Hawaiian Electric

Stakeholder Technical Working Group

July 14, 2021

Agenda

- Overview and methodology of each IGP sensitivity
- Seek input on assumptions to use for each sensitivity
  - Data needs
  - Adjustments to assumptions
  - Assessing resource portfolio resilience by modeling prolonged poor weather scenarios
- Resource additions to enable unit deactivation or retirement of generating units
  - How using a unit retirement plan in the base case changes the optimization of new renewable and storage resources outside of incremental RPS compliance needs for Oahu.

Meeting Objectives

Objectives

- Finalize details of proposed sensitivities for IGP and solicit stakeholder feedback.

Key Questions

- Do modifications need to be made to the key inputs identified for each proposed sensitivity?
- Are other sensitivities needed to identify technology-neutral grid needs?
- Are additional generating unit sensitivities needed?

Areas of Consensus on DER Forecasts

- DER Schedule-R forecast contains customer groups that are not currently addressed by the available DER programs. Consideration should be given to expanding the addressable market for DER adoption, assuming that new programs would facilitate access to other segments of the market.
- Before looking at the impact that the individual forecasted layers have on the resource plan, we should look at the aggregated bookend case first to see if the resource plan changes materially.
- Makes sense to look at the 100% EV by 2045 for the high EV adoption bookend. We must think about the timing of how we get to 100% ZEV by 2045, but one idea is to just straight-line where we are now and 2045.
  - Provide additional information/explanation on the EV managed charging shapes
- Evaluate the TOU layers based on AMI rollout schedules

Parking Lot Items

- Separating DER Schedule-R forecast into individual customer types:
  - Single Family Residences
  - Multi-Family Residences
  - Rentals
- Incorporating LoadSEER needs into RESOLVE
- Modeling EVs as a selectable resource in RESOLVE
  - Defining the services EVs can provide.
- Modeling EV as a selectable resource and V2G
- Medium and heavy duty electric vehicle forecast

IGP Scenarios and Sensitivities

Base

Purpose

- Reference case established using reference forecasts

Inputs

- Distributed PV and BESS
  - Continue with the same addressable market, updated resource costs using the NREL ATB, new EDR program and DER docket proposals
- Electric Vehicles
  - Market forecast updated for Hawaii charging data
- Energy Efficiency
  - Adjusted forecast to assume a minimum energy efficiency uptake based on Business as Usual and Codes & Standards (Market) from potential study
  - AEG to provide a proposal for additional work to bundle energy efficiency measures from potential study for resource modeling
- Time of Use Rates
  - Managed EV, consider AMI rollout schedule, KIUC opt-out rate

Modeling Tools

- RESOLVE only

Stakeholder Feedback

Evaluating Bookend Impacts of Customer Technology Adoption

Faster Customer Tech Adoption Bookend

Purpose

- A scenario where customer adoption of distributed PV and BESS, electric vehicles, energy efficiency, and time of use rates is accelerated

Inputs

- Distributed PV and BESS
  - Expanded addressable market, updated resource costs using the NREL ATB, new EDR program and DER docket proposals
- Electric Vehicles
  - Updated for Hawaii charging data, 100% ZEV by 2045
- Energy Efficiency
  - Adjusted forecast to assume a minimum energy efficiency uptake based on Achievable High plus Codes & Standards from potential study
  - AEG to provide a proposal for additional work to bundle energy efficiency measures from potential study for resource modeling
- Time of Use Rates
  - Managed EV, consider AMI rollout schedule, KIUC opt-out rate

Modeling Tools

- RESOLVE only

Stakeholder Feedback

Slower Customer Tech Adoption Bookend

Purpose

- A scenario where customer adoption of distributed PV and BESS, electric vehicles, energy efficiency, and time of use rates is slowed

Inputs

- Distributed PV and BESS
  - Low uptake forecast, primarily self-consumption
- Electric Vehicles
  - Updated for Hawaii charging data, lower adoption saturation curve
- Energy Efficiency
  - Adjusted forecast to assume a minimum energy efficiency uptake using the Business As Usual from potential study
  - AEG to provide a proposal for additional work to bundle energy efficiency measures from potential study for resource modeling
- Time of Use Rates
  - No time of use rates assumed

Modeling Tools

- RESOLVE only

High Load

Purpose

- A scenario where customer adoption of distributed PV and BESS, electric vehicles, energy efficiency, and time of use rates from the customer adoption bookends is purposefully combined to lead to higher load

Inputs

- Distributed PV and BESS
  - Low uptake forecast, primarily self-consumption, same as Slow Customer Tech Adoption bookend
- Electric Vehicles
  - Updated for Hawaii charging data, 100% Zero Emissions Vehicles by 2045
- Energy Efficiency
  - Adjusted forecast to assume a minimum energy efficiency uptake using the Business As Usual from potential study
  - AEG to provide a proposal for additional work to bundle energy efficiency measures from potential study for resource modeling
- Time of Use Rates
  - No time of use rates assumed

