Hawaiian Electric

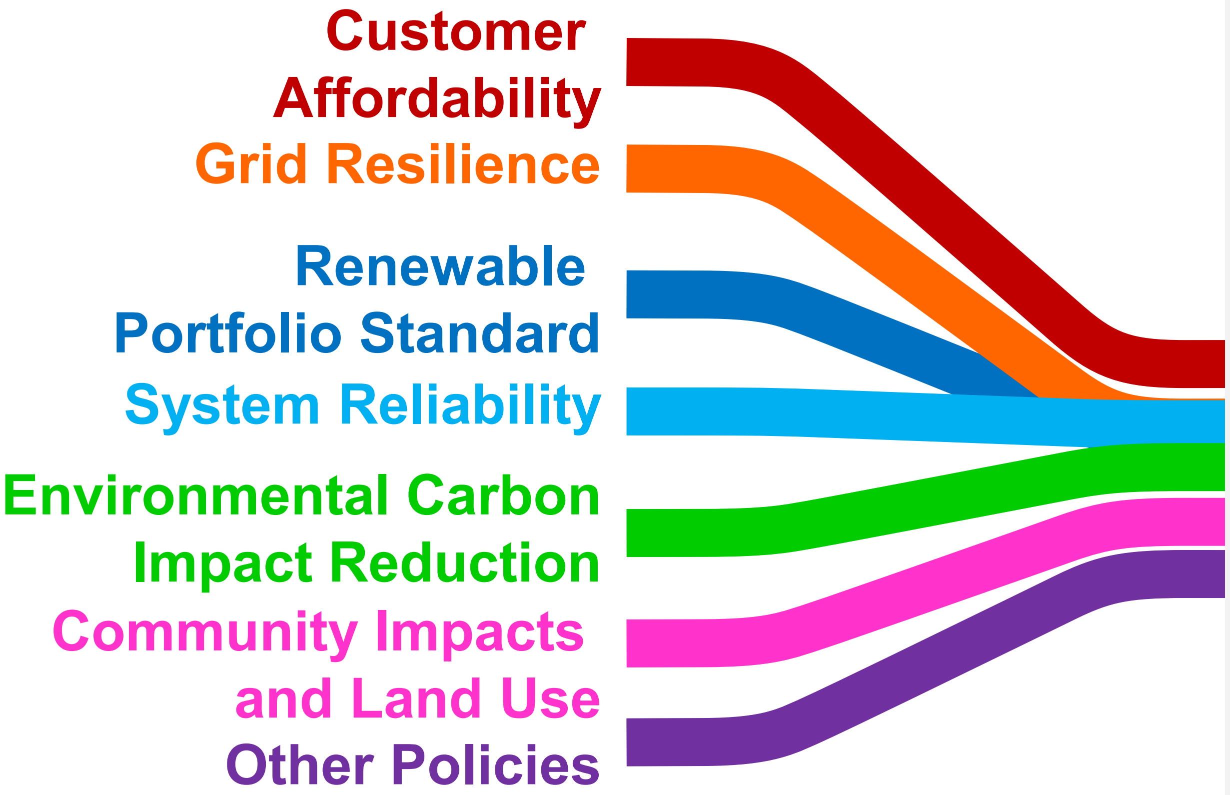
Integrated Grid Planning ("IGP")
Docket No. 2018-0165
PUC Technical Conference

June 4, 2021

IGP Commitment

- The Company remains focused on customer affordability, decarbonization and resilience - important dimensions of system planning
- The Company recognizes the important role of distributed resources to achieve Hawaii's goals
- The Company is committed to meaningfully incorporate stakeholder feedback throughout the IGP process
  - The Company has made refinements to the stakeholder process to ensure robust stakeholder discussion and feedback
  - Many comments received have been addressed - focus now is on the remaining few items highlighted by the Commission
- Hawaii is at the forefront of decarbonization and the utilization of distributed resources at scale in island systems – this continues to require breaking new ground collectively

Key IGP Objectives and Stakeholder Questions



- Are the IGP assumptions (and application of assumptions) appropriate, relevant and reasonable for the IGP planning process?
- Do the IGP modeling methods, scenarios and plan options robust and ultimately result in a robust action plan?
- Is Hawaiian Electric reasonably planning for the future of Electrification?
- What are Hawaiian Electric’s reliability and resilience needs, and how are these maintained as generators age and retire and intermittent renewable energy resources, and energy storage, increase?
- How can IGP improve the effectiveness of DER resources?
- What improvements should the Utility and development partners consider to engage affected communities to ensure project success?
- How should the IGP and key foundational proceedings such as, Performance Based Regulation (PBR), Distributed Energy Resource (DER) and other dockets be aligned and integrated?

Developed by Stakeholder Council

The Company have been meeting with stakeholders to incorporate their feedback on the four deep dive areas.

Energy Efficiency	Recap of the two meetings held with AEG regarding energy efficiency modeling.
Resource and Fuel Cost Forecasts	Met with Ulupono Initiative regarding their feedback to use NREL ATB cost forecasts and EIA fuel cost forecasts. Provide next steps on adjusting resource and fuel cost forecasts.
DER and Load Forecasts	Recap of discussions from June 2, 2021 STWG meeting on bookend scenarios and updated DER forecasts assumptions based on best estimates.
Planning Criteria	Met with stakeholders and Ulupono Initiative to discuss the four modeling suggestions. Recommendations were made to the TAP for their independent review. Recap discussions with the TAP.
Technical Advisory Panel	Reached out to NREL based on the list provided by Ulupono for additional TAP members. Held an initial discussion, NREL needed time to think about the time commitment.

Stakeholder & TAP input continues to be reflected in IGP

- General consensus on sales and peak forecasts, incorporated Forecast Assumptions Working Group feedback
- Filed stakeholder comments acknowledged EV forecast and treatment of managed and unmanaged charging are reasonable
- Working groups, Stakeholder Council and TAP reviewed sensitivities and scenarios.
  - Many DER sensitivities, including the DER Freeze, were modeled in the DER Docket for grid services
- TAP previously reviewed regulating reserve definitions. The Company incorporated additional analyses to examine different time durations and confidence intervals
- TAP indicated prudency of transitioning to a reliability planning criteria that uses a new methodology that evaluates all hours of the year and chronological operations of the grid (Energy Reserve Margin)

Earlier Stakeholder Feedback Incorporated into March 4, 2021 Input & Assumption Reply Comments

Increased Transparency

Provided workbook of model inputs and assumptions and 8760 profiles/data for each forecast layer

High and Low Bookend Sensitivity

Add bookends scenarios to test a range of customer technology adoption: PV, BESS, EV, EE, TOU rates. Estimate best guess of future program/rate design.

Resource Costs and New Resource Options

- Dec 2020 IHS Markit update for grid-scale and distributed PV, onshore wind, and Jan 2021 update for utility and distributed storage.
- Latest 2020 Annual Technology Baseline ("ATB") to update geothermal, biomass, and concentrated solar power and future trendlines for CTs, ICE, municipal solid waste, and synchronous condensers
- NREL-State Energy Office study for offshore wind costs
- Add residential PV+BESS as a supply side resource option that can export energy, provide grid services

Wind/Solar Resource Potential

Re-engaged NREL to model an additional scenario to modify assumptions on slope, land exclusions, minimum wind speed, minimum parcel size and array density

Generation Unit Retirements

A fossil generation retirement plan will be provided for O'ahu to reduce the risk of an aging generation fleet and to assess the impact of accelerating renewable resource development.

The Company is committed to adjusting inputs & assumptions in the 10 areas highlighted by the Commission

1/2 Adjust resource/technology cost projections; Adjust its fuel price forecasts;

3 Adjust and better explain its DER and load forecasts;

4 Qualitative and quantitative summaries of LoadSEER findings and disaggregated location-specific load forecasts;

5 Results of the probabilistic DER hosting capacity analysis from the Synergi circuit models;

6 Demonstrate how LoadSEER forecasts will inform the scenarios established using the "bookends“ approach;

7 Develop a retirement schedule for the baseline forecast;

8 Further develop and clearly explain modeling sensitivities;

9 Better explain and analytically support grid services and planning criteria;

10 Work with AEG to develop modeling inputs for energy efficiency.

The Company will collaborate with stakeholders through WG meetings to refine details of the 10 areas identified by the Commission

1 Apr 27	**Modeling Methods**	Overview of modeling methods and planning criteria proposed by Ulupono Initiative
2 Jun 2	**Modeling Methods and Planning Criteria And Sensitivities**	Further clarify the modeling process proposed in IGP; Discuss the day sampling methodology; Review the planning criteria and ancillary service rules; Bookend Scenario Overview; and DER forecasts inputs
3 TBD	**DER Forecasts and LoadSEER Modeling**	Finalize recommendations for bookend sensitivity assumptions; Provide stakeholders information on the purpose of the LoadSEER model and how it is used to inform DER forecasts; Review EV charging assumptions
4 TBD	**Scenarios and Sensitivities**	Seek feedback on inputs and assumptions to be used for each proposed sensitivity; discuss generator unit retirement scenarios
5 TBD	**Resource Cost and Fuel Forecast**	Review resource and fuel cost forecasts presented at Technical Conference; Review results of additional NREL resource potential study and Renewable Energy Zones

Stood up the stakeholder technical working group to workout details of inputs and assumptions in collaboration with stakeholders

Various avenues to receive stakeholder feedback & technical review

STWG

Stakeholder Technical Working Group

Industry stakeholders and subject matter experts. Solicit feedback, provide opportunities for stakeholders to present, vet modeling methods grid needs assessments, etc.

