Hawaiian Electric

Hawai‘i Island Grid Needs Assessment Update

April 2022

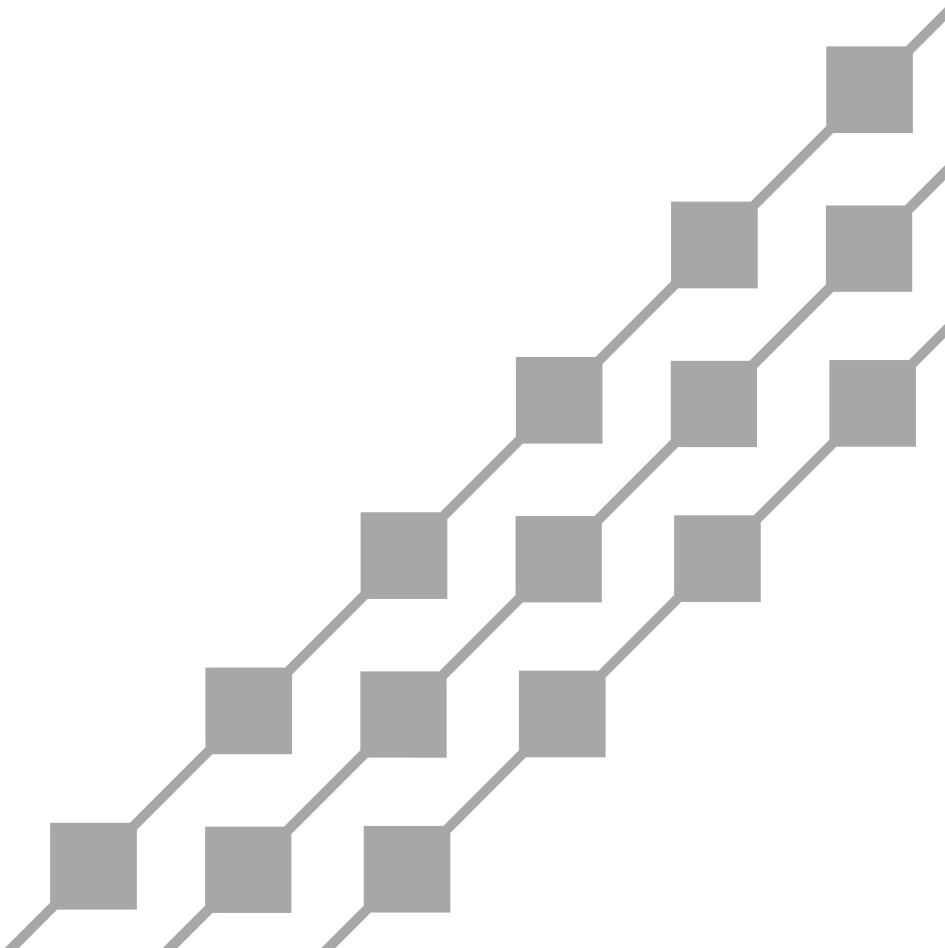
Executive Summary

- Compared to the July 2021 *Hawaii Island Near-Term Grid Needs Assessment,* the capacity target is lower and energy target is higher.
  - The capacity target is lower (from 95 MW to 63 MW) due to the change in assumption for Hourly Dependable Capacity that defines the capacity value of variable renewables. As discussed with the IGP Technical Advisory Panel, an 80th percentile calculation was adopted that increased the capacity contribution from variable renewables.
  - The energy target is higher (from 206 GWh to 319 GWh) due to the removal of the Puako Solar project that withdrew from the RFP process. Assumptions to continue HRD Wind and Wailuku Hydro and expand PGV to 46 MW also provided offsetting reductions to the energy target.
- Capacity needs on Hawai‘i Island are driven by the availability of thermal generating resources, consistent with the July 2021 filing.
  - The assumed removal of the Hamakua Energy Partners (HEP) facility at the end of its contract term in the Base Scenario causes capacity needs beginning in 2031.
  - In a scenario where HEP continues and Hu Honua is in-service, there are no capacity needs through 2035.
- Energy needs on Hawai‘i Island are driven by the availability of low cost variable renewable resources.
  - Using the March 31, 2022 PUC approved assumptions, including the updated resource cost assumptions, onshore wind, standalone BESS, and paired PV+BESS are selected by the RESOLVE model to provide renewable energy as a portfolio to the Hawai‘i Island system.
- Based on the modeled expected dispatch, new resources being procured as part of the Stage 3 RFP should be flexible and may be dispatched to meet morning peak, evening peak, cycle off midday, or provide continuous hours of energy.

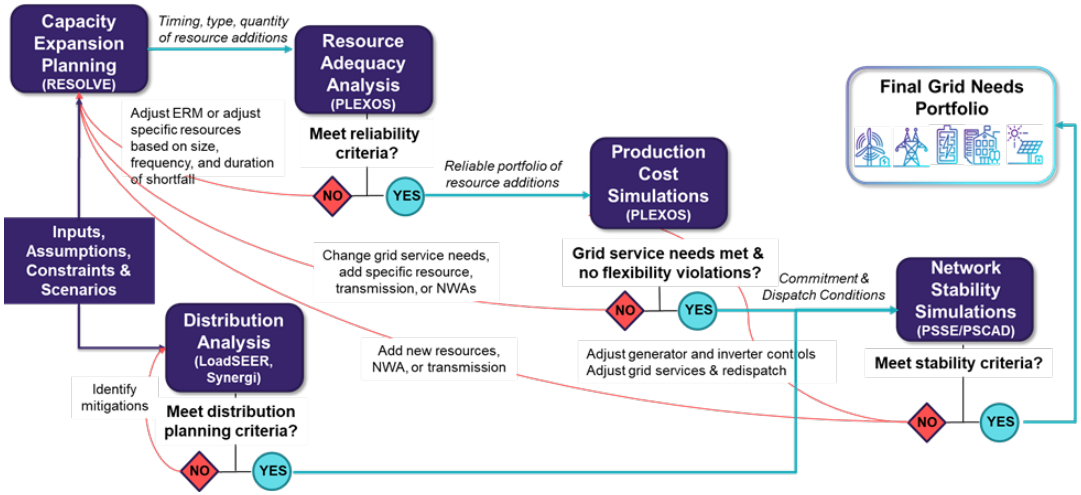
Objective

- Identify the capacity, energy, and regulating reserve needs for Hawai‘i Island
  - Updated to include the PUC approved March 31, 2022 Final Inputs and Assumptions for the Integrated Grid Planning process
  - Updated assumptions for status of existing and planned resources to inform incremental grid needs
- Update the July 2021 *Hawaii Island Near-Term Grid Needs Assessment*

Inputs, Assumptions, Methodology



Modeling Process



- Consistent with the IGP modeling framework,
  - The RESOLVE capacity expansion model was run to develop an optimized resource plan
  - The PLEXOS production simulation model was run to determine:
    - Resource adequacy using the Energy Reserve Margin criteria and Hourly Dependable Capacities, updated with feedback from the Technical Advisory Panel to use the 80th percentile calculation instead of 2-sigma
    - Production cost simulation to identify energy and regulating reserve needs and assess system operations with the new resource portfolio

Scenarios Modeled for this GNA Update

- **Base Scenario**: This scenario uses the PUC approved March 31, 2022 IGP inputs and assumptions where new resources are allowed to be built in RESOLVE. HRD Wind is assumed to operate under the proposed Amended and Restated Power Purchase Agreement (PPA). Wailuku Hydro is continued through the planning horizon assuming the PPA is renegotiated, which is scheduled to expire in 2023, prior to the requested commercial operations date of the RFP. Pakini Nui's PPA is assumed to expire in 2027. PGV is assumed to operate at 46 MW under its approved amended and restated PPA. The HEP PPA is assumed to expire in 2031. PPAs that are assumed to end allow for their capacity and energy to be re-optimized in the RESOLVE model. The Base Scenario also assumes a managed charging profile for electric vehicles and base level of customer response to time varying pricing for customers without DER.

