 = 200 MW = 4x50 MW SCCT
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Test Case Result Summary

Test Case	LOLE (days/year)	LOLEv (events/year)	LOLH (h/year)	EUE (GWh)
Existing (2021)	1.18	1.30	2.90	0.13
Existing (2029)	2.49	4.16	11.49	1.08
Base	27.02	49.58	170.76	22.09
Base_200	1.69	3.10	8.22	0.80
Base_300	0.22	0.38	0.86	0.07
Base_399	0.00	0.00	0.00	0.00
Base_480	0.00	0.00	0.00	0.00

- All Base scenarios and Existing (2029) modeled in year 2029.
- Existing (2021) scenario modeled in year 2021.

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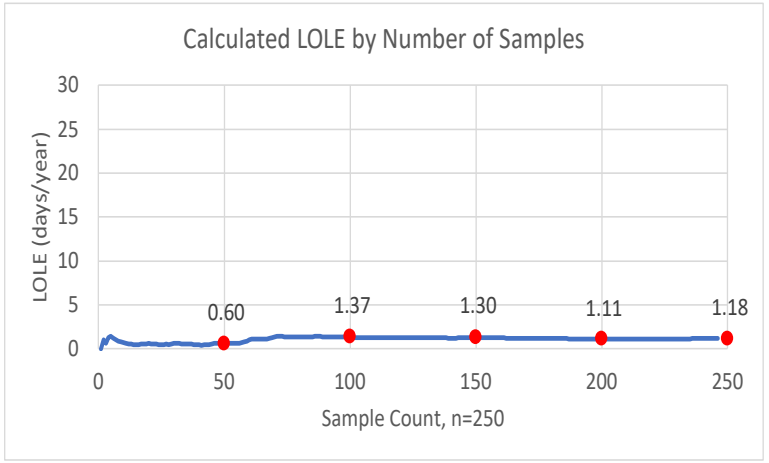
Results – Loss of Load Expectation



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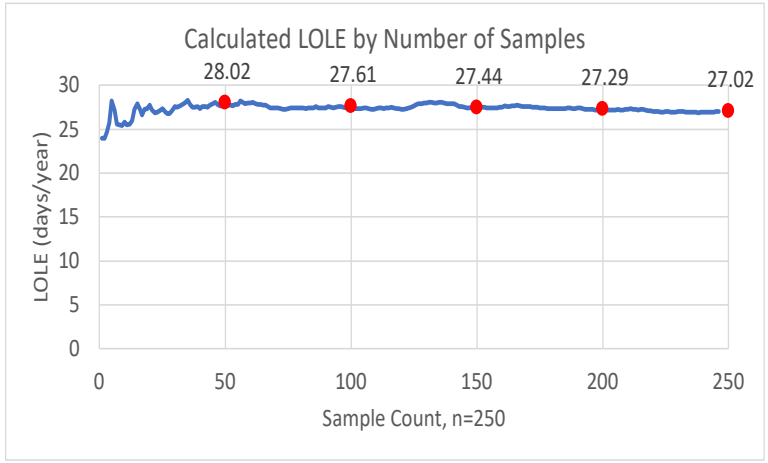

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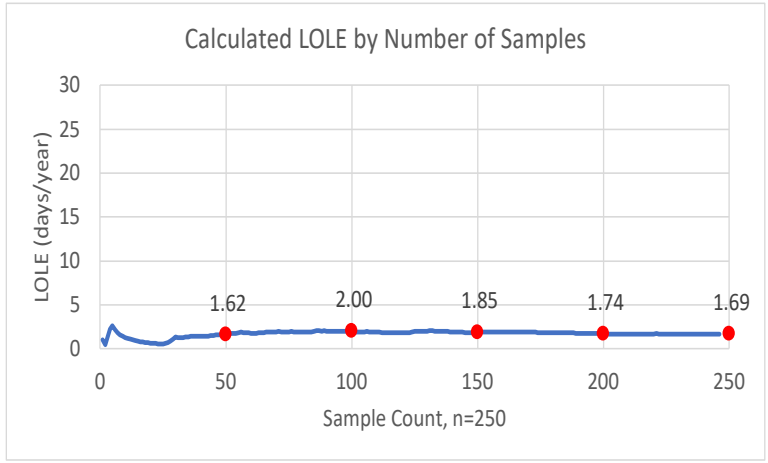
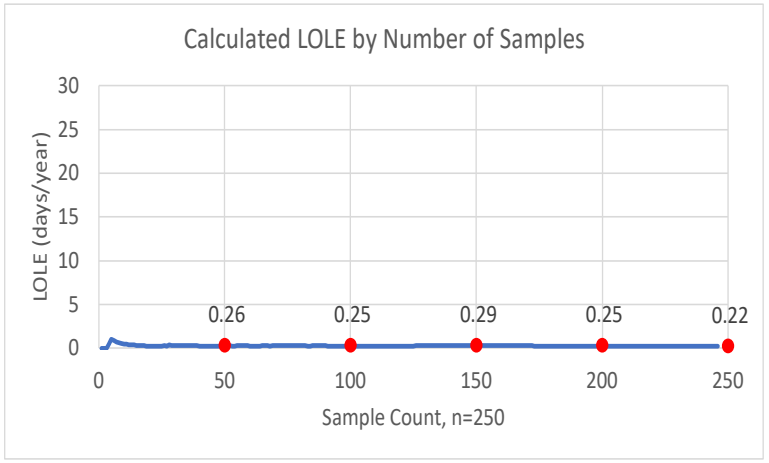


Base_200



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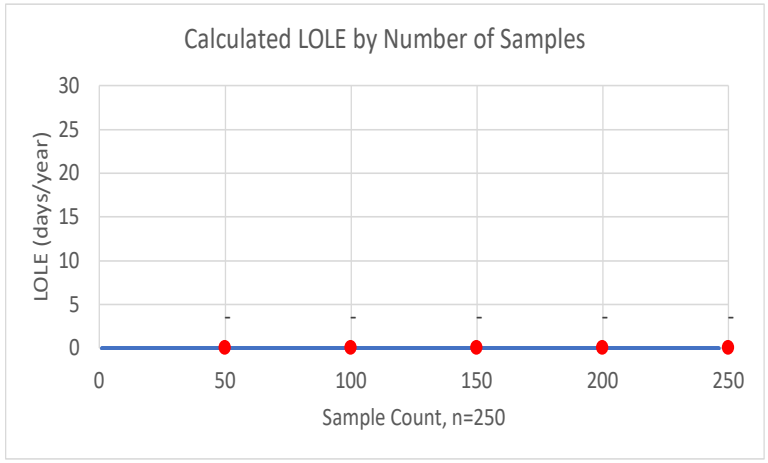
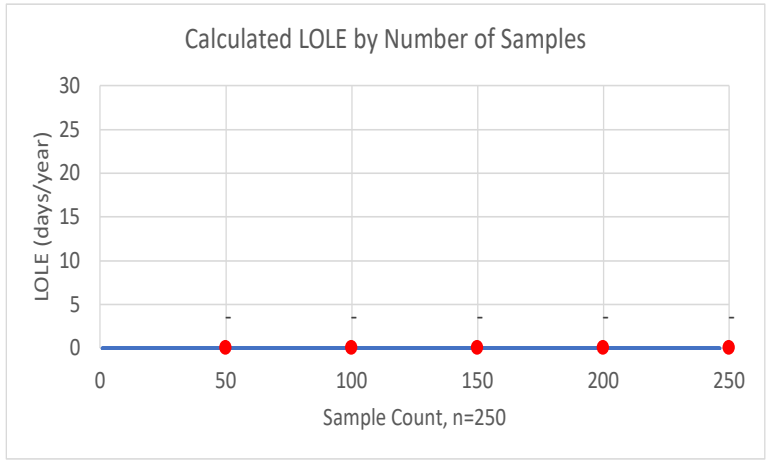


Base_399



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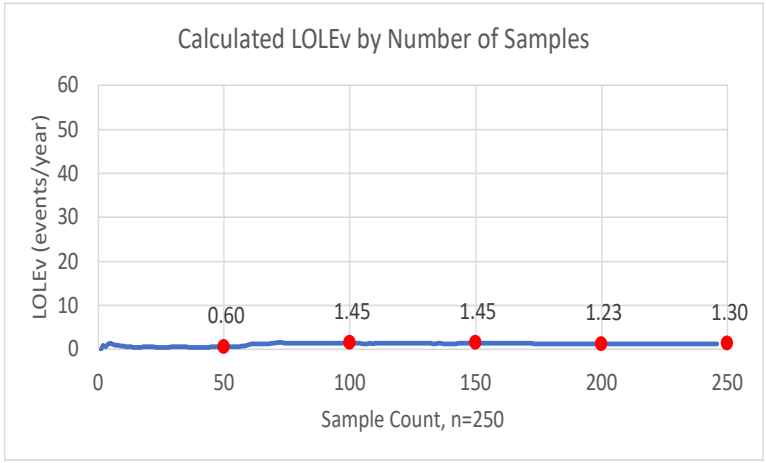

