HNEI Grid Integration

ERM Calibration and Resource Adequacy | November 1, 2021

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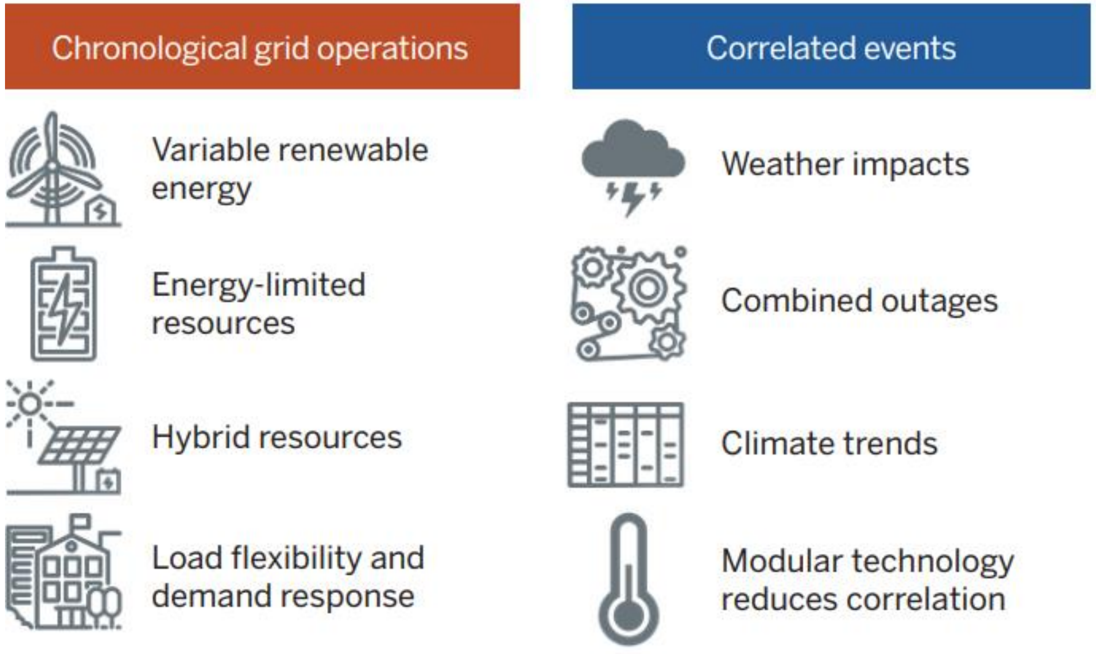
Why does the planning reserve margin need to change?

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

FIGURE 3
Two Driving Factors That Require New Approaches to Resource Adequacy



Source: Energy Systems Integration Group.

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)

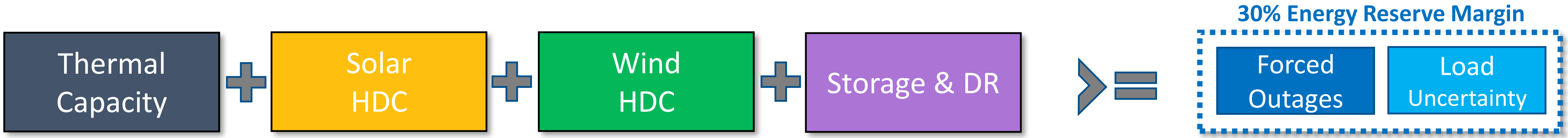
Probabilistic Analysis (LOLP)

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

21-years solar data X Random outage draws = 100s Monte Carlo samples

- Historical inter-annual solar variability applied to future grid
- Uncertainty and timing of generator outages considered
- Each analysis evaluates capacity shortage across 4.4 million hours of possible operation.
- Methodology allows detailed month-by-month characterization of LOL events
- PLEXOS is the modeling tool for stochastic simulations

