Hawaiian Electric

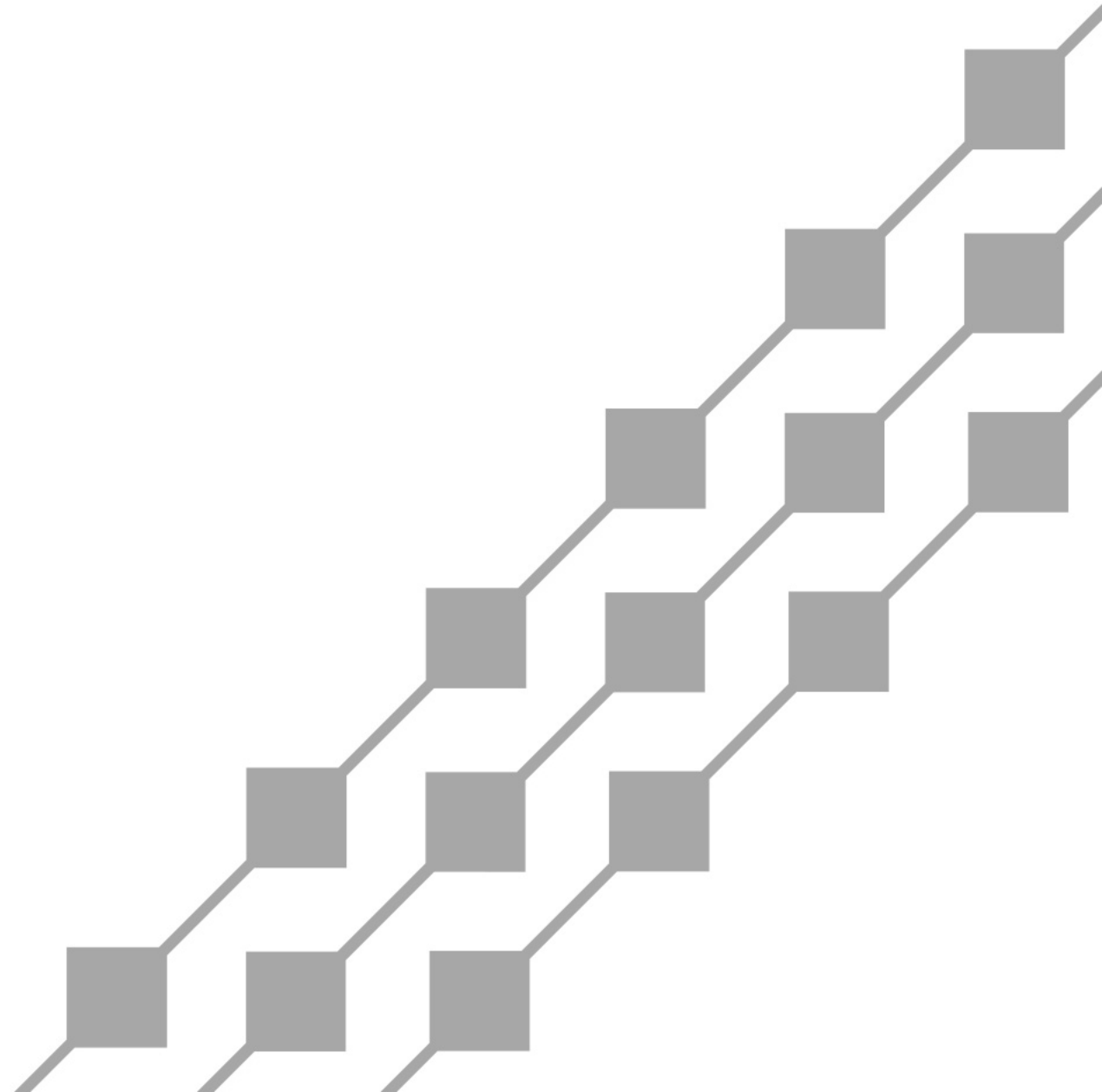
IGP Technical Advisory Panel

June 2, 2022

Agenda

- Present updated analysis for Oahu capacity expansion and probabilistic resource adequacy testing based on TAP suggestions.
- TAP Feedback and Suggestions include:
  - Update distributed PV generation based on NREL NSRDB data rather than scaled monthly capacity factors
  - Apply higher forced outages for existing thermal generating units to reflect recent increases in forced outage rate for the Hawaiian Electric fleet
  - Apply an hourly dependable capacity to thermal generation in RESOLVE

DER Profile



Resource Adequacy Test Cases

- Base_300
  - Base case with 6x50 MW SCCT added in 2029
  - DER profile scaled to match historical monthly capacity factor
- Base_300_NREL
  - Base case with 6x50 MW SCCT added in 2029
  - DER profile based on NREL NSRDB

Base case is 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_300 = 300 MW = 6x50 MW SCCT, Historical CF DER
Base_300_NREL = 300 MW = 6x50 MW SCCT, NREL NSRDB DER

Outage Rate Comparison

	NREL NSRDB Capacity Factor – Historical Capacity Factor (Negative = Historical Capacity Factor was higher)				
	2015	2016	2017	2018	2019
January	-2.61%	-3.62%	-3.75%	-2.71%	-2.28%
February	-3.30%	-4.25%	-0.64%	-2.69%	-1.93%
March	-2.19%	-5.64%	-6.07%	-0.78%	-2.86%
April	-5.78%	-4.82%	-3.16%	-0.62%	-1.30%
May	-4.32%	-0.74%	-4.53%	-1.89%	-2.49%
June	-5.87%	-1.56%	-2.08%	-0.88%	-1.15%
July	-3.94%	0.41%	-1.82%	1.46%	-0.66%
August	-1.72%	-0.35%	-1.21%	1.58%	-2.55%
September	0.42%	-2.19%	-3.72%	-1.63%	-3.83%
October	-2.17%	-2.19%	-2.18%	-3.07%	-2.01%
November	-0.62%	-2.06%	-2.46%	-1.91%	-3.54%
December	-2.24%	-2.07%	-0.82%	-2.84%	-1.41%

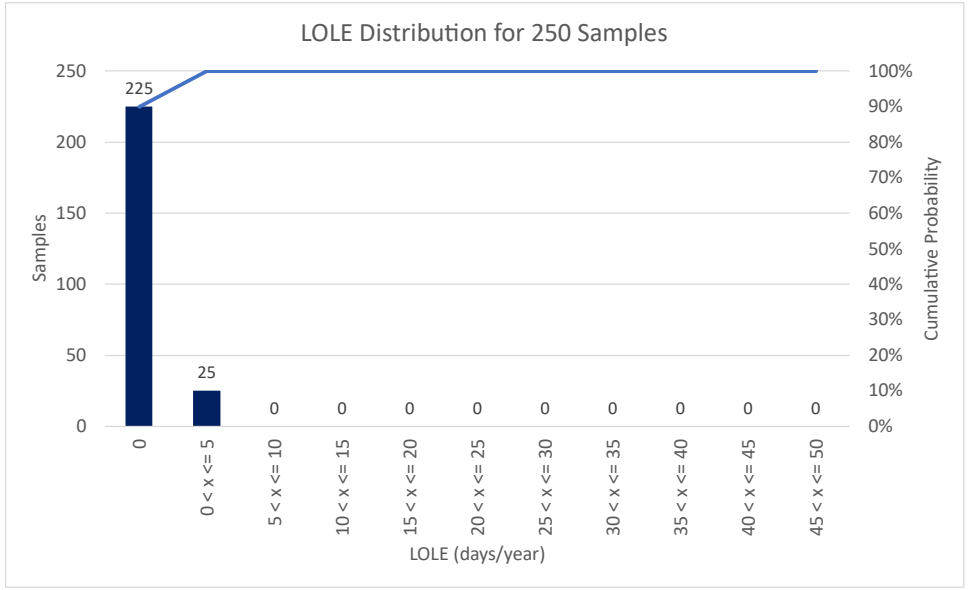
Base_300 = 300 MW = 6x50 MW SCCT, Historical CF DER
Base_300_NREL = 300 MW = 6x50 MW SCCT, NREL NSRDB DER

Test Case Result Summary

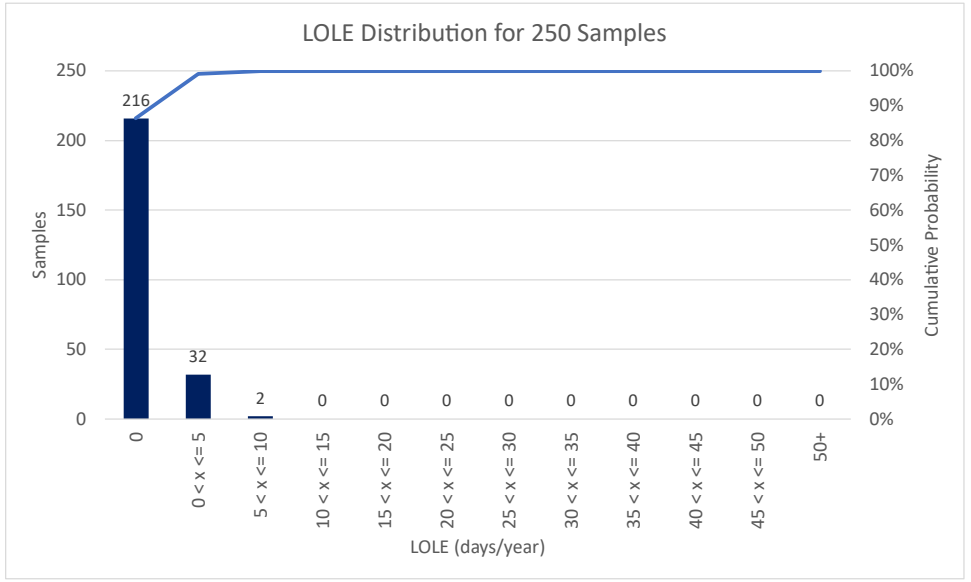
Year 2029	LOLE (days/year)	LOLEv (events/year)	LOLH (h/year)	EUE (GWh)
Base_300	0.22	0.38	0.86	0.07
Base_300_NREL	0.34	0.70	2.28	0.23

Results – Loss of Load Expectation

Base_300 = 300 MW = 6x50 MW SCCT, Historical CF DER
Base_300_NREL = 300 MW = 6x50 MW SCCT, NREL NSRDB DER



Base_300



Base_300_NREL

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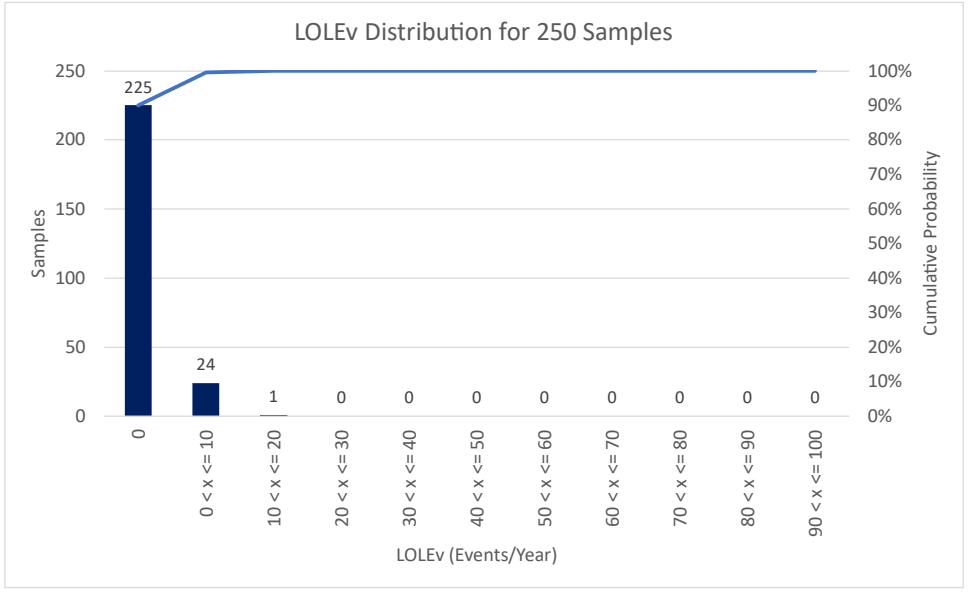
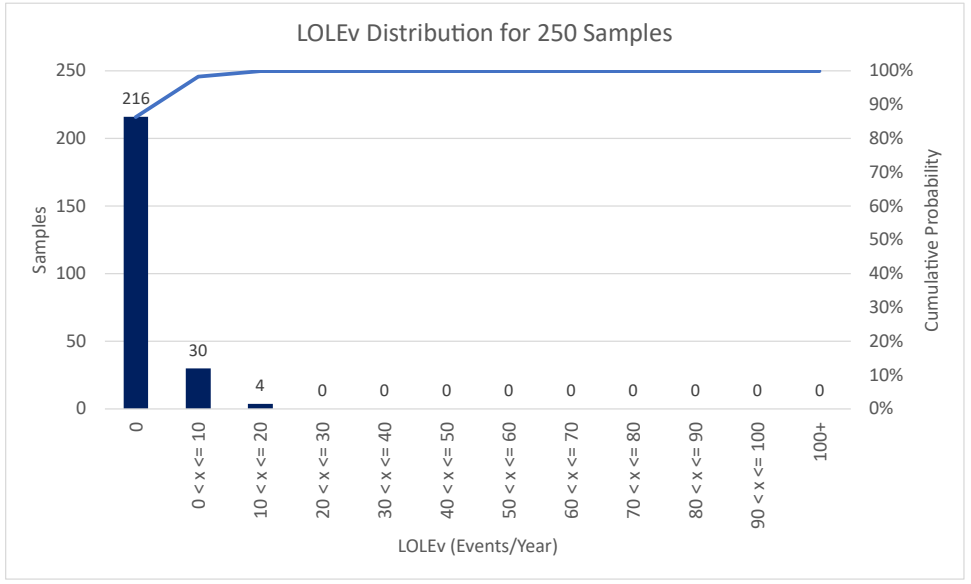
Results – Loss of Load Events



Base_300



Base_300_NREL

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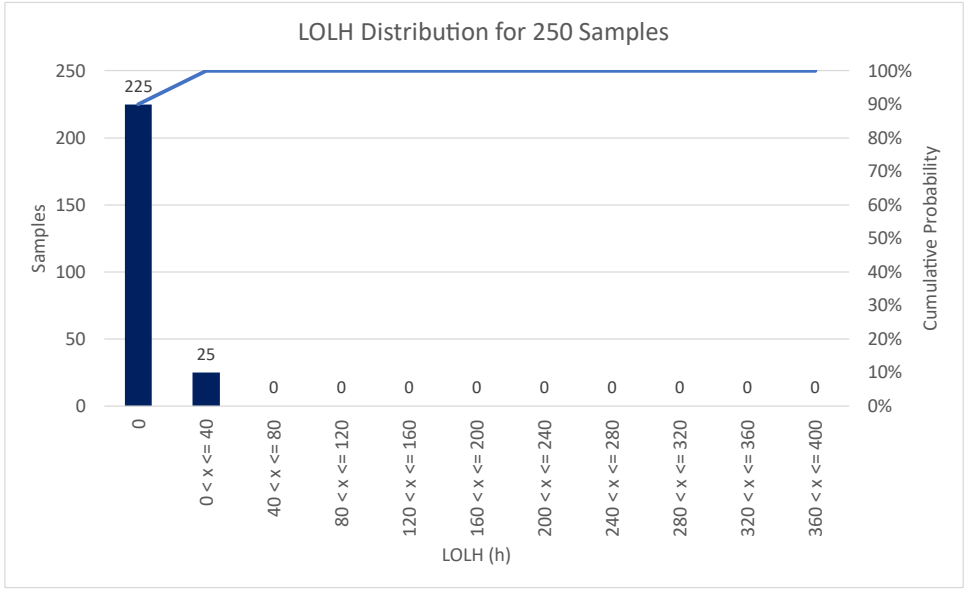
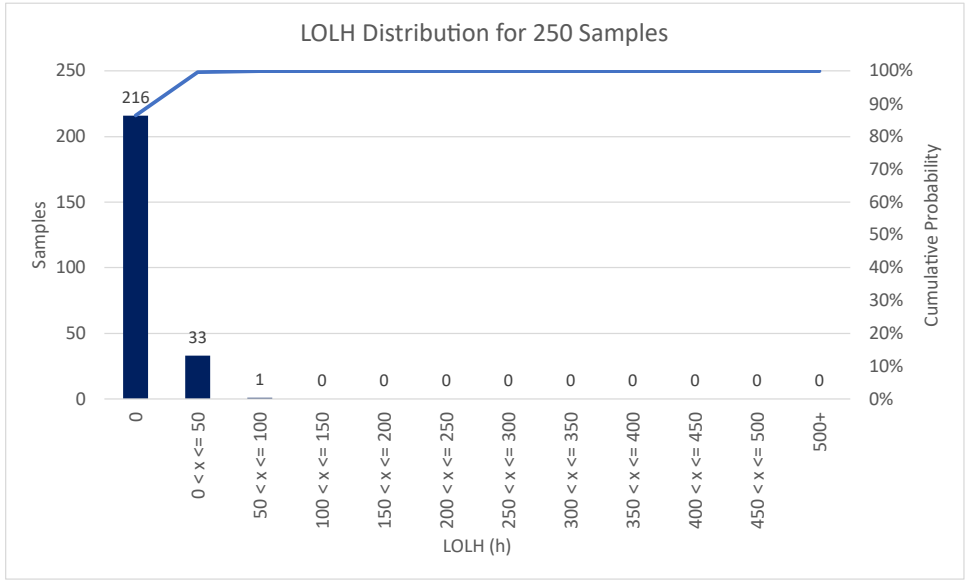
Results – Loss of Load Hours



