HNEI Grid Integration

ERM Calibration and Resource Adequacy | October 13, 2021

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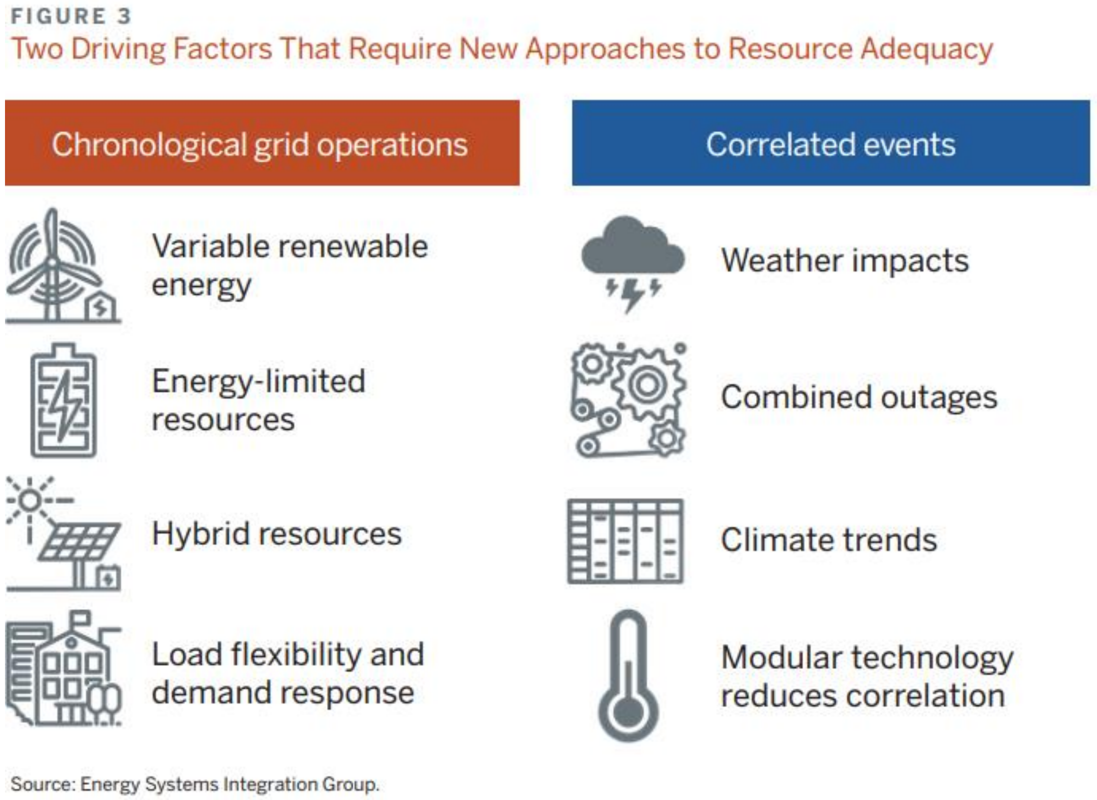
Why does the planning reserve margin need to change?

Traditional capacity expansion planning used a ***planning reserve margin***, that required some amount of surplus capacity above ***peak load*** to cover uncertainty in generator outages and load variability



But…

- Reliability risk is shifting outside of single peak load hour (all hours matter)
- Availability of variable renewable resources fluctuate on an hourly basis
- Correlation among resource availability
- Storage and demand resources have energy limitations

More info: Gord Stephen, "Getting Past Capacity Credits, Better Deterministic Adequacy Analysis via Energy Reserve Margins," NERC Probabilistic Assessment Forum, Oct 6, 2021.

More info: Energy Systems Integration Group, *Redefining Resource Adequacy for Modern Power Systems*, Aug 2021.