Merged w/ STWG
Distribution Planning
Forecasting Assumptions
Competitive Procurement
Standardized Contract

SC

Stakeholder Council

Represents a broad cross section of stakeholders. Provide guidance on strategic issues.

TAP

Technical Advisory Panel

Technical experts and independent review of technical challenges facing company planning and operations

Public

Public

Community and customer engagement on IGP plans as well as specific projects

RWG

Resilience Working Group

Define resilience, identify threats and critical customers, provide feedback on resilience solutions

The Company will also further engage stakeholders outside of formal WGs to seek additional clarification and feedback

Several interrelated dockets must be coordinated with IGP

DER Docket development and valuation of DER Programs, including decision on export constraints (and grid upgrades)

Big Island Stage 3 RFP in developing the scope of the Grid Needs

CBRE Docket, including whether program will be expanding without BESS

Resource additions to enable retirement of fossil generation

Direct and Immediate Impacts to Grid Needs Assessment – Inputs and Assumptions related to these topics should be decided before starting grid needs assessment.

IGP
Inputs and Assumptions

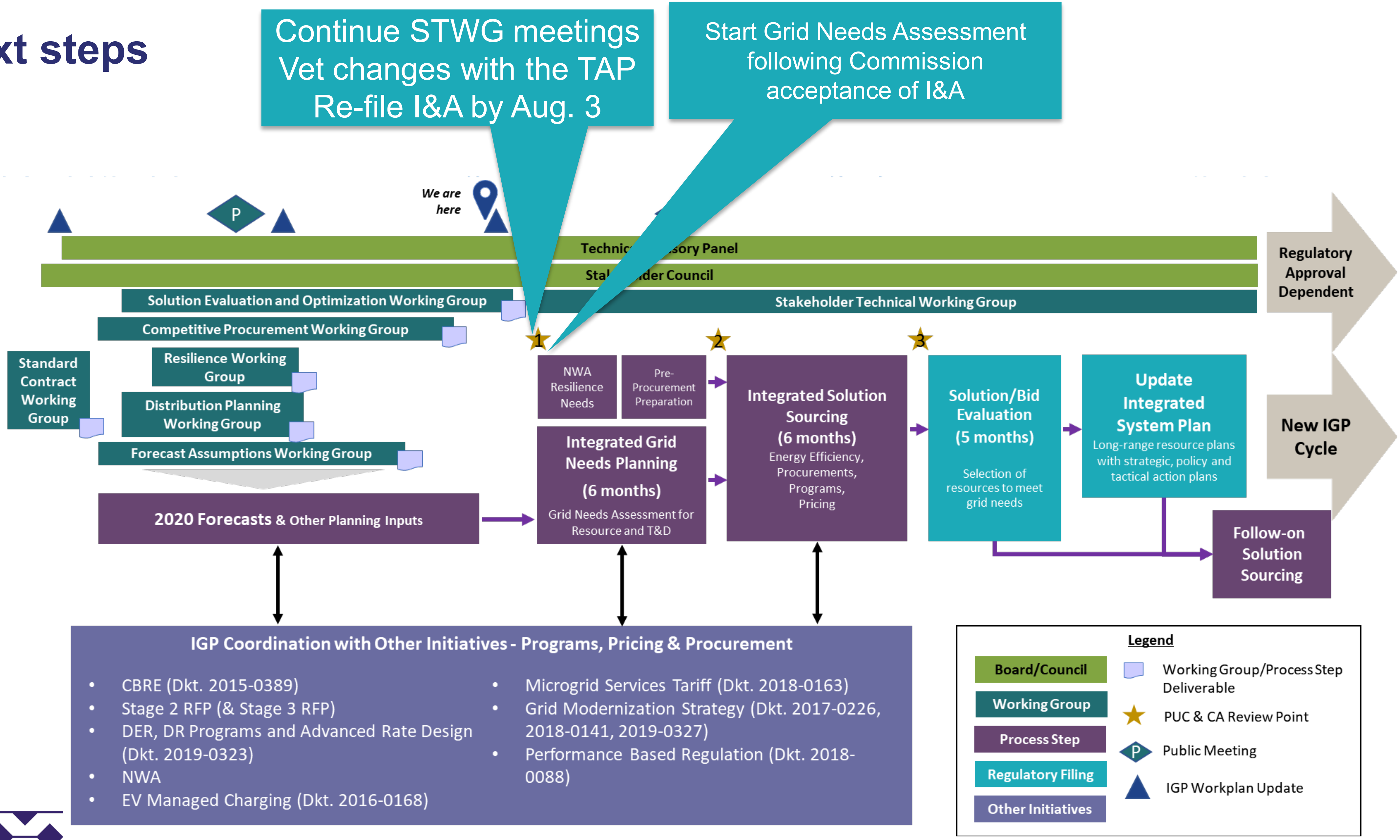
EOT Roadmap Updates or Updates to EOT Programs

Unapproved Stage 2 PPA Applications

Other upcoming proceedings? Green Tariff? Microgrid Services?

Lessor Impact or Impact TBD

Next steps



Continue STWG meetings
Vet changes with the TAP
Re-file I&A by Aug. 3
Start Grid Needs Assessment following Commission acceptance of I&A
We are here
P
Technic… …sory Panel
Stal… …der Council
Solution Evaluation and Optimization Working Group
Stakeholder Technical Working Group
Competitive Procurement Working Group
Standard Contract Working Group
Resilience Working Group
Distribution Planning Working Group
Forecast Assumptions Working Group
2020 Forecasts & Other Planning Inputs
1
2
3
NWA Resilience Needs
Pre-Procurement Preparation
Integrated Grid Needs Planning
(6 months)
Grid Needs Assessment for Resource and T&D
Integrated Solution Sourcing
(6 months)
Energy Efficiency, Procurements, Programs, Pricing
Solution/Bid Evaluation
(5 months)
Selection of resources to meet grid needs
Update Integrated System Plan
Long-range resource plans with strategic, policy and tactical action plans
Regulatory Approval Dependent
New IGP Cycle
Follow-on Solution Sourcing
IGP Coordination with Other Initiatives - Programs, Pricing & Procurement
• CBRE (Dkt. 2015-0389)
• Stage 2 RFP (& Stage 3 RFP)
• DER, DR Programs and Advanced Rate Design (Dkt. 2019-0323)
• NWA
• EV Managed Charging (Dkt. 2016-0168)
• Microgrid Services Tariff (Dkt. 2018-0163)
• Grid Modernization Strategy (Dkt. 2017-0226, 2018-0141, 2019-0327)
• Performance Based Regulation (Dkt. 2018-0088)
Legend
Board/Council
Working Group
Process Step
Regulatory Filing
Other Initiatives
Working Group/Process Step Deliverable
PUC & CA Review Point
Public Meeting
IGP Workplan Update

9:50am: Deep Dive 1: Energy Efficiency Modeling

Energy Efficiency

- On May 20, the Company met with Applied Energy Group, 2050 Partners, and Hawaiʻi Energy to begin initial discussions on the data needed to model energy efficiency on a comparable basis to other supply side options.
  - The potential study would need to be updated to model energy efficiency on the supply side; the supply curves are a derivation of this work.
  - Applied Energy Group, 2050 Partners, and Hawaiʻi Energy noted that this was not part of their current scope of work and funding would be needed to develop the specific modeling inputs.
  - Some of the terminology between the resource planning and potential study will need to be reconciled to ensure that the data inputs meet the modeling needs.