TO DO: Update with multi-year wind data dataset

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					

Retirements

Additions

Net Capacity Change	**-496**	**-395**	**-309**	**-168**	**-76**

after Stage 2

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					

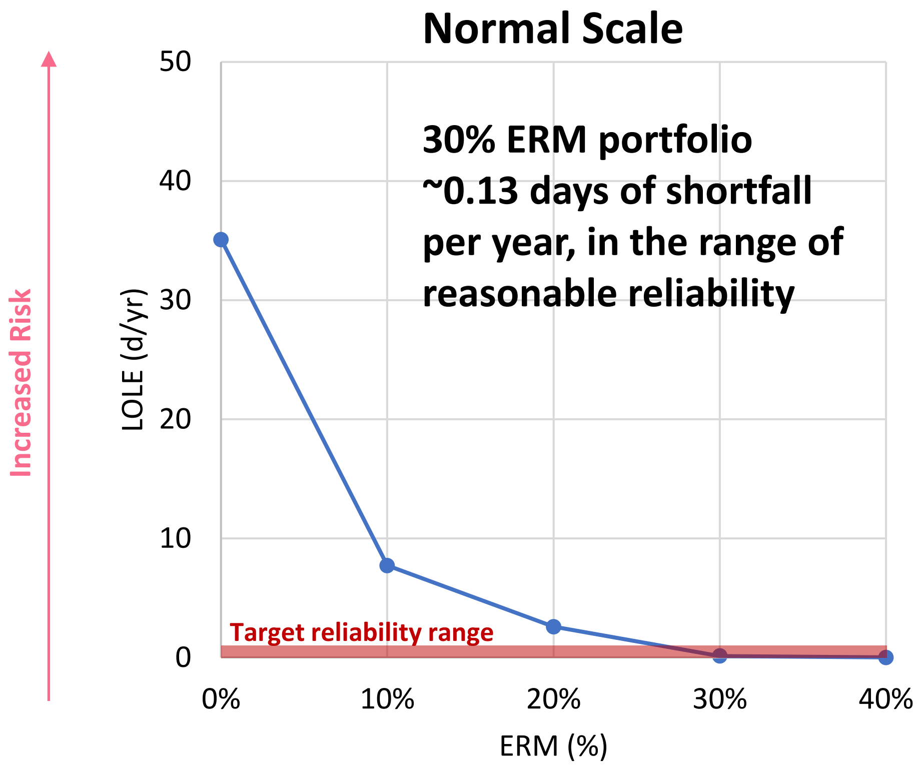
Net Capacity Change	**-115**	**-103**	**-90**	**-78**	**-66**

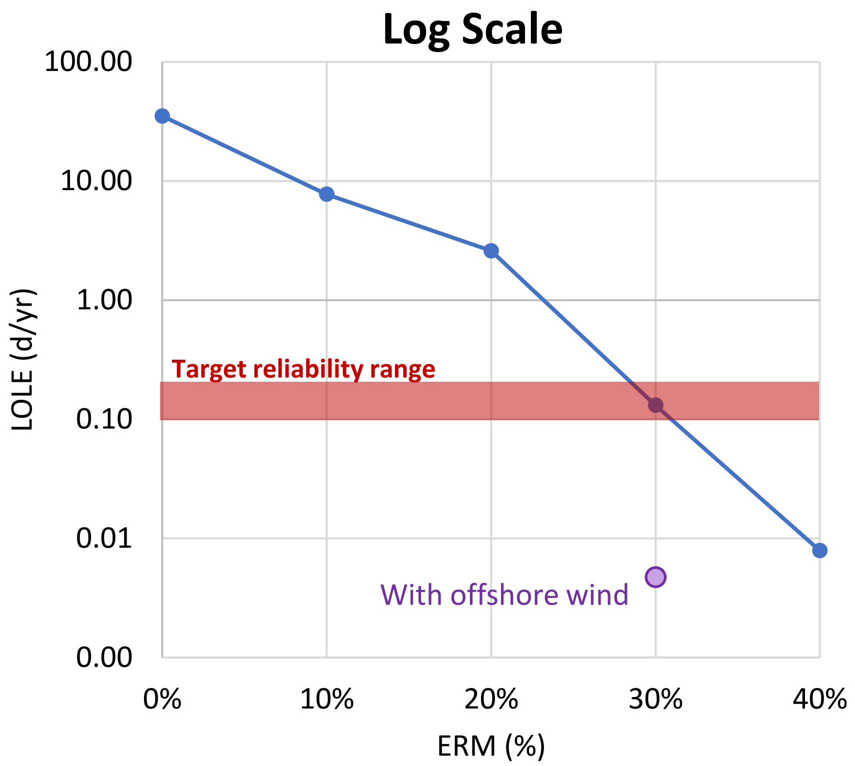
Other assumptions

- ✓ 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), (N = 504)