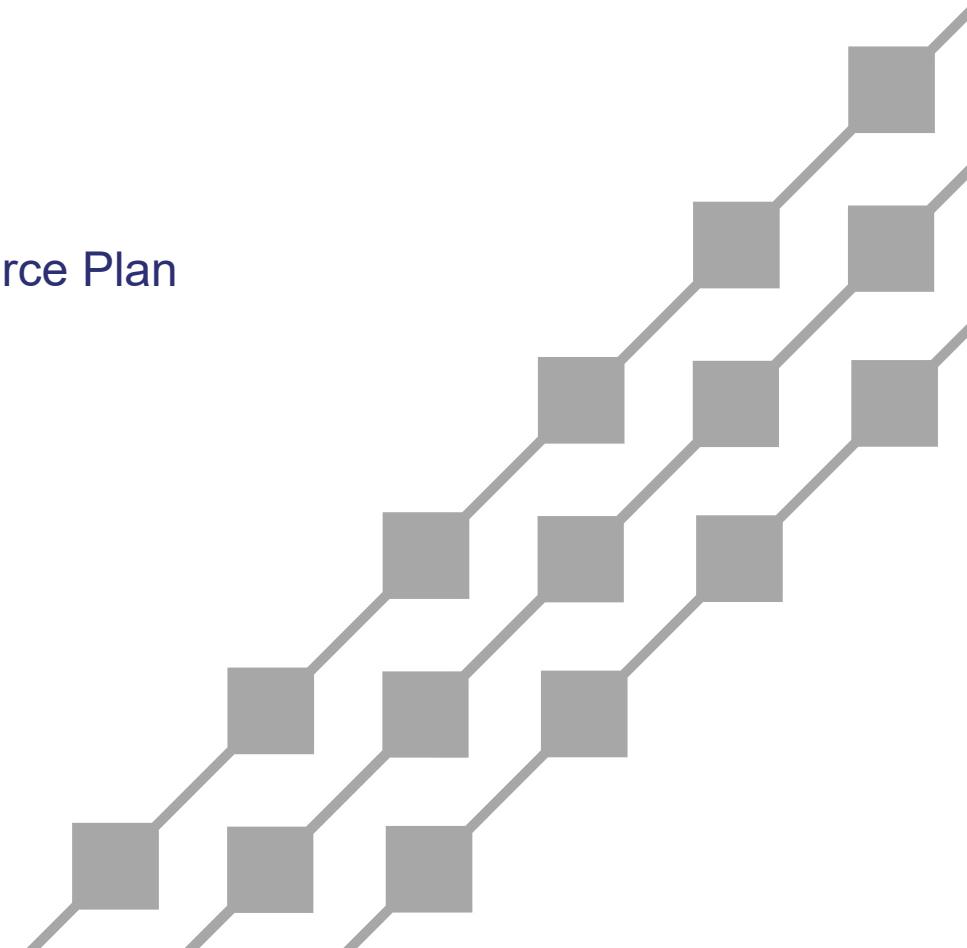
- **Renewable Firm Generation (Renewable Firm) Scenario**: Using the Base Scenario above, the Renewable Firm Generation scenario assumes known firm renewable generation projects achieve commercial operations to determine changes in the resource selection compared to the Base Scenario as well as changes to incremental grid needs. This scenario is the same as the Base except HEP is assumed to continue through the planning horizon and Hu Honua is assumed to be in service under its Amended and Restated PPA in 2023.

Assumptions Comparison

Assumptions	2021 Grid Need Assessment	2022 Grid Need Assessment
Load Forecast	March 2021	March 2022
Resource Cost	March 2021	March 2022
Resource Assumption	- HRD and Wailuku Hydro expired - Pakini Nui expires in 2027 - Puako Solar in-service - 38 MW PGV	- HRD under A&R PPA and Wailuku Hydro continues. - Pakini Nui expires in 2027 - Puako Solar not in-service (project declared null and void) - 46 MW PGV under approved A&R PPA
Fossil Fuel Generators	2025: Puna Steam put into standby 2027: Hill 5 & 6 removed from service	2025: Puna Steam put into standby 2027: Hill 5 & 6 removed from service
Hourly Dependable Capacity for renewables	1-sigma hydro and wind, 2-sigma PV	80th Percentile (See January 20, 2022 TAP Meeting[1])

[1] https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning/stakeholder-and-community-engagement/technical-advisory-panel

Summary of Grid Needs and Resource Plan



Summary of Near-Term Grid Needs Portfolio (2027-2035)

Grid Need	Base	Renewable Firm
Energy, GWh	319	320
Up Reg, MW	45	43
Up Ramp, MW	26	26
Down Reg, MW	19	19
Down Ramp, MW	5	5
Energy Reserve Margin (ERM), MW	63	0

Comparing the Base Scenario to the Renewable Firm Scenario,

- The energy need in the Renewable Firm Scenario is slightly higher than the Base Scenario due to a slightly higher buildout of onshore wind and PV+BESS resources.
- The upward regulating reserve required in the Base Scenario reflects that the new RESOLVE selected resources (onshore wind, standalone BESS, PV+BESS) will be carrying a larger portion of the reserves compared to the Renewable Firm Scenario that continued HEP and added Hu Honua.