Energy Efficiency

- On June 1, the Company met with Applied Energy Group to continue discussions on the data needed to model energy efficiency as a supply side option.
  - The current potential study represents 85-90% of the work needed to develop supply curves
  - Further discussions are needed to determine how the efficiency measures are bundled to create the supply curves for all 5 islands
  - Clarity needed whether energy efficiency includes other resources beyond traditional demand side management such as demand response and distributed PV and battery systems.
  - AEG is developing a scope of work and costs for the incremental work needed to develop the energy efficiency supply curves

Energy Efficiency

- The market forecast is based on the Statewide Market Potential Study prepared by AEG[1]
- Uses the achievable Business as Usual and Codes & Standards potential forecast by island for 2020-2045
- Forecast was extended thru 2050 using trends in AEG's forecast
- Further adjustments were made to exclude free riders from the energy savings estimates (assumed to be embedded in the underlying forecast) and ramp the annualized impacts by month for each forecasted year

[1] See February 25, 2020 EEPS TWG Meeting, https://622c4de9-1fe4-418c-ac8a-695cbe1a8f60.filesusr.com/ugd/0c9650_647db07744d248fab7a9f563cf5b416d.pdf

Hawaiian Electric

11:10am: Deep Dive 2: Resource Cost and Fuel Price Projections

Fuel Price and Resource Cost Forecast Discussion with Ulupono

- On May 27, the Company and Ulupono met to discuss the fuel price and resource cost forecasts as part of the inputs and assumptions for IGP.
  - For the fuel price forecasts, comparisons between the FGE and EIA forecasts were shared. In discussing the merits of both forecasts, one suggested approach was to use the EIA reference as a high forecast and the FGE forecast as the low forecast if there was a wide enough spread between the two forecasts. There was general agreement that the EIA high forecast was not reasonable. The final resource plans could be tested across multiple fuel price forecasts, but it would be better to develop the plans using fewer fuel price forecasts to limit the number of iterations.
  - For the resource cost forecasts, comparisons between the IHS based and NREL ATB based forecasts were shared. It was noted that the near term levelized costs for PV-storage was higher than recent procurements. A proposed method to reconcile the forecasts was to align the near-term forecast in real dollars to actual projects, then allow the forecast trend to determine the future costs.
- To further discussions on the fuel price and resource cost forecasts,
  - FGE will compile the historical record of FGE forecasts and EIA forecasts to compare their performance against actuals
  - The Company will share the resource cost forecast updates in real dollars to better understand the technology cost trend in the NREL ATB

Resource Cost Forecasts

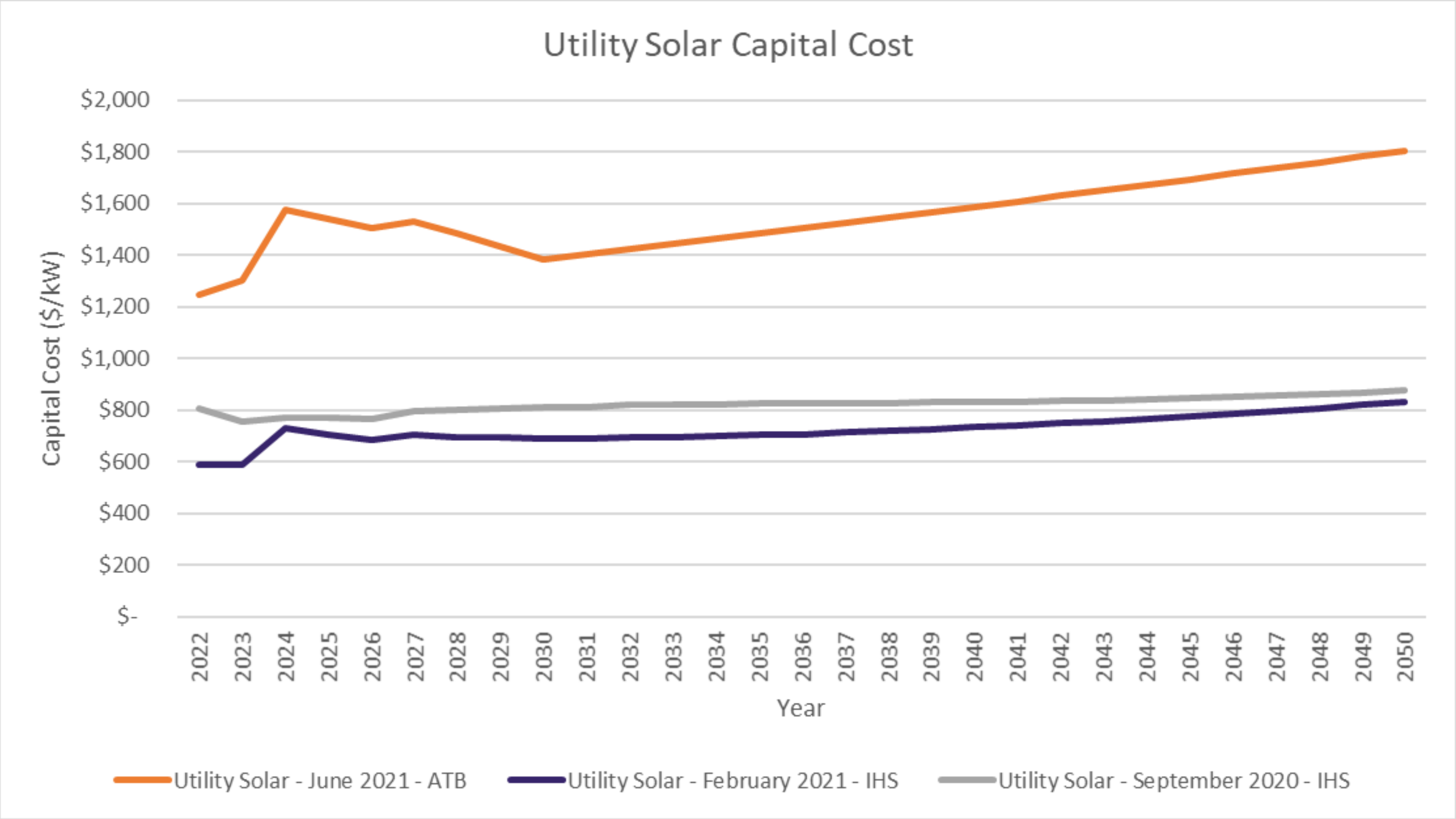
Data Source	Technology
U.S. Department of Energy	• Distributed Wind
National Renewable Energy Laboratory	• Geothermal • Biomass • Offshore Wind
U.S. Energy Information Administration	• Waste-to-energy
IHS Markit	• Grid-scale PV[1] • Distributed PV[1] • Onshore Wind[1] • Grid-scale storage[1] • Distributed storage[1,2]
Hawaiian Electric	• ICE • Pumped storage hydro
General Electric	• CT and CC[1]
Siemens	• Synchronous condenser[1]

- Start with a data source that provides a forecasted cost for the candidate technology
- Apply location adjustment factors to bring the forecasted cost to Hawai‘i
- Apply any applicable Federal and State investment tax credits as a reduction in the technology cost
- Apply a long-term trend to forecasted costs that are point estimates

[1] Proprietary cost estimates provided by IHS, General Electric, and Siemens have been replaced by cost estimates from the NREL ATB