Deterministic Analysis (ERM) vs. Probabilistic Analysis

Deterministic Analysis (ERM)

Used directly as an input capacity expansion models (i.e. RESOLVE)

- Reliability screening metric
- Metrics: planning reserve margin (peak load) or energy reserve margin (based on all hours)
- Requires capacity value (accreditation) to count variable renewables (HDC) and energy storage
- Evaluated on a single weather year for wind, solar, and load
- Does not explicitly model forced outages of thermal fleet (this is why the reserve margin is required)

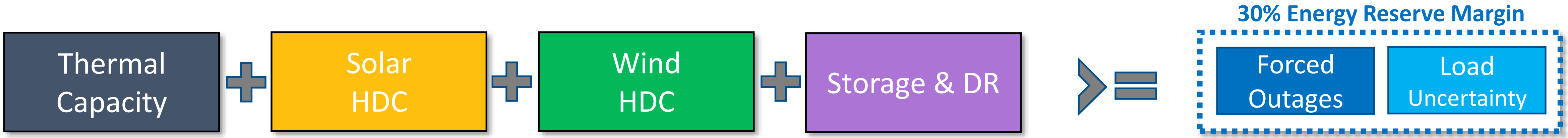
Probabilistic Analysis (LOLP)

Used to measure the reliability resulting from a capacity expansion model

- Detailed resource adequacy assessment
- Metrics: loss of load probability (LOLP), LOLE, LOLH, and expected unserved energy (EUE)
- Used to develop inputs into deterministic analysis (reserve margin and capacity accreditation)
- Many chronological weather years for solar, wind, and load variability
- Randomly draws hundreds of different generator outage possibilities

A robust modeling process should include *both* deterministic and probabilistic analysis

HECO Energy Reserve Margin Overview



Thermal Capacity: assumes full nameplate capacity for fossil-fuel units.

Solar HDC: Hourly dependable Capacity (HDC) discounts solar capacity value (assumes 2σ of hourly output across multiple years of data). Includes the same hour of the day before, day of, day after.

Wind HDC: same as solar, but assumes 1σ of hourly output

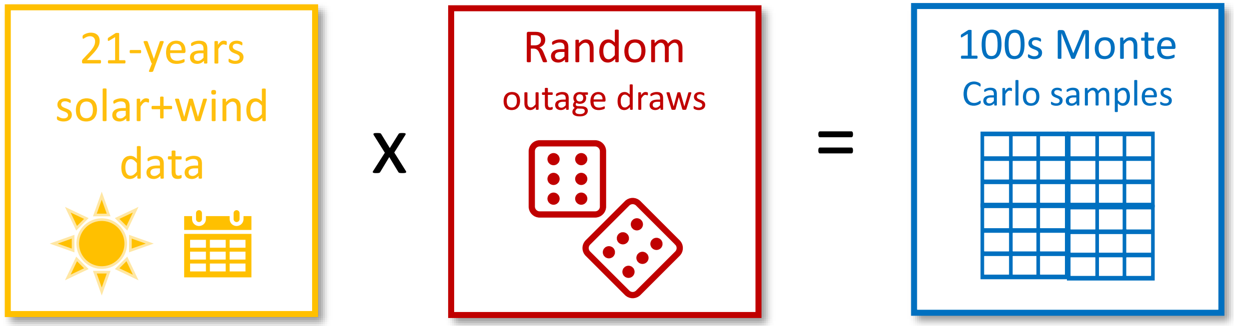
Storage & DR: Scheduled based on energy limitations

ERM: 30% for Oahu, Maui, Big Island required to cover **forced outages** and **load uncertainty**

Q: How was the minimum ERM determined?

TAP recommended additional analysis here (focus of today)

HNEI & Telos Approach to Stochastic Analysis of Resource Adequacy to Address Interannual Resource Variability



- Historical inter-annual solar variability applied to future grid
- Uncertainty and timing of generator outages considered
- Each analysis evaluates capacity shortage across 2.5 million hours of possible operation.
- Methodology allows detailed month-by-month characterization of LOL events
- PLEXOS is the modeling tool for stochastic simulations

Example of Loss of Load Hours by Sample

Outage Draws (columns) × Wind & Solar Years (rows)