Compared to the Grid Needs Assessment filed in July 2021,

- The removal of Puako as a planned resource addition increased energy needs from 206 GWH to 319 GWh
- The use of 80th percentile HDCs reduced the ERM capacity needs from 95 to 63 MW (by increasing the capacity credit for variable renewables)

Resource Plan Summary

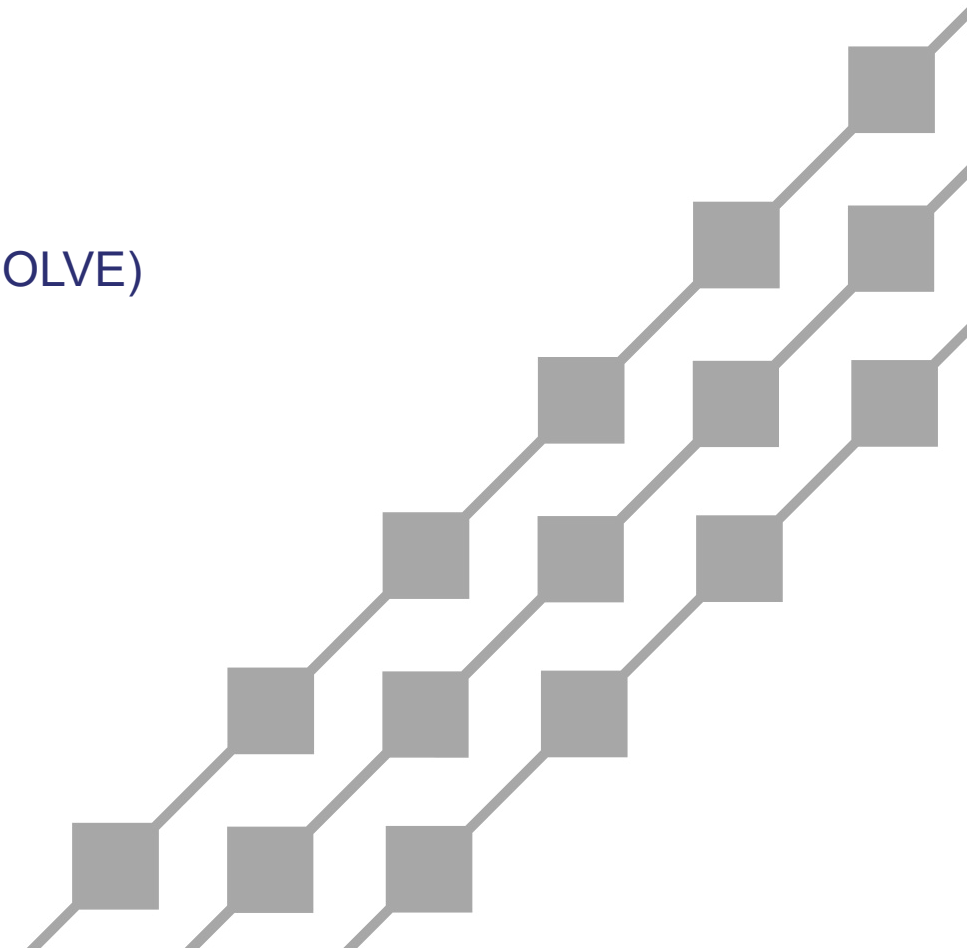
- The following table summarizes the cumulative near-term resource additions by type through 2035. The table includes adjustments made for assumed resource block sizes.

Scenario	Base			Renewable Firm		
Year	Standalone Battery (MW)	PV+BESS (MW)	Onshore Wind (MW)	Standalone Battery (MW)	PV+BESS (MW)	Onshore Wind (MW)
2027	6.25	0	60.27	6.22	0	70.94
2028	7.5	0	64.53	6.22	0	70.94
2029	8.09	0	64.53	6.22	0	70.94
2030	9.21	24.31	64.53	7.04	25.34	70.94
2031	9.27	24.31	64.53	7.13	26.17	70.94
2032	9.33	24.31	64.53	7.55	26.65	70.94
2033	9.65	24.31	64.53	7.77	26.65	70.94
2034	9.75	24.31	64.53	7.77	26.65	70.94
2035	9.75	24.31	64.53	7.77	26.65	70.94

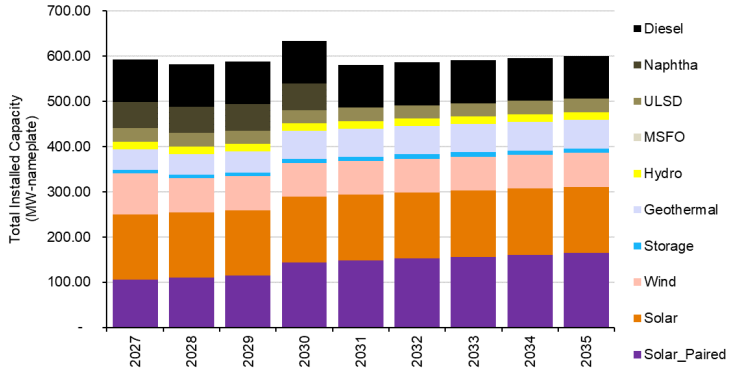
- It is important to note that the resources selected by RESOLVE and modeled in PLEXOS are intended to be proxies for the grid needs of the system. The specific additions of wind, BESS, and PV+storage are not intended to be recommendations for specific capacities by resource type but rather aggregated needs of the system to be met by proposals in the Hawai‘i Island Stage 3 RFP on a portfolio basis.
- The RESOLVE model selected resource additions were adjusted for modeling in PLEXOS. Based on an assumed 30 MW block size for future geothermal, consistent with the National Renewable Energy Laboratory Annual Technology Baseline resource cost forecast assumptions[1] , the geothermal additions in 2030 were delayed until 2040 (outside the planning horizon window of interest) when a cumulative 30 MW was installed. Inverter based resources (onshore wind, BESS) are expected to be more modular and their capacities are not adjusted prior to modeling PLEXOS. The detailed resource plans that were output from RESOLVE and used in PLEXOS are included in the Appendix.

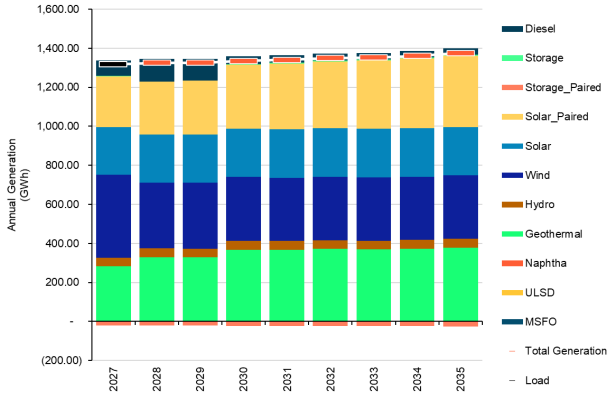
[1] See https://atb.nrel.gov/electricity/2021/geothermal

Capacity Expansion Modeling (RESOLVE)