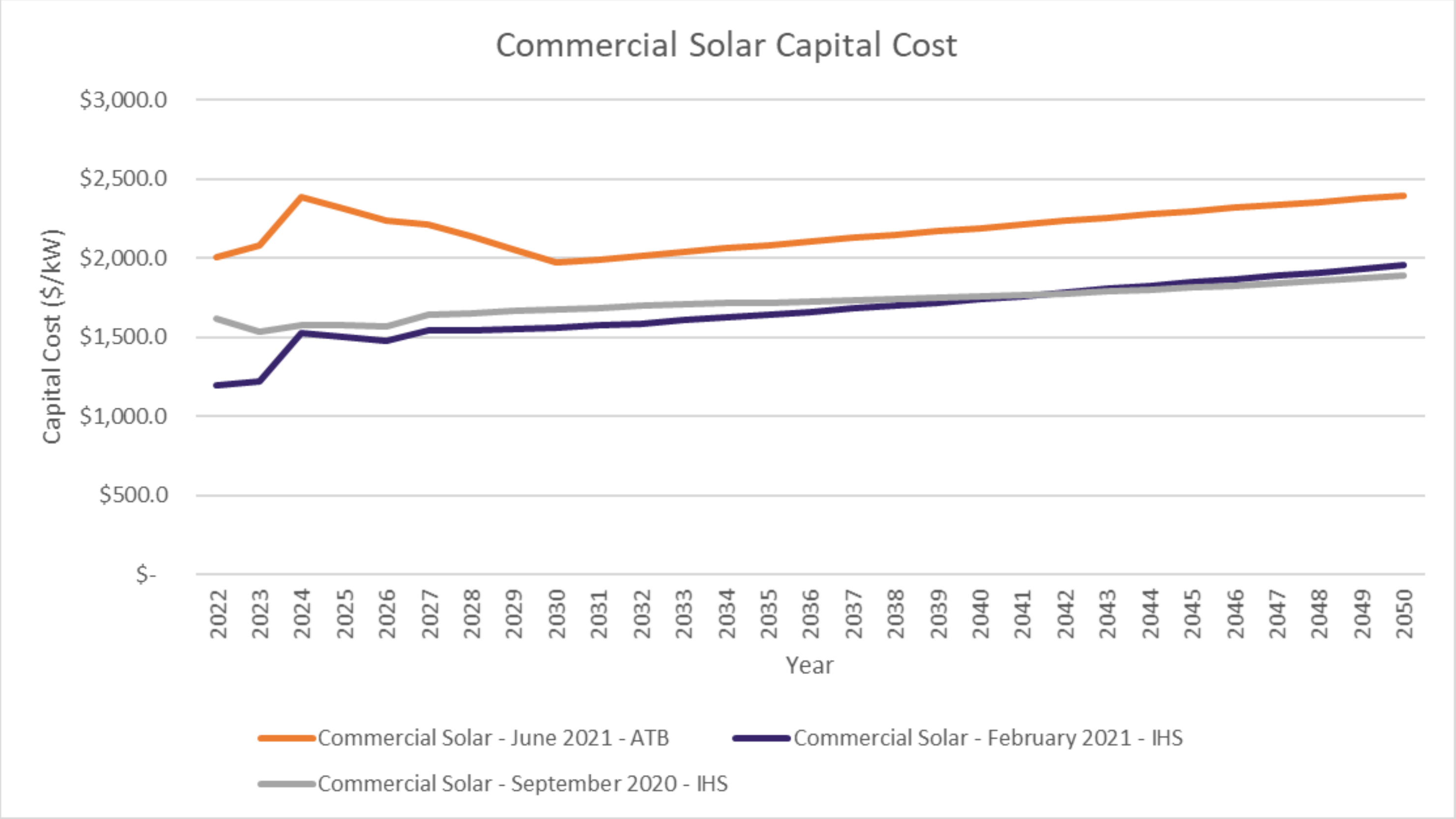
[2] NREL ATB does not provide a cost estimate specifically for distributed storage

Updated Utility Solar Costs



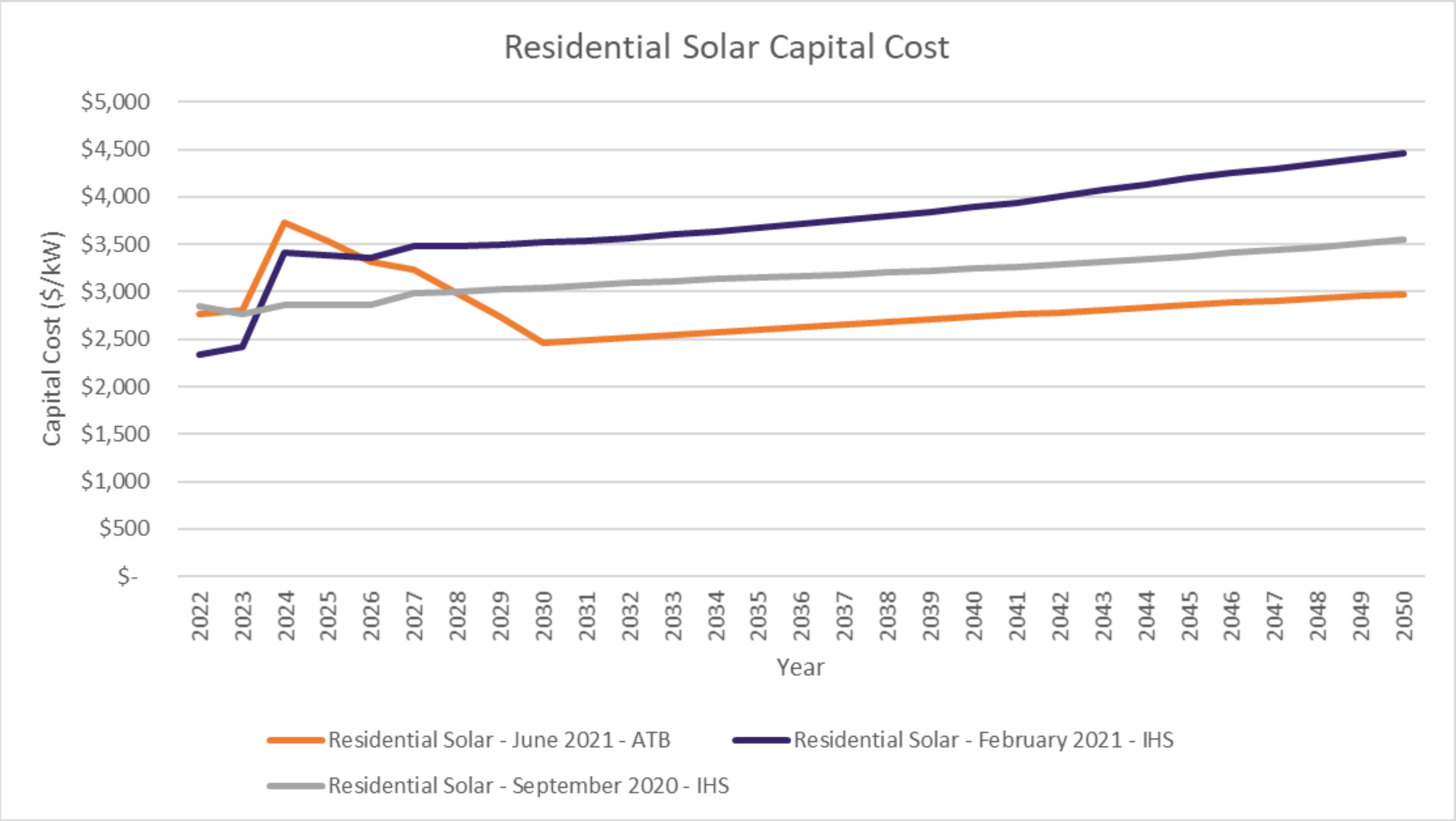
- Current forecast based on ATB forecast for Utility Solar
- Previous forecast based on IHS forecast for Utility Solar

Updated Commercial Solar Costs



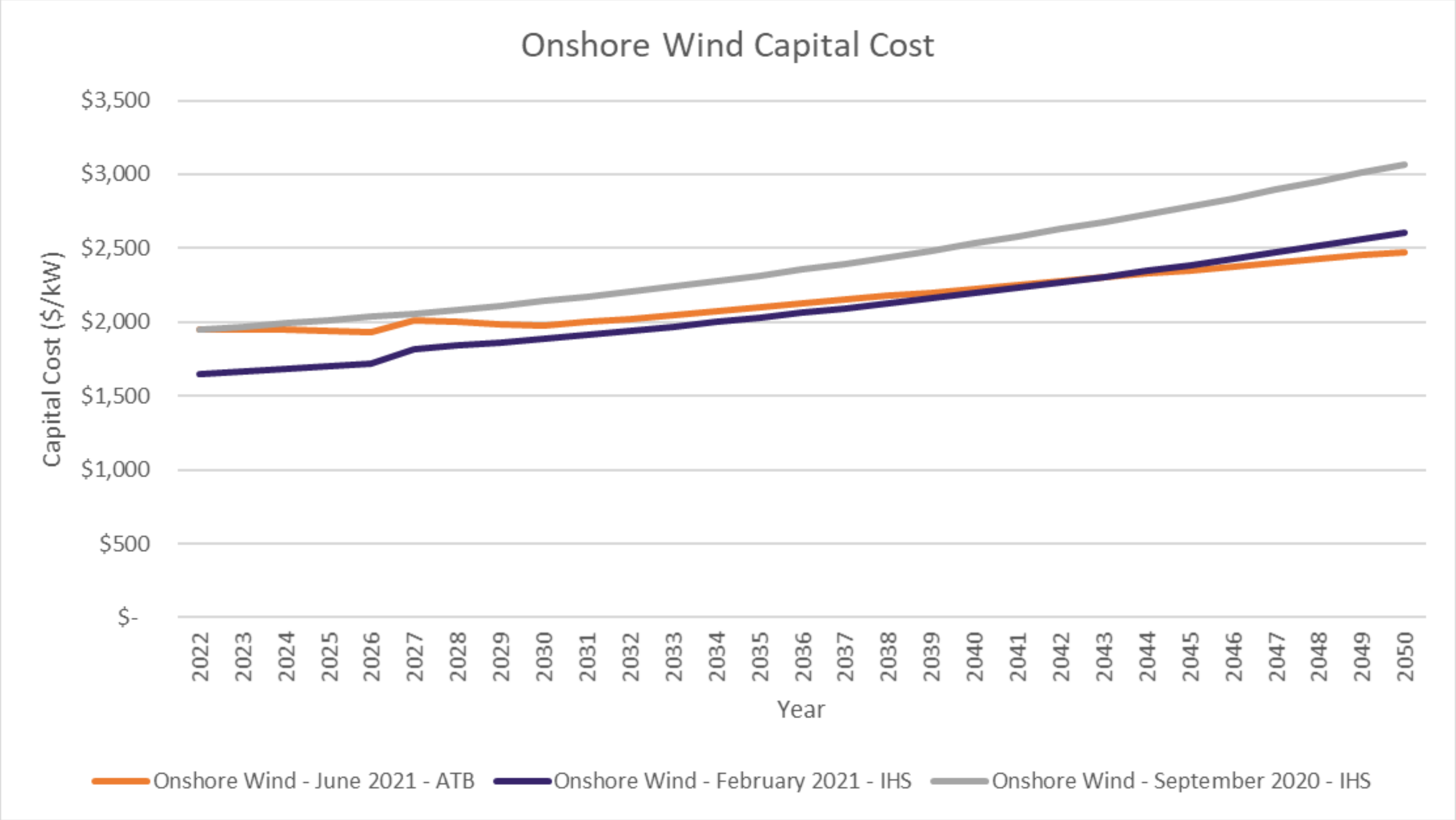
- Current forecast based on ATB forecast for Commercial Solar
- Previous forecast based on IHS forecast for Commercial Solar