Solar Year	1	2	3	4	5	6	7	8	9	10	...	N
1998	0	0	10	3	0	0	2	0	3	6	0	0
1999	2	0	9	0	3	0	0	0	0	0	3	0
2000	0	0	0	0	0	0	0	2	0	0	6	0
2001	0	0	0	2	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	6	0	0	0	0
2003	0	0	1	0	0	0	0	0	0	0	0	1
2004	0	2	0	0	0	1	0	0	0	0	0	0
2005	0	0	0	4	0	0	0	1	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	3	0
2007	0	3	0	0	0	2	0	0	0	0	0	0
2008	3	0	0	0	0	0	0	5	0	0	0	0
2009	0	0	2	0	1	0	0	1	0	0	3	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	11	0	2	0	0	0	0	0	1	0	3	0
2012	0	3	0	0	0	0	0	0	0	0	0	0
2013	2	0	3	3	0	2	0	0	0	0	0	7
2014	0	0	10	0	0	0	0	0	0	0	0	0
2015	1	0	0	0	3	0	8	0	0	0	0	0
2016	0	1	0	2	0	0	0	0	1	0	0	0
2017	0	0	0	0	0	0	1	1	0	0	0	0
2018	0	10	0	0	0	0	0	0	0	0	0	1

Average across 504 simulations yields LOLE for one specified grid conditions
~4.4 million hours of simulation per case

ERM Test Cases, Key Inputs & Assumptions

HECO ran RESOLVE cases at various levels of thermal retirements and ERM levels…

… resulting portfolios were input into probabilistic analysis

Oahu

	Energy Reserve Margin				
ERM Level	**0%**	**10%**	**20%**	**30%**	**40%**
Waiau 3					
Waiau 4					
Waiau 5					
Waiau 6					
Waiau 7					
Waiau 8					
Kahe 1					
Kahe 2					
Kahe 5					
Kahe 6					
BESS 140MW					
LM6000 1					
LM6000 2					
LM6000 3					
Net Capacity Change after Stage 2	**-496**	**-395**	**-309**	**-168**	**-76**

Retirements

Additions

5 scenarios evaluated in more detailed probabilistic model (next slides)

Maui

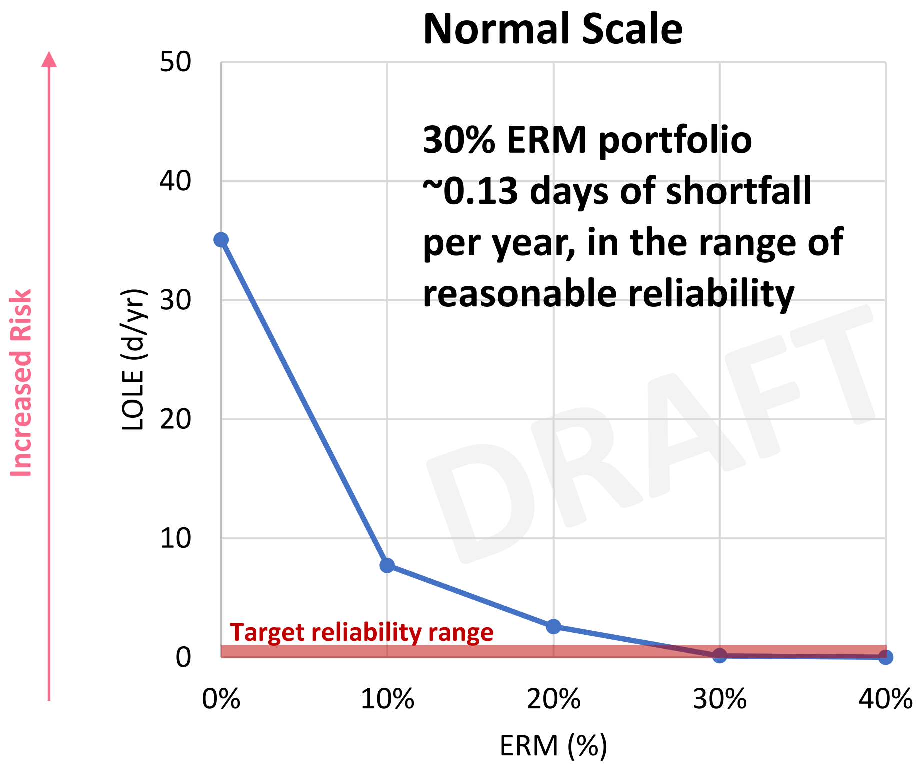
	Energy Reserve Margin				
ERM Level	**0%**	**10%**	**20%**	**30%**	**40%**
Kahului 1-4					
Maalaea 4-9					
Maalaea 10					
Maalaea 11					
Maalaea 12					
Maalaea 13					
Net Capacity Change	**-115**	**-103**	**-90**	**-78**	**-66**