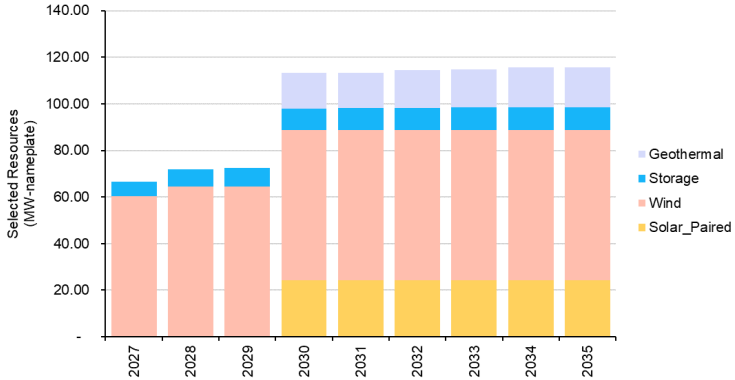


RESOLVE Results for Base Scenario





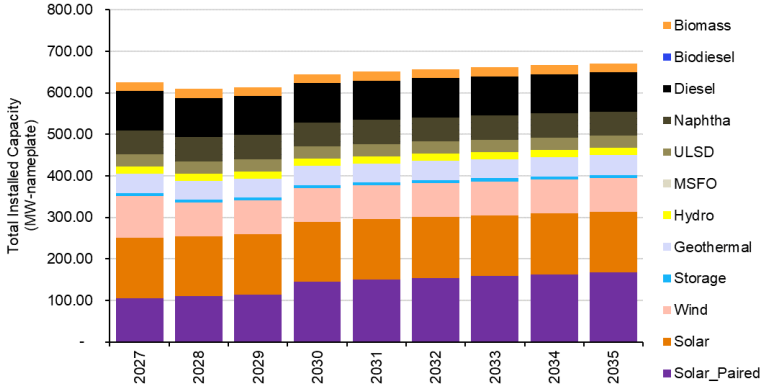
Note: Solar and Solar_Paired includes DER, which was modeled as a supply-side resource

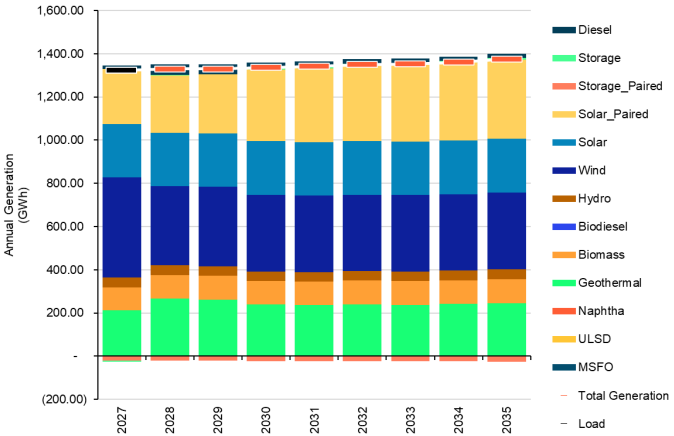


The Capacity Expansion model selects wind due to its favorable cost and energy output compared to other available resources. Storage is selected to shift a portion of wind energy. While new geothermal adds capacity, it is selected based on its favorable cost of energy.

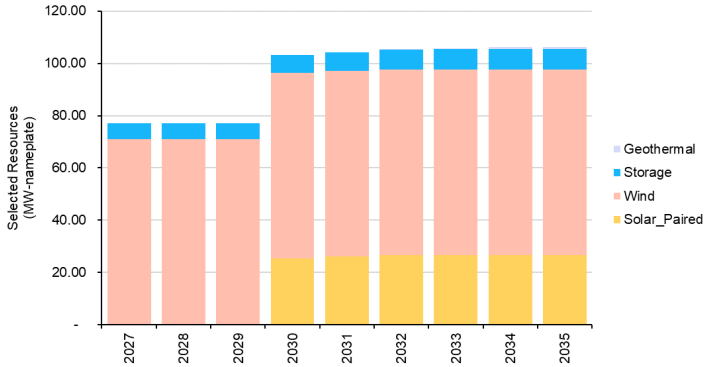
Even though fossil fuel capacity remains installed in the resource plan, small amounts of fossil fuels are used to serve load. This means the Hawaii Island system has the potential to achieve a high level of RPS in the near-term.

RESOLVE Results for Renewable Firm Scenario





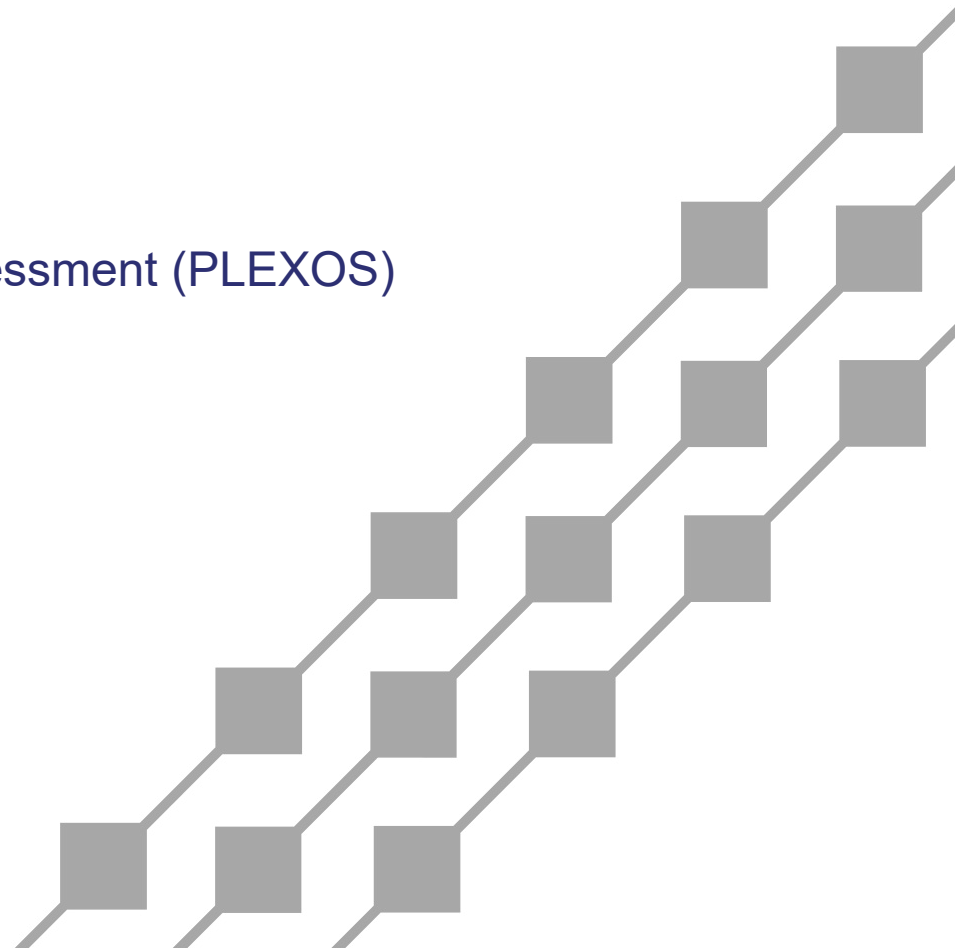
Note: Solar and Solar_Paired includes DER, which was modeled as a supply-side resource



With the addition of Hu Honua and the continuation of HEP, the Capacity Expansion model still selects wind resources due to its favorable cost and energy output compared to other available resources. However, a lower amount of geothermal and standalone storage is selected compared to the Base scenario.

The annual generation figures show that less fossil fuel is used in the earlier years with Hu Honua online compared to the Base scenario.