Modeling Tools

- RESOLVE only

Stakeholder Feedback

Evaluating Potential Program Design for Distributed PV and BESS, Energy Efficiency, and Electric Vehicles

Potential Program Design

DER Freeze

__Purpose__

- Determine the value of the forecasted Base case uptake of distributed PV/BESS

__Inputs__

- Distributed PV/BESS capacity fixed at 2021 levels

__Modeling Tools__

- RESOLVE only

EV Freeze

__Purpose__

- Determine the value of the forecasted Base case uptake of electric vehicles

__Inputs__

- Electric vehicle capacity fixed at 2021 levels

__Modeling Tools__

- RESOLVE only

EE Freeze

__Purpose__

- Determine the value of the forecasted Base case uptake of energy efficiency

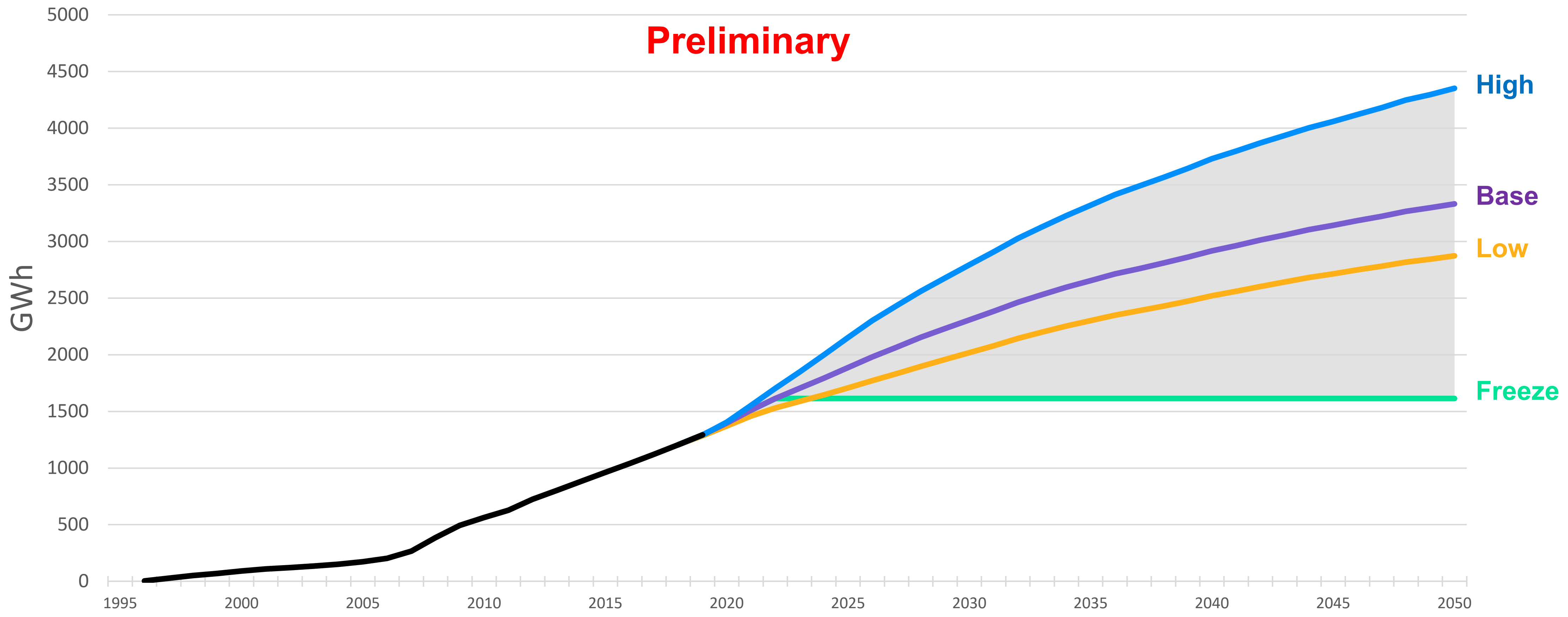
__Inputs__

- Energy efficiency capacity fixed at 2021 levels

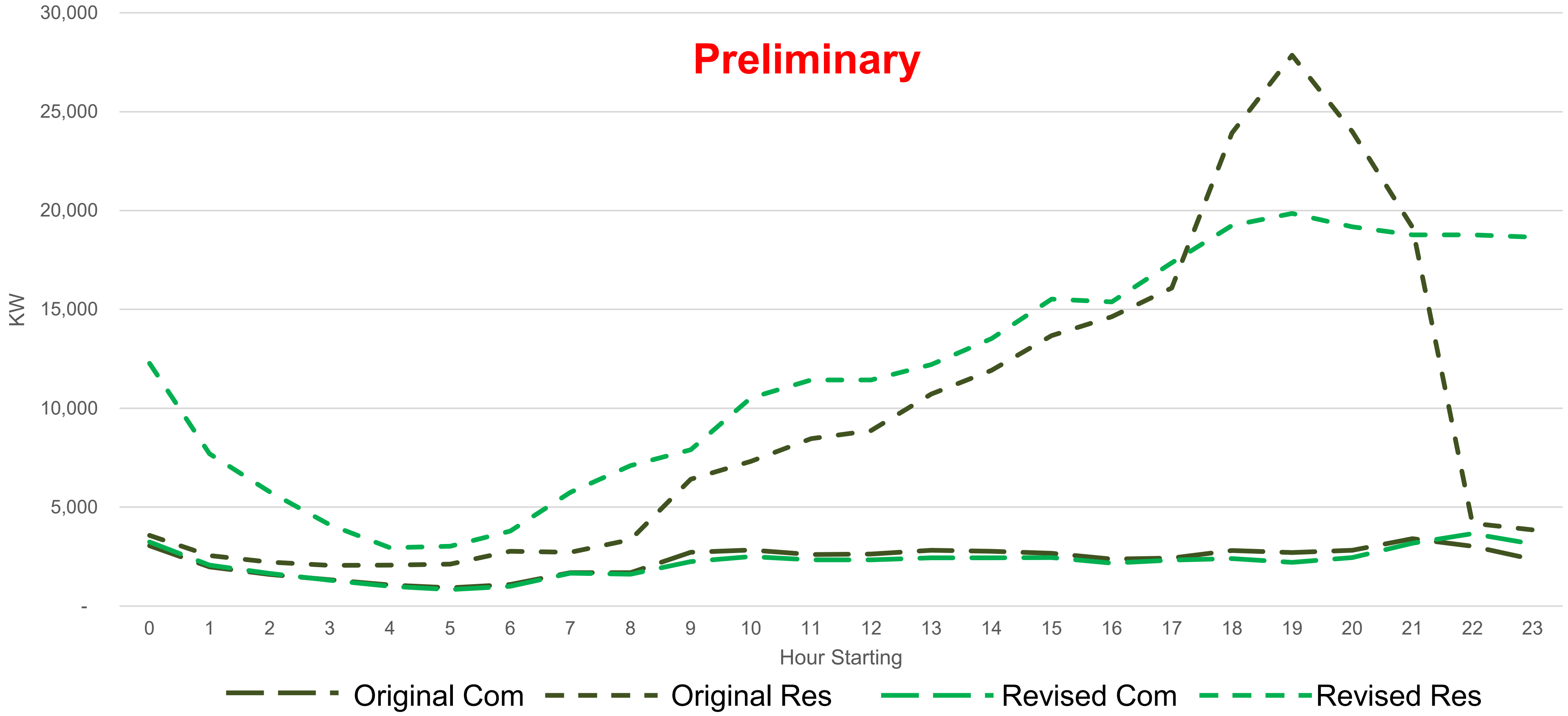
__Modeling Tools__

- RESOLVE only

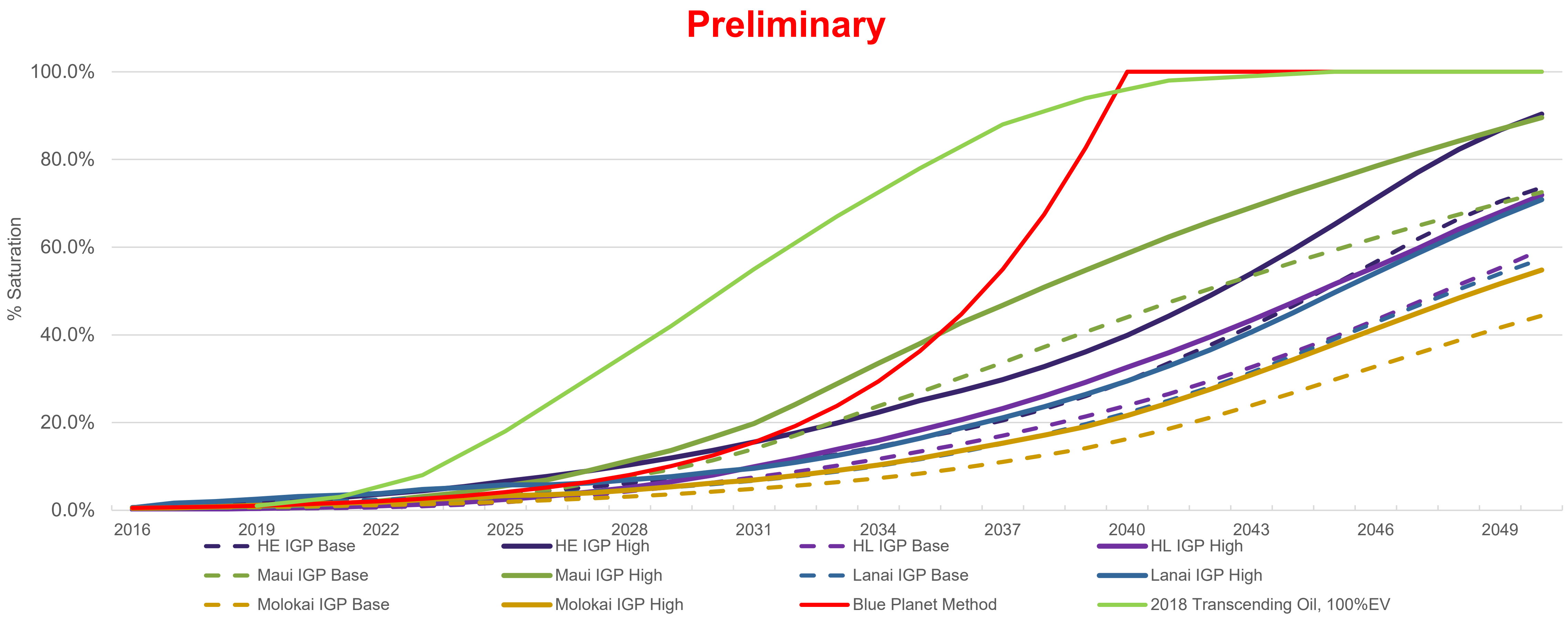
EE Forecast Sensitivities



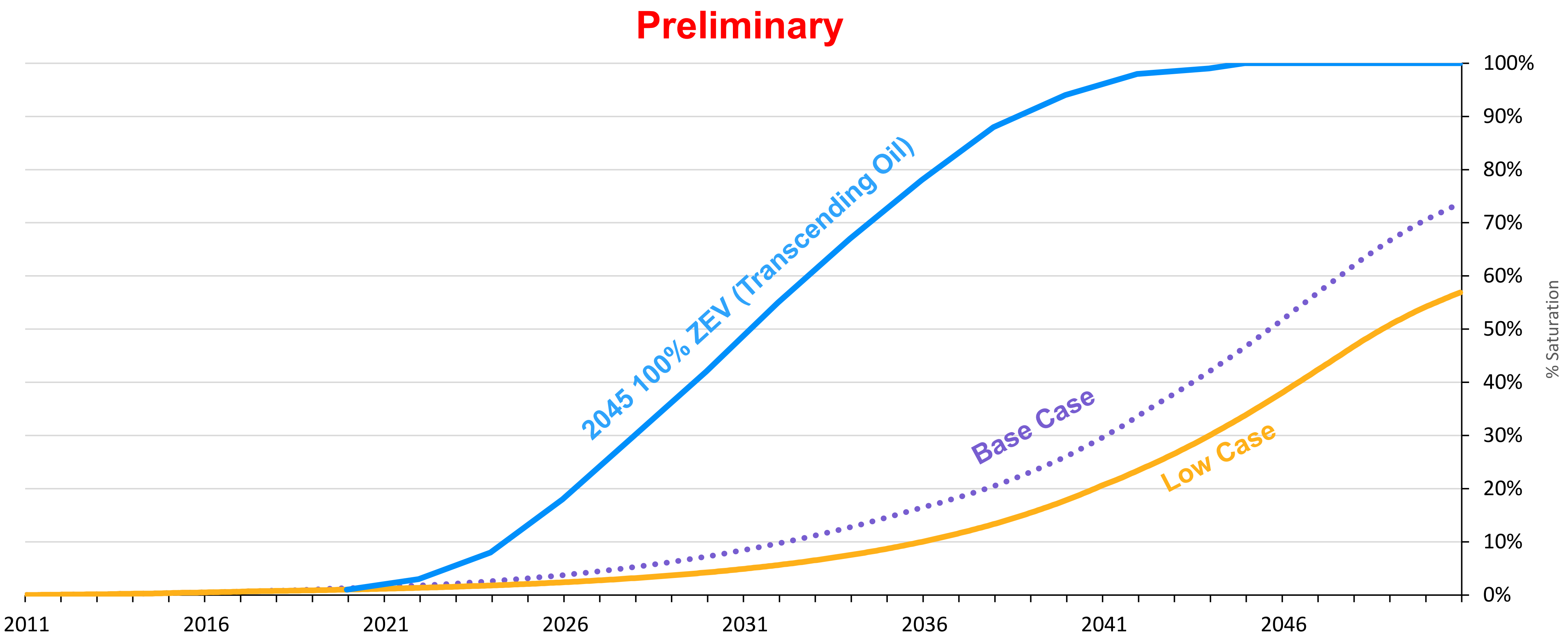
EV Charging Profile Comparison



Light Duty Electric Vehicle Saturation Comparison



EV Saturation Scenarios - Oahu



Evaluating impacts of onshore and offshore resource mixes

Onshore and Offshore Resource Mix

No Onshore Development

<u>Purpose</u>

- Determine the value of offshore resources, specifically for Oahu, if future onshore grid-scale options are limited

<u>Inputs</u>

- Base case DER forecast
- Only offshore wind will be available as a resource option