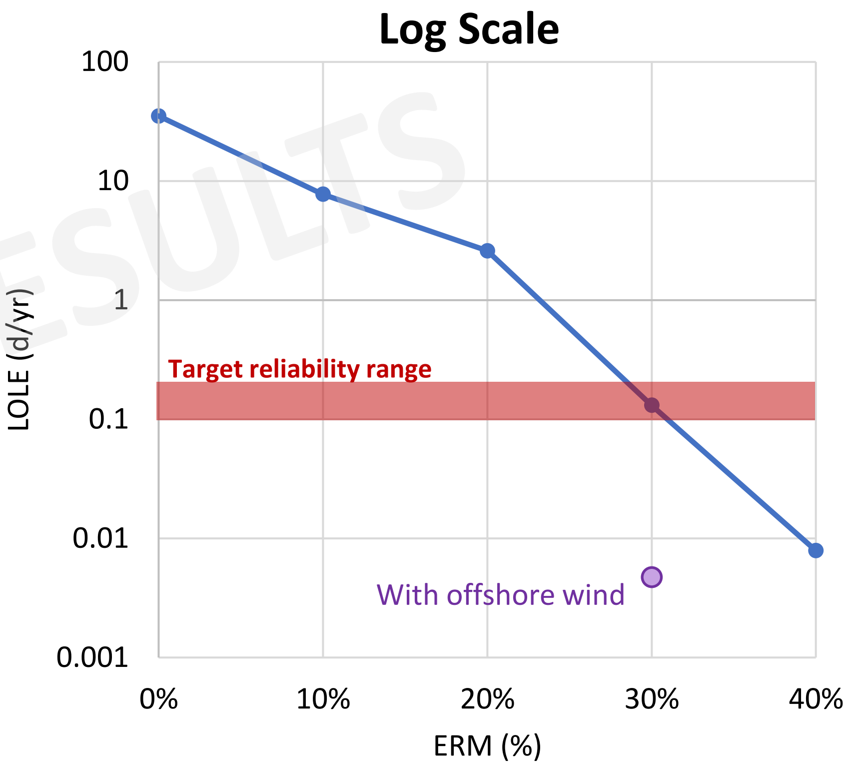
Other assumptions

- ✓ AES and Kahului Retirements
- ✓ Full Stage 1 & 2 deployment
- ✓ CBRE and DR program installations
- ✓ 2030 IGP DER forecast
- ✓ 2030 IGP Load Forecast

Oahu Preliminary Results

Evaluating the relationship between ERM and probabilistic model results (LOLE), preliminary (N = 252)