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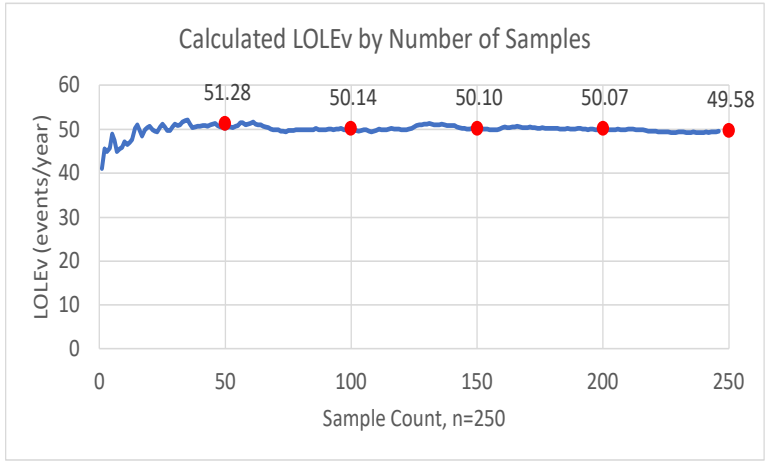

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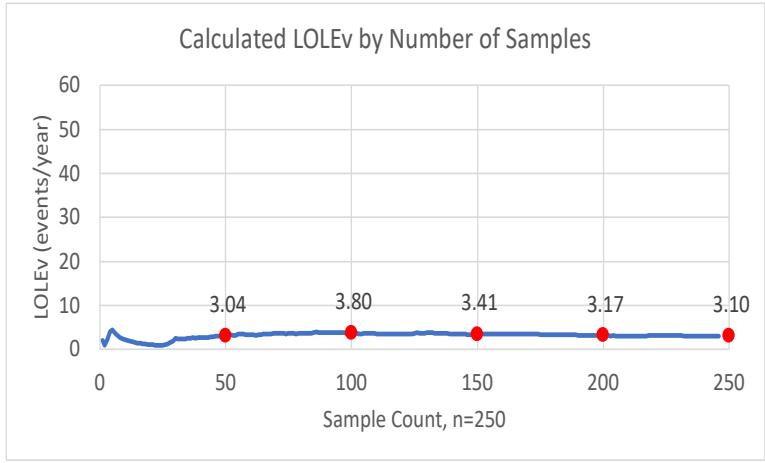

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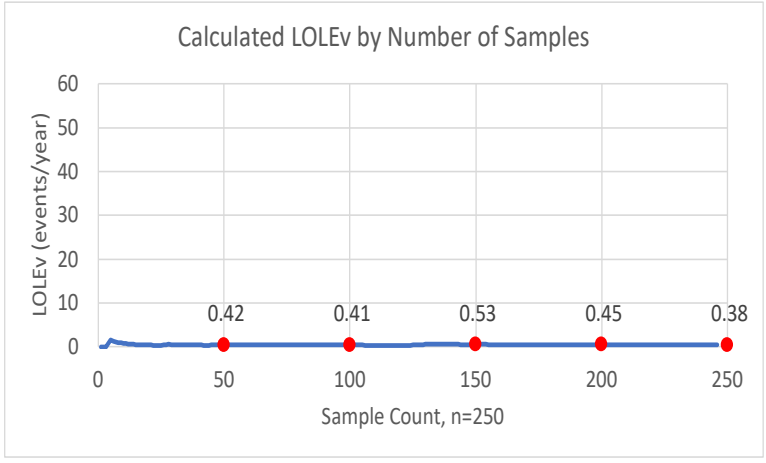

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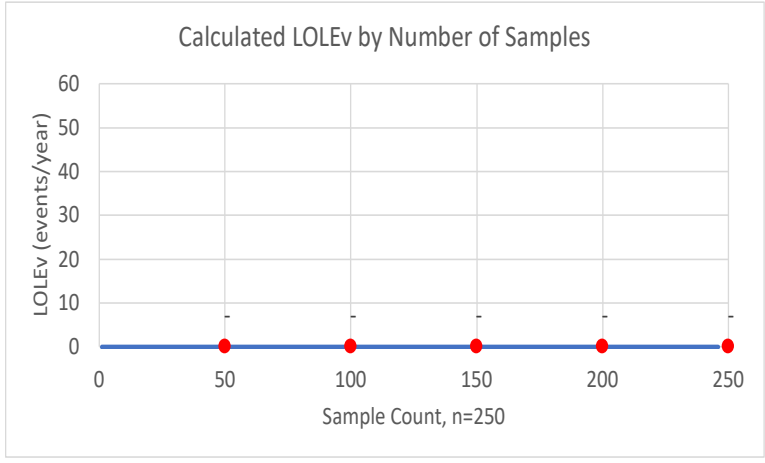
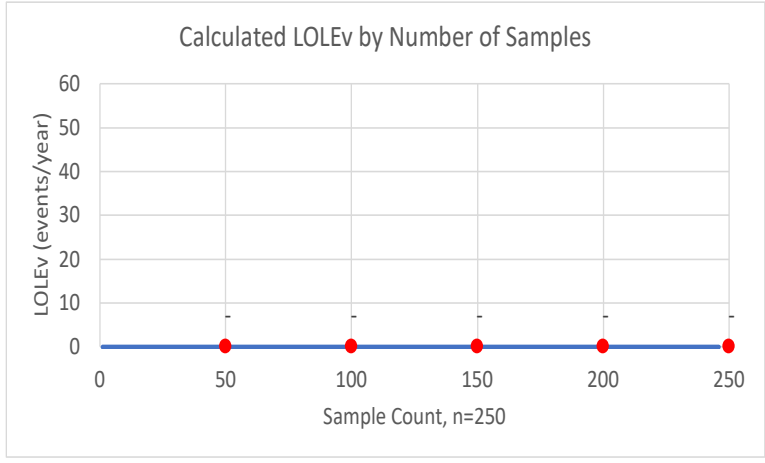


Base_399



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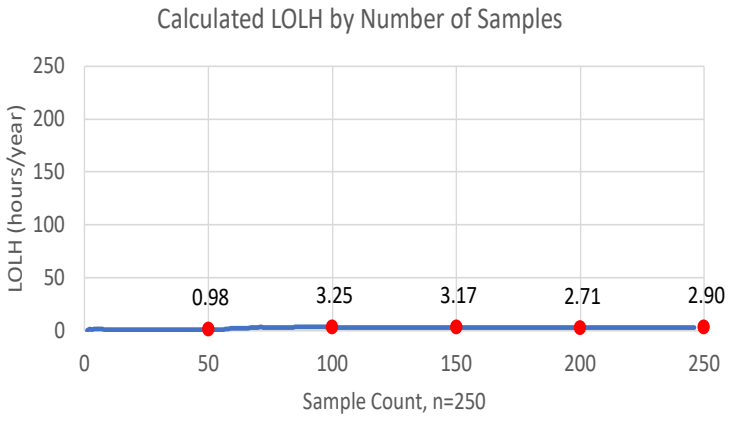

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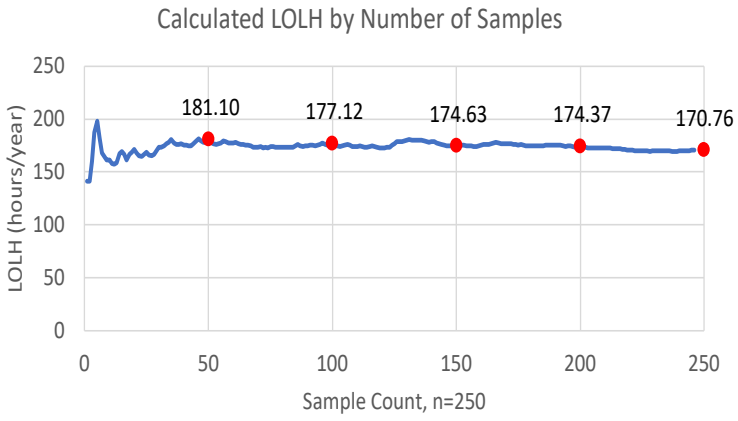

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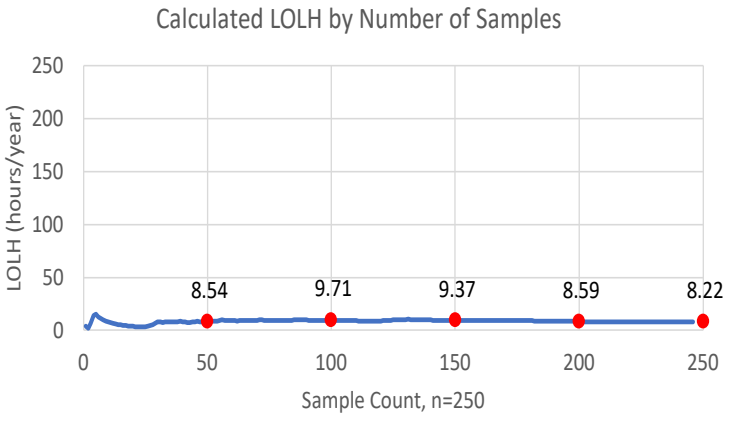