<u>Modeling Tools</u>

- RESOLVE only

No Future Transmission Infrastructure

<u>Purpose</u>

- Determine the value of additional DER above the Base case uptake

<u>Inputs</u>

- Future grid-scale resources allowed to build up to the available transmission capacity
- Base case DER forecast
- DER aggregators will be an available resource option to meet future grid needs

<u>Modeling Tools</u>

- RESOLVE only

More Offshore Wind ⟷ More Distributed PV/BESS

Other Sensitivities

No State ITC for PV

Purpose

- Determine the impact of removing the State investment tax credit for PV

Inputs

- Revised lower distributed PV/BESS uptake below the Base case forecast
- Revised higher capital costs for grid-scale and aggregator PV resources

Modeling Tools

- RESOLVE only

Low Renewable Generation

Purpose

- Stress test a resource portfolio for select time periods using low variable renewable generation based on historical production / past weather years and additional forced outage combinations

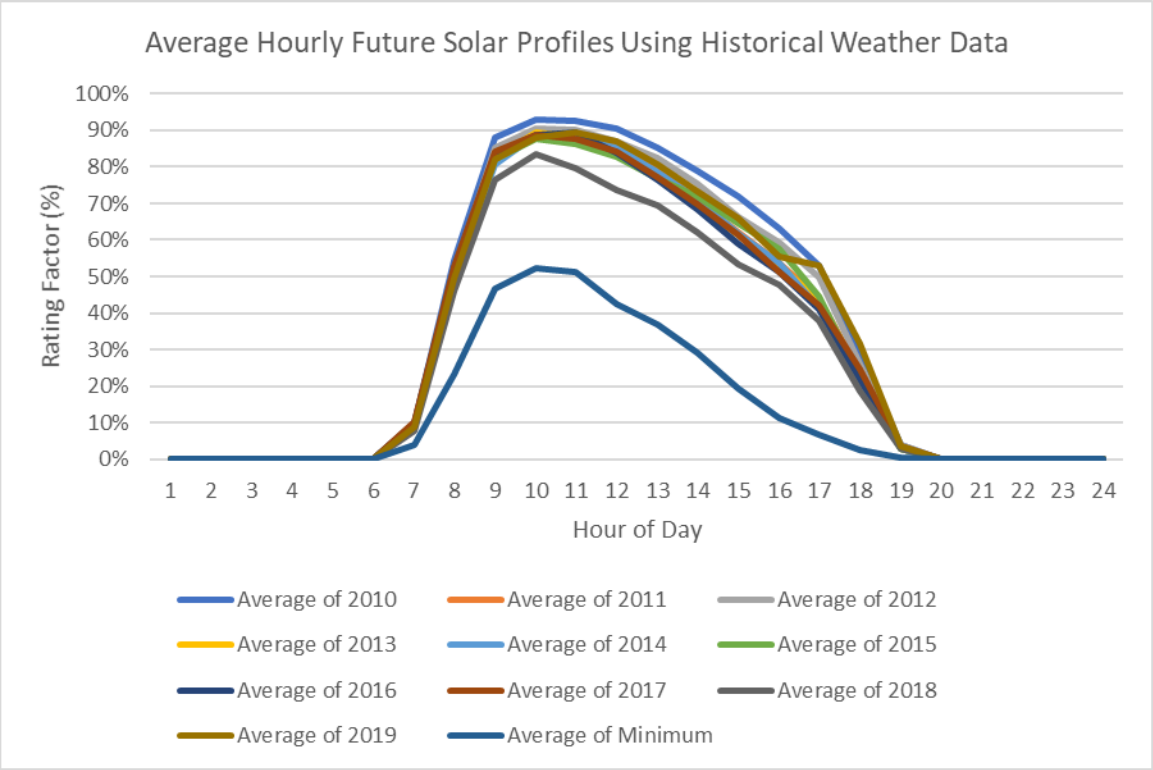
Inputs

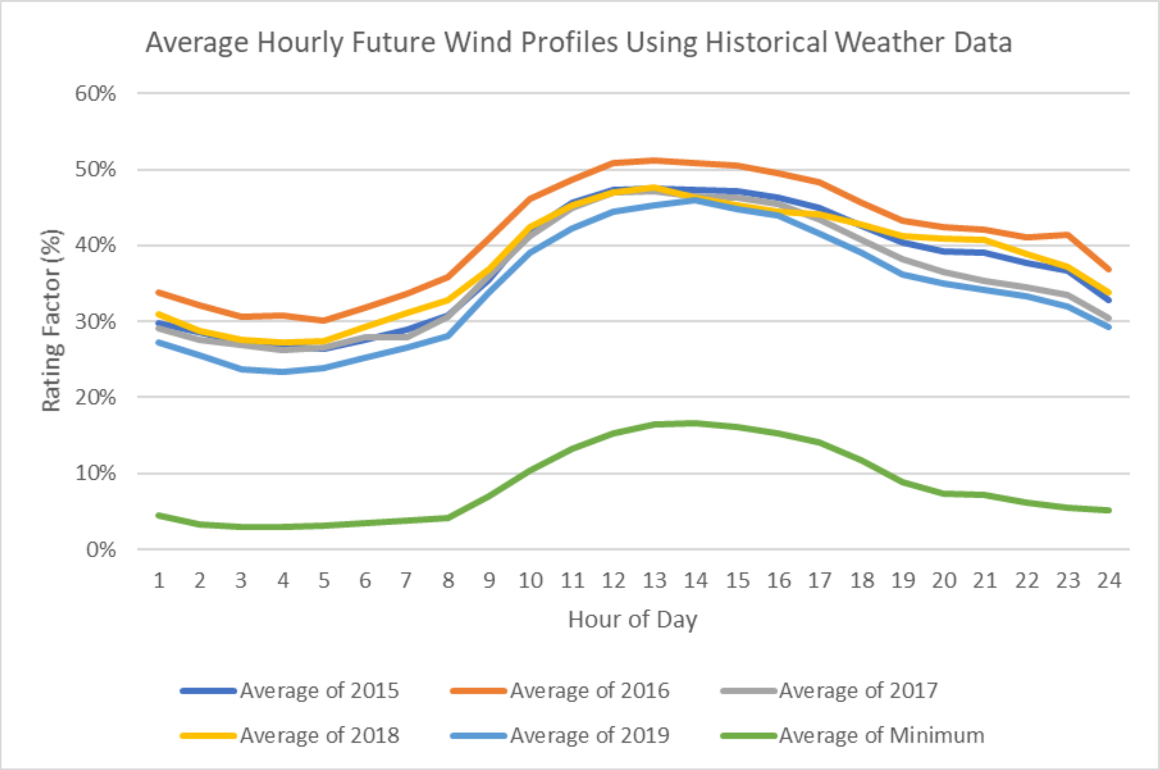
- Historical production for existing PV, wind, and hydro facilities
- Estimated production in past weather years using NREL System Advisor Model and NREL National Solar Radiation Database weather data
- Utilizing the historical and estimated production, develop minimum generation profiles to define a reasonable