Energy Reserve Margin (ERM) Assessment (PLEXOS)



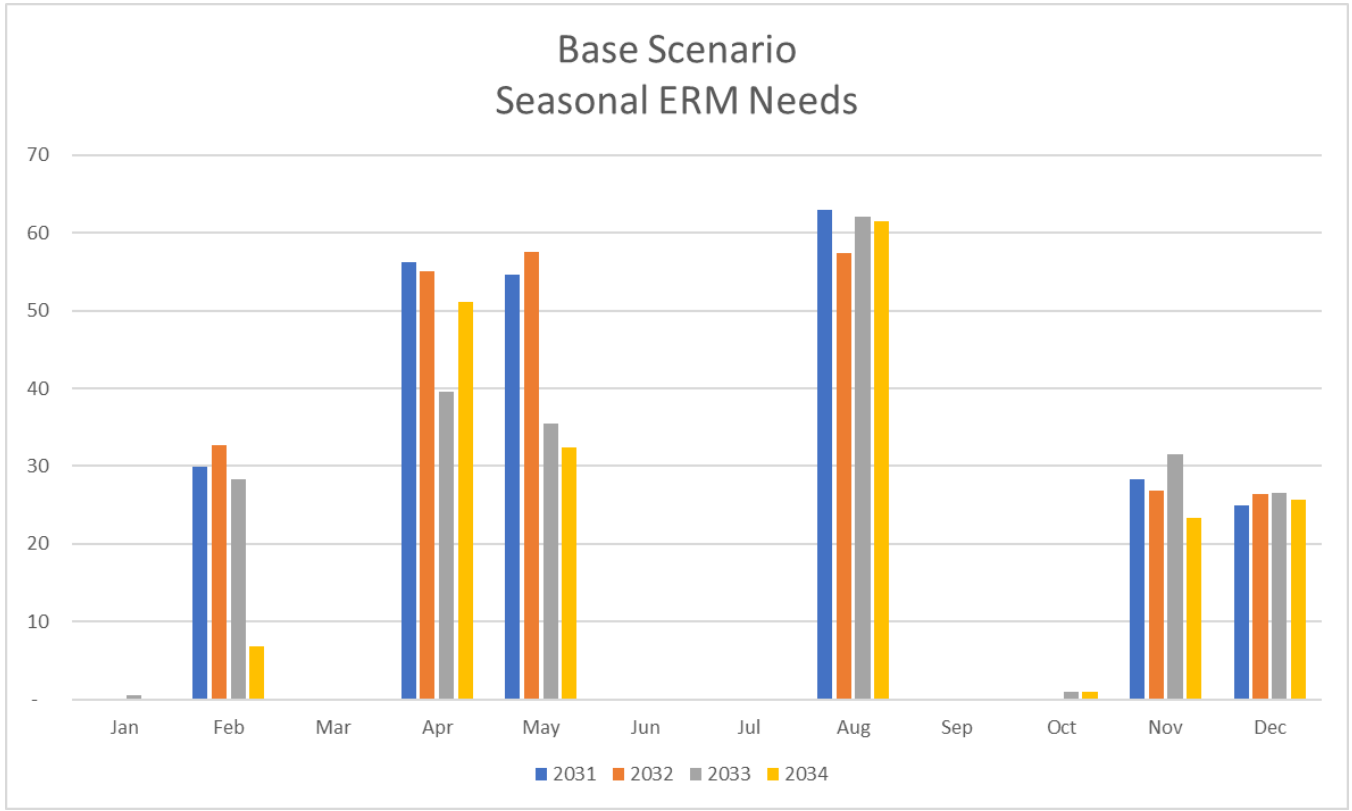
Resource Adequacy Analyses

- The Energy Reserve Margin (ERM) criteria was used to assess future reliability needs. Two key inputs for the ERM are the target percentage and hourly dependable capacities.
  - For Hawai‘i Island, the target ERM is 30% [1]. As noted in the TAP feedback on the proposed energy reserve margin criteria, it is sufficiently justified for use in the current IGP and 30% seems appropriate for the first IGP cycle.
  - Based on recent discussions with the IGP Technical Advisory Panel, the hourly dependable capacities for variable renewables have been updated from the 1 sigma for wind, 2 sigma for PV to use the 80th percentile calculation and data provided by the NREL National Solar Radiation Database was used for historical weather to inform past PV production.
- For the purposes of defining the ERM need, no future RESOLVE selected resources are included in the resource adequacy analyses to better understand what capacity need they can fulfill if they were acquired through the Stage 3 RFP.

[1] See TAP feedback filed in Attachment 1 of the Supplemental Response to PUC-HECO-IR-26 in Docket No. 2018-0165 on December 1, 2021.