Updated Residential Solar Costs



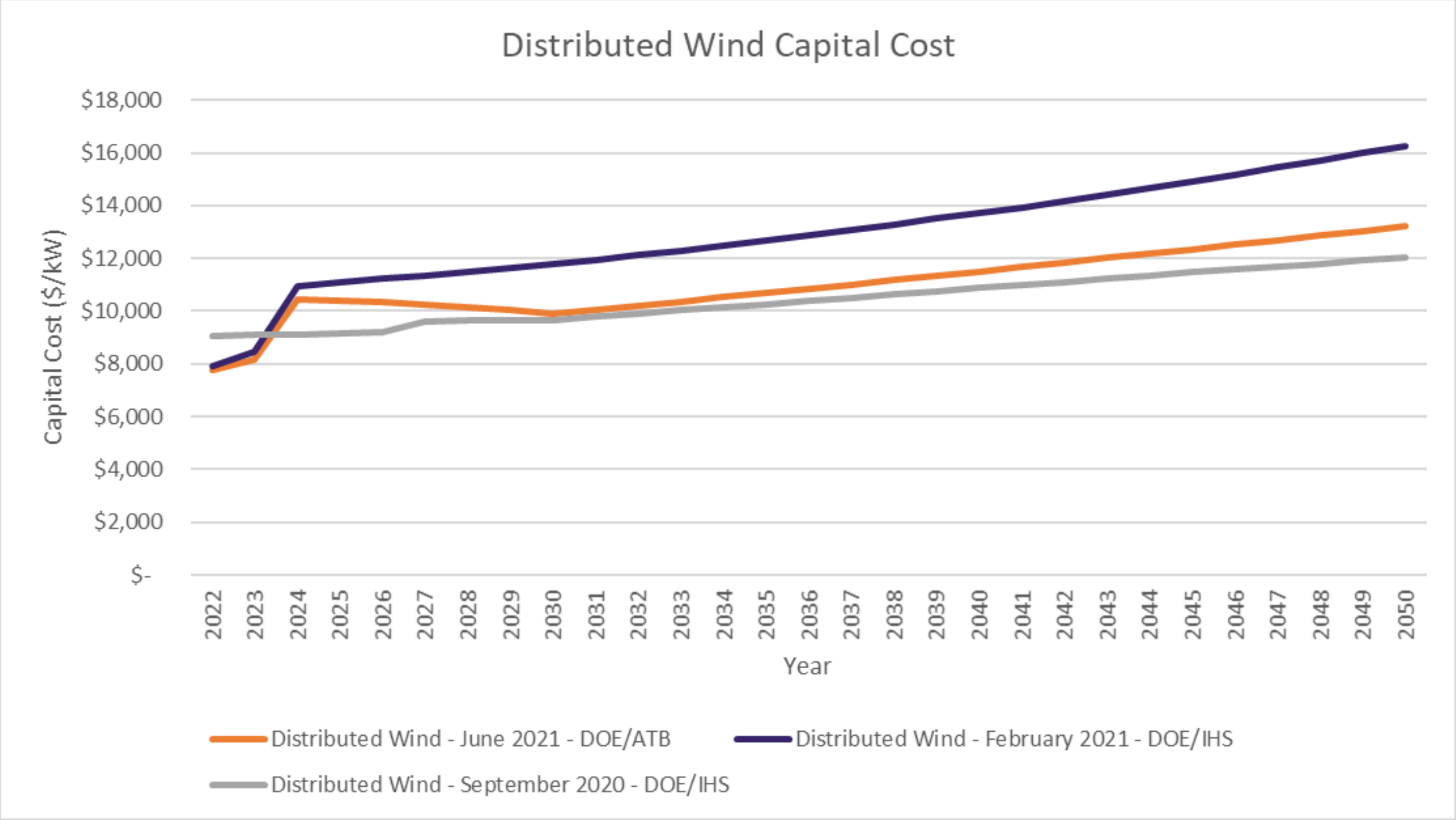
- Current forecast based on ATB forecast for Residential Solar
- Previous forecast based on IHS forecast for Residential Solar

Updated Onshore Wind Costs



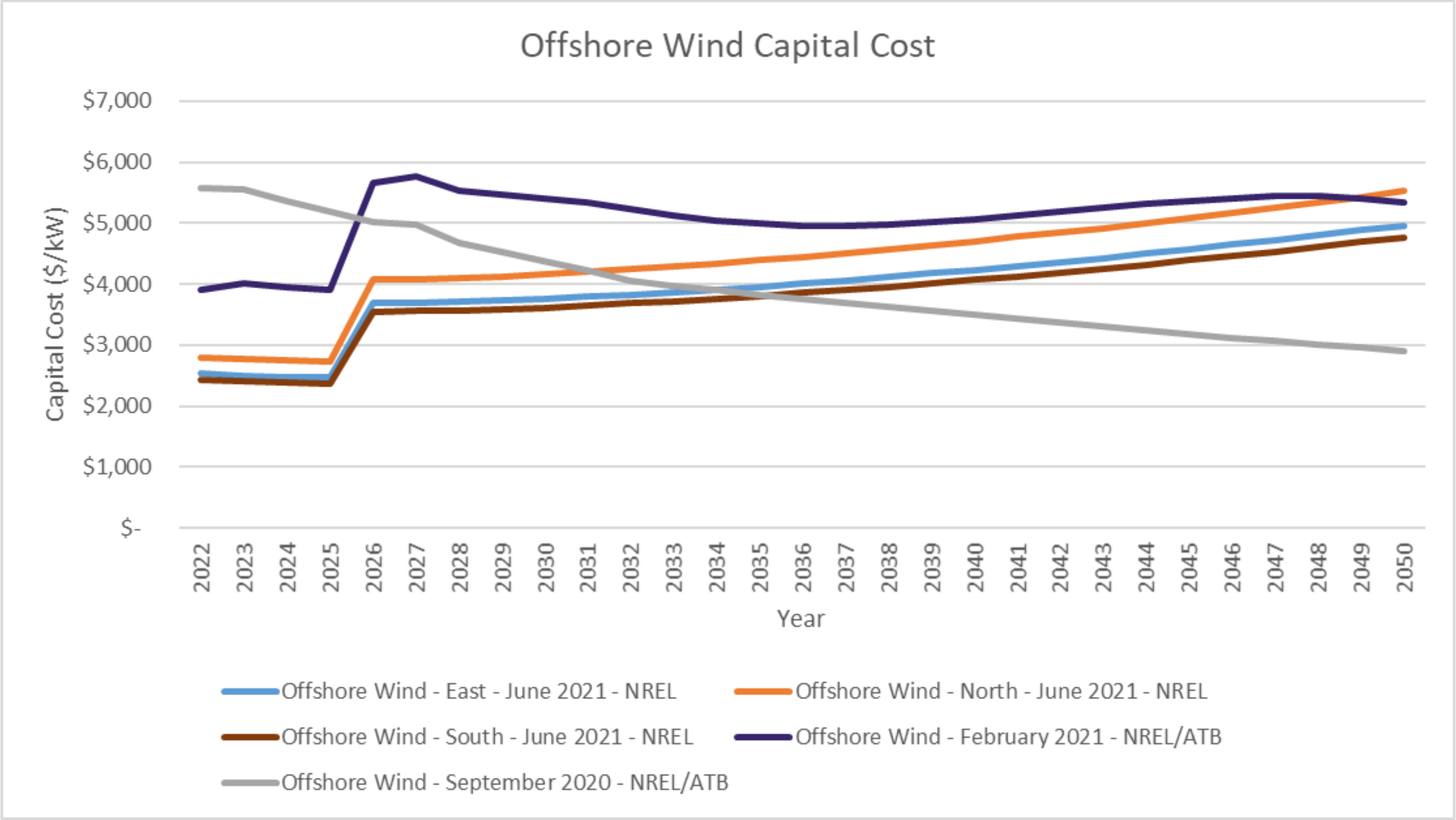
- Current forecast based on ATB forecast for Land-Based Wind
- Previous forecast based on IHS forecast for Onshore Wind