Base_300



Base_300_NREL

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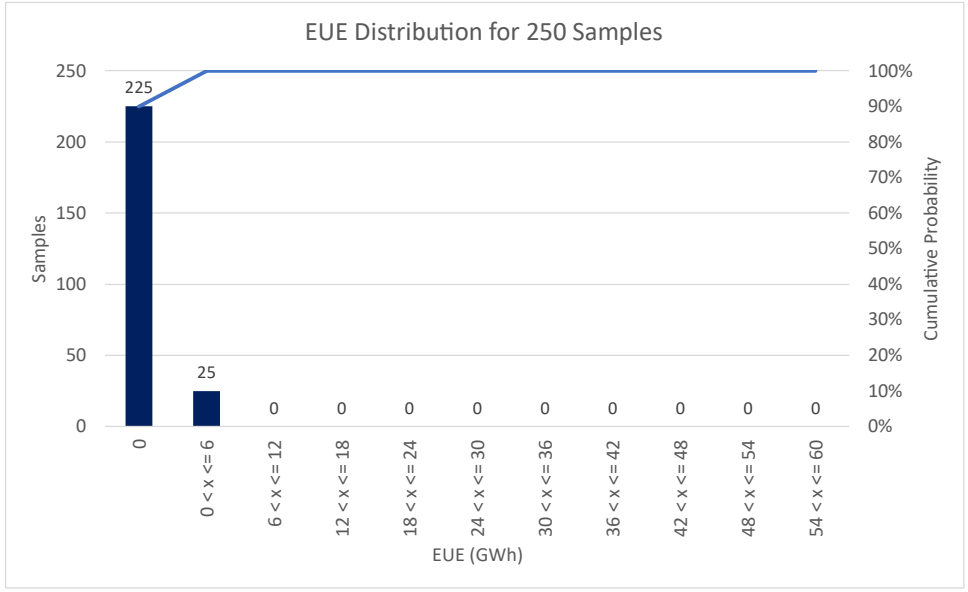
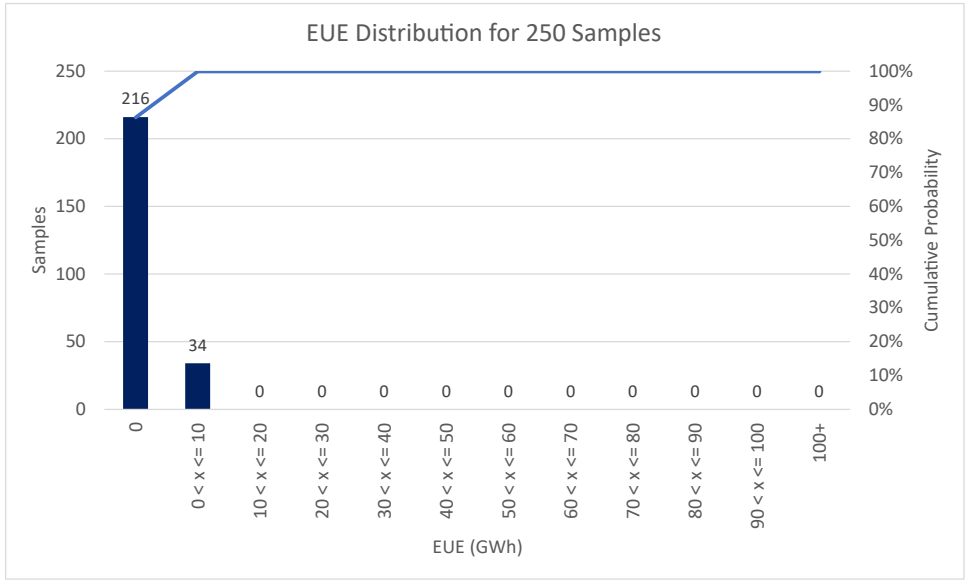
Results – Estimated Unserved Energy

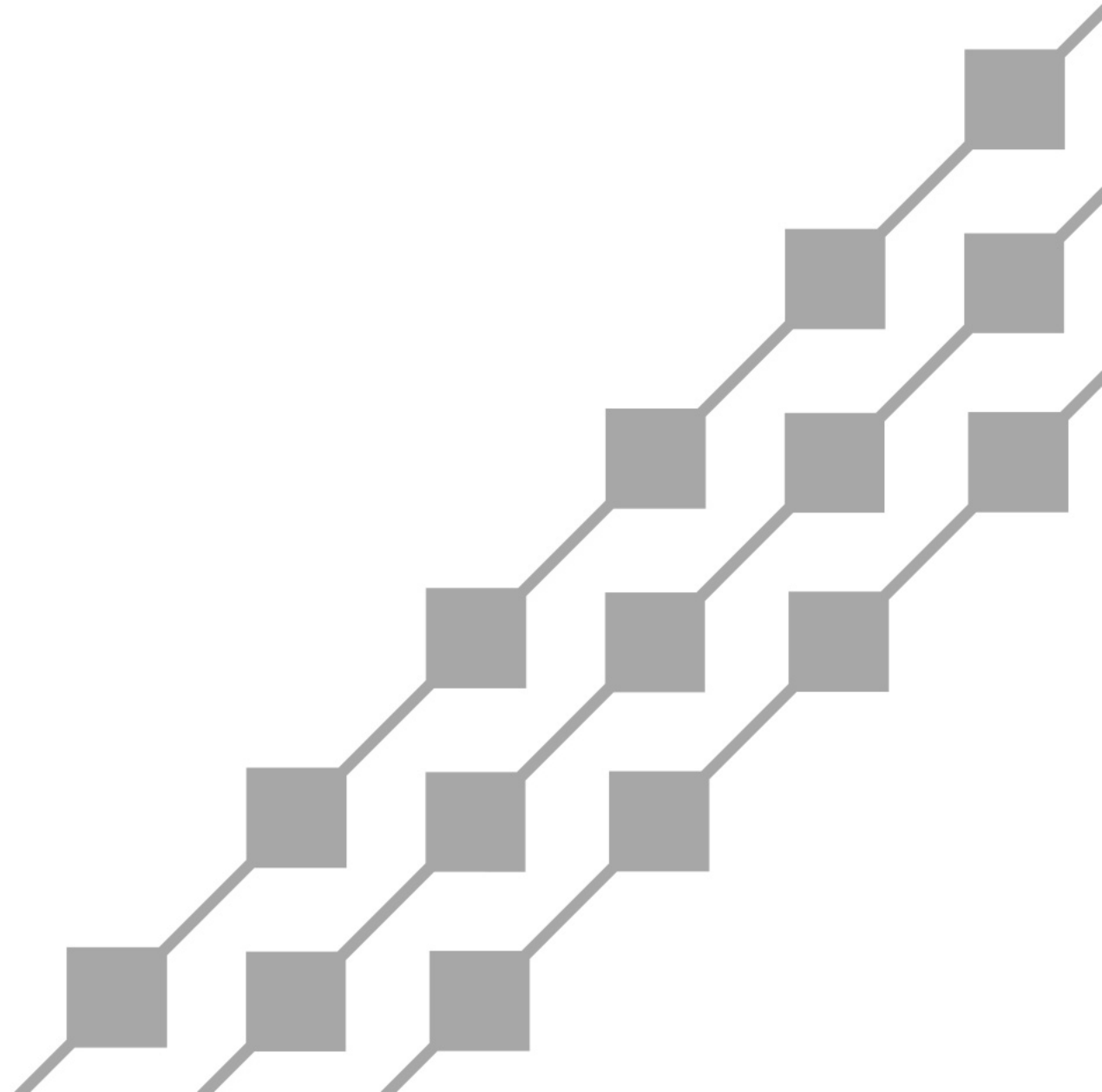


Base_300



Base_300_NREL

Higher Outage Rate



Resource Adequacy Test Cases

- Base_300
  - Base case with 6x50 MW SCCT added in 2029
- Base_480
  - Base case with 6x50 MW SCCT and 9x20 MW Biomass added in 2029
- Base_Accel
  - Base case with 2030 Renewables accelerated to 2029
- Base_Accel_300
  - Base case with 2030 Renewables accelerated to 2029 with 6x50 MW SCCT added in 2029

- Base_300_Mar22Out
  - Base_300 with latest outage rates published in March 31, 2022 Integrated Grid Planning Inputs and Assumptions
- Base_480_Mar22Out
  - Base_480 with latest outage rates published in March 31, 2022 Integrated Grid Planning Inputs and Assumptions
- Base_Accel_Mar22Out
  - Base_Accel with latest outage rates published in March 31, 2022 Integrated Grid Planning Inputs and Assumptio
- Base_Accel_300_Mar22Out
  - Base_Accel_300 with latest outage rates published in March 31, 2022 Integrated Grid Planning Inputs and Assumptions

Base case is 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

Outage Rate Comparison

Base_300 = 300 MW = 6x50 MW SCCT
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass
Base_Accel_300 = 300 MW with 2030 Renewables = 6x50 MW SCCT with 2030 Renewables
Base_###_Mar22Out = ### MW = March 31, 2022 Outage

Generator	Maintenance Outage Rate (%)		Forced Outage Rate (%)	
	August 2021	March 2022	August 2021	March 2022
Waiau 5	1.9	11.5	5.0	15.0
Waiau 6	1.9	11.5	5.0	15.0
Waiau 7	13.4	32.0	4.5	13.0
Waiau 8	21.1	11.5	4.5	13.0
Waiau 9	3.8	3.8	4.0	4.0
Waiau 10	3.8	3.8	4.0	4.0
Kahe 1	3.8	11.5	4.5	13.0
Kahe 2	3.8	11.5	4.5	13.0
Kahe 3	13.4	11.5	4.5	13.0
Kahe 4	3.8	11.5	4.5	13.0
Kahe 5	1.9	11.5	5.0	10.0
Kahe 6	13.4	11.5	5.0	10.0
CIP CT-1	3.8	3.8	3.0	4.0
H-POWER	0.0	0.0	3.0	3.0
Airport DSG	1.9	1.9	5.0	5.0
Schofield	1.9	1.9	2.0	2.0

Probabilistic Resource Adequacy Sensitivities

Base_300 = 300 MW = 6x50 MW SCCT
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass
Base_Accel_300 = 300 MW with 2030 Renewables = 6x50 MW SCCT with 2030 Renewables
Base_###_Mar22Out = ### MW = March 31, 2022 Outage

- Using the higher outage rates shows that 300 MW of firm generation may be needed, even with a new large tranche of variable renewables in the Base_Accel_300_Mar22Out case.
- If the addition of future variable renewables is more modest (less than the 1,600 MW selected by RESOLVE), an additional 180 MW of firm generation may be needed to get to similar levels of reliability, as shown in the Base_480_Mar22Out case.

Green = LOLE ≤ 0.22 Days/Yr (US Mainland – O'ahu guideline), LOLH ≤ 3 hrs (Belgium, France, GB, Poland), EUE ≤ 0.02% of load/131 MWh (AEMO)

Year 2029	Existing Firm (MW)	Future Firm (MW)	Future Variable (MW)	Future SA BESS (MW)	LOLE (Days/Year)	LOLEv (Events/Year)	LOLH (Hours/Year)	EUE (MWH/Year)
Existing (2021)	1,729	0	0	0	1.18	1.30	2.90	130
Base_300	970	300	582	287	0.22	0.38	0.86	70
Base_300_Mar22Out	970	300	582	287	1.30	2.19	5.98	630
Base_480	970	480	582	287	0.00	0.00	0.00	0.00
Base_480_Mar22Out	970	480	582	287	0.04	0.06	0.17	20
Base_Accel	970	0	2,159	379	0.52	1.05	2.01	440
Base_Accel_Mar22Out	970	0	2,159	379	2.08	4.36	8.40	2,030
Base_Accel_300	970	300	2,159	379	0.00	0.00	0.00	0.00
Base_Accel_300_Mar22Out	970	300	2,159	379	0.03	0.07	0.10	20

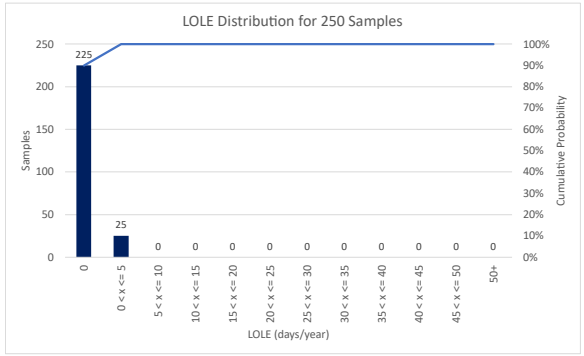
Future Variable includes: [S1 (Hoohana, Mililani, Waiawa, West O'ahu), S2 (Barbers Point, Kupono, Mountain View, Waiawa Ph 2), CBRE Ph 2] = 419 MW Solar+BESS
Future resources selected by RESOLVE [wind (163 MW) and PV+BESS (1,577 MW in Base or 270 MW in Land Constrained)]

Takeaways From Probabilistic Resource Adequacy

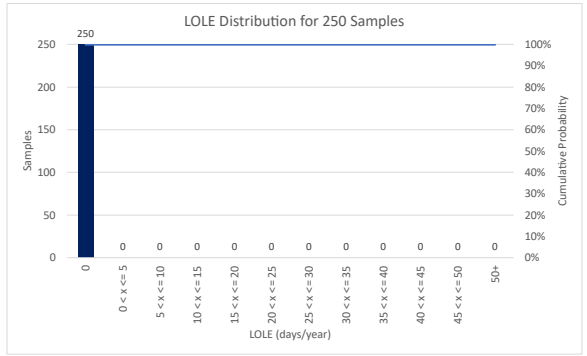
- Forced outages are a significant driver of reliability, especially when considering more recent trends in generator unit availability.
- In the Base_300 case, 300 MW of new CT results in a LOLE of 0.22 days / yr, or probability of an outage of 1 day in 4.5 years.
- Accelerating 1,600 MW PV+BESS in Base_Accel (no new firm generation) does not provide the same reduction in LOLE as new firm generation (Base_300 and Base_480). This demonstrates that some level of firm generation is needed.
- With a modest amount of renewables added beyond Stage 1 and Stage 2, and using higher outage rates, 300 MW of firm far exceeds historical planning guidelines with a LOLE of 1.2 days/year (Base_300_Mar22Out).
- Using higher outage rates, the addition of 1,600 MW of future PV+BESS beyond Stage 1 and 2 provides similar levels of reliability as an additional 180 MW of firm capacity (Base_Accel_300_Mar22Out vs Base_480_Mar22Out).