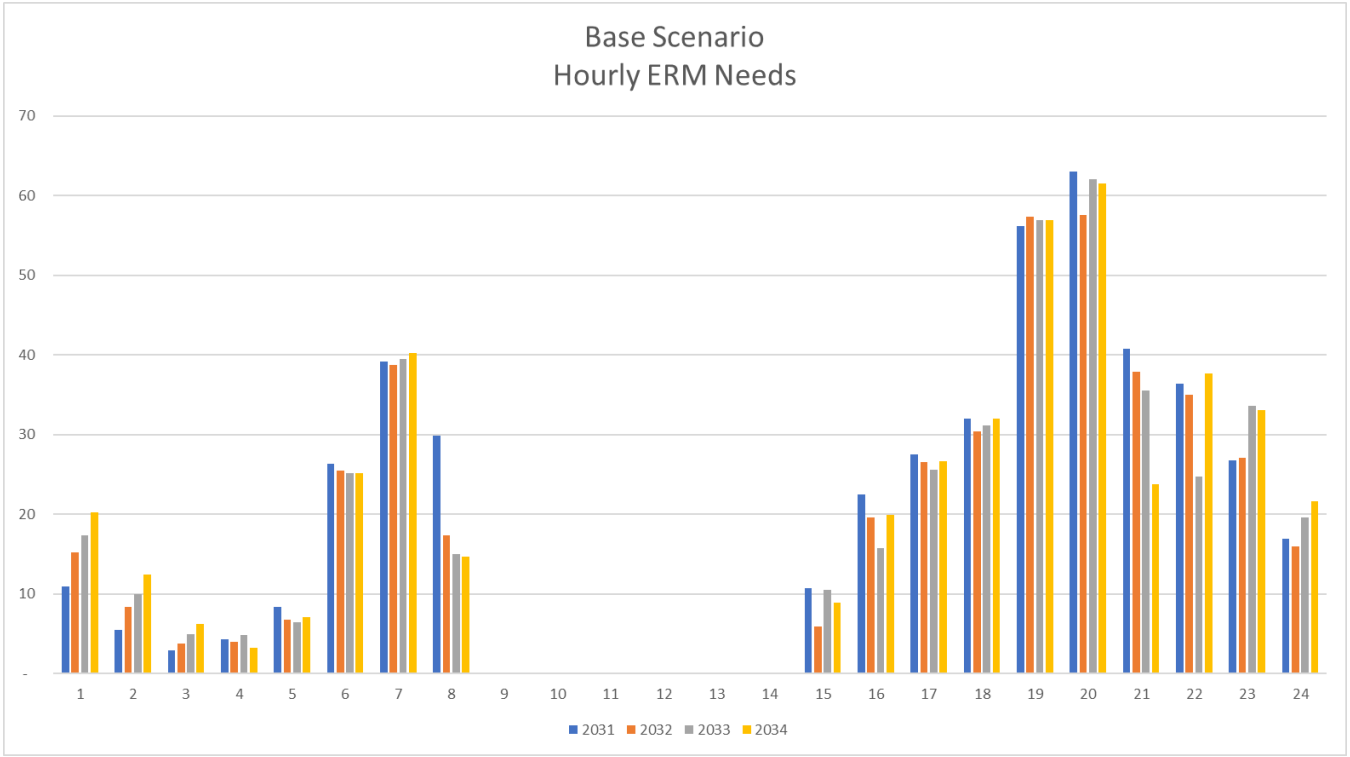
Monthly ERM Need in the Base Scenario

- Monthly ERM needs are driven by the timing of maintenance outages.
- ERM needs in future years are lumpy, where some months have no capacity needs due to greater availability of thermal generating resources and other months have large capacity needs, coincident with large thermal generating resources being out on maintenance.



Hourly ERM Need in the Base Scenario

- The hourly ERM need provides another view into the time of day when the max capacity needs for ERM occur.
- Although the max need occurs during the evening peak, there are other times of day where significant capacity may be needed, including the morning peak.



Monthly ERM Need in the Renewable Firm Scenario

- The Base Scenario shows ~65 MW ERM need following the expiration of HEP.
- The Base Scenario has ERM needs that vary seasonally by month as well as time of day. These needs are resolved in the Renewable Firm Scenario by the planned continuation of HEP and in service of Hu Honua, both dispatchable firm generators.

Confirmation of ERM Needs in the Base Scenario

No RESOLVE Additions

Year	Total EUE (MWh)	Max Hourly EUE (MW)
2027	-	-
2028	-	-
2029	-	-
2030	-	-
2031	3,142	63
2032	3,317	58
2033	2,991	62
2034	3,228	62
2035	4,444	61

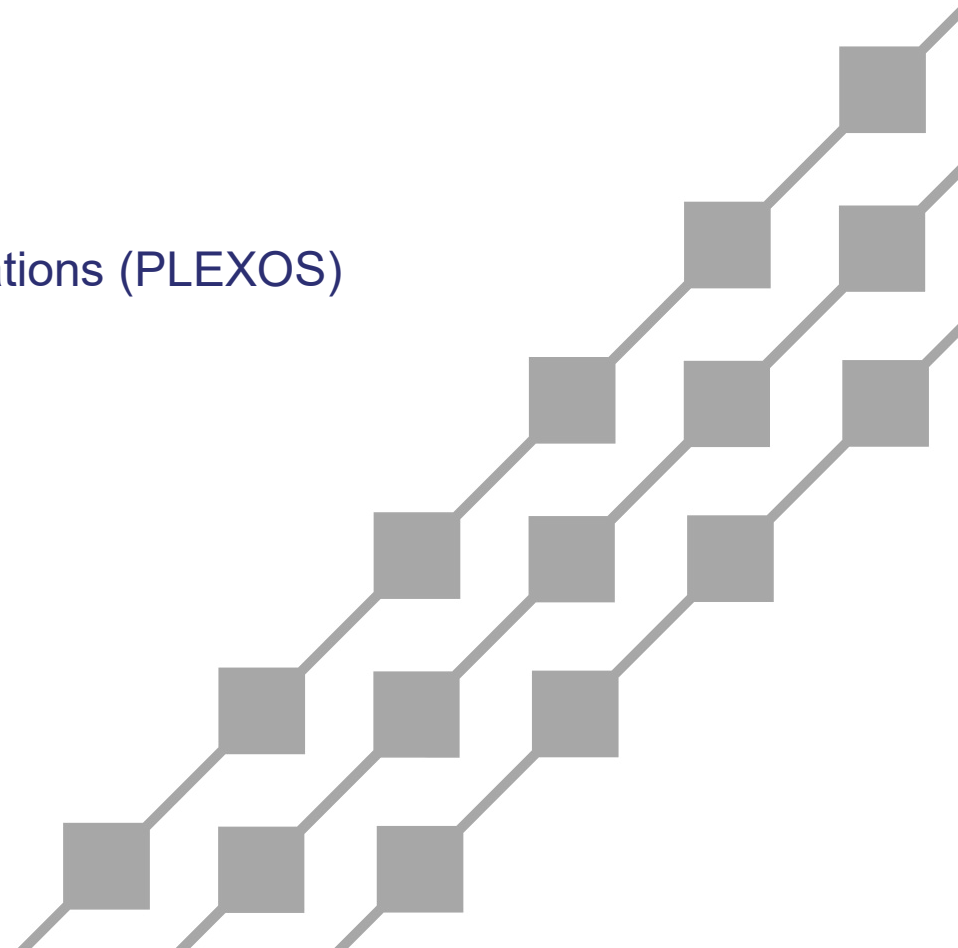
With RESOLVE Additions (i.e., selected Wind, PV+BESS, and standalone BESS resources)

Year	Total EUE (MWh)	Max Hourly EUE (MW)
2027	-	-
2028	-	-
2029	-	-
2030	-	-
2031	0.2	0.2
2032	0.6	0.6
2033	-	-
2034	0.01	0.01
2035	-	-