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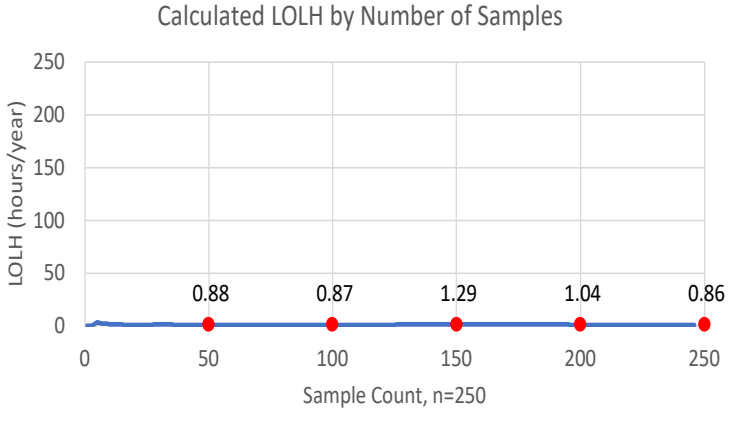

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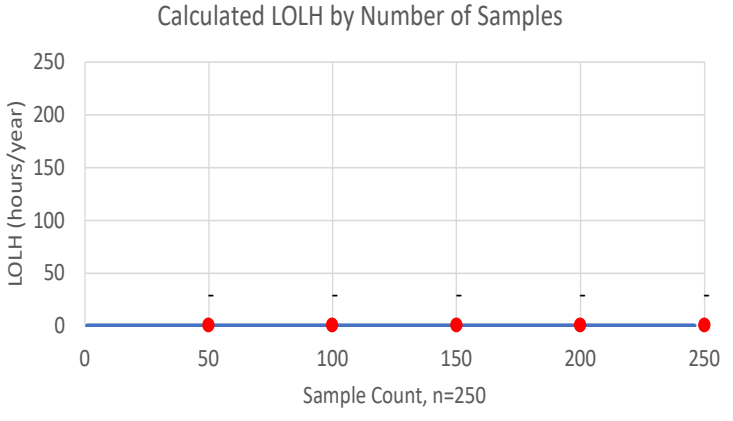

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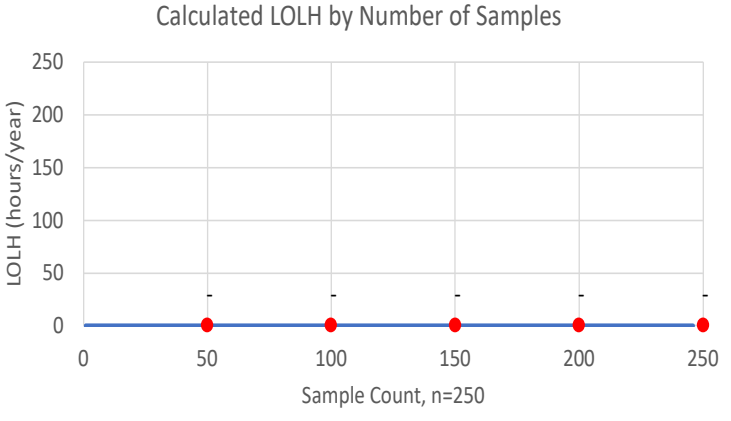

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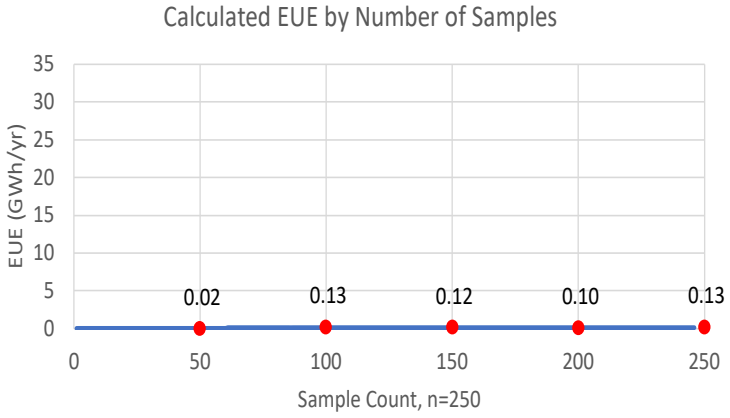

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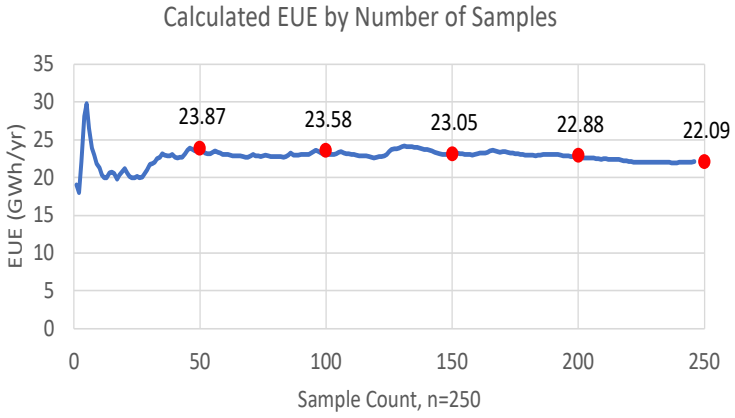

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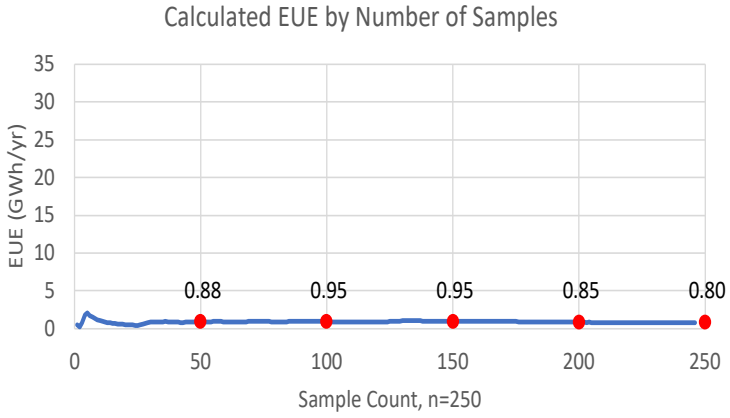

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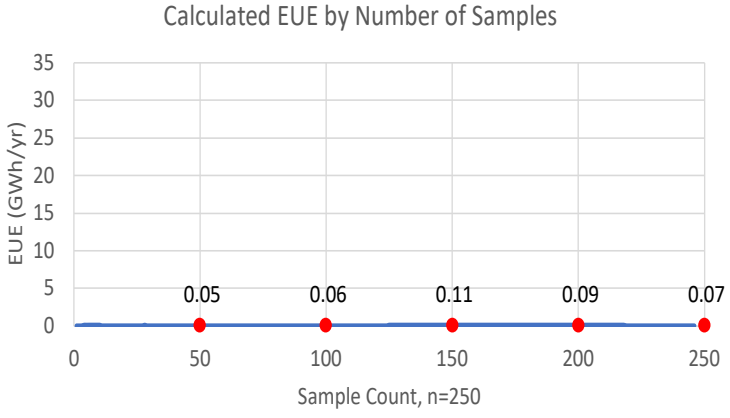

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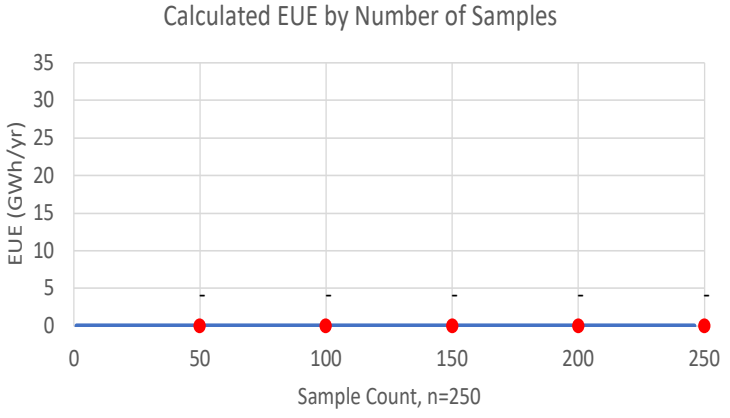
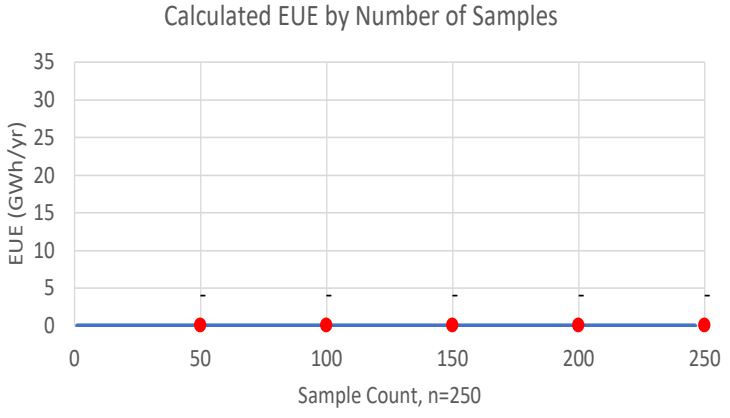