Results – Loss of Load Expectation

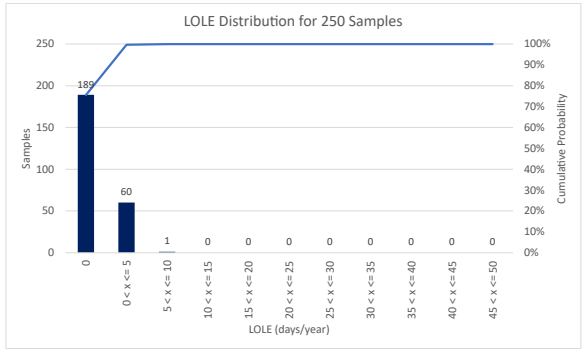
Base_300 = 300 MW = 6x50 MW SCCT
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass
Base_Accel_300 = 300 MW with 2030 Renewables = 6x50 MW SCCT with 2030 Renewables
Base_###_Mar22Out = ### MW = March 31, 2022 Outage



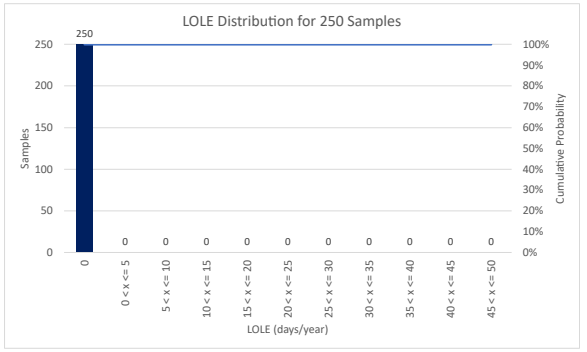
Base_300



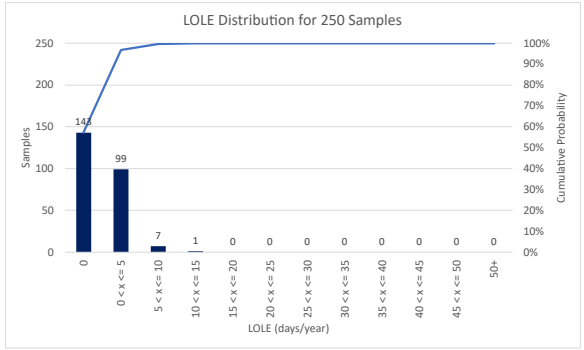
Base_480



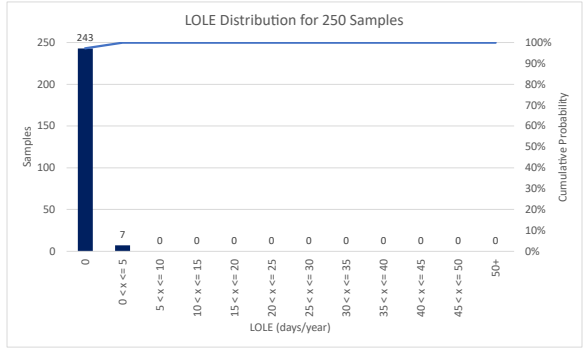
Base_Accel



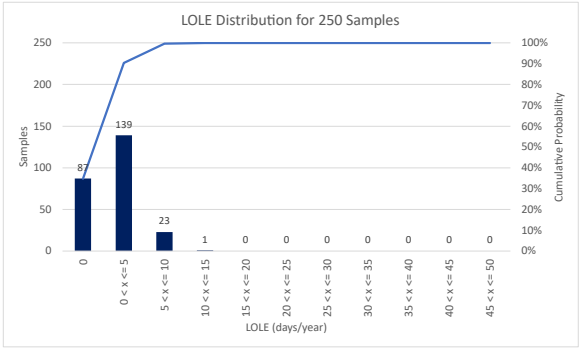
Base_Accel_300



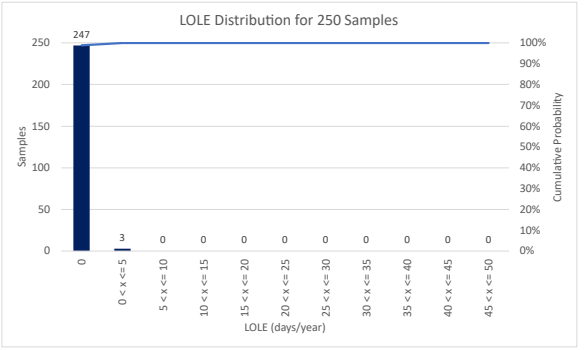
Base_300_Mar22Out



Base_480_Mar22Out



Base_Accel_Mar22Out



Base_Accel_300_Mar22Out

Results – Loss of Load Events

Base_300 = 300 MW = 6x50 MW SCCT
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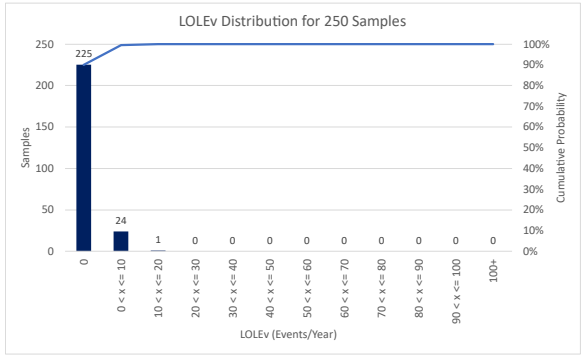
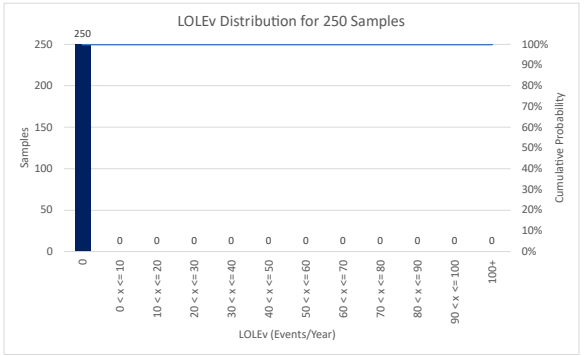
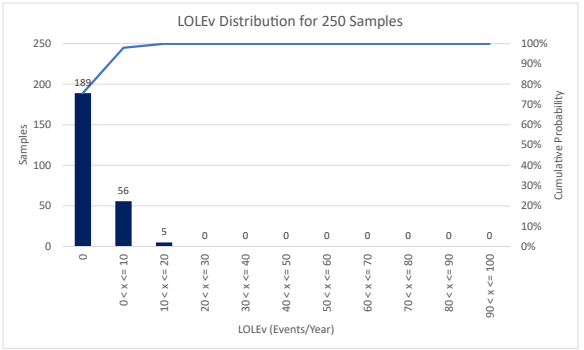


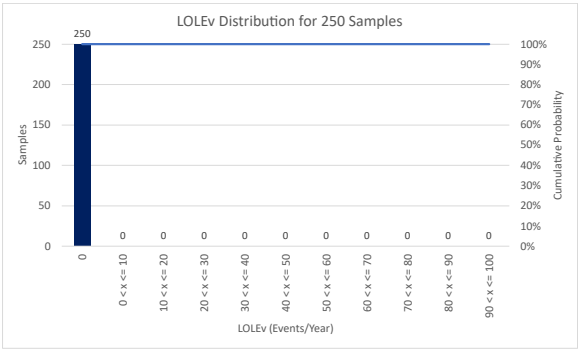
Base_300



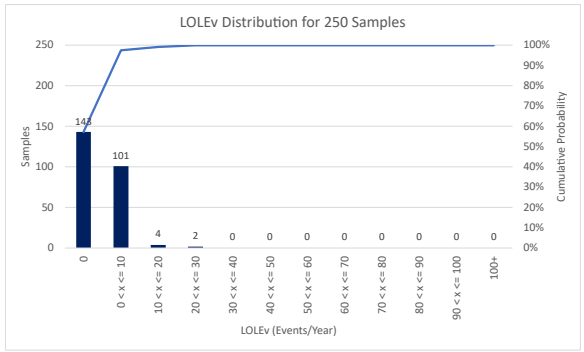
Base_480



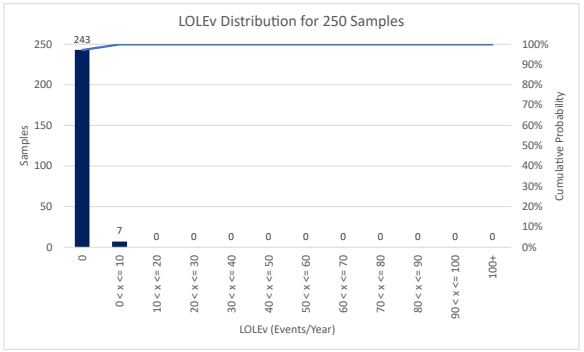
Base_Accel



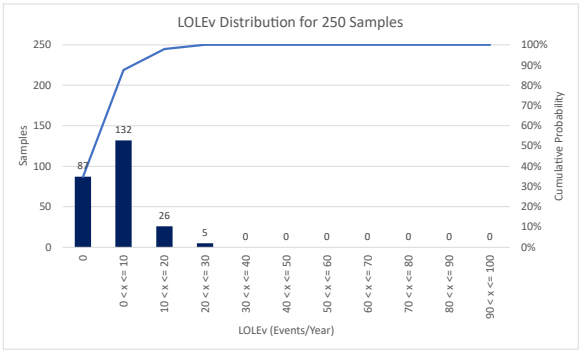
Base_Accel_300



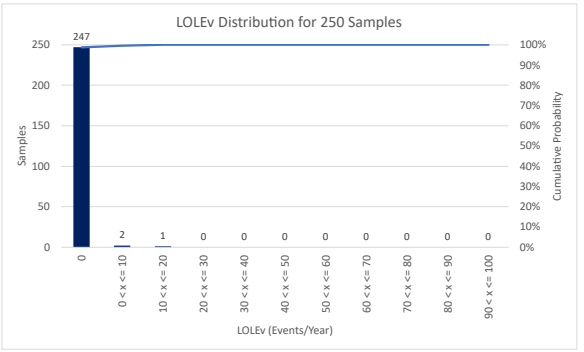
Base_300_Mar22Out



Base_480_Mar22Out



Base_Accel_Mar22Out



Base_Accel_300_Mar22Out

Results – Loss of Load Hours

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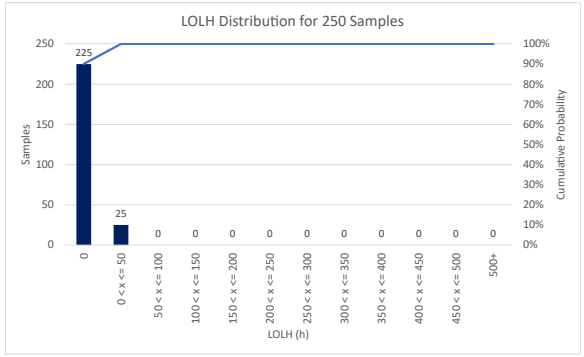
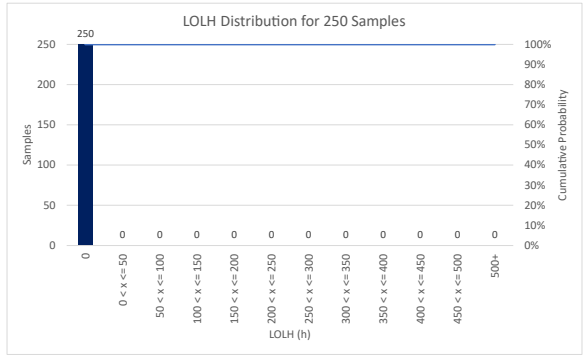
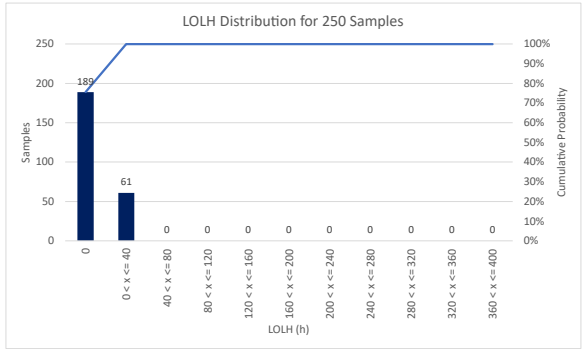


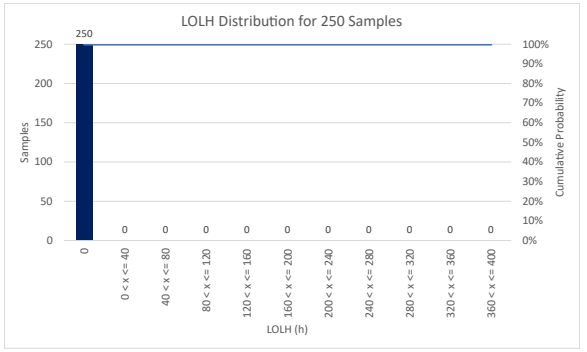
Base_300



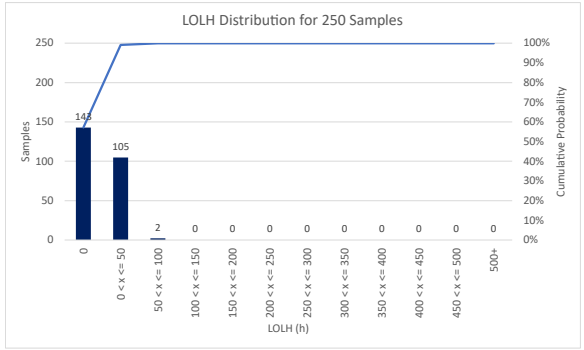
Base_480



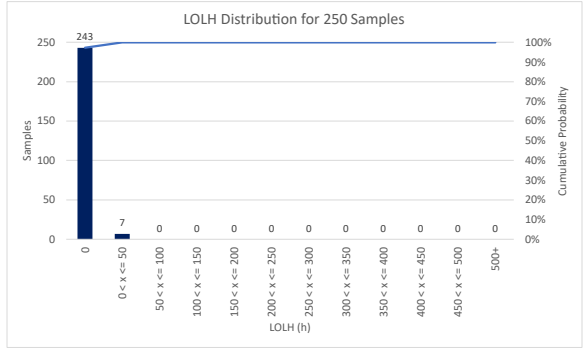
Base_Accel



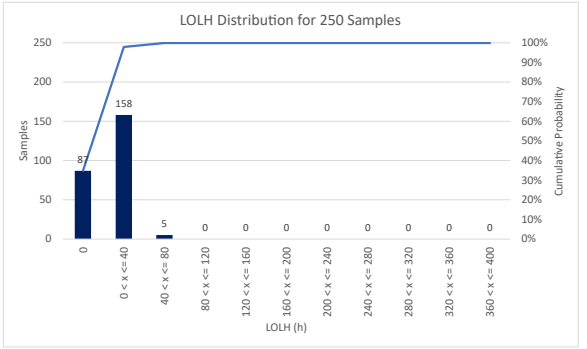
Base_Accel_300



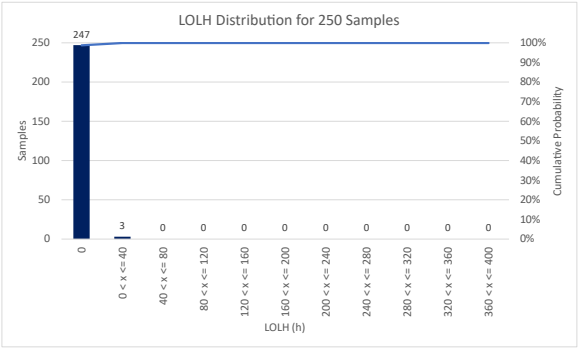
Base_300_Mar22Out



Base_480_Mar22Out



Base_Accel_Mar22Out



Base_Accel_300_Mar22Out

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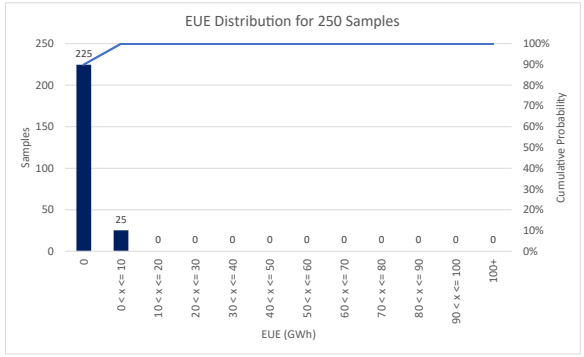
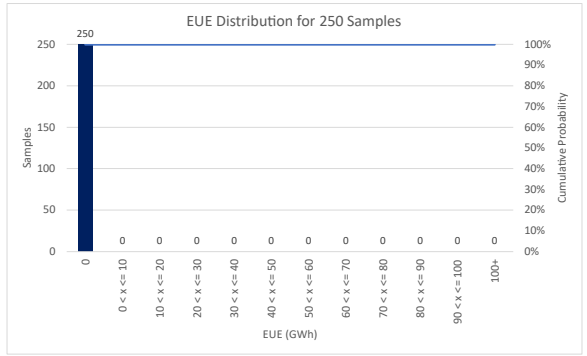
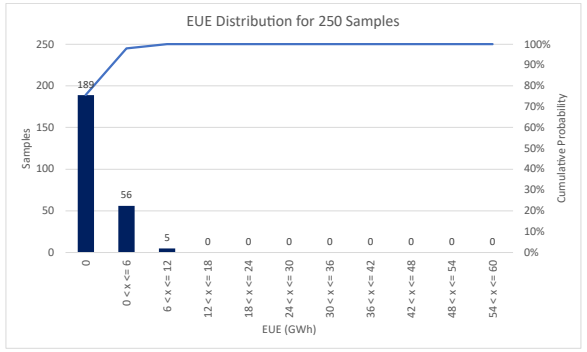


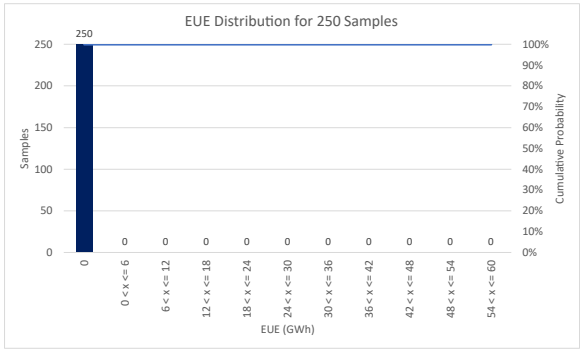
Base_300



Base_480



Base_Accel



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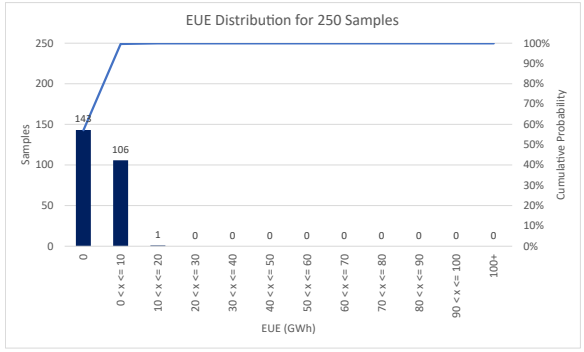
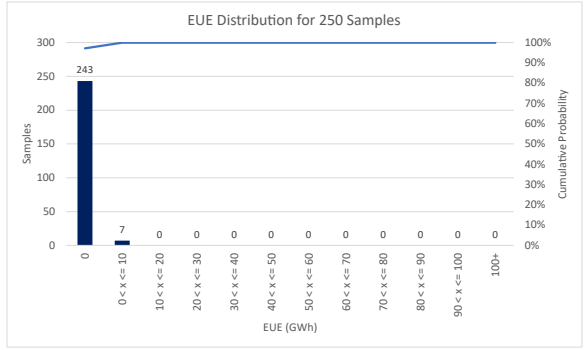