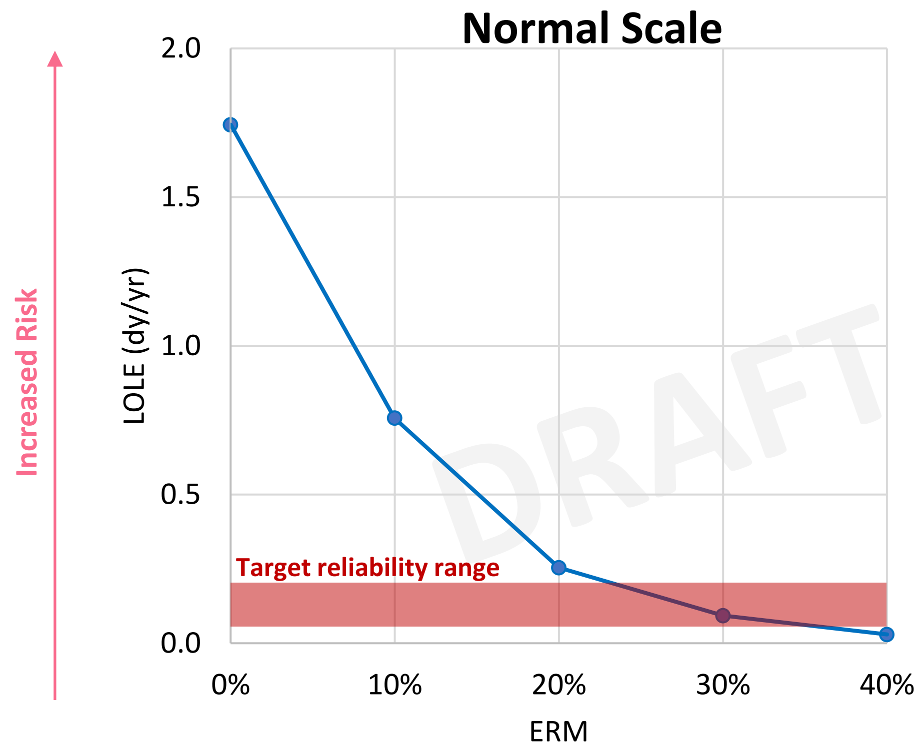


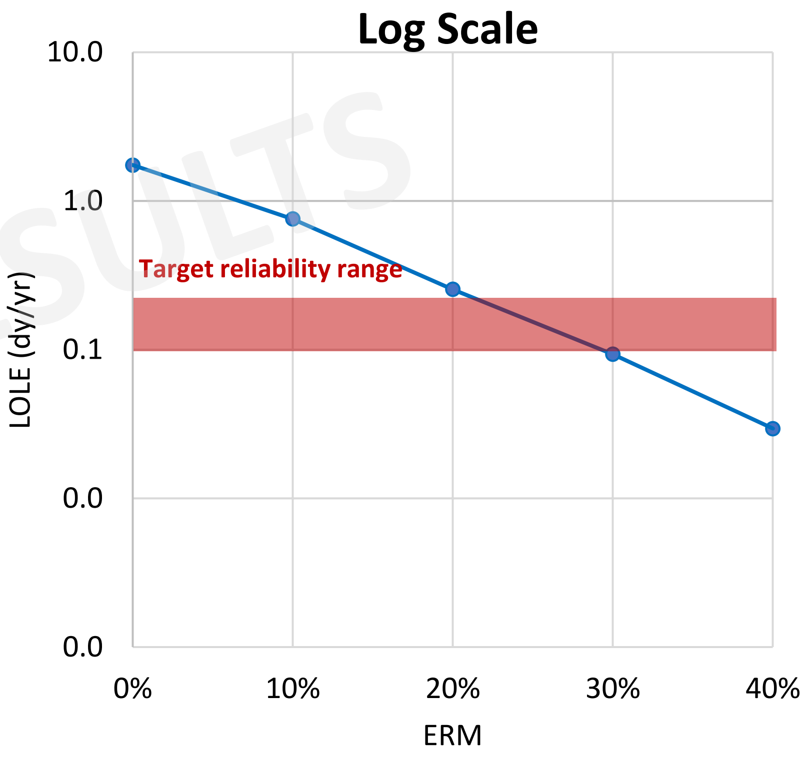


30% seems to be there, but potentially very sensitive to portfolio resources
need to do the more analysis on future resources mixes to determine if it is appropriate moving forward?

Maui Preliminary Results

Evaluating the relationship between ERM and probabilistic model results (LOLE), <u>preliminary</u> results (N = 220)





30% ERM portfolio ~0.09 days of shortfall per year, in the range of reasonable reliability

Observations and Next Steps

- Based on initial test cases, a 30% ERM proposed by HECO shows a reasonable level of reliability - for the current resource mix - when evaluated with more detailed probabilistic assessment
- The difference between the ERM and probabilistic analysis when OSW is added indicates more calibration may be necessary for future resources
- Grid planning should include *both* a simplified ERM deterministic metric and more detailed probabilistic metrics for resulting portfolios
- **Next steps:**
  - Additional evaluation of HDC values for variable renewable resources is warranted
  - More analysis around wind resources and 20-years of wind data for both LBW and OSW