Modeling Tools

- PLEXOS using a resource plan established in RESOLVE

Low Renewable Generation





High Fuel Price

Purpose

- Assess the impact to the resource plan under a high fuel price

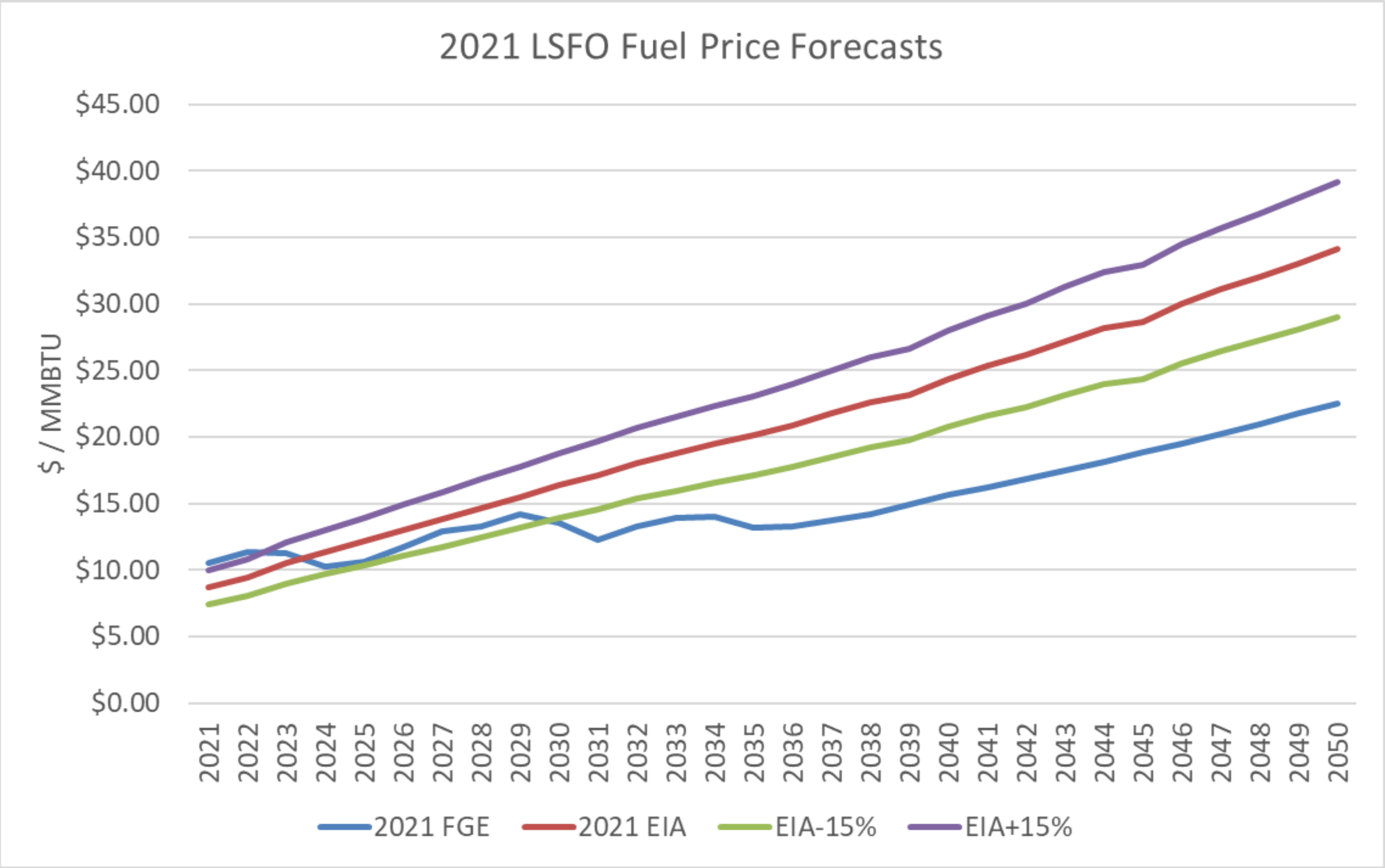
Inputs

- High fuel price forecast based on U.S. Energy Information Administration Annual Energy Outlook
- Allow thermal generating unit retirements to be optimized by RESOLVE

Modeling Tools

- RESOLVE Only

Fuel Price Forecasts



Inertia Criteria Testing

Purpose

- Assess the impact of the minimum inertia requirement on the resource plan

Inputs

- Remove the modeled minimum inertia requirement

Modeling Tools

- RESOLVE Only

Inertia Criteria Testing

Preliminary

Oahu

Year	Base	Base – Remove Inertia Requirement
2025	375 MW Solar	375 MW Solar
2029	32MW Paired 4 Hr PV 272MW Biomass	32MW Paired 4 Hr PV 272MW Biomass
2031	30MW Onshore Wind	30MW Onshore Wind
2034	139MW Paired 4 Hr PV 18MW Biomass 93MW LM6000 SCCT 15MW LM6000 2x1	139MW Paired 4 Hr PV 31MW Biomass 92MW ICE 4MW LM6000 2x1
2040	617MW Paired 4 Hr PV 69MW Onshore Wind 211MW LM6000 SCCT	725MW Paired 4 Hr PV 69MW Onshore Wind 204MW ICE