Base_ 399



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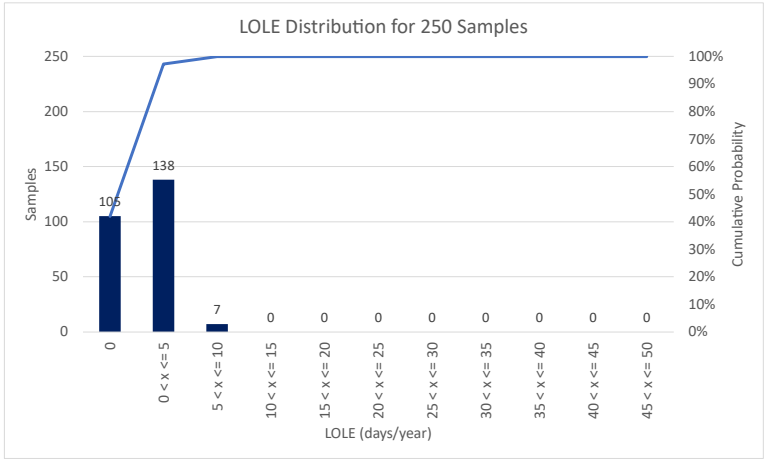

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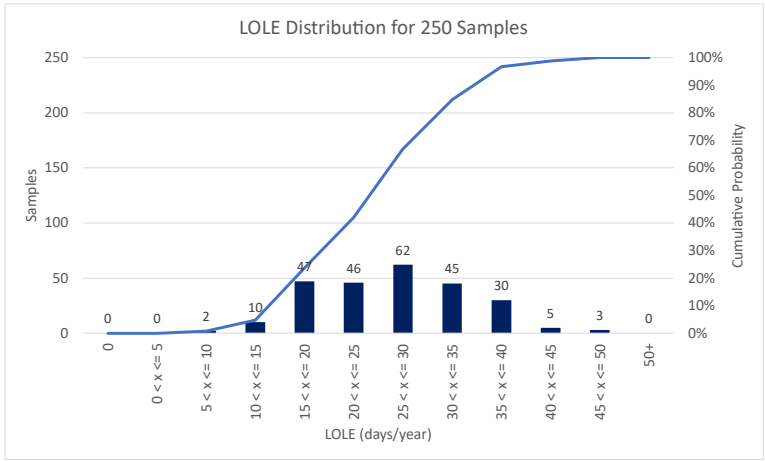

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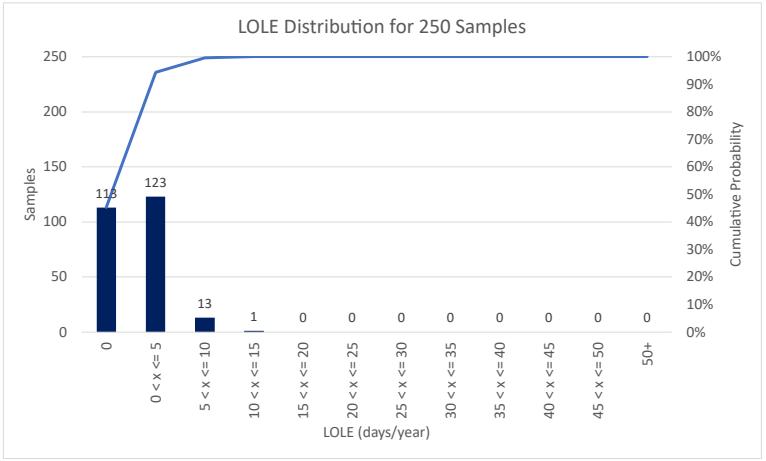

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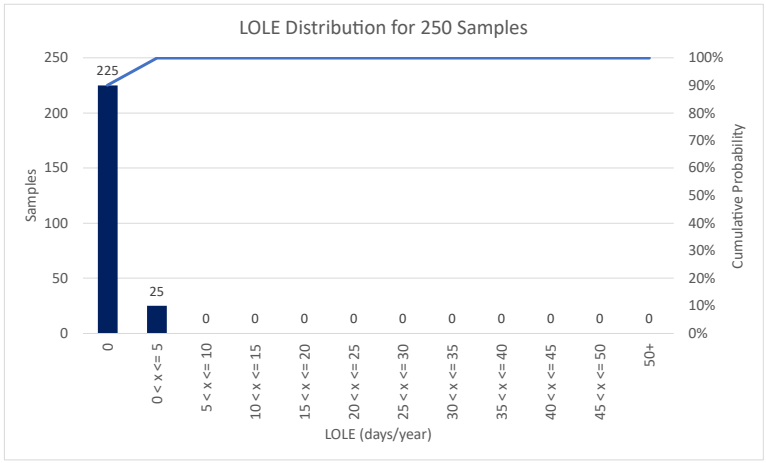

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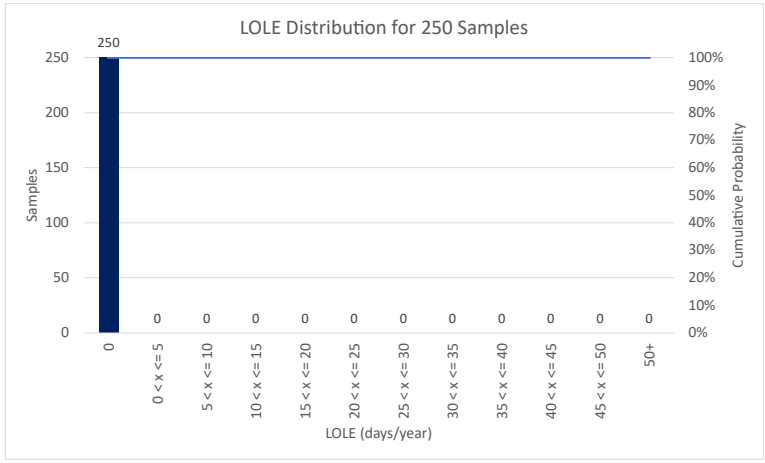

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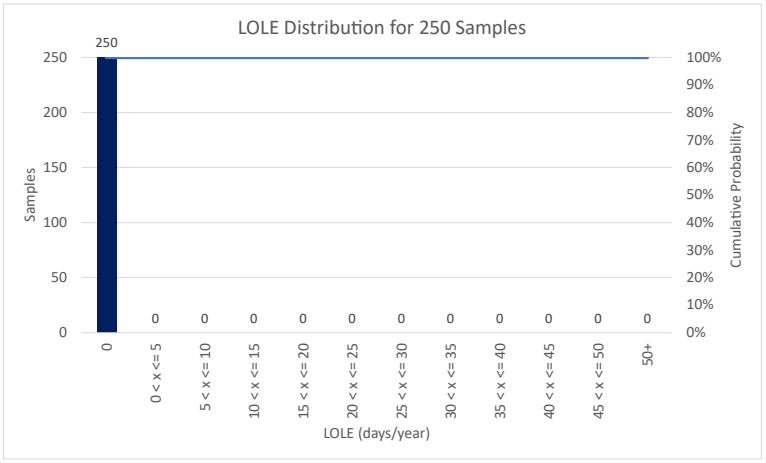

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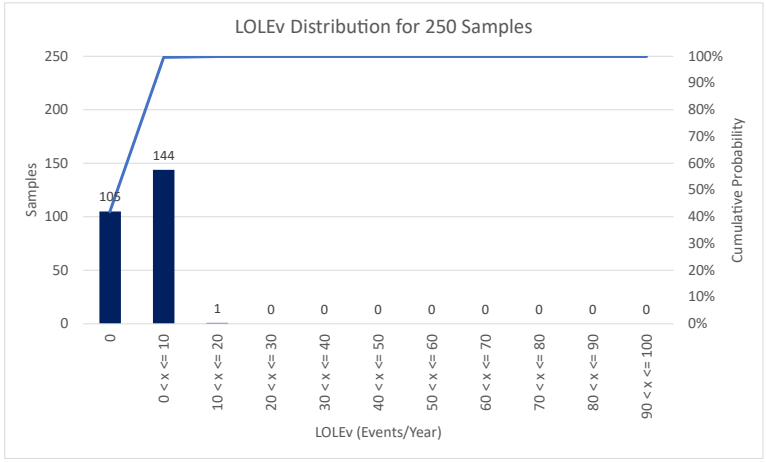

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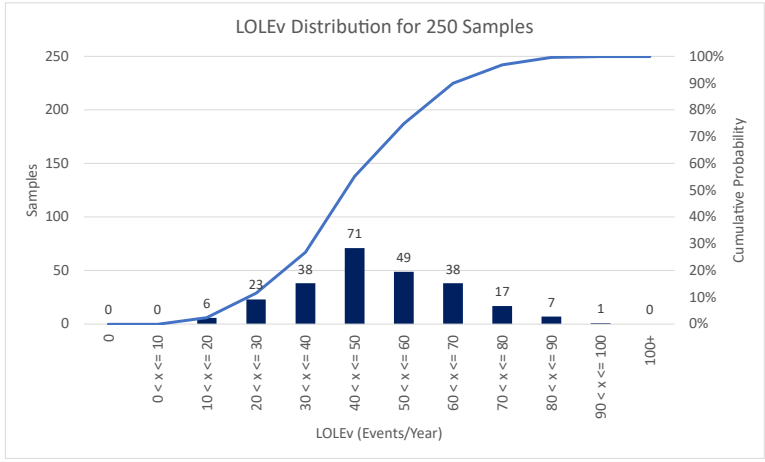