Base_300_Mar22Out



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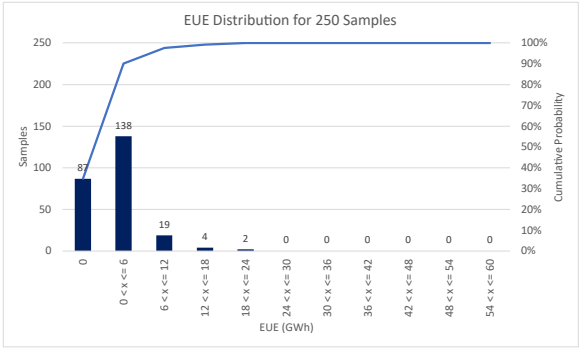
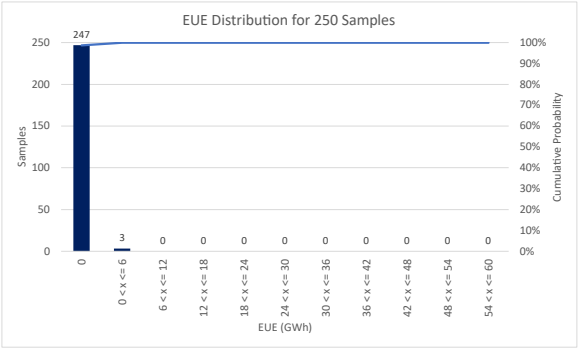


Base_Accel_Mar22Out



Base_Accel_300_Mar22Out

Thermal HDC Test

Weighted Equivalent Availability Factor

Current

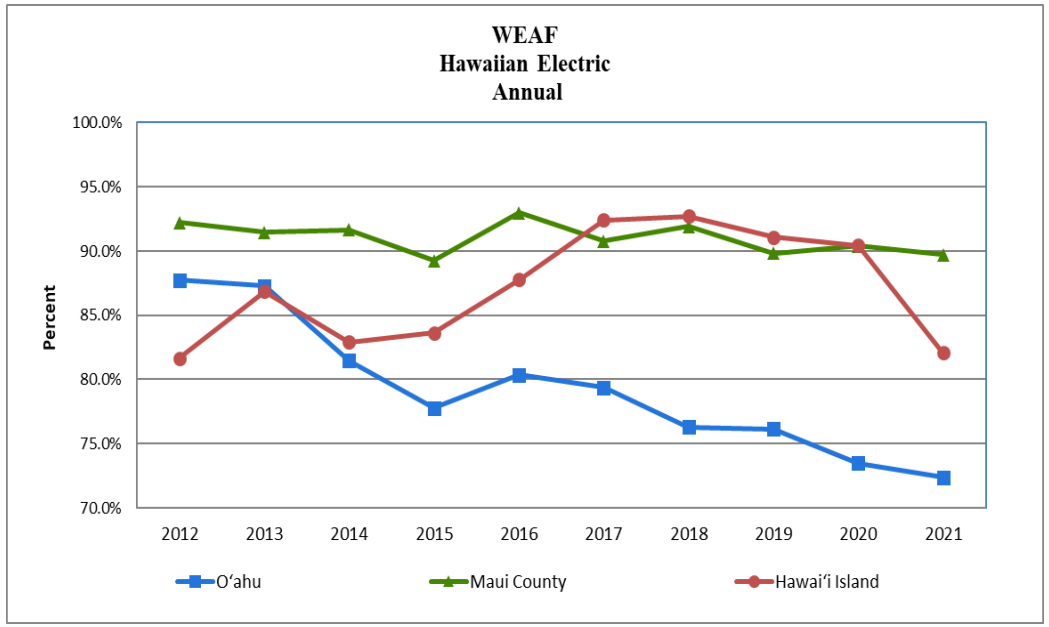
- Existing/New firm generation HDC = 1

Sensitivity Tested

Current	Sensitivity Tested
Existing firm generation HDC = 100%	Oahu existing firm HDC = 72.37% Maui County existing firm HDC = 89.72% Hawaii Island existing firm HDC = 82.08%
New firm generation HDC = 100%	New firm generation HDC = 97.4%

Where:

- Weighted Equivalent Availability Factor (WEAF) – Percentage of time a fleet of generating units is available to generate electricity
  - Weighted for size of generators – larger generators have greater influence on WEAF
  - Includes planned and unplanned outages
- New firm generation HDC based on assumption of 1.3% FOR and 1.3% MOR



https://www.hawaiianelectric.com/about-us/performance-scorecards-and-metrics/power-supply-and-generation

Thermal HDC Test

- Base_wKPLPMahi
  - Original Base case including KPLP and Mahi
  - Existing firm HDC = 100%, New firm HDC = 100%. ERM Requirement = 30%
- Base.v2
  - Base case without KPLP and Mahi
  - Existing firm HDC = 100%, New firm HDC = 100%. ERM Requirement = 30%
- Base.v3_30ERM
  - Base.v2 with HDC applied to firm units.
  - Existing firm HDC = 72.37%, New firm HDC = 97.4%. ERM Requirement = 30%
- Base.v3_20ERM
  - Base.v2 with HDC applied to firm units.
  - Existing firm HDC = 72.37%, New firm HDC = 97.4%. ERM Requirement = 20%
- Base.v3_10ERM
  - Base.v2 with HDC applied to firm units.
  - Existing firm HDC = 72.37%, New firm HDC = 97.4%. ERM Requirement = 10%
- Base.v3_0ERM
  - Base.v2 with HDC applied to firm units.
  - Existing firm HDC = 72.37%, New firm HDC = 97.4%. ERM Requirement = 0%
- Land Constrained
  - Base case without Future Onshore Wind Potential, with 270MW Limit on Paired PV
  - Firm HDC = 100%. ERM Requirement = 30%
- LC.v3_10ERM
  - Land Constrained without KPLP and Mahi, with HDC applied to firm units.
  - Existing firm HDC = 72.37%, New firm HDC = 97.4%. ERM Requirement = 10%

Thermal HDC Test

Base_wKPLPMahi = Original plan with KPLP/Mahi with 100% firm HDC with 30% ERM
Base.v2 = Base without KPLP/Mahi
Base.v3_#ERM = Base without KPLP/Mahi, with firm HDC, with #% ERM

	RESOLVE Resource Plan							
	Base_wKPLP Mahi	**Base.v2**	**Base.v3_30ERM**	**Base.v3_20ERM**	**Base.v3_10ERM**	**Base.v3_0ERM**	**Land Constrained**	**LC.v3_10ERM**
Existing firm HDC (%)	100	100	72.37	72.37	72.37	72.37	100	72.37
New firm HDC (%)	100	100	97.4	97.4	97.4	97.4	100	97.4
ERM Requirement (%)	30	30	30	20	10	0	30	10
Year 2030								
New Firm (selected by RESOLVE)	35	264	521	408	300	213	39	342
Existing Firm	1,175	967	967	967	967	967	967	967
Standalone PV	0	0	0	0	0	0	0	0
Paired PV	1,577	1,640	1,401	1,556	1,594	1,741	270	270
Onshore Wind	163	163	163	163	163	163	0	0
Offshore Wind	0	0	0	0	0	0	0	0
Standalone Storage (MW/MWH)	379 MW / 712 MWh	66 MW / 124 MWh	67 MW / 127 MWh	64 MW / 122 MWh	61 MW / 115 MWh	75 MW / 140 MWh	321 MW / 600 MWh	14 MW / 26 MWh
Paired Storage (MW/MWH)	1,577 MW / 4,461 MWh	1640 MW / 5,100 MWh	1401 MW / 3,639 MWh	1,556 MW / 4,502 MWh	1,594 MW / 4,770 MWh	1,741 MW / 5,613 MWh	270 MW / 270 MWh	270 MW / 270 MWh

Utility Firm Removal/Deactivation: 90MW in 2024, 110 MW in 2027, 170 MW in 2029

Summary of Thermal HDC Tests in RESOLVE

- Multiple sensitivities were tested including:
  - Removing KPLP in 2027.
  - Not Building the Mahi PV Project.
  - Range of ERM's: 30%, 20%, 10%, 0%.
  - Using calculated HDC's for existing and new thermal resources.
- The removal of KPLP and Mahi led to an increase in firm resources being selected.
- When applying HDC's to the firm units, the amount of firm resources selected increased and the amount of variable resources remained relatively flat.
- Decreasing the ERM with firm HDCs decreased the amount of firm resources selected and slightly increased the amount of variable resources selected in the near term (2030).

Discussion

- Is a minimum of 300 MW of new firm generation by 2029 appropriate?
- Based on the probabilistic analysis, does the TAP recommend that more than 300 MW of firm generation be acquired by 2029, as prudent or least regrets, given the following uncertainties and risks:
  - Uncertainties in >15% sloped land development for solar, continued supply chain issues, elevated pricing/inflation, land availability regardless of slope or type of renewable.
  - The risk of continued operation of existing fossil fuel units
  - Diversification and grid resilience enhancement against extreme events.
  - For context, the RESOLVE models select all of Groups 1 and 2 by 2030 as being cost-effective:

RESOLVE REZ Group Capacity (MW)	Slope ≤ 15%	15% > Slope ≤ 30%	Total
Group 1 (1, 2, 7 from REZ Study)	84	426	**510**
Group 2 (3, 4, 5, 6 from REZ Study)	439	1,235	**1,674**
Group 3 (8 from REZ Study)	435	725	**1,160**
Total by Slope	**958**	**2,386**	**3,344**

Next Steps

- Calculate the 2030 LOLE for the Base.v3_10ERM and LC.v3_10ERM case.
- Present preliminary results from Maui's probabilistic tests.

2022-04 TAP Slides

Hawaiian Electric

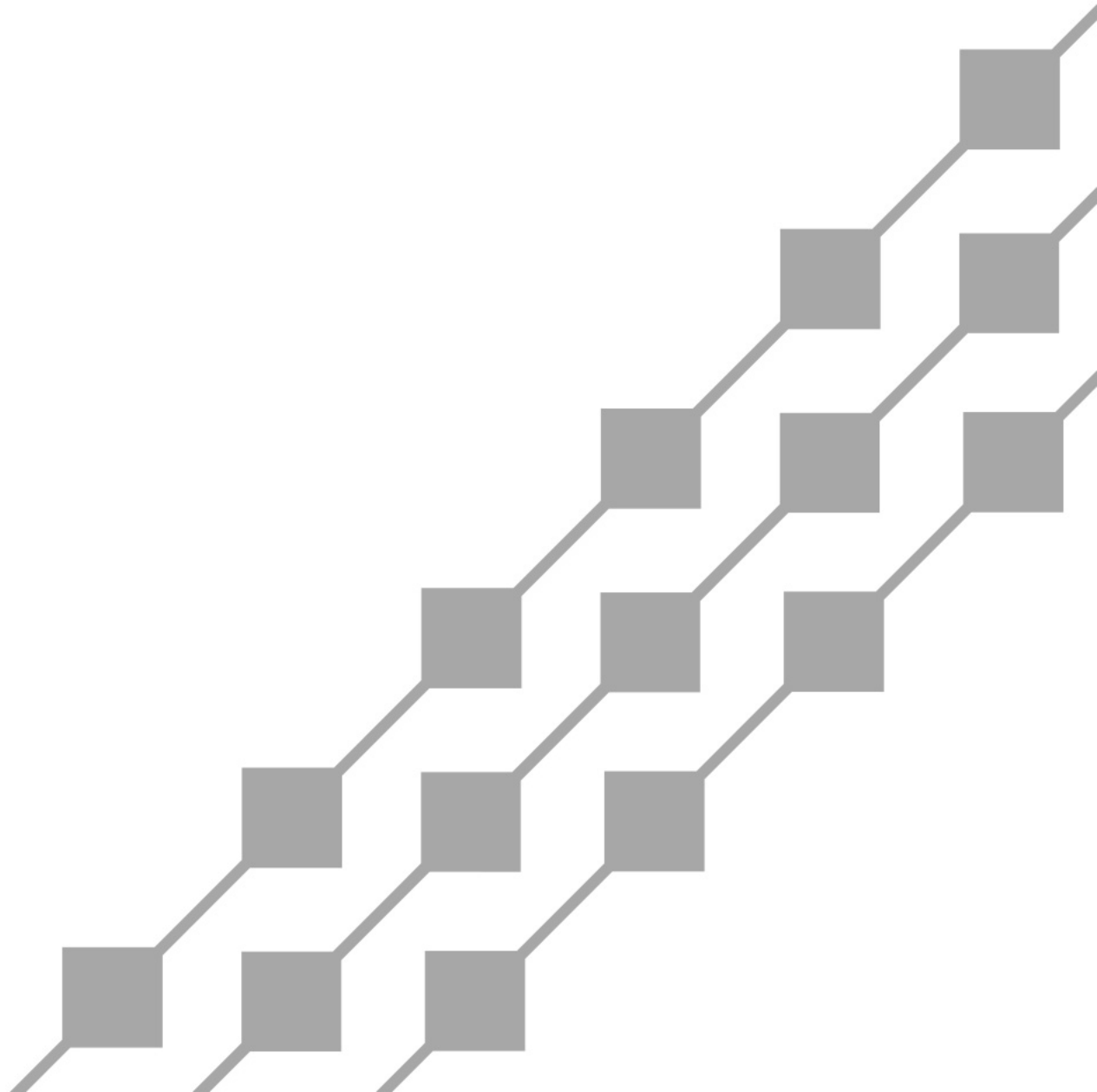
IGP Technical Advisory Panel

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

Test Case Result Summary

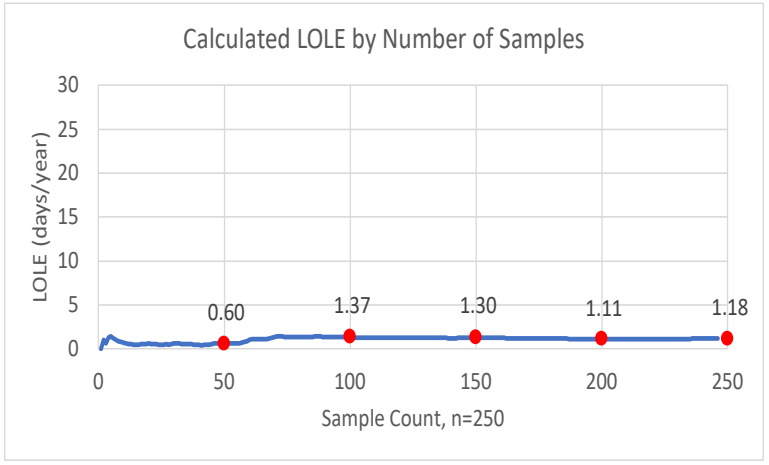
Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass

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

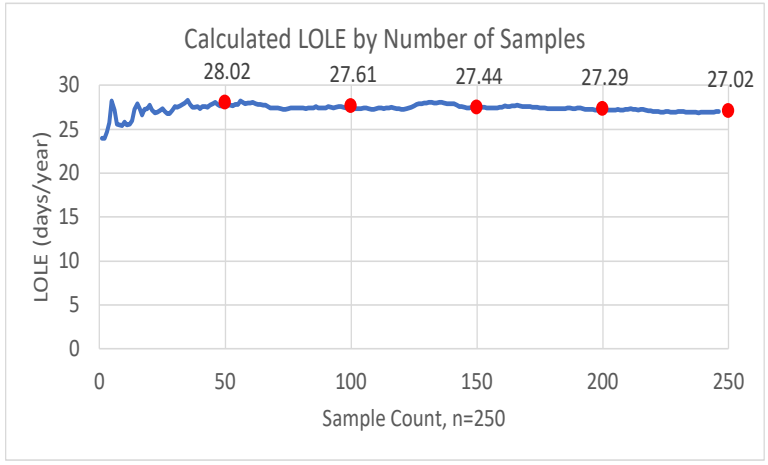
- All Base scenarios and Existing (2029) modeled in year 2029.
- Existing (2021) scenario modeled in year 2021.