Updated Distributed Wind Costs



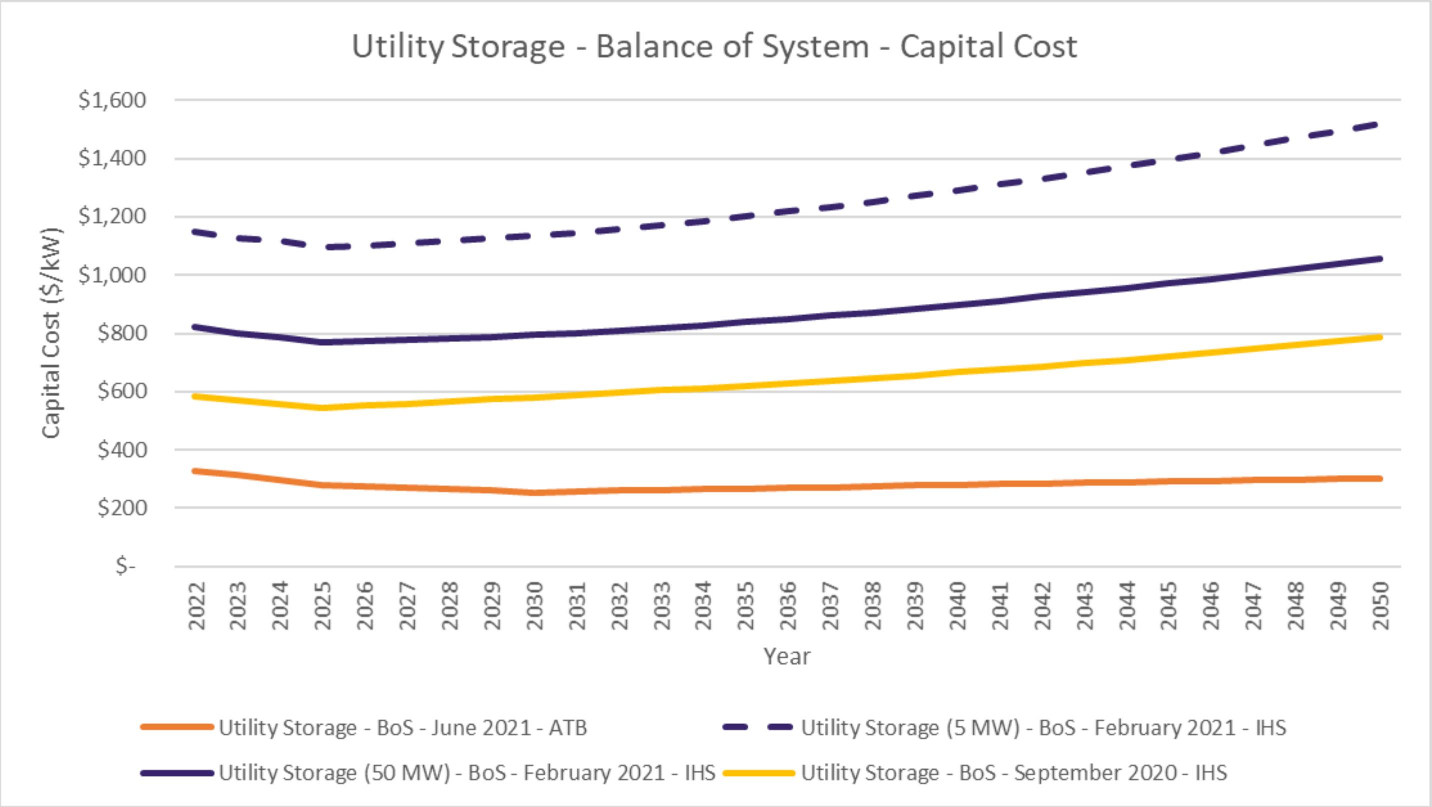
- Current forecast based on US DOE 2017 Distributed Wind Market Report with ATB trend for Land-Based Wind applied
- Previous forecast based on US DOE 2017 Distributed Wind Market Report with IHS trend for Onshore Wind applied

Updated Offshore Wind Costs



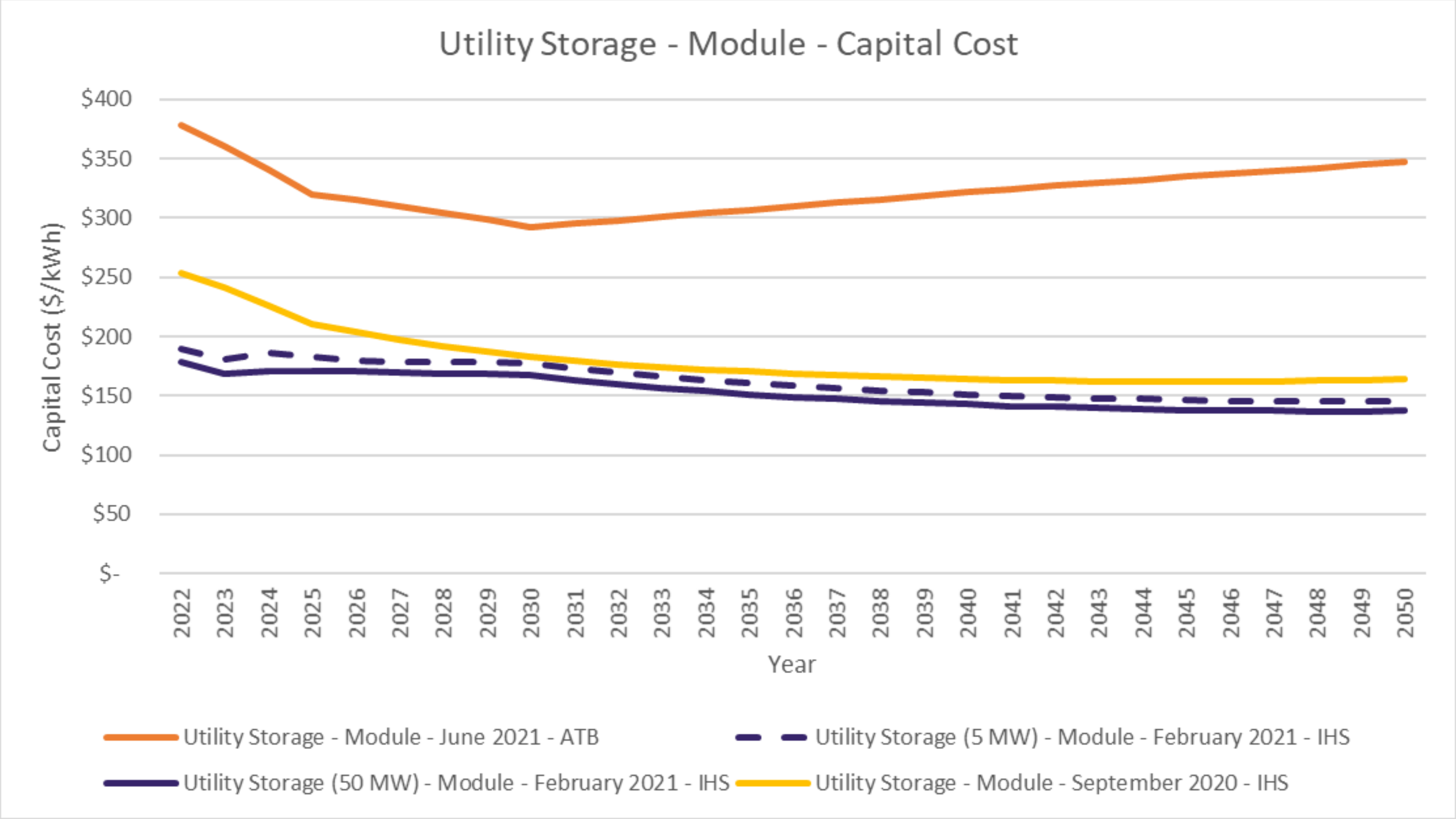
- Current forecast based on forecast developed by NREL specifically for O‘ahu as part of a Hawai‘i Offshore Floating Wind Energy Cost Analysis
- Previous forecast based on NREL’s 2020 report *Cost of Floating Offshore Wind Energy Using New England Aqua Ventus Concrete Semisubmersible Technology* for years 2020-2032 along with ATB trend for Offshore Wind for years 2033-2050