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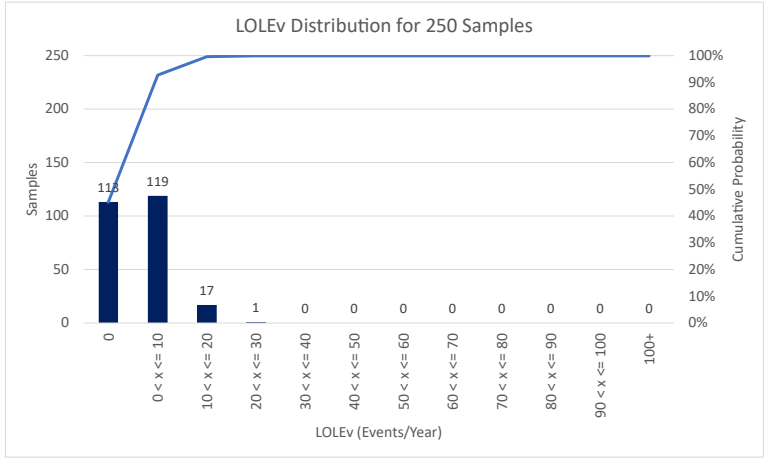

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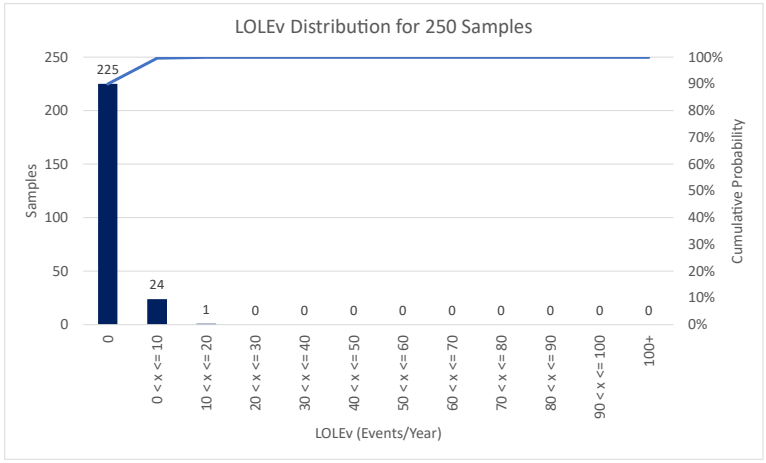

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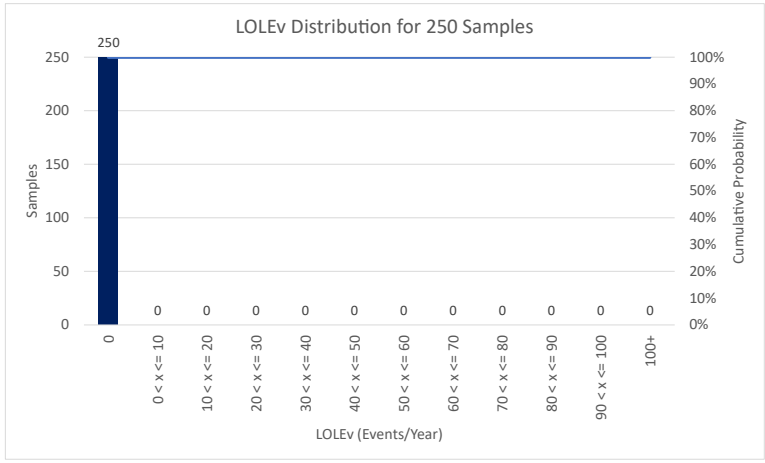
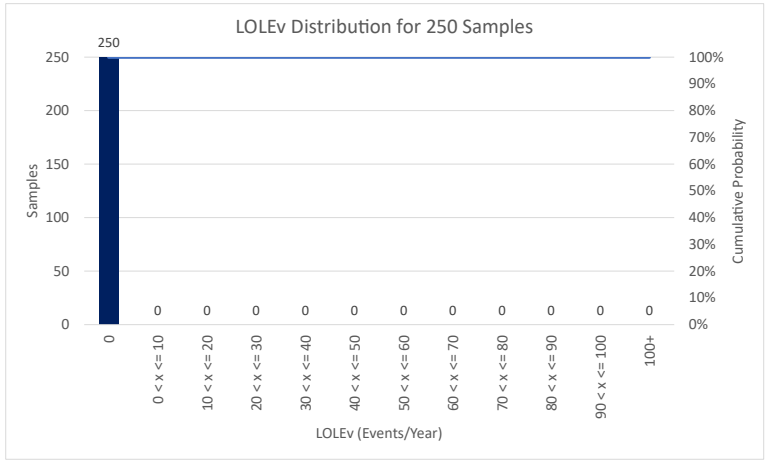


Base_399



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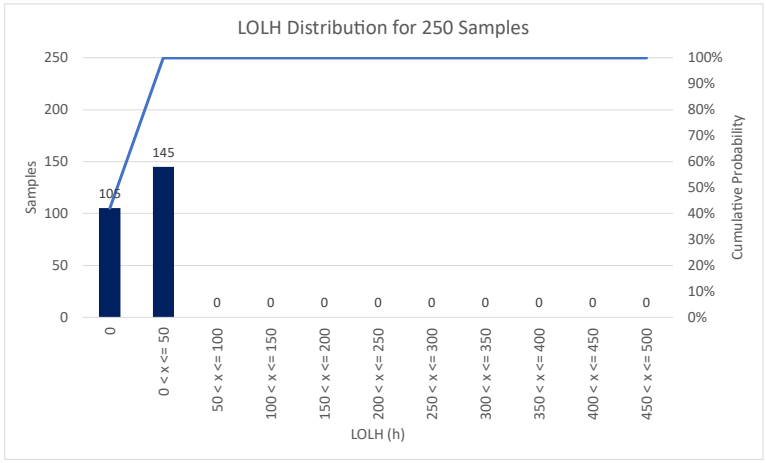

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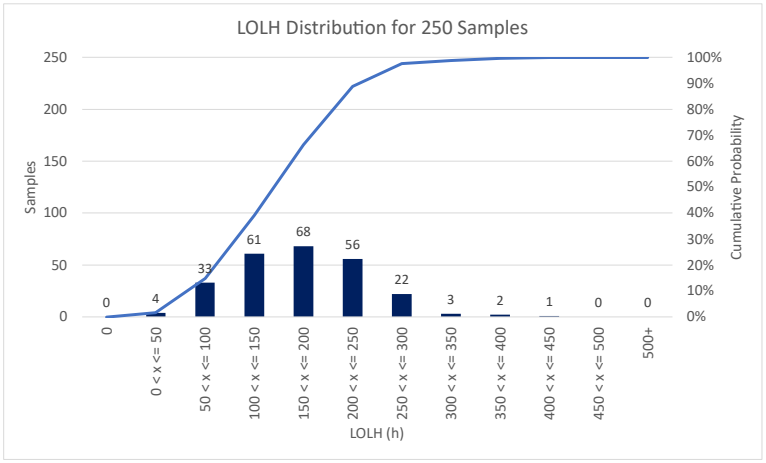

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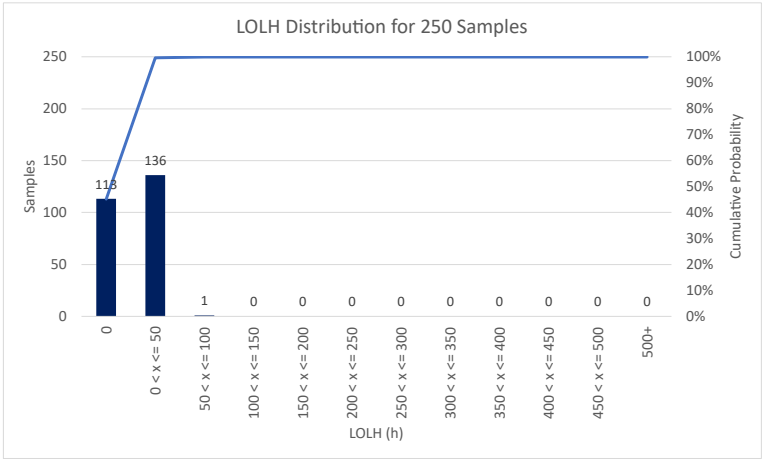
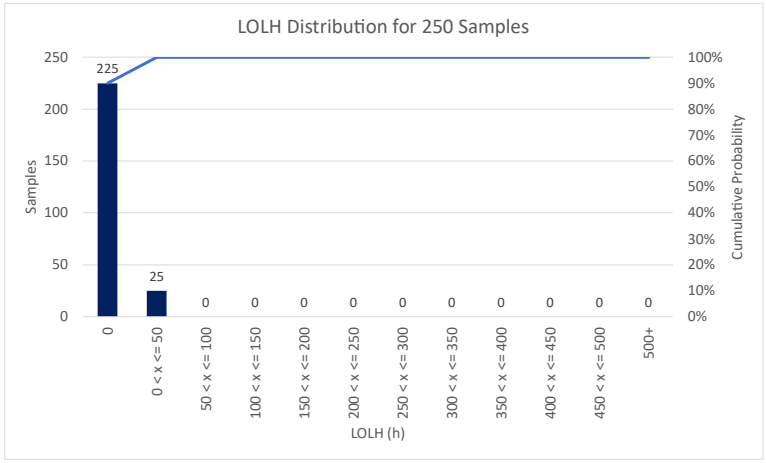