Results – Loss of Load Expectation

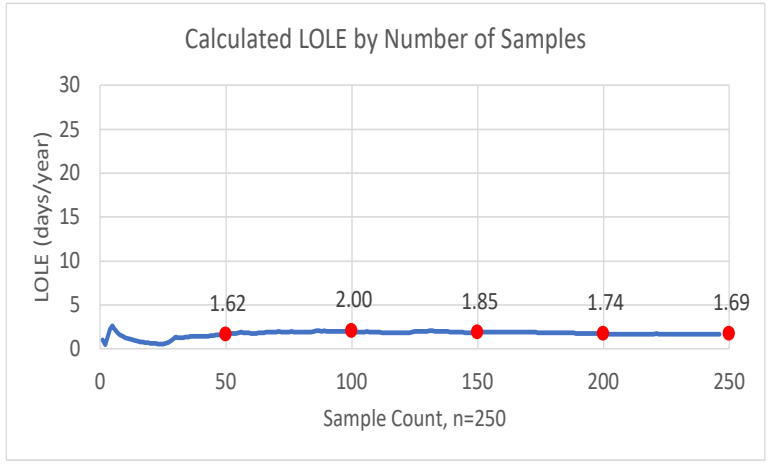
Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



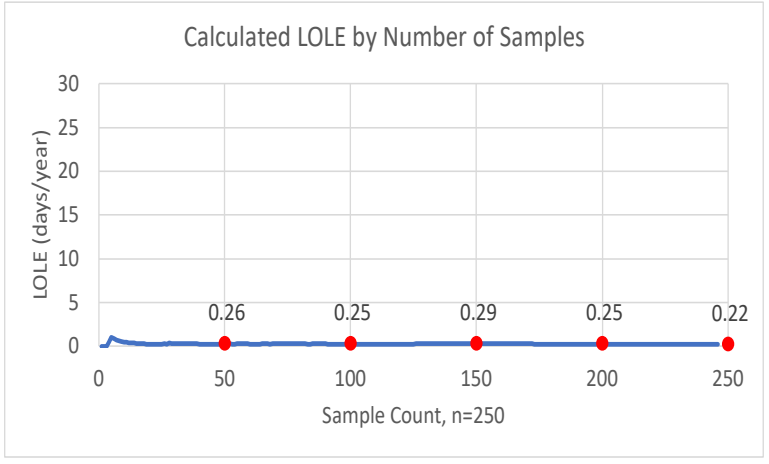
Existing



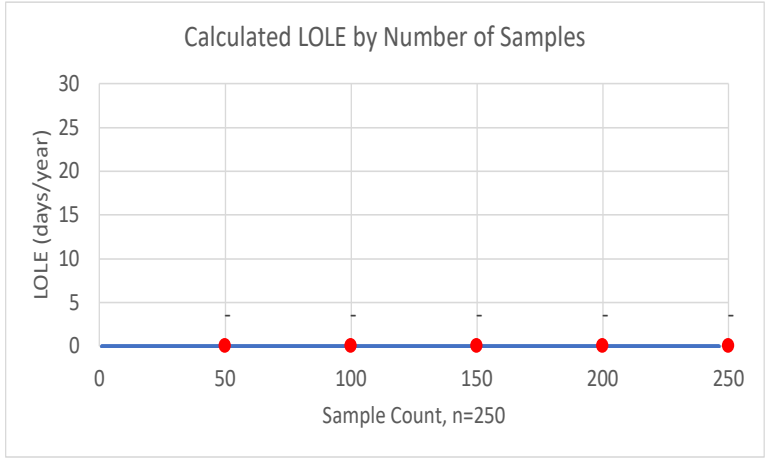
Base



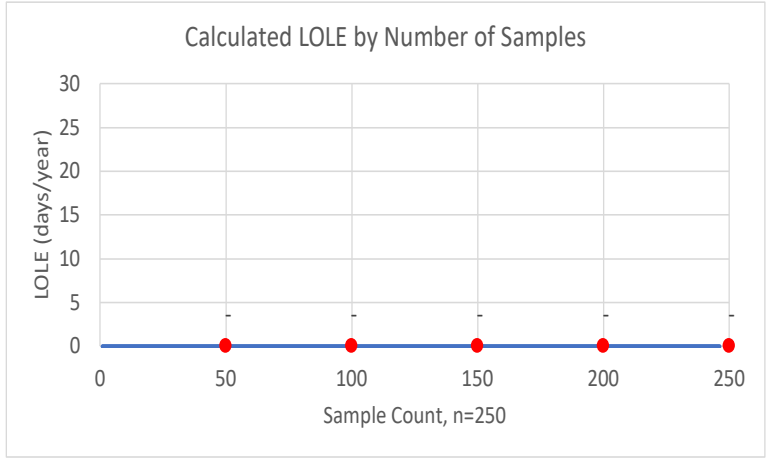
Base_200



Base_300



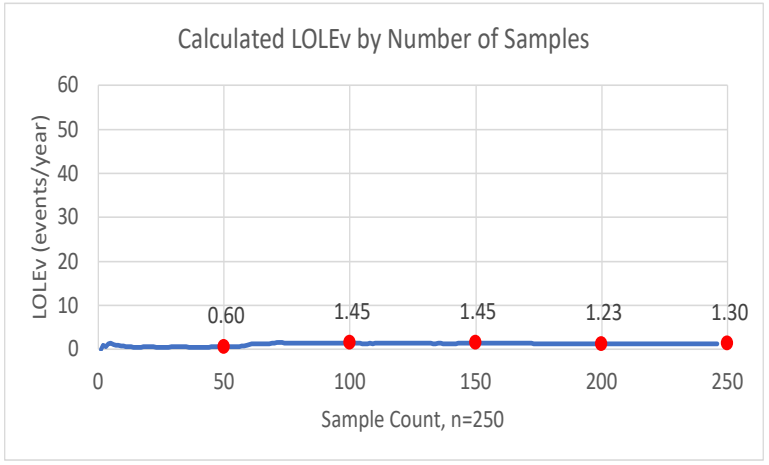
Base_399



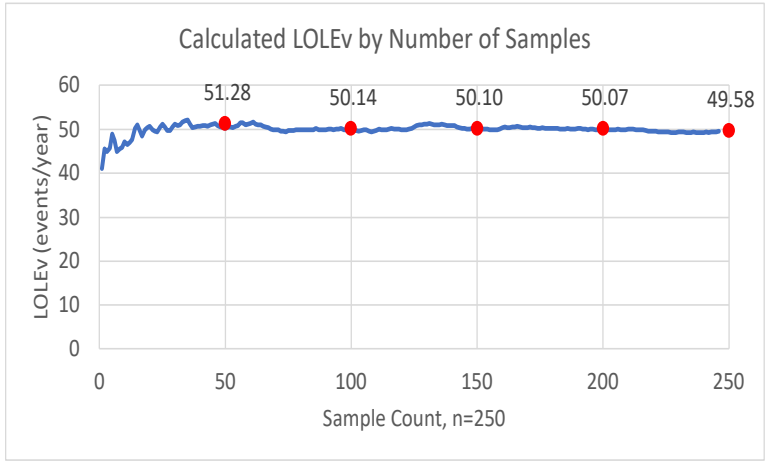
Base_480

Results – Loss of Load Events

Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



Existing



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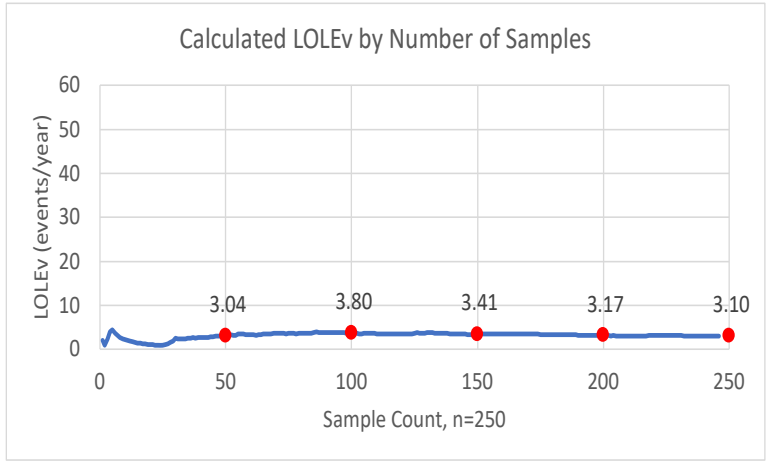
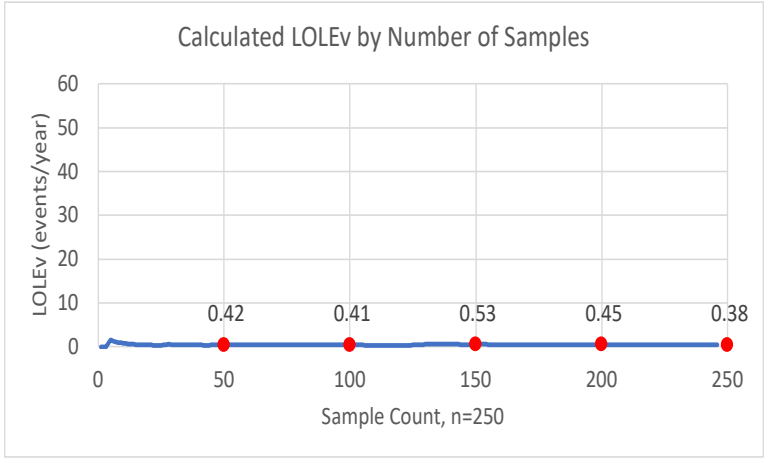
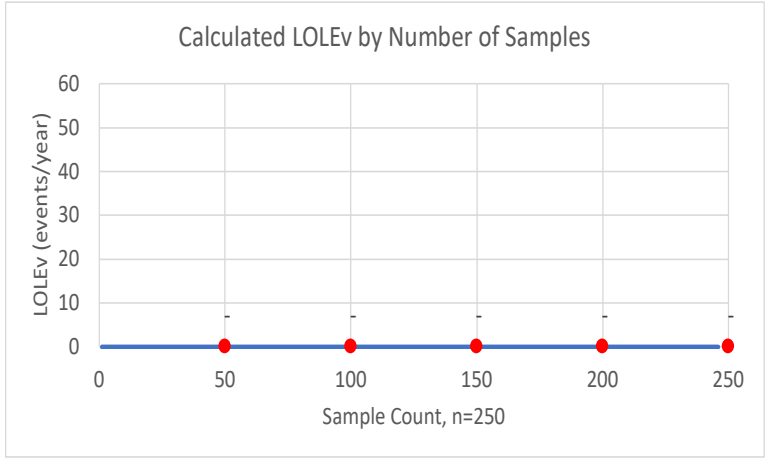


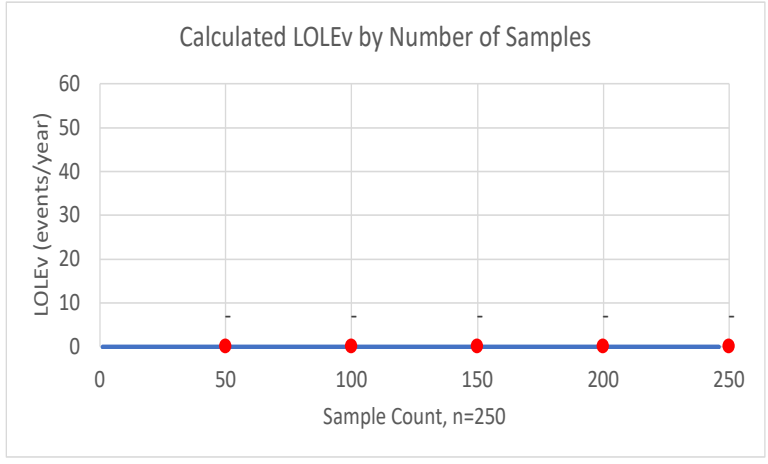
Base_200



Base_300



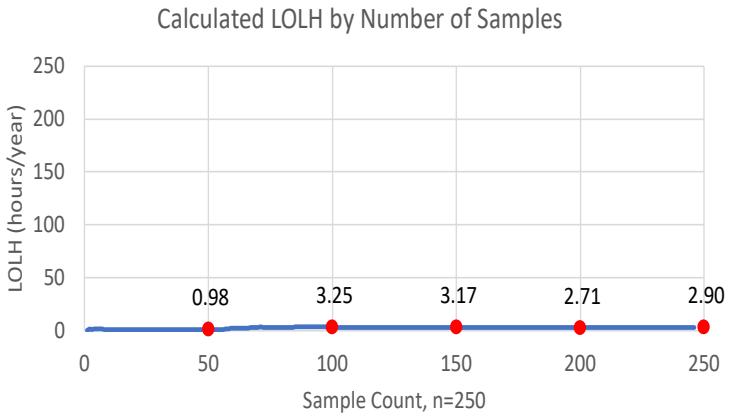
Base_399



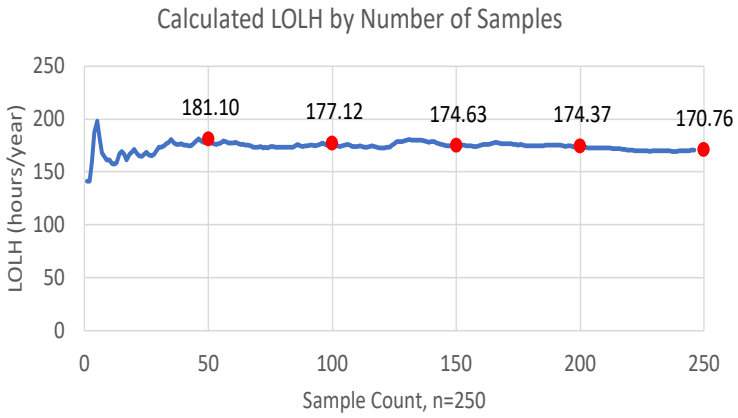
Base_480

Results – Loss of Load Hours

Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



Existing



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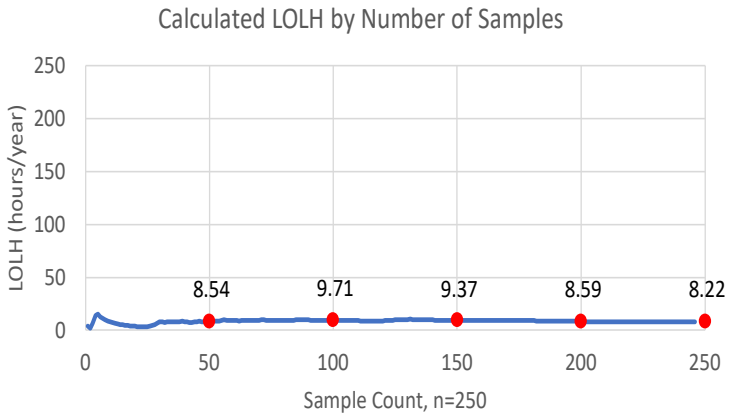
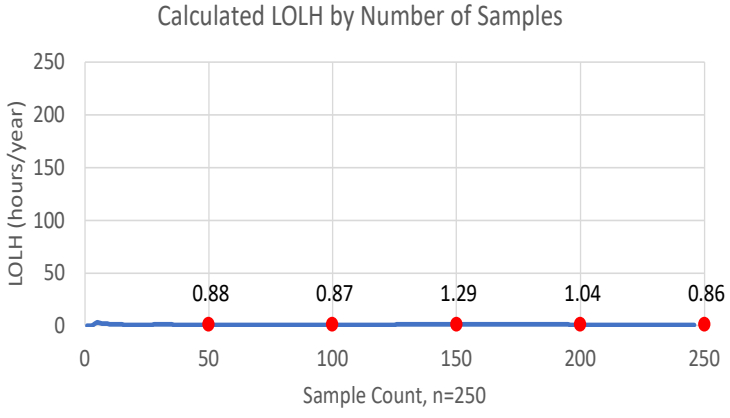
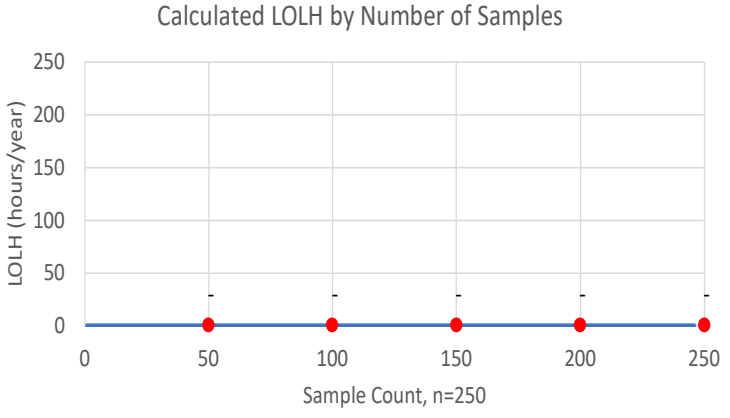