Updated Utility BESS Balance of System Costs



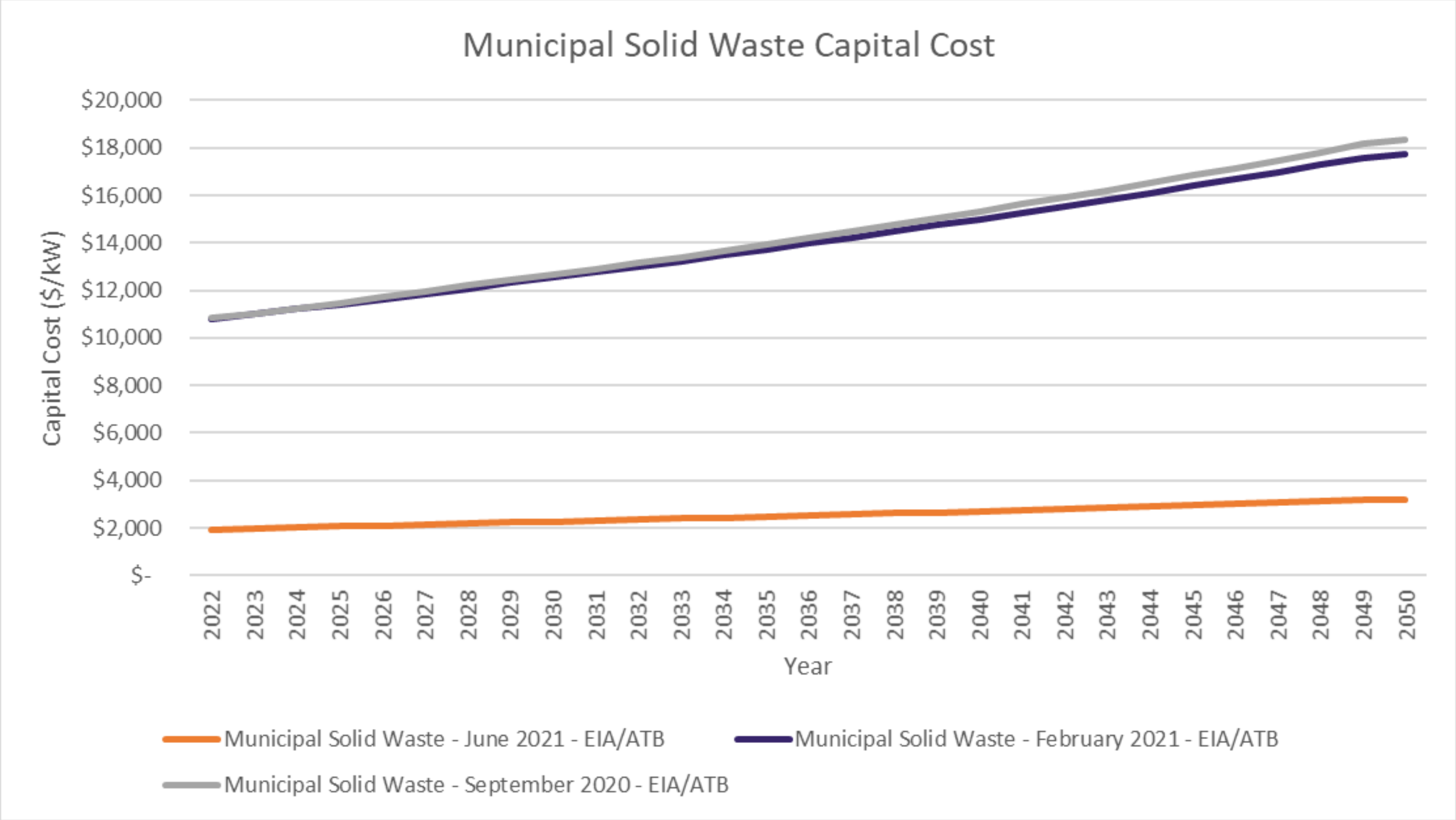
- Current forecast based on ATB forecast for Storage
- Previous forecast based on IHS forecast for Storage

Updated Utility BESS Module Costs



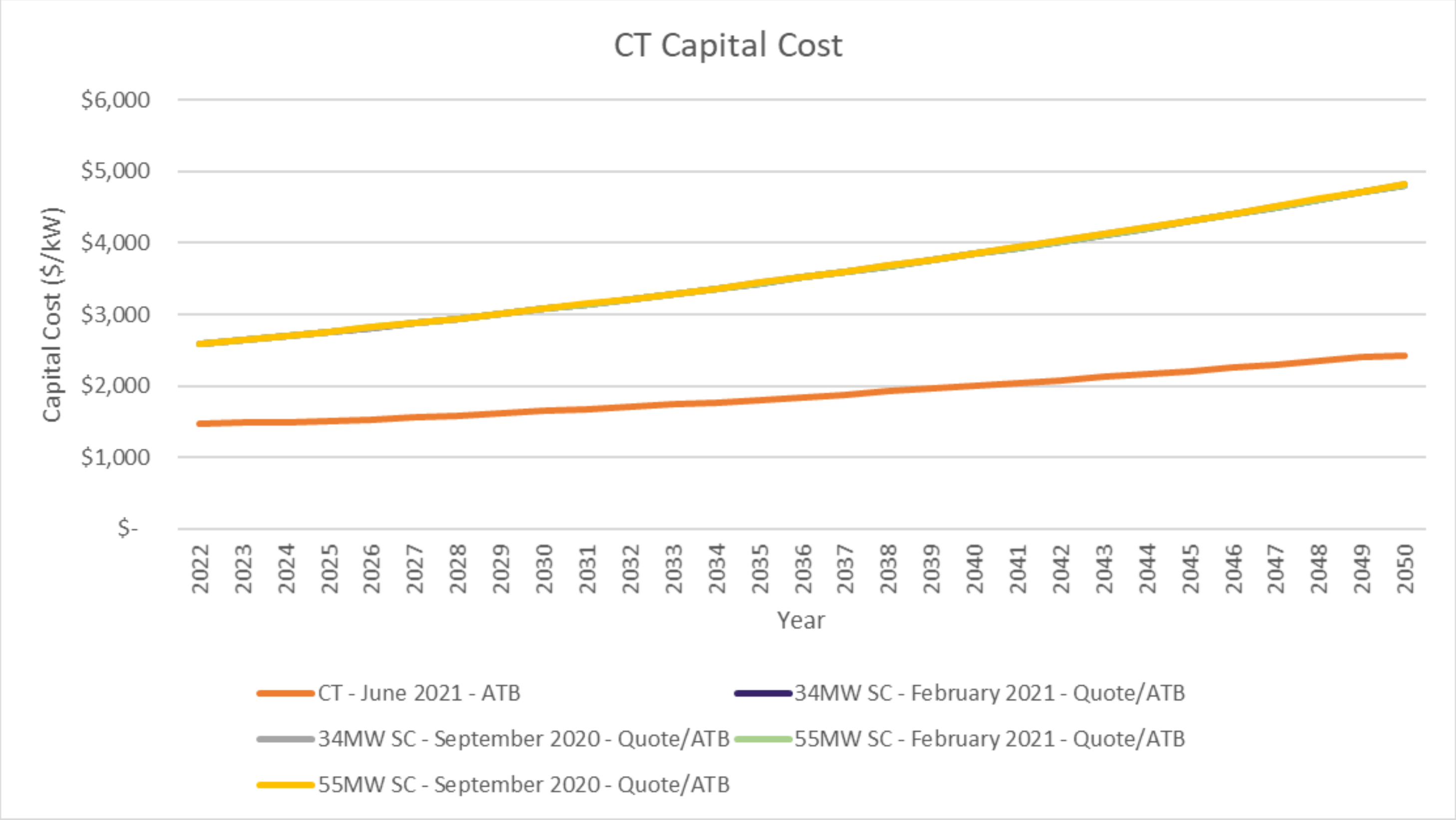
- Current forecast based on ATB forecast for Storage
- Previous forecast based on IHS forecast for Storage