Base_200



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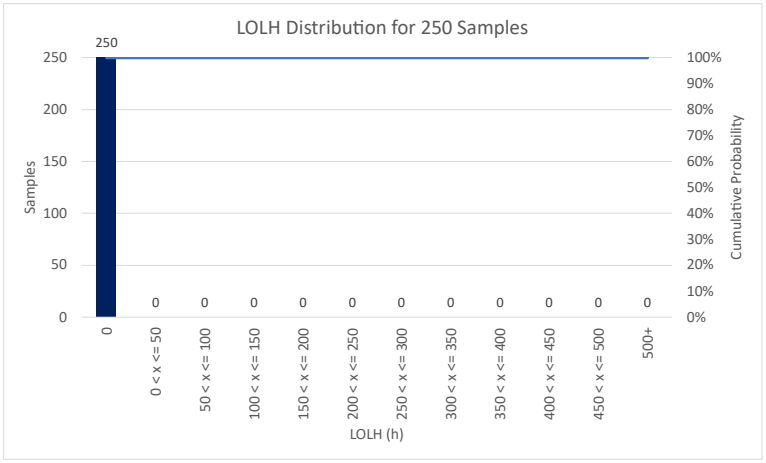
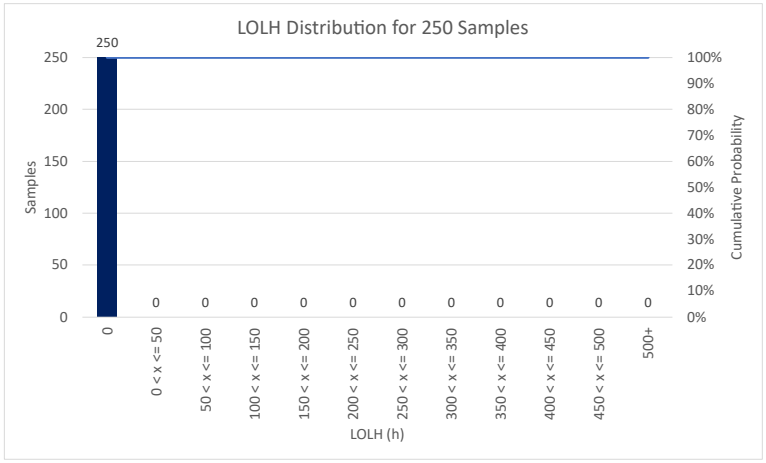


Base_399



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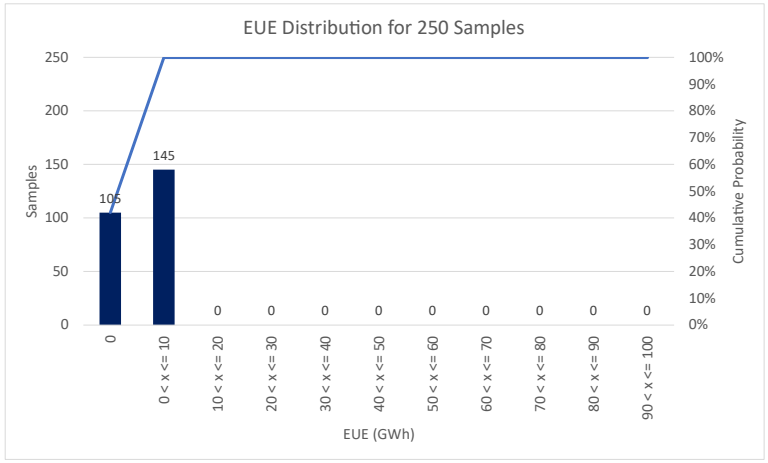
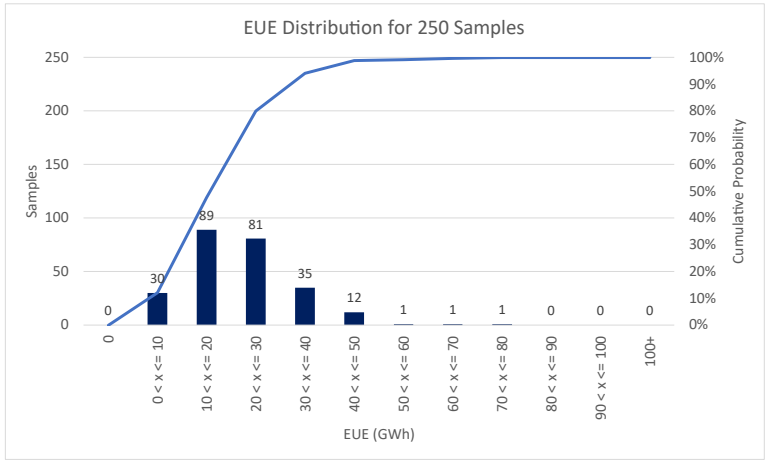
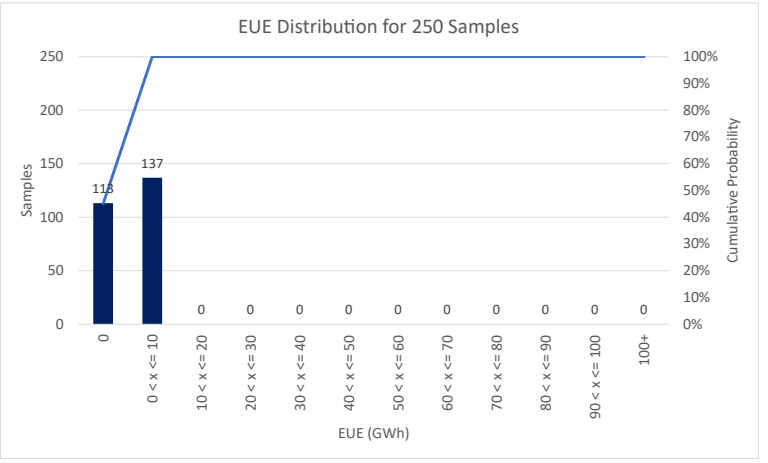


Existing



Base



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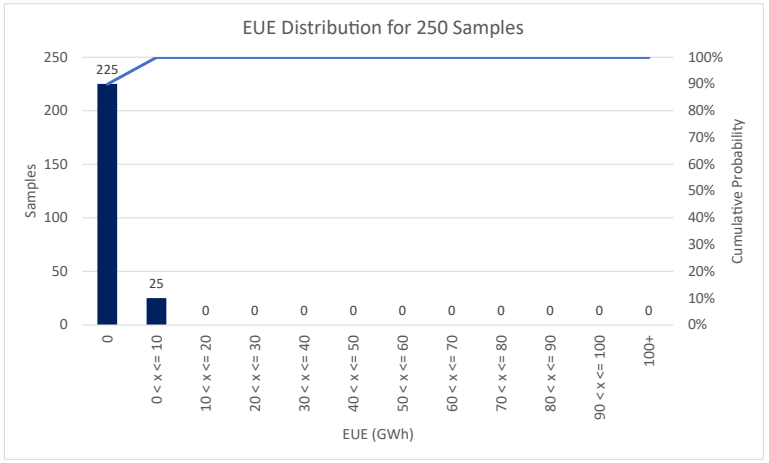

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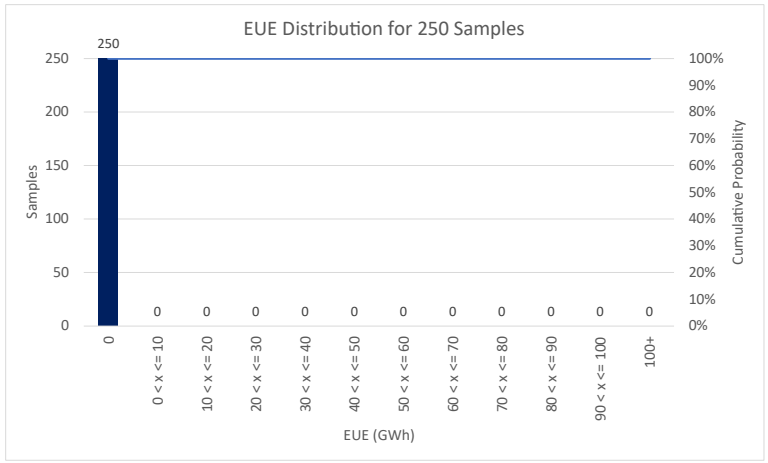