Confirmation of ERM Needs in the Base Scenario

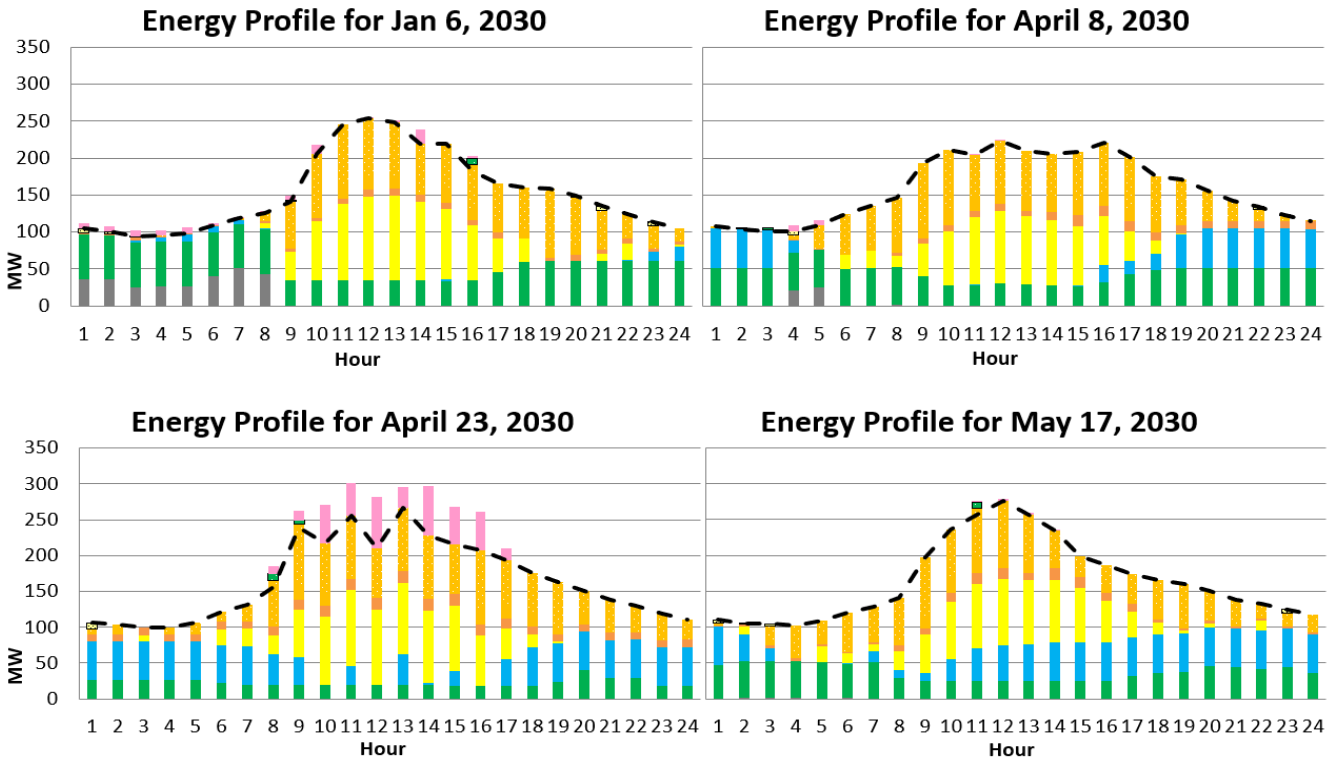
- The ERM summary tables confirm that the ~65 MW of ERM need can be met with the portfolio of standalone BESS, PV+BESS, and onshore wind that were selected in the Base Scenario.
- Similarly, the Renewable Firm Scenario indicates that firm generation can also meet the ERM criteria.
- The portfolio of proposals will be evaluated to determine if the ERM needs are met. Diversity of project locations for resilience and reliability (potential voltage issues in East Hawaii) will also be considered.

Production Simulation of Grid Operations (PLEXOS)



Illustrative Daily Dispatch

- Daily charts provide the expected dispatch of the resource portfolio, including resources to be procured in this RFP
- New modeled PV, wind, and storage resources are expected to be flexible and may be dispatched to meet morning peak, evening peak, cycle off midday, or provide continuous energy similar to a baseload resource.
- Capacity value of new resources to be determined by P80 Hourly Dependable Capacity as part of the Energy Reserve Margin capacity planning criteria.

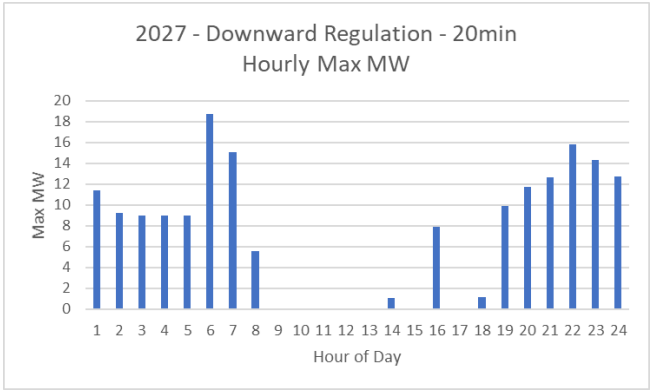


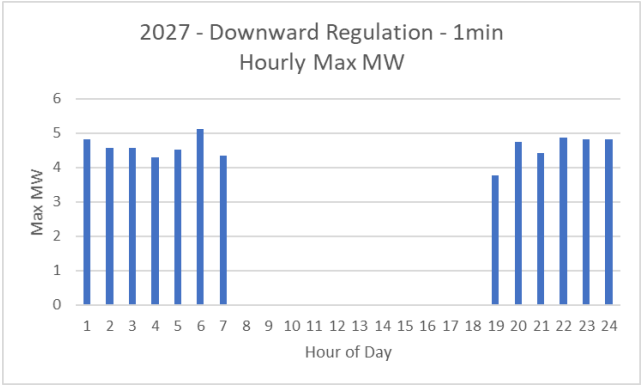
Energy Needs

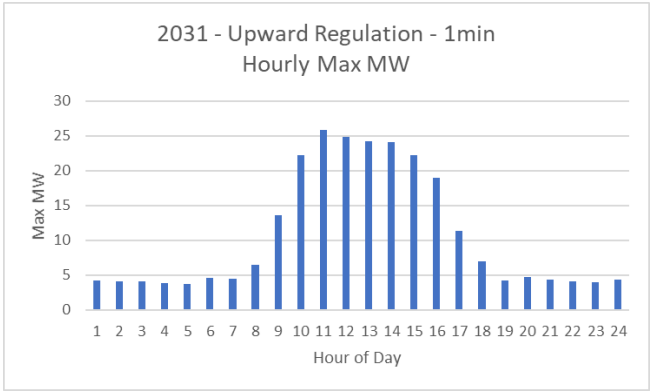
- The energy needs are defined using the production simulation to assess the annual energy taken from the aggregated dispatch of the new resources selected by RESOLVE.
- In combination with the daily charts, this information can help to inform developers on how their proposed resources will be utilized to serve system demand.

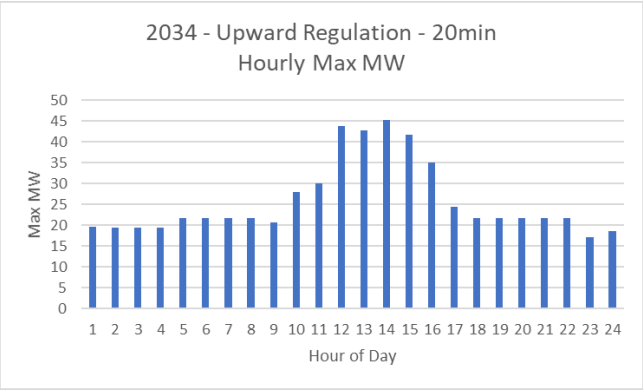
Regulating Reserve Needs

- In addition to energy, the new resources added to the system will be expected to provide other grid services.
- The new resources may need to provide upward and downward regulating reserve on a 20 minute or 1 minute basis to help balance the variability in variable renewables and load
- Regulating reserve needs defined as the hourly max of the total reserve requirement less the reserve provided by planned and existing resources
- Consistent with the GNA methodology proposed in IGP, paired renewables with storage do not increase the regulating reserve requirements. However, standalone variable renewables do increase regulating reserve requirements.
- The portfolio of proposals will be evaluated to determine if the regulating reserve needs are met.