Updated Municipal Solid Waste Costs



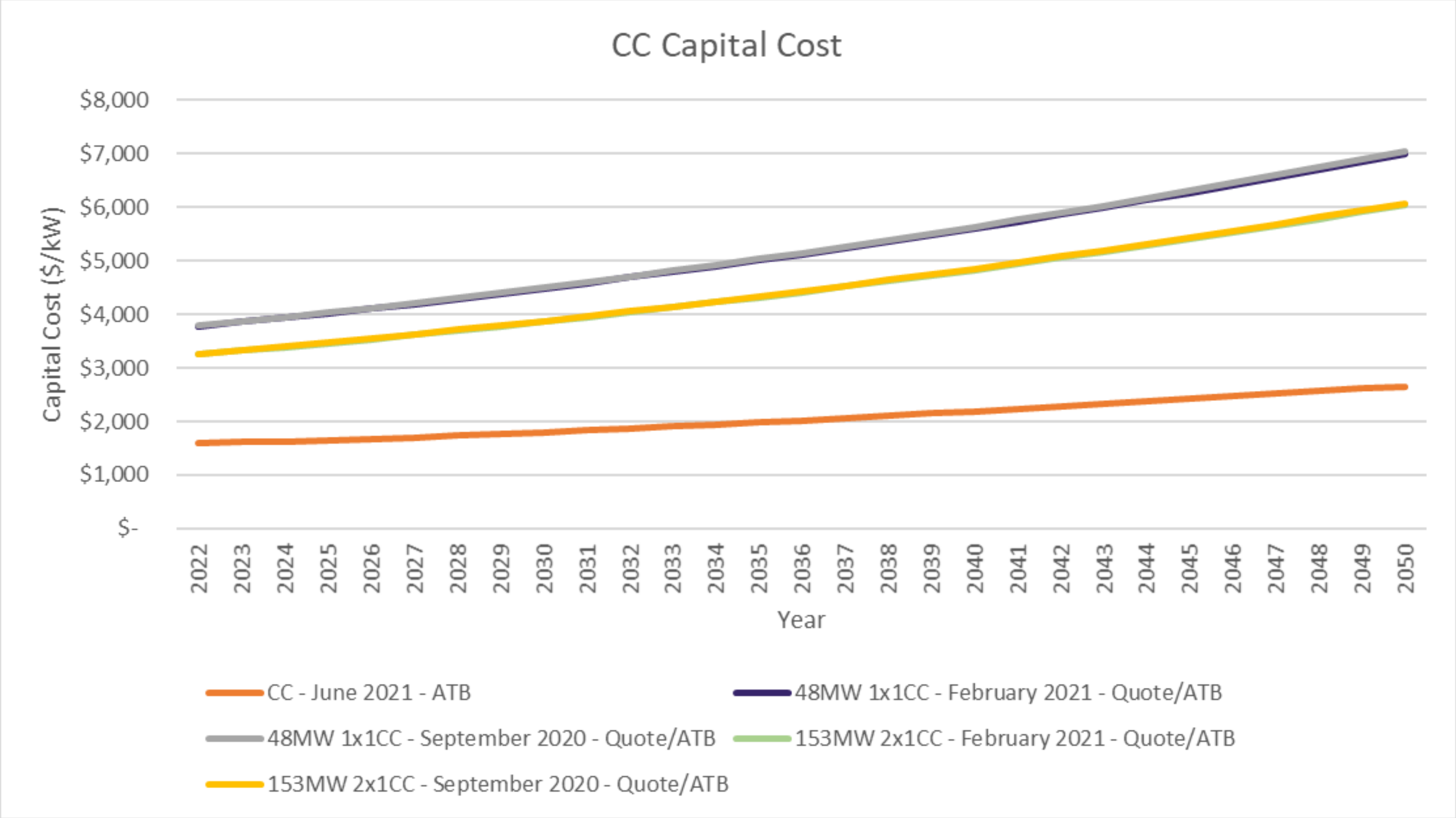
- Current forecast based on U.S. EIA Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2021 with ATB trend for Biomass applied
- Previous forecast based on U.S. EIA Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2019 with ATB trend for Biomass applied

Updated Combustion Turbine (CT) Costs



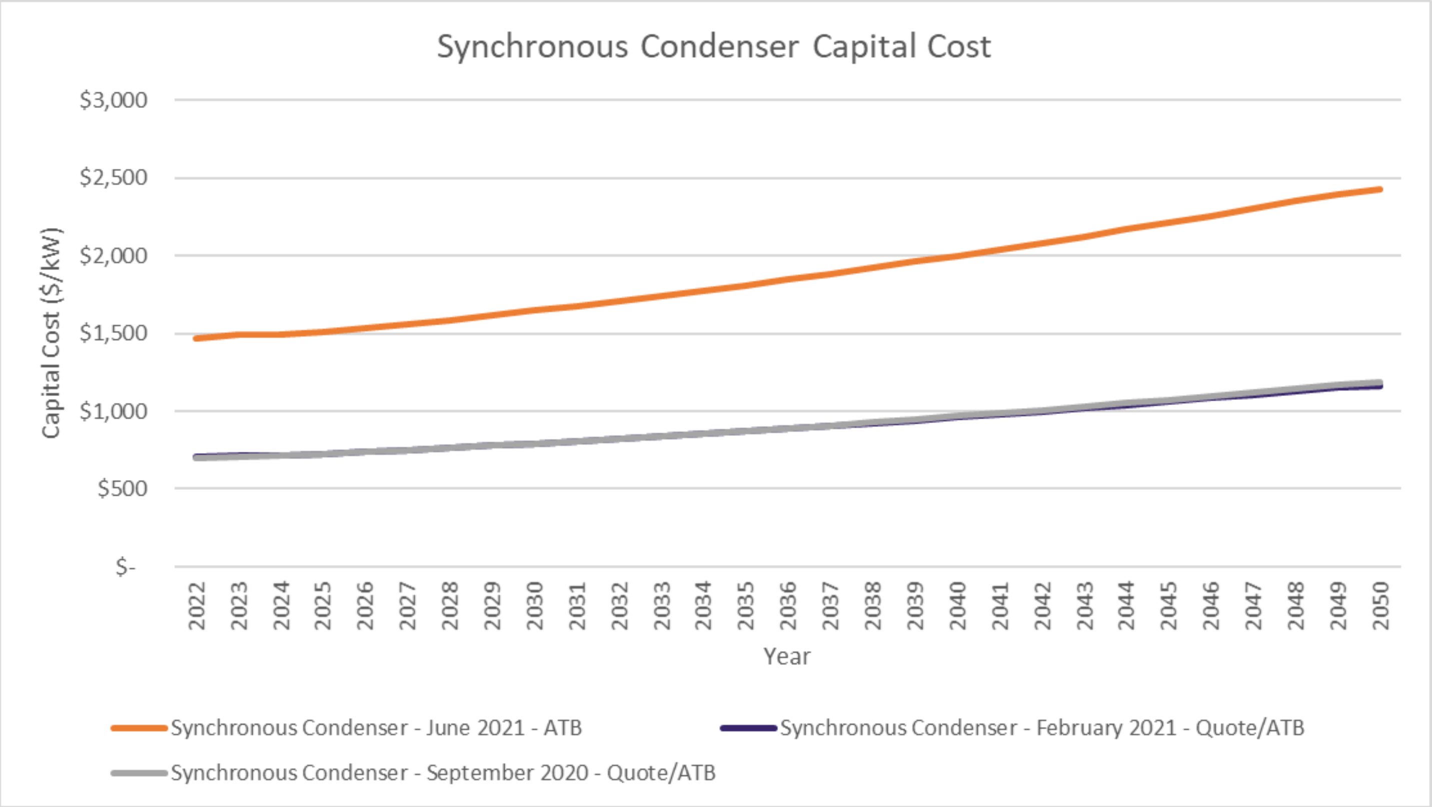
- Current forecast based on ATB forecast for CT
- Previous forecast based on estimate provided by General Electric with ATB trend for CT applied
- ATB provides a flat heat rate of 9.51 MMBTU/MWh
- The ATB CT is assumed to be a 171 MW plant
- What additional public data sources can be used to align the resource cost and heat rate/operating characteristics of a CT candidate resource?

Updated Combined Cycle (CC) Costs