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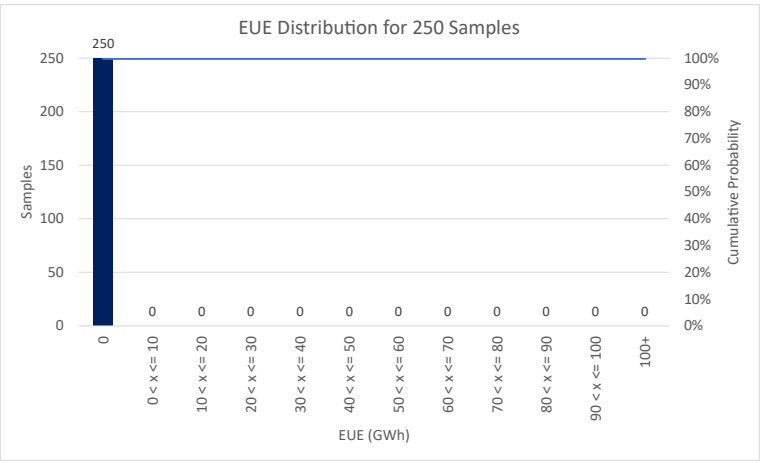
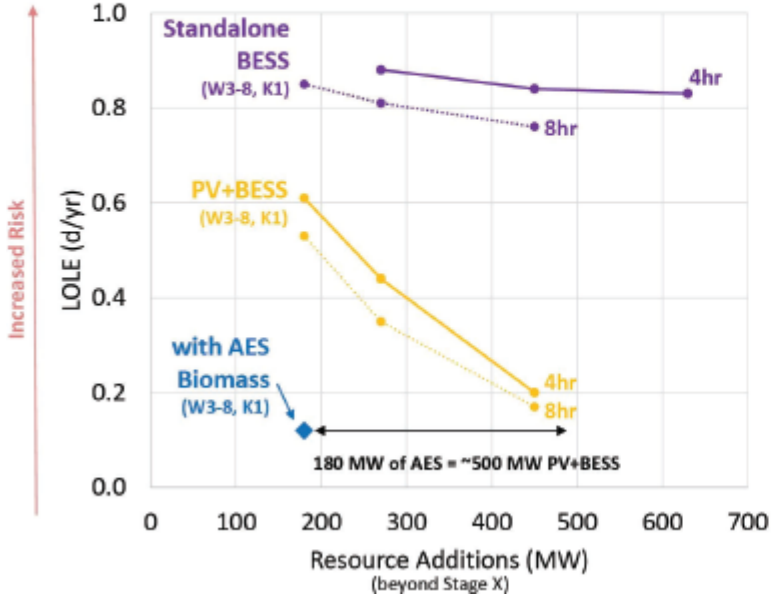


Base_480

Alignment with HNEI Analyses

Provides Capacity that is Difficult to Achieve with Solar or Storage

*at high penetration levels



- AES Biomass plus Stage X solar allows retirement of Waiau 3-8 and Kahe 1; or equivalent
- 500MW of utility scale PV+storage (beyond Stage X) required to achieve comparable reliability if W3-8 and K-1 are retired
- Storage alone cannot provide the capacity to allow additional fossil retirement – without solar additions, there is not enough *energy* to charge the batteries

- In year 2030, 180 MW of thermal generation (AES on biomass) plus 400 MW of PV+storage provides similar reliability as 900 MW of PV+storage, at or below 0.2 LOLE
- This includes the removal of 454 MW of thermal generation (Waiau 3-8 and Kahe 1)

See HNEI Grid Integration: AES Biomass Conversion slides filed on November 5, 2021 in Docket No. 2021-0024

Alignment with HNEI Analyses

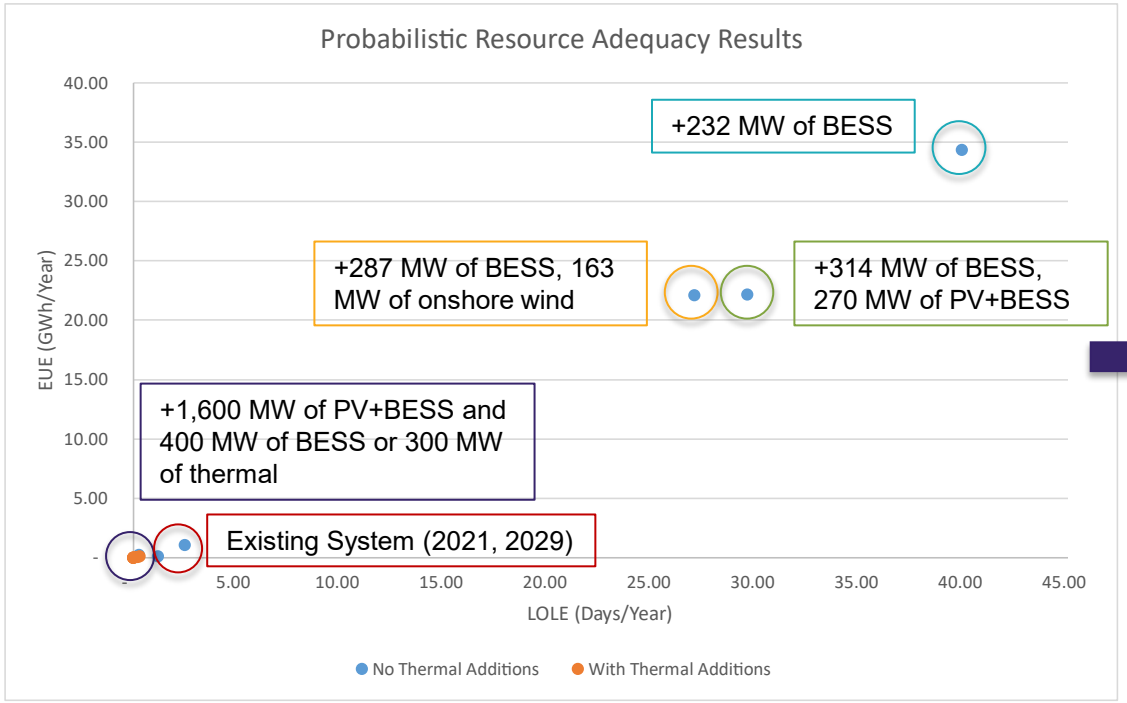
	HE	HNEI
Thermal Generation Removed (MW)	-180 (AES) -208 (KPLP) -371 (HECO) -759	-180 (AES) -454 (HECO) -634
Thermal Generation Added (MW)	+300	+180 / +0
Net Thermal Generation Removed (MW)	-459	-454 / -634
Variable Renewable Added (MW)	+185 (PV+BESS) +163 (Onshore Wind) +348	+400 / +900 (PV+BESS)
LOLE (days/yr)	0.22	<=0.2

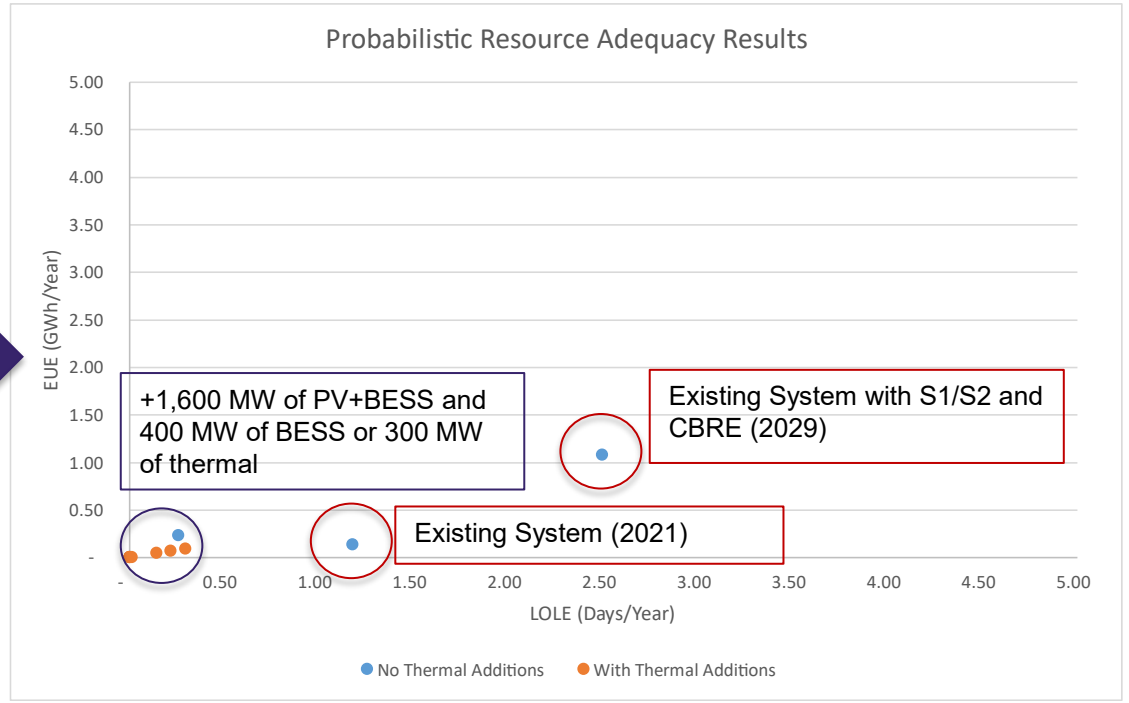
Similar net removals of thermal generation (~450 MW) and additions of variable renewables (350-400 MW) result in similar levels of LOLE.

Reliability Impacts of Different Resource Types

- Additional probabilistic sensitivities were run with different amounts of thermal and variable renewable resources to establish a relationship between LOLE/EUE and capacity additions.