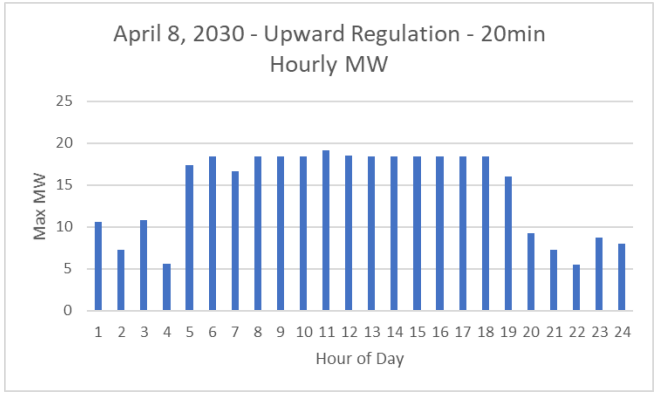


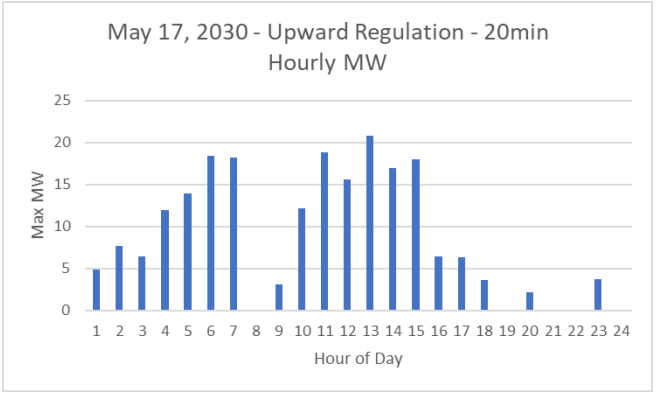


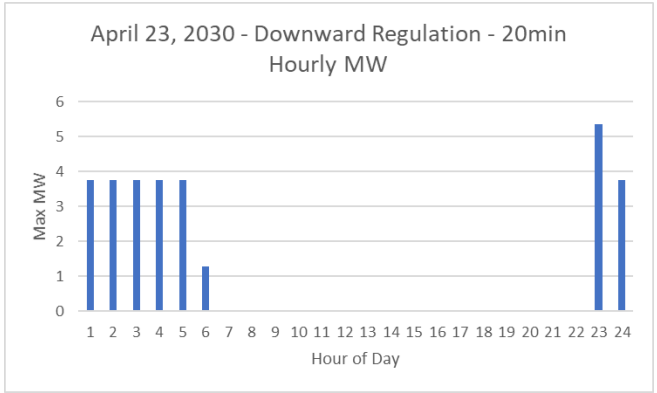


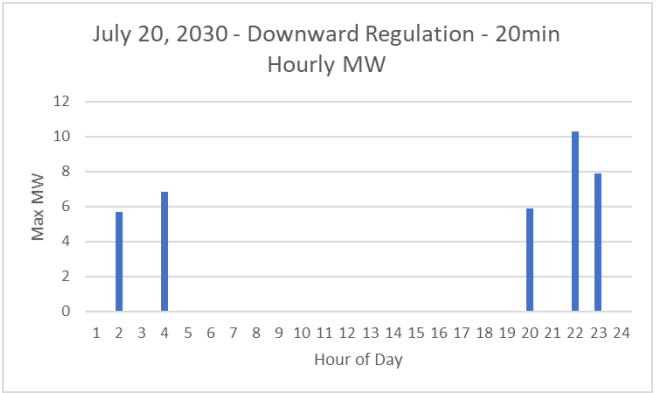
Regulating Reserve Needs

- Although the regulating reserve needs are defined as the max reserve that may need to be provided by the new resources selected by RESOLVE in each hour, on most days, the typical reserve needed will be much less and, in many hours, may be zero.
- On April 8 and May 17 (see daily charts on Slide 22), regulating reserve needs during the day are driven by DG-PV; the production simulation shows that firm renewable generation (green bar) and new standalone BESS may be dispatched less or standing by to provide regulating reserve – the paired PV+BESS and wind can then be dispatched for energy.
- With the abundance of existing flexible resources on the system that can quickly reduce their output, downward regulating reserve needs are minimal.
- This reinforces that the portfolio of resources selected in the Stage 3 RFP will need to be flexible in their dispatch for energy and provision of regulating reserve.









Appendix

Detailed Resource Plans

Year	Base Scenario	Renewable Firm Scenario
2023	38 MW PGV In-service 10.5 MW Hawi Wind In-service 12.1 MW Wailuku Hydro continues 20.5 MW Pakini Nui Wind In-service 0.75 MW CBRE Phase 1 In-service 30 MW / 120 MWH Hale Kuawehi Solar In-service 30 MW / 120 WH AES Waikoloa Solar In-service 3.17 MW Load Build In-service 4.27 MW Load Reduce In-service	38 MW PGV In-service 10.5 MW Hawi Wind In-service 12.1 MW Wailuku Hydro continues 20.5 MW Pakini Nui Wind In-service 0.75 MW CBRE Phase 1 In-service 30 MW / 120 MWH Hale Kuawehi Solar In-service 30 MW / 120 WH AES Waikoloa Solar In-service 3.17 MW Load Build In-service 4.27 MW Load Reduce In-service 20.5 Hu Honua In-service
2024	46 MW PGV Upgrade In-Service	46 MW PGV Upgrade In-Service
2025	15.5 MW Puna Steam put into standby	15.5 MW Puna Steam put into standby
2026	30 MW CBRE Phase 2 In-Service 3.17 MW Load build Removed 4.27 MW Load reduce Removed	30 MW CBRE Phase 2 In-Service 3.17 MW Load build Removed 4.27 MW Load reduce Removed

Detailed Resource Plans

Year	Base Scenario	Renewable Firm Scenario
2027	6.25 MW Standalone Battery 60.27 MW Onshore Wind 33.8 MW Hill 5 & 6 removed from service	6.22 MW Standalone Battery 70.94 MW Onshore Wind 33.8 MW Hill 5 & 6 removed from service
2028	1.25 MW Standalone Battery 4.26 MW Onshore Wind 20.5 MW Pakini Nui Wind PPA expires	20.5 MW Pakini Nui Wind PPA expires
2029	0.59 MW Standalone Battery	
2030	1.12 MW Standalone Battery 24.3 MW PV Paired	0.82 MW Standalone Battery 25.3 MW PV Paired
2031	60 MW Hamakua Energy PPA expires 0.06 MW Standalone Battery	60 MW Hamakua Energy Continues 0.09 MW Standalone Battery 0.83 MW PV Paired
2032	0.06 MW Standalone Battery	0.42 MW Standalone Battery 0.48 MW PV Paired
2033	0.32 MW Standalone Battery	0.22 MW Standalone Battery
2034	0.1 MW Standalone Battery