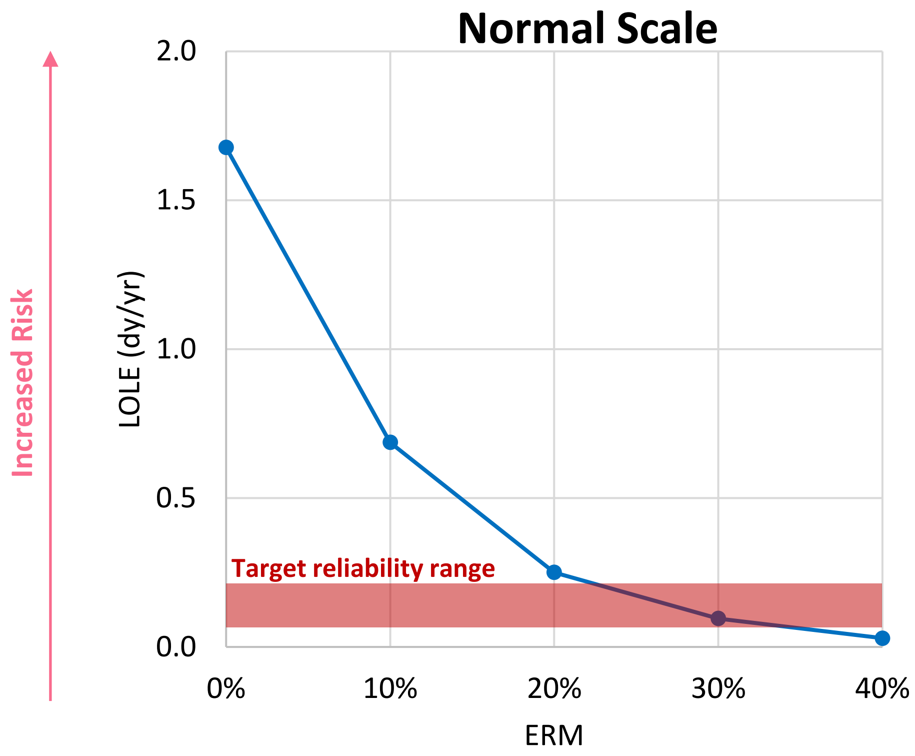


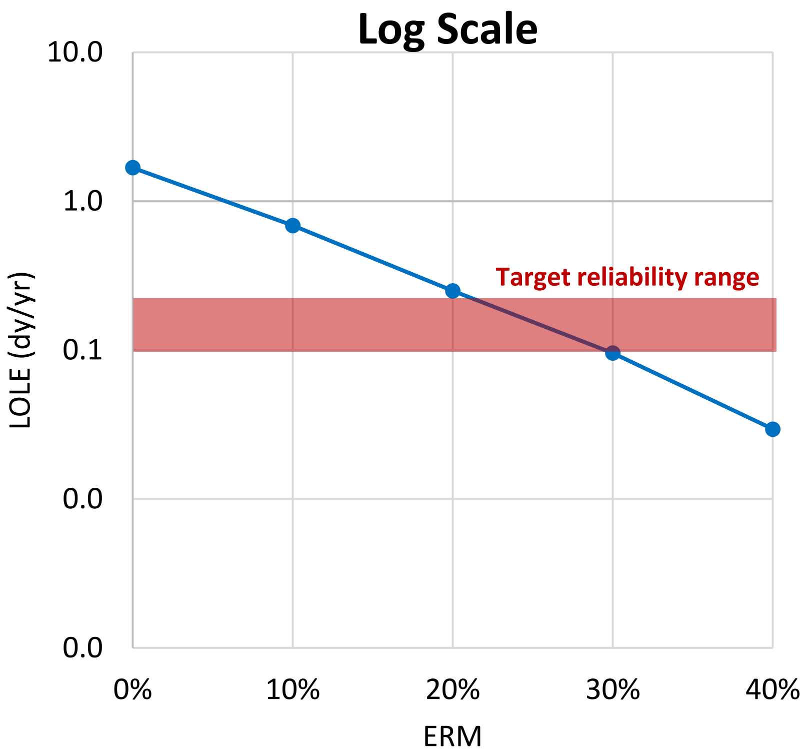


30% seems to be there, but potentially very sensitive to portfolio resources
need to do the more analysis on future resources mixes to determine if it is appropriate moving forward?

Maui Preliminary Results

Evaluating the relationship between ERM and probabilistic model results (LOLE), (N = 440)





30% ERM portfolio ~0.1 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
  while ERM may be appropriate for near-term grid changes, need to confirm on a higher VRE system
- Grid planning should include *both* a simplified ERM deterministic metric and more detailed probabilistic metrics for resulting portfolios.
  Resource adequacy back-check is still needed to confirm reliability of resulting portfolio
- **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

Telos Energy Recommendations

- **Provide justification for the 30% ERM**
  - Provide justification based on historical generator outages and load uncertainty. While it appears reasonable given the RA analysis, it should still be justified.
  - Some of these may change over time; for example, the impact of forced outages may decrease as generators are retired, but load uncertainty may increase with electrification
- **Continue further evaluation of ERM in high VRE grids**
  - While 30% ERM currently aligns well with probabilistic analysis, further investigation is warranted for higher VRE levels,
  - Specific attention to OSW which may be complimentary to the solar resource availability
- **Resource adequacy back-check is needed**
  - ERM does not replace detailed probabilistic RA simulations to confirm reliability of resulting portfolio.
  - ERM can be used in RESOLVE, but not a replacement for a more detailed resource adequacy assessment on resulting portfolios
  - Method is similar to downstream analysis with PLEXOS production cost and PSS/E stability considerations
- **HDC calculations should be considered further.**
  - Wind vs. solar should both have the same 1sigma from mean to avoid perception of discrimination
  - Consider aggregating like-hour data across a month rather than a 3-day rolling average for HDC calculations
  - Use long-term dataset of simulated weather conditions, rather than recent historical output
  - Review California's *exceedance* methodology and compare to HDC method
  - Calculate HDC for the *portfolio* of VRE (or by resource) rather than individual projects