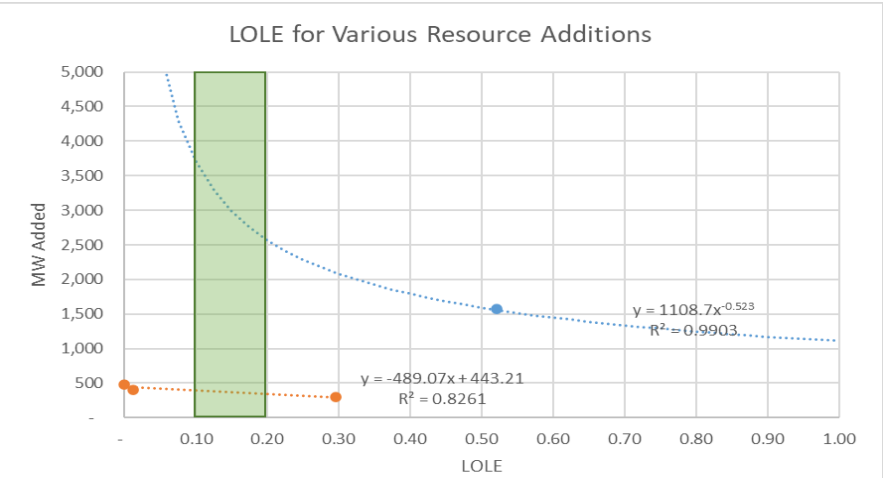
Addition of Variable Renewables and Thermal Resources Can Improve Reliability

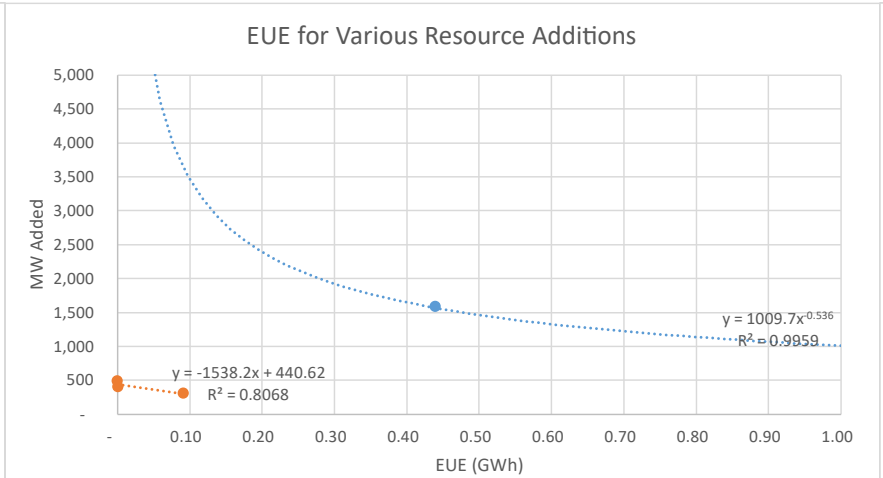


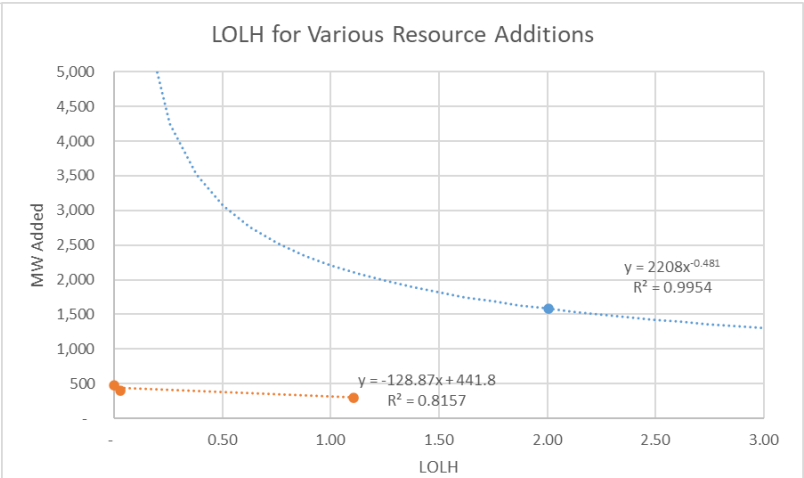


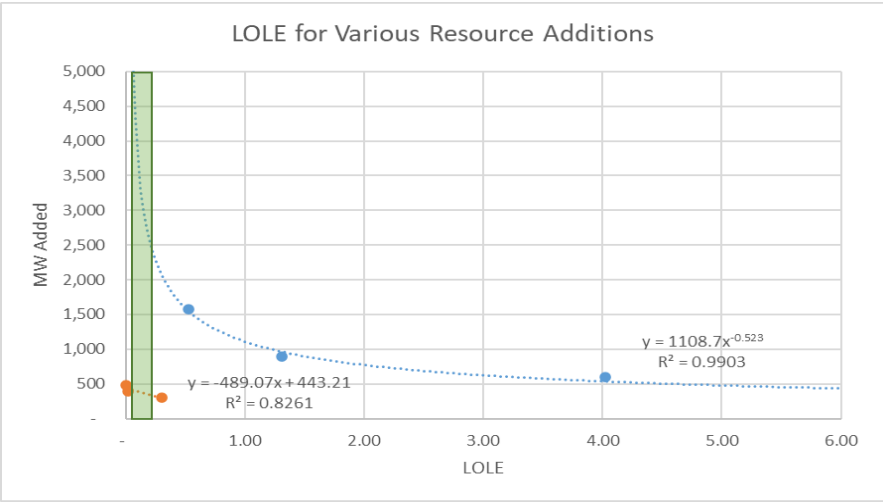
- Clustering of probabilistic simulation results shows that similar levels of EUE and LOLE can be achieved with additions of either PV+BESS or thermal resources.
  - Approximately 1,600 MW of Paired PV and 400 MW of BESS
  - At least 300 MW of thermal generation

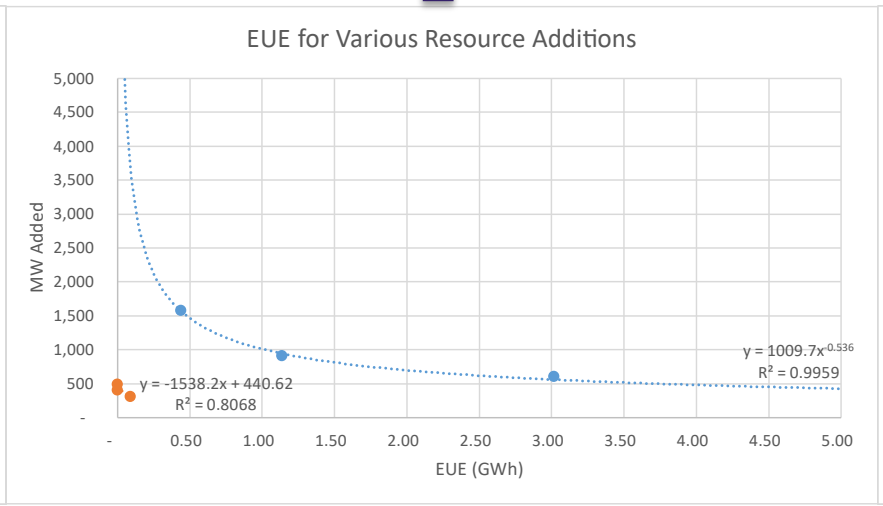
Greater Capacity of Variable Renewables Needed to Achieve Similar Levels of LOLE, EUE, and LOLH

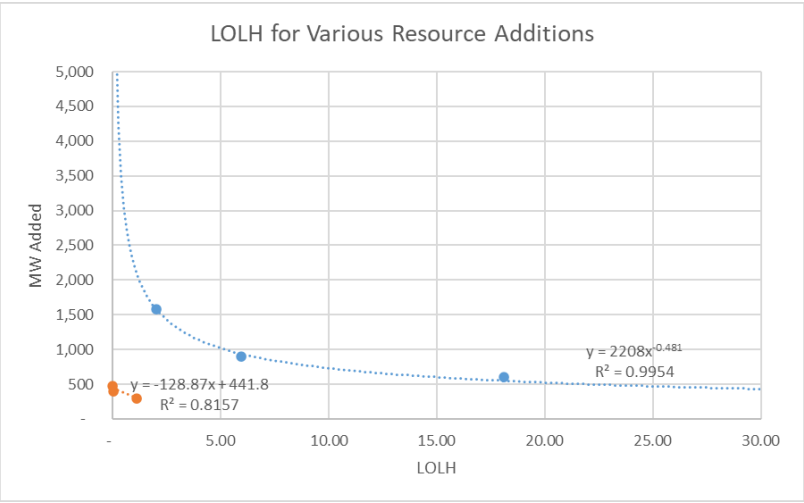












PV+BESS Thermal

O‘ahu Renewable Firm RFP

- Seeks to acquire 500-700 MW of capacity
  - 300-500 MW in service by end of 2029
  - 200 MW in service by end of 2033
- Should procurements be based on the “just right” amount of capacity or should “long” capacity be procured? The renewable firm RFP considered a range of capacity that could take us “long” to: ensure reliability, hedge against future high load scenarios (i.e., accelerated EV uptake), and to mitigate long-term adverse impacts from continuing to operate old baseloaded steam plants as flexible generation.

See https://www.hawaiianelectric.com/documents/clean_energy_hawaii/selling_power_to_the_utility/competitive_bidding/oahu_renewable_firm_rfp_transmittal_exhibit_1_background.pdf

Next Steps

- Continue to refine probabilistic RA modeling on Oʻahu
- Begin development of probabilistic RA databases for Maui, Hawaiʻi Island, Molokaʻi, and Lānaʻi