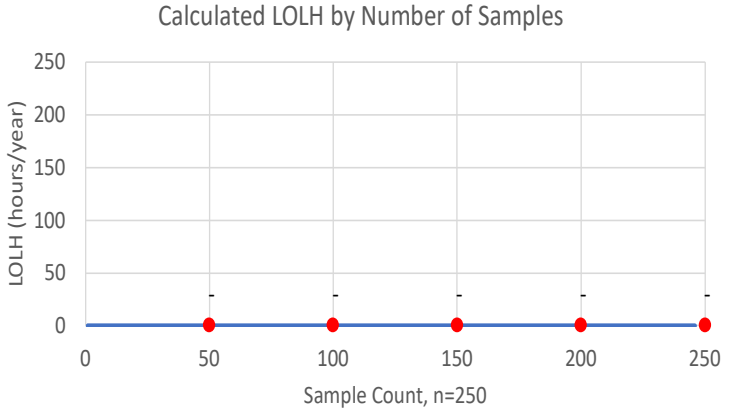
Base_200



Base_300



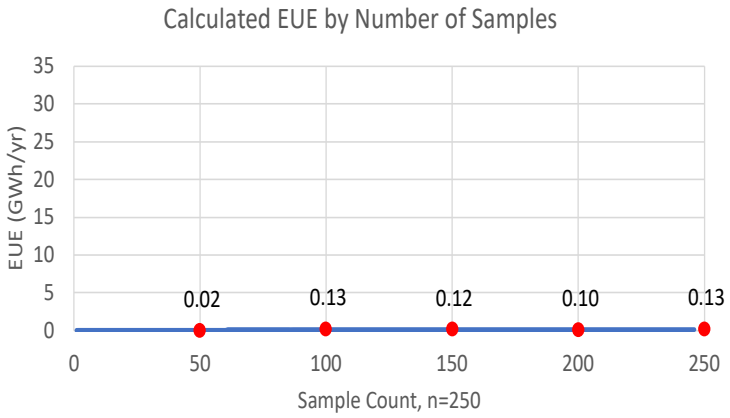
Base_ 399



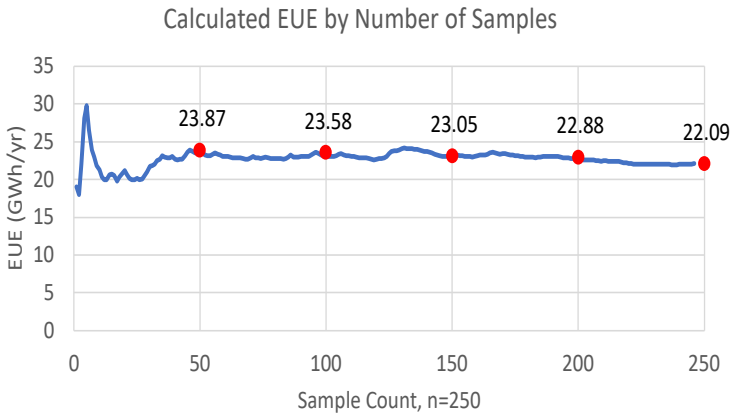
Base_480

Results – Estimated Unserved Energy

Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



Existing



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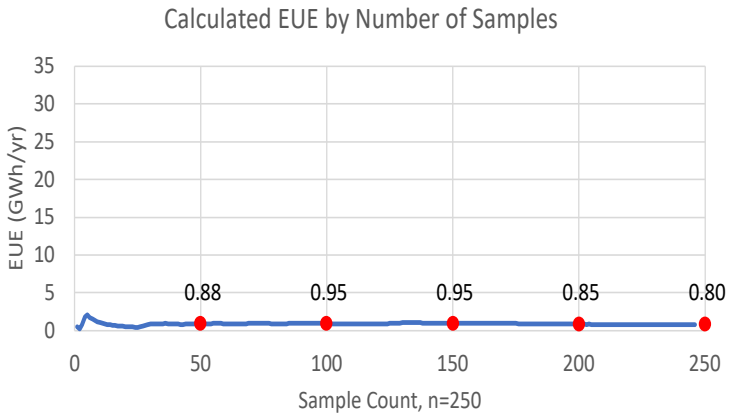
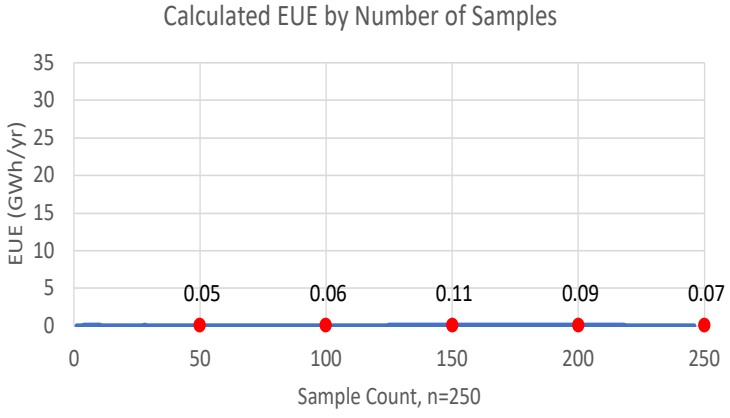


Base_200



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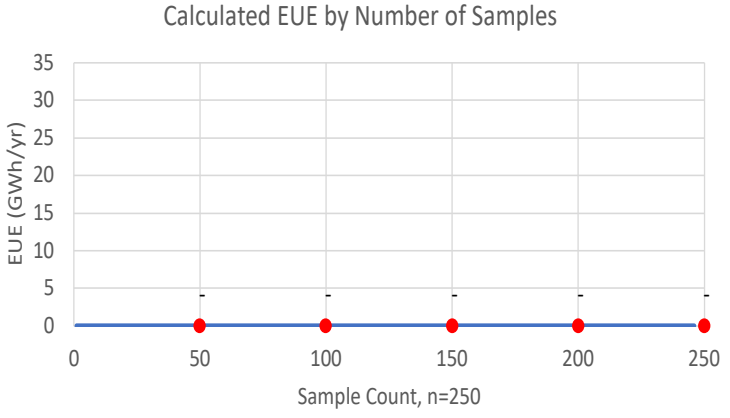
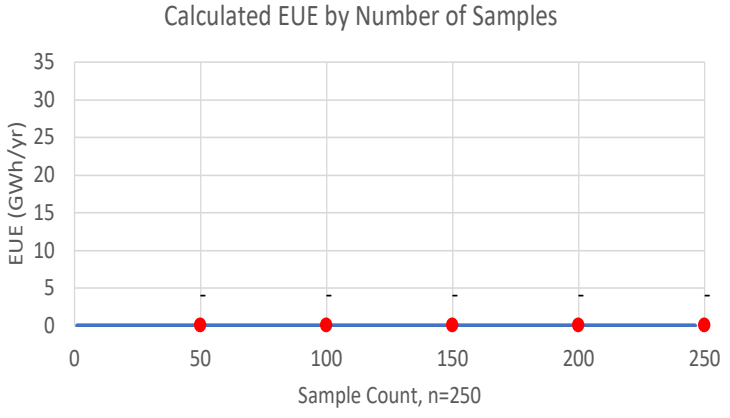


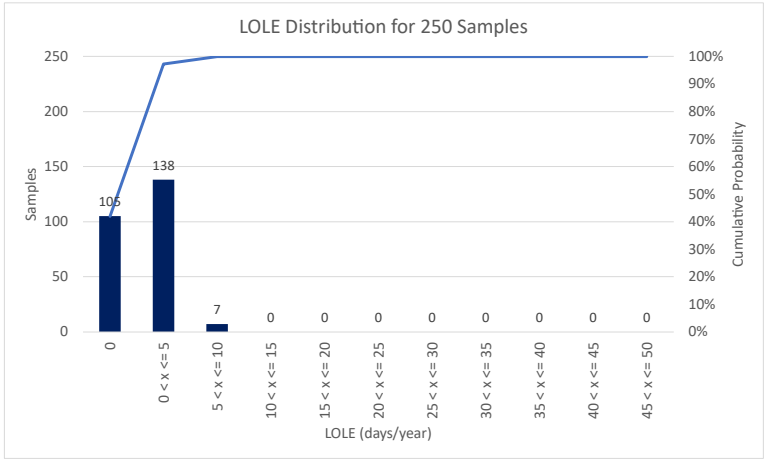
Base_ 399



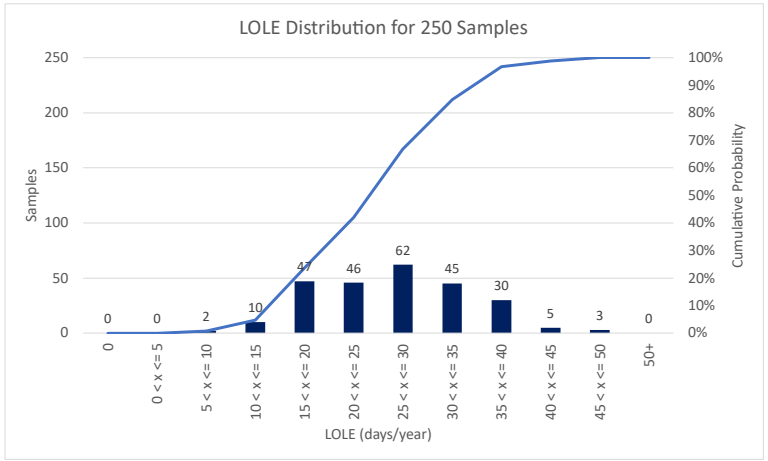
Base_480

Results – Loss of Load Expectation

Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



Existing



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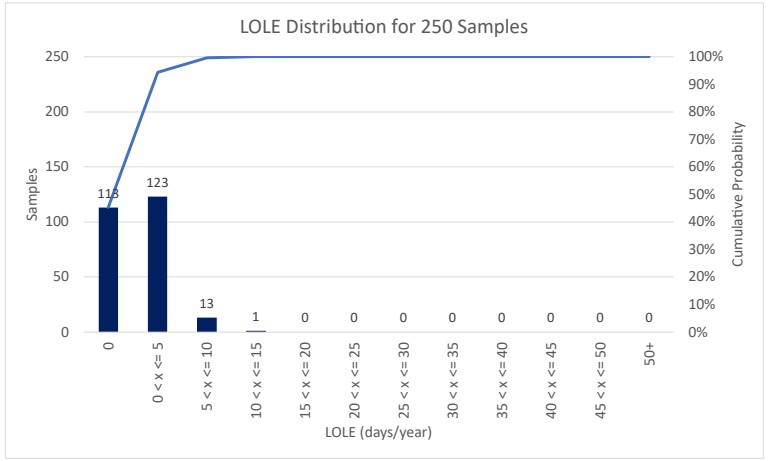
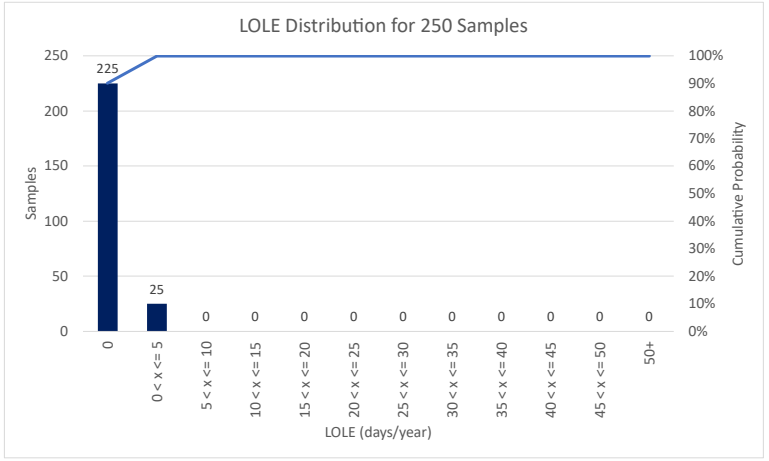
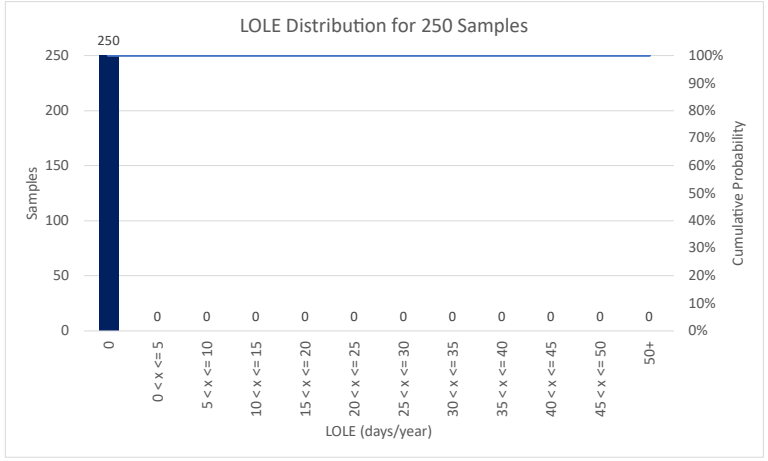


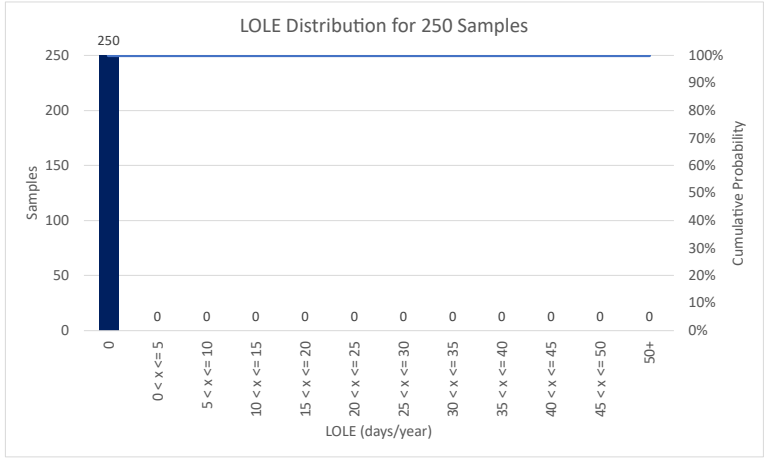
Base_200



Base_300



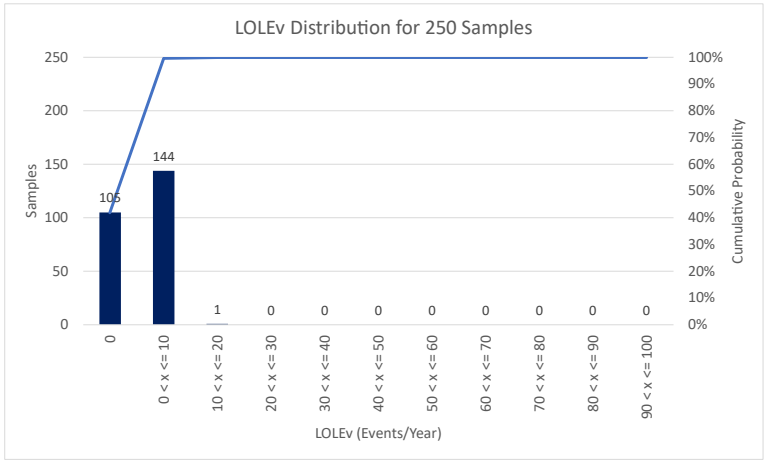
Base_399



Base_480

Results – Loss of Load Events

Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



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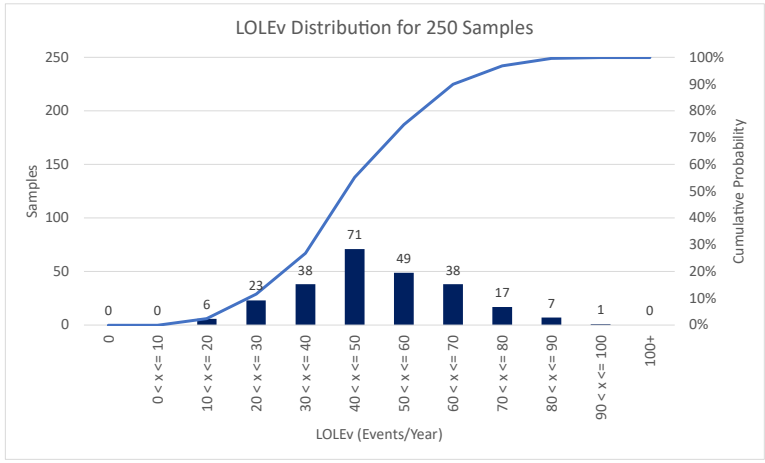
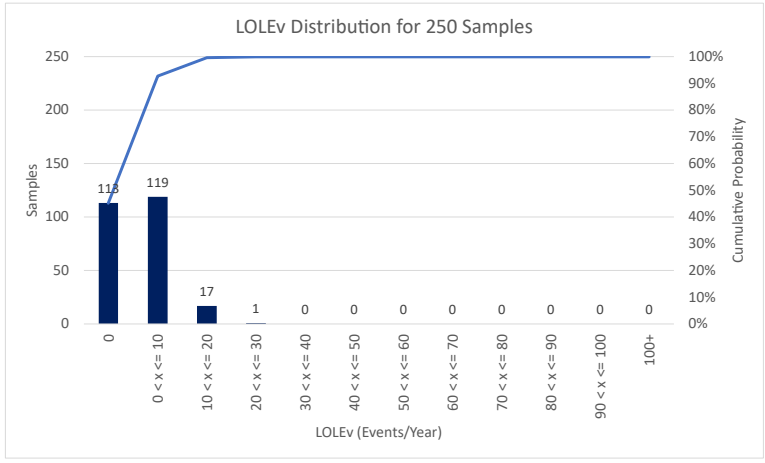
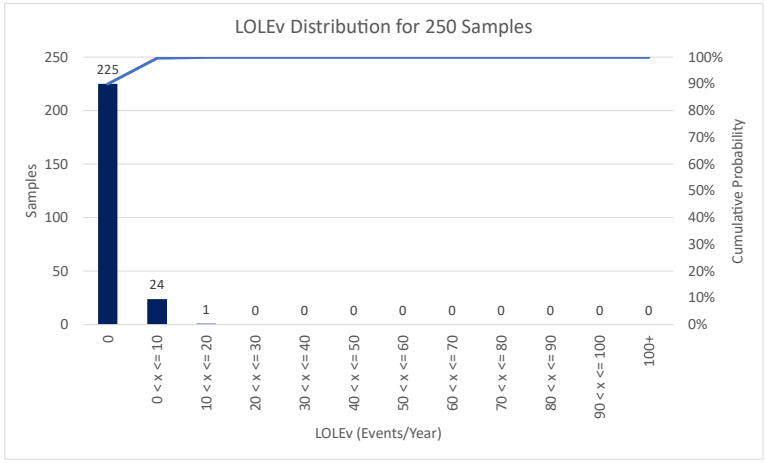