2045	426MW Paired 4 Hr PV 28MW Offshore Wind 24MW Onshore Wind 30MW 59 MWh of Standalone BESS 289MW Biomass 14MW LM6000 SCCT	893MW Paired 4 Hr PV 24MW Onshore Wind 54MW 114 MWh of Standalone BESS 117MW Biomass 161MW ICE
2050	334MW Offshore Wind 35MW 78 MWh Standalone BESS 161MW of LM6000 SCCT	354MW Offshore Wind 41MW 107 MWh Standalone BESS 160MW of ICE
NPV (2018$, $MM)	$15,772	$15,646 **(0.8% lower compared to Base)**

Hawaii Island

Year	Base	Base – Remove Inertia Requirement
2025	45MW Wind 6MW 12MWh Standalone BESS	54MW Wind 8MW 16MWh Standalone BESS
2026	3MW Wind 0.5MW 0.9MWh Standalone BESS	1MW Wind 2MW 5MWh Standalone BESS
2027	7MW 14MWh Standalone BESS	4MW 8MWh Standalone BESS
2028	4MW 9MWh Standalone BESS	4MW 9MWh Standalone BESS
2029	0.2MW Standalone BESS	0.2MW 0.2MWh Standalone BESS
2031	0.5MW Geothermal 0.4MWh Standalone BESS	0.4MW Geothermal 1.5MWh Standalone BESS
2032		0.4MW Standalone BESS
2033	0.03MW 0.1MWh Standalone BESS	0.1MW Standalone BESS
2040	9MW Geothermal 2MW 23MWh Standalone BESS	9MW Geothermal 4MW 27MWh Standalone BESS
2045	23MW Geothermal 5MW 33MWh Standalone BESS	23MW Geothermal 2MW 31MWh Standalone BESS
2050	25MW Geothermal 11MW ICE 2MW LM2500 SCCT 5MW 88MWh Standalone BESS	22MW Geothermal 15MW ICE 1MW LM2500 SCCT 4MW 72MWh Standalone BESS
NPV (2018$, $MM)	$2,103	$2,092 **(0.5% lower compared to Base)**