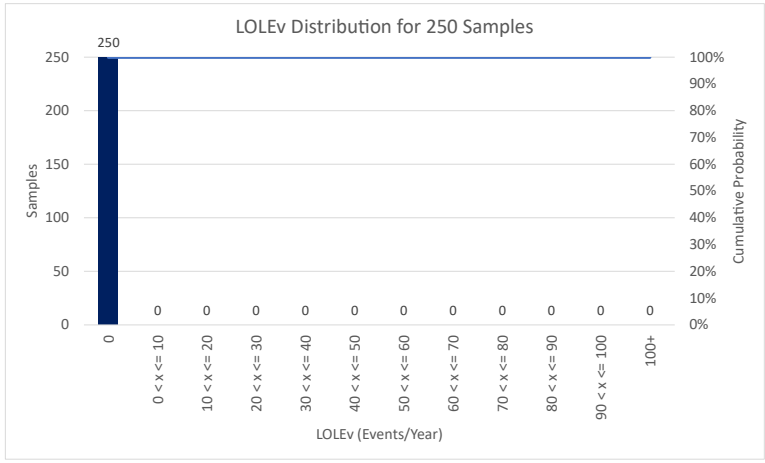
Base



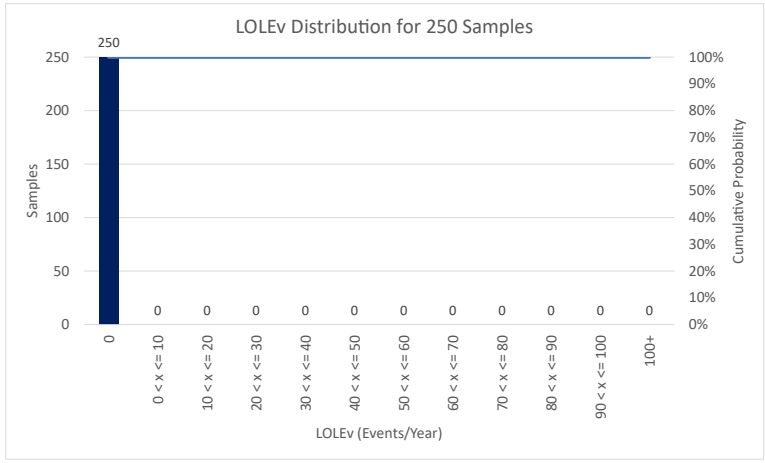
Base_200



Base_300



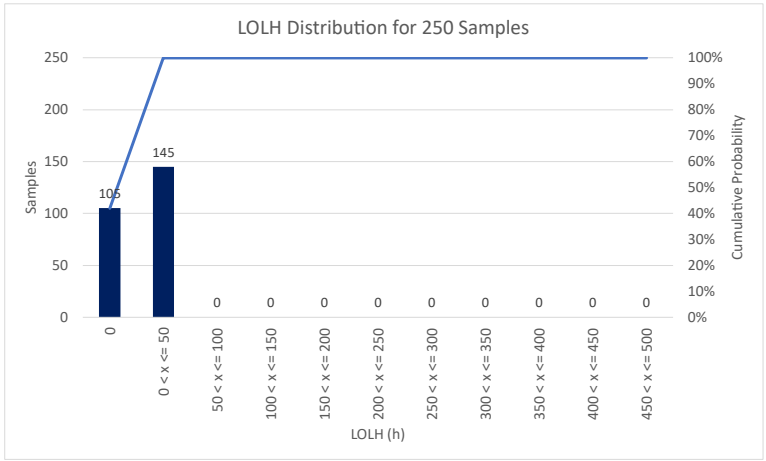
Base_399



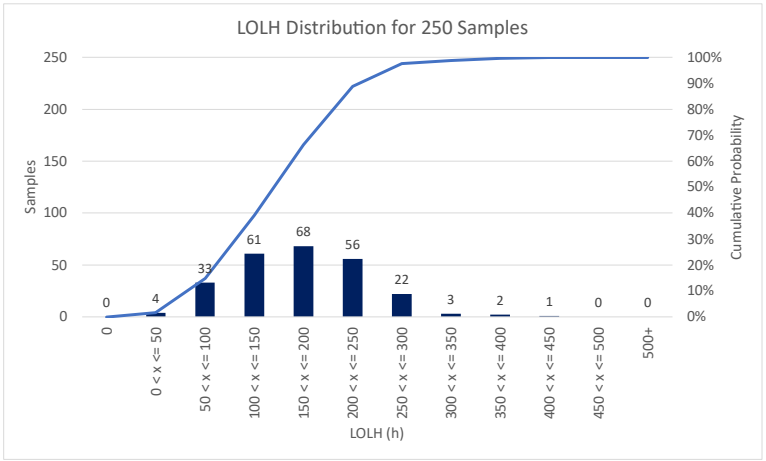
Base_480

Results – Loss of Load Hours

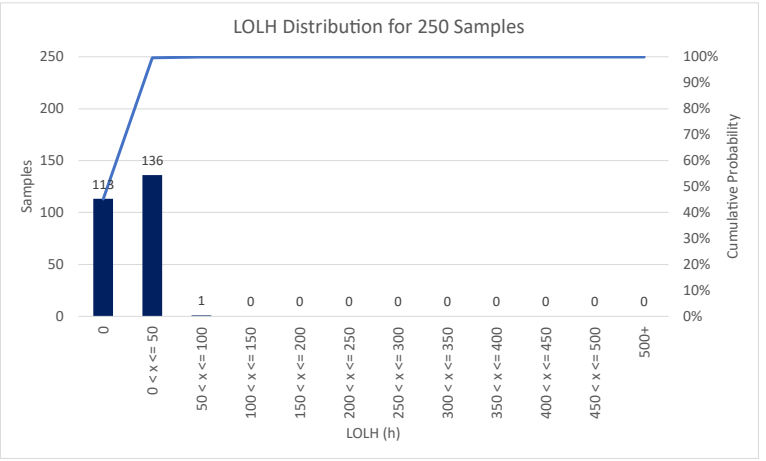
Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



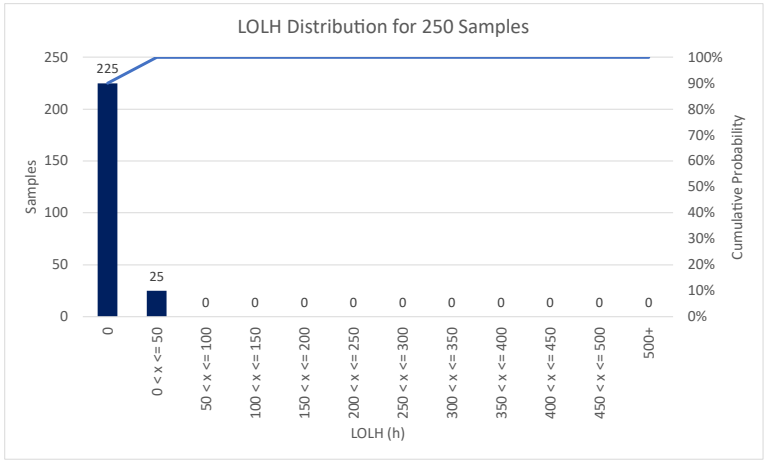
Existing



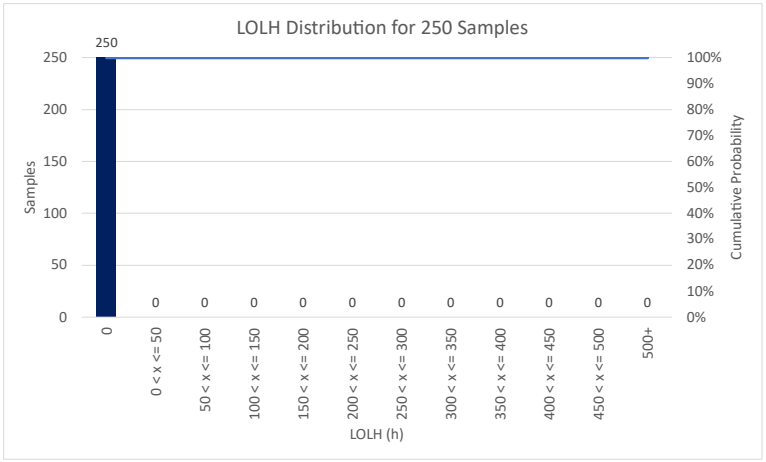
Base



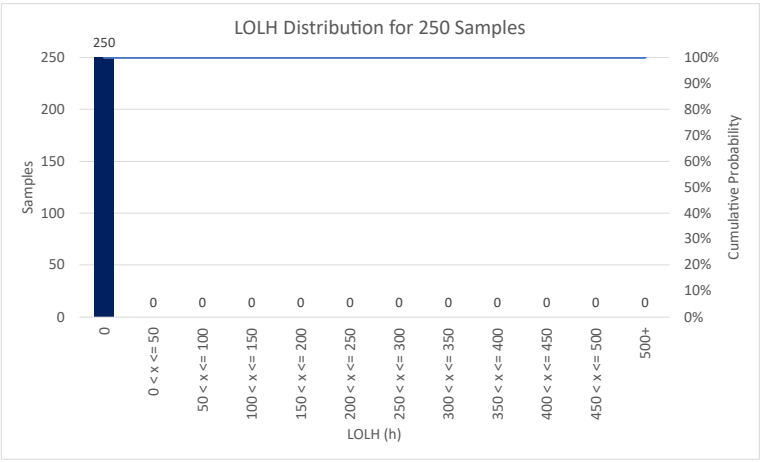
Base_200



Base_300



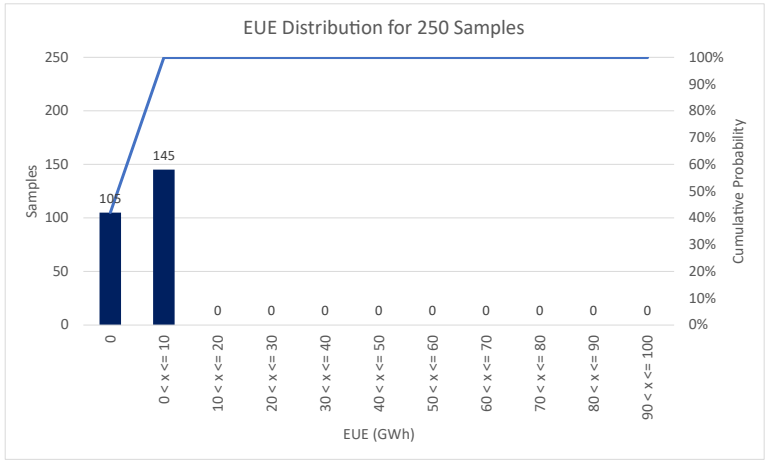
Base_399



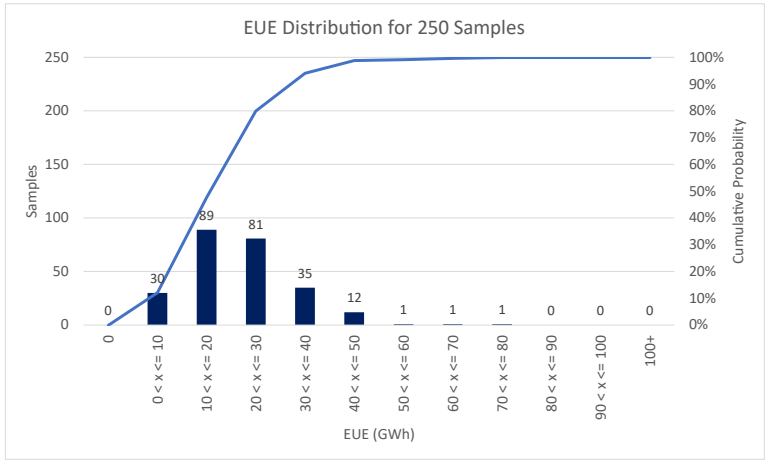
Base_480

Results – Estimated Unserved Energy

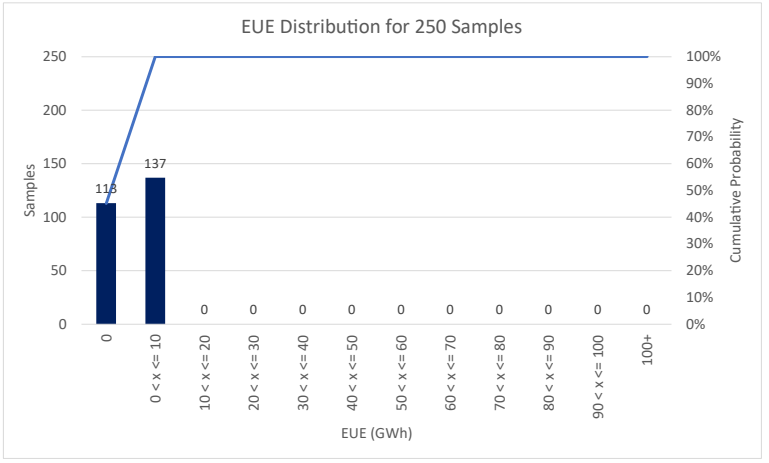
Base_200 = 200 MW = 4x50 MW SCCT
Base_300 = 300 MW = 6x50 MW SCCT
Base_399 = 399 MW = 6x50 MW SCCT, 11x9 MW ICE
Base_480 = 480 MW = 6x50 MW SCCT, 9x20 MW Biomass



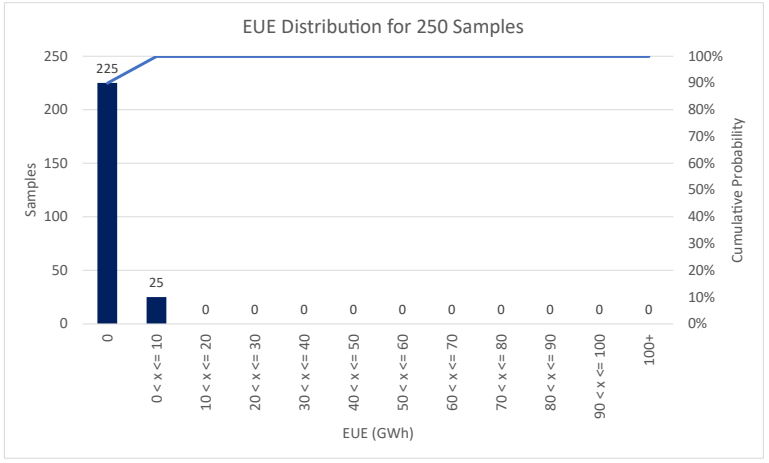
Existing



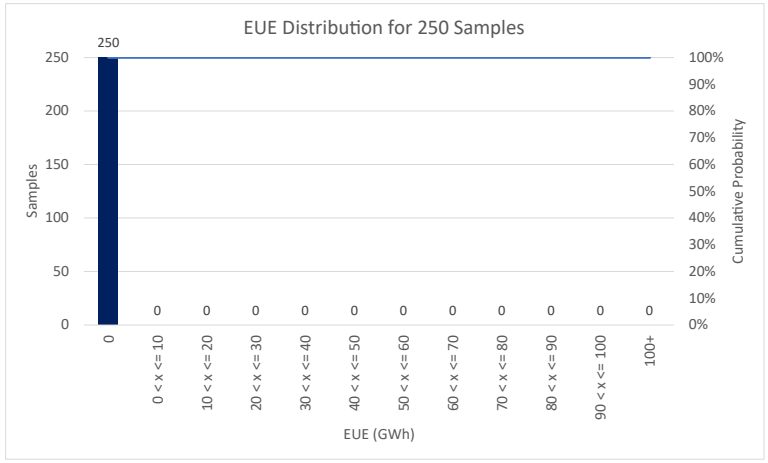
Base



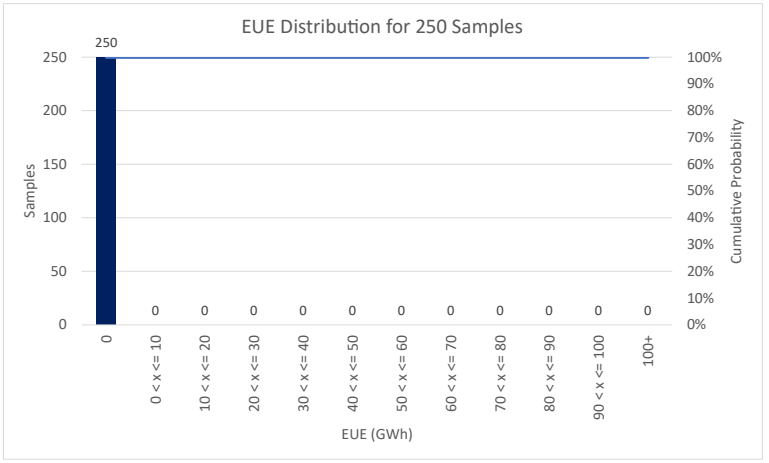
Base_200



Base_300



Base_399

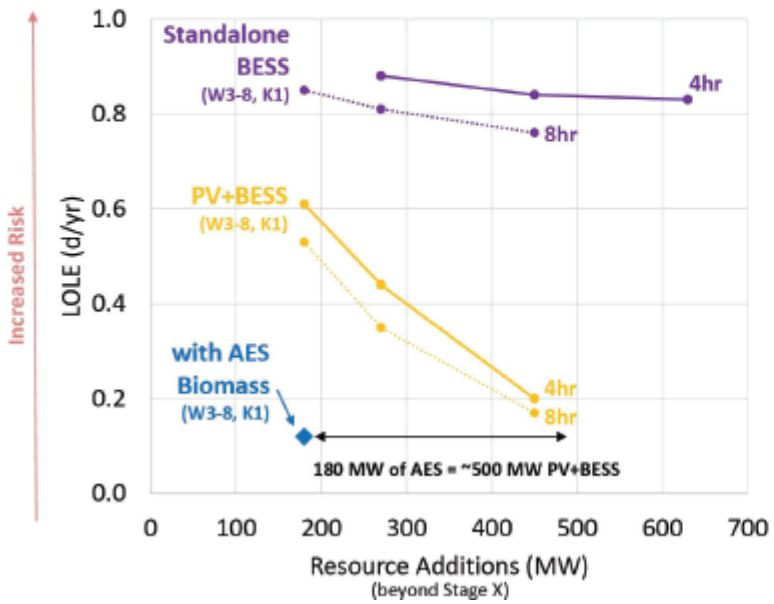


Base_480

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

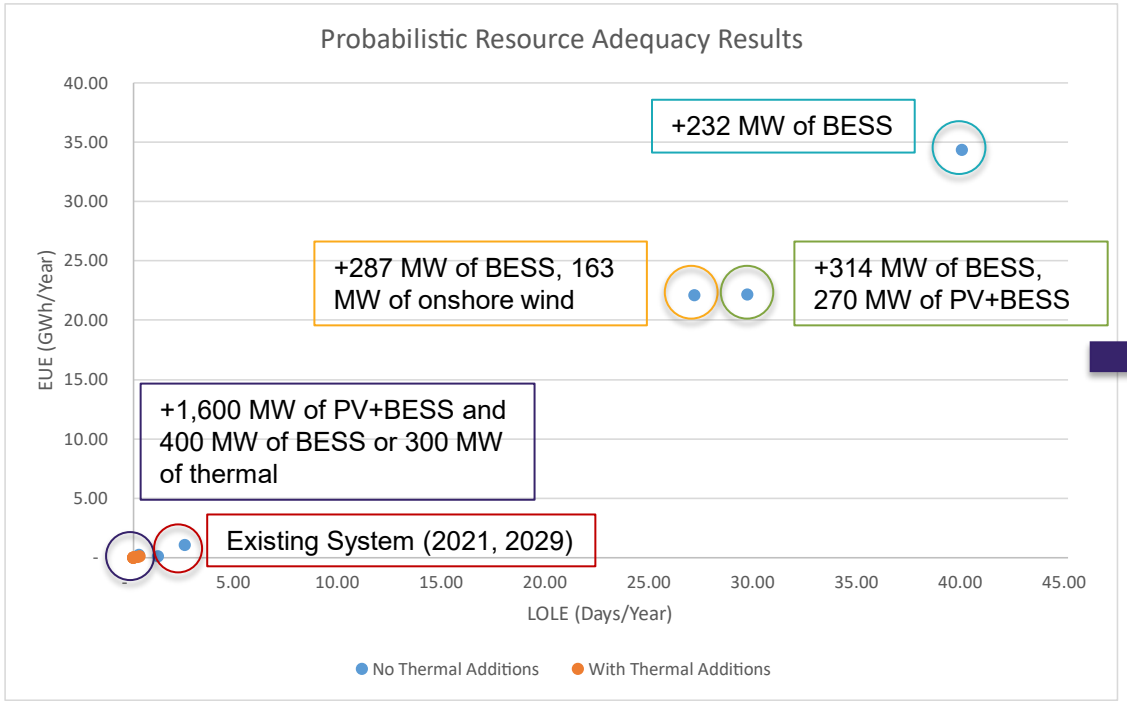
	HE	HNEI
Thermal Generation Removed (MW)	-180 (AES) -208 (KPLP) -371 (HECO) -759	-180 (AES) -454 (HECO) -634
Thermal Generation Added (MW)	+300	+180 / +0
Net Thermal Generation Removed (MW)	-459	-454 / -634
Variable Renewable Added (MW)	+185 (PV+BESS) +163 (Onshore Wind) +348	+400 / +900 (PV+BESS)
LOLE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

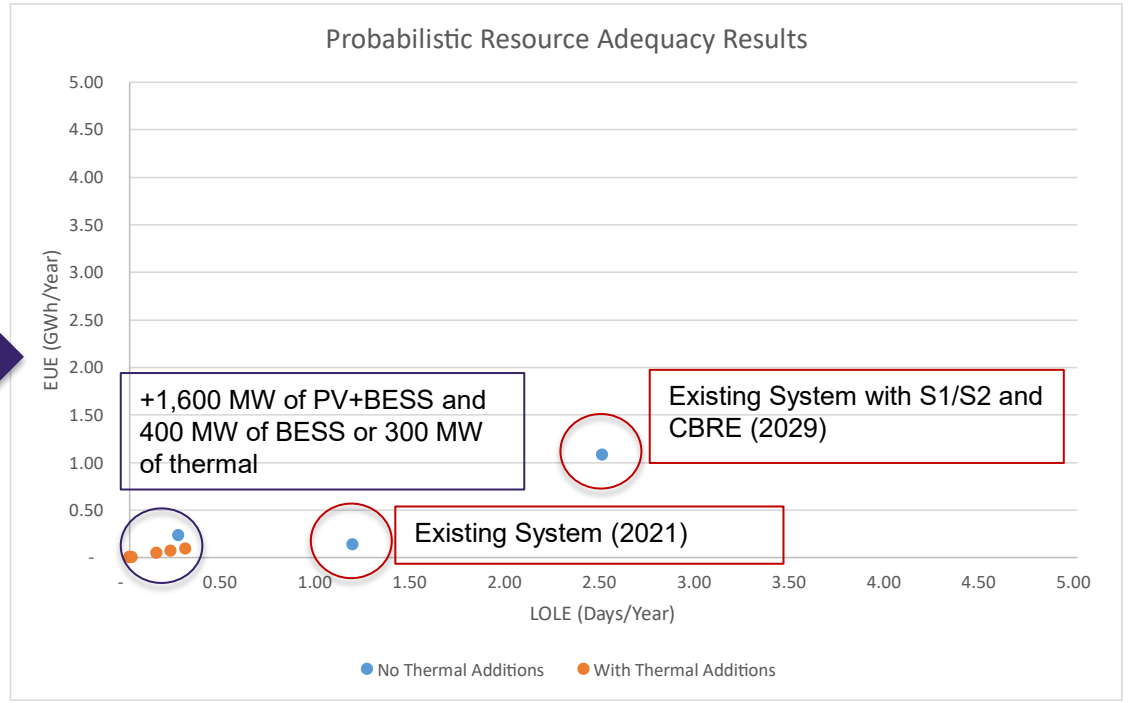
Similar net removals of thermal generation (~450 MW) and additions of variable renewables (350-400 MW) result in similar levels of LOLE.

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.

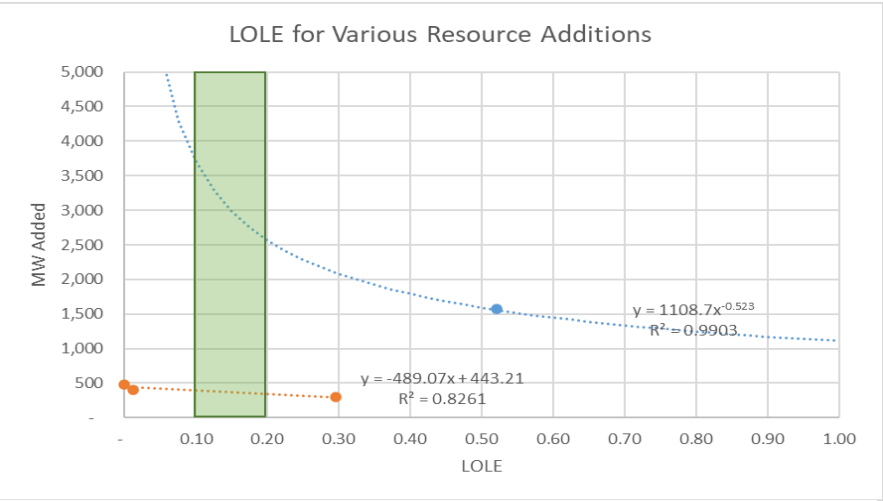
Addition of Variable Renewables and Thermal Resources Can ~~Improve Reliability~~

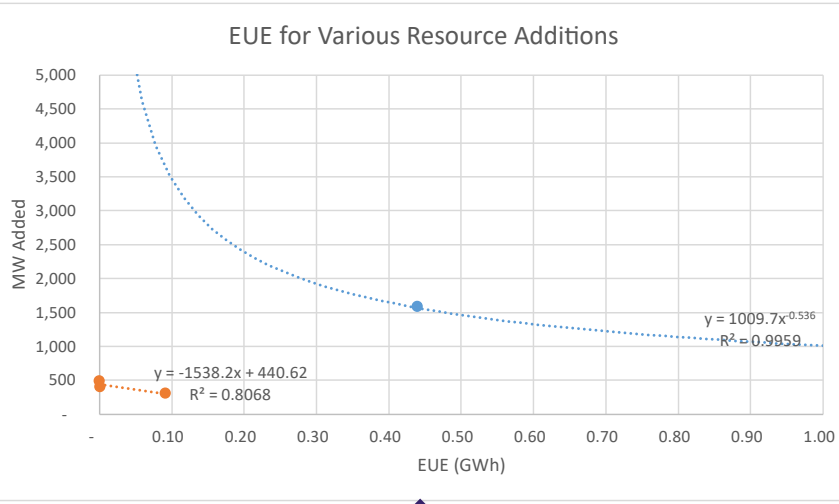


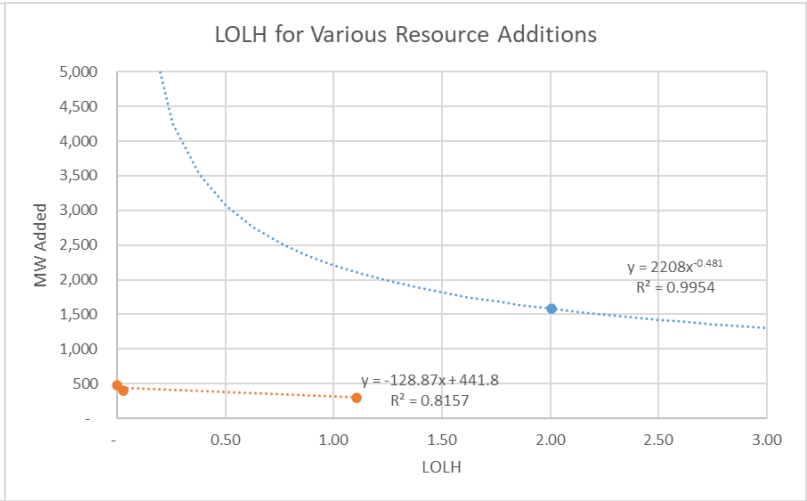


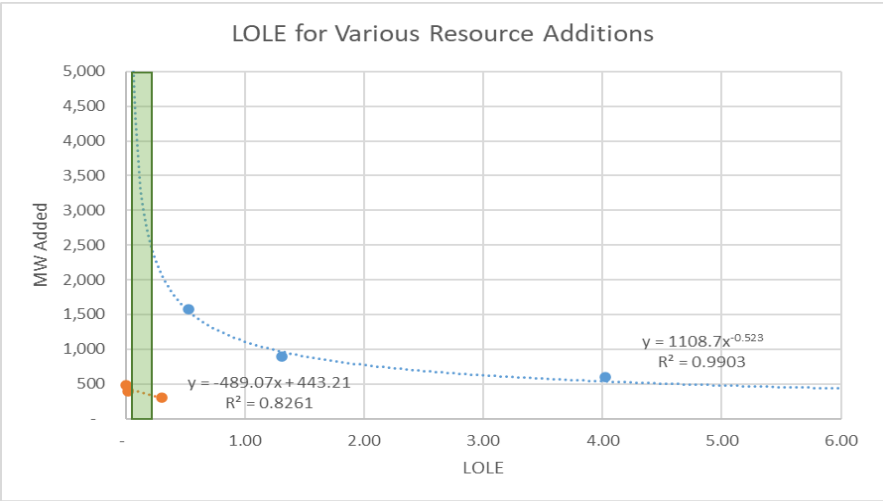
- Clustering of probabilistic simulation results shows that similar levels of EUE and LOLE can be achieved with additions of either PV+BESS or thermal resources.
  - Approximately 1,600 MW of Paired PV and 400 MW of BESS
  - At least 300 MW of thermal generation

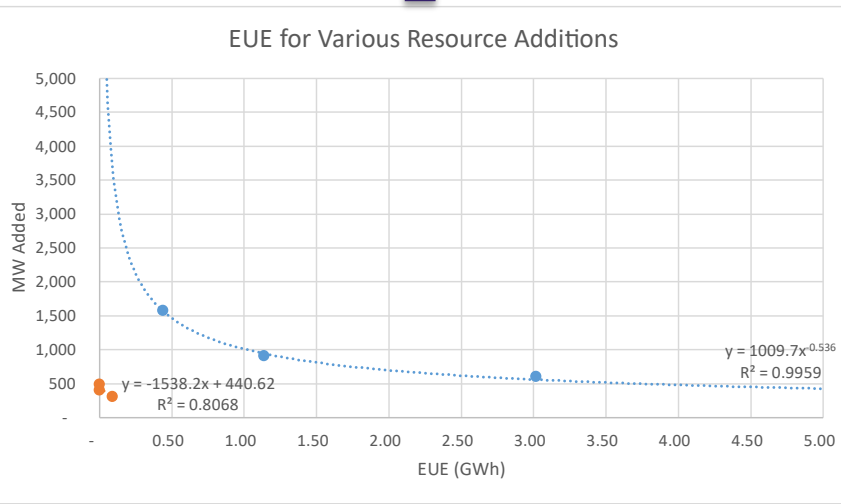
Greater Capacity of Variable Renewables Needed to Achieve Similar ~~Levels of LOLE, EUE, and LOLH~~

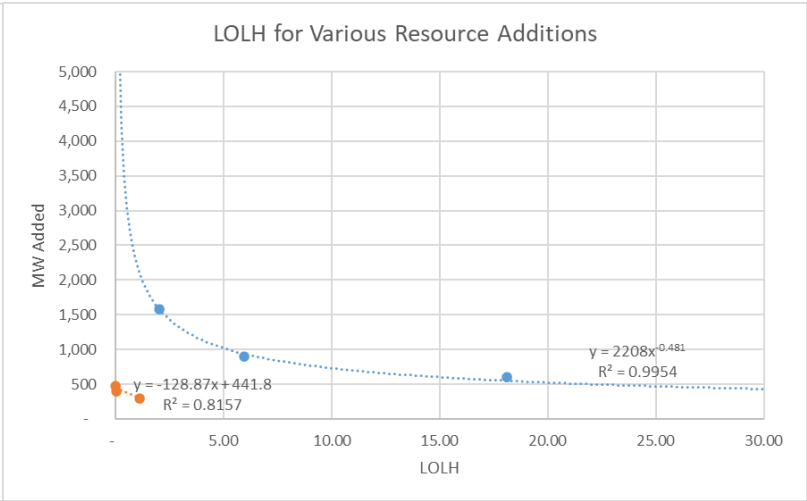












PV+BESS Thermal

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