Maui

Year	Base	Base – Remove Inertia Requirement
2025	4 MW Synchronous Condenser 6 MW Onshore Wind	17 MW Onshore Wind
2026	6 MW Synchronous Condenser 22 MW Onshore Wind	28 MW Onshore Wind
2027	17 MW Onshore Wind	12 MW Onshore Wind
2028	2 MW Onshore Wind	2 MW Onshore Wind
2029	2 MW Onshore Wind	3 MW Onshore Wind
2032	3 MW Onshore Wind	3 MW Onshore Wind
2033	29 MW Onshore Wind	20 MW Onshore Wind
2034	1 MW Biomass	1 MW Biomass
2040	20 MW Biomass 48 MW / 192 MWH Paired PV + 4h Storage 2 MW / 12 MWH Paired PV + 6h Storage	19 MW Biomass 51 MW / 204 MWH Paired PV + 4h Storage 12 MW / 72 MWH Paired PV + 6h Storage
2045	24 MW Biomass 3 MW Synchronous Condenser 72 MW / 288 MWH Paired PV + 4h Storage	16 MW Biomass 98 MW / 392 MWH Paired PV + 4h Storage
2050	17 MW Biomass 38 MW / 152 MWH Paired PV + 4h Storage	25 MW Biomass 8 MW / 32 MWH Paired PV + 4h Storage 4 MW / 24 MWH Paired PV + 6h Storage
NPV (2018$, $MM)	$2,471	$2,405 **(2.7% lower compared to Base)**

Inertia Criteria Testing

- Thermal units continue to be selected (biomass, geothermal, CC, ICE) without a minimum inertia requirement to provide capacity for ERM, energy, and regulating reserves
- There are minimal cost differences between the cases with and without the inertia requirements
- On Oahu,
  - Lower H-constant, “lighter” internal combustion engines are selected instead of combustion turbines
  - Greater amounts of paired PV+BESS are selected
  - Less biomass is selected
- On Maui, no synchronous condensers are selected
- On Hawaii Island, the resource plan is similar with and without the inertia requirement

Energy Reserve Margin Criteria Testing

Purpose

- Assess the cost and reliability impact of lower and higher ERM target values

Inputs

- Oahu, Hawaii Island, Maui
  - Develop resource plans in RESOLVE using ERM target values of 40%, 30%, 20%, 10% and 0%
  - Develop an additional resource plan at the 30% ERM target but swap the hourly dependable capacity with the production profile
- Molokai, Lanai
  - Develop resource plans in RESOLVE using ERM target values of 60%, 40%, 20%, and 0%
  - Develop an additional resource plan at the 60% ERM target but swap the hourly dependable capacity with the production profile
- Assess the reliability and system cost of all resource plans in PLEXOS

Modeling Tools

- RESOLVE and PLEXOS

Impact of Unit Retirements

Considerations for Unit Retirements

- Actual retirement decisions are operational decisions based on a number of factors:
  - Whether sufficient replacement resources have been acquired and are in service
  - Grid services provided by the thermal units have been sufficiently replaced
    - Capacity, energy, regulating reserves, inertia, voltage, fault current, among others
  - Reliability and resilience impacts

Alignment with Ulupono / SWITCH Analysis

- In modeling analyses conducted by Ulupono, significant thermal capacity remains in 2045, with up to 300 MW of new combined cycle generation when use of Class B and C Ag lands is limited to at most 1.8%
- Ulupono is currently using the same retirement schedule as Hawaiian Electric (based on the age of the unit)

2045 Resource Capacity—0 to 30% Slope

Resources Type and Amount of Capacity (MW)

Scenarios	Thermal	Batteries	Hydro	Utility -Scale Solar	Distributed Solar	Onshore Wind
Unrestricted (100% Use of B and C Lands)	973	1,219	150	3,497	1,432	150
10% Use of B and C Lands	973	1,210	150	3,456	1,432	150
Current Use (1.8% Use of B Lands and 1.1% Use of C Lands)	1,124	1,339	150	3,361	1,432	150

https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/igp_meetings/20210618_igp_stakeholder_council_switch_analysis_slides.pdf

Generator deactivation/retirement assumptions, provided adequate replacement resources are available

- The removal from service schedules assume that adequate replacement resources can be installed in a timely manner to facilitate the generating units' removal, and operational utilization of the unit is minimal.
- The schedules are intended to be initial assumptions that may be iterated upon through the IGP modeling process.
- Generating units may also be modified or re-purposed as synchronous condensers

Island	O‘ahu	Hawai‘i Island	Maui
2024	Waiau 3-4 Removed from Service		
2025		Puna Steam Removed from Service	
2027	Waiau 5-6 Removed from Service	Hill 5-6 Removed from Service	
2029	Kahe 1-2 Removed from Service		
2030			Maalaea 4-9 Removed from Service
2033	Waiau 7-8 Removed from Service		
2037	Kahe 3-4 Removed from Service		
2046	Kahe 5-6 Removed from Service		

Discussion and Next Steps

- Key Questions
  - Do modifications need to be made to the key inputs identified for each proposed sensitivity?
  - Are other sensitivities needed to identify technology-neutral grid needs?
  - Are additional generating unit sensitivities needed?
- Past Meeting Materials: https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning
- Next Meeting July 16, 2021, 9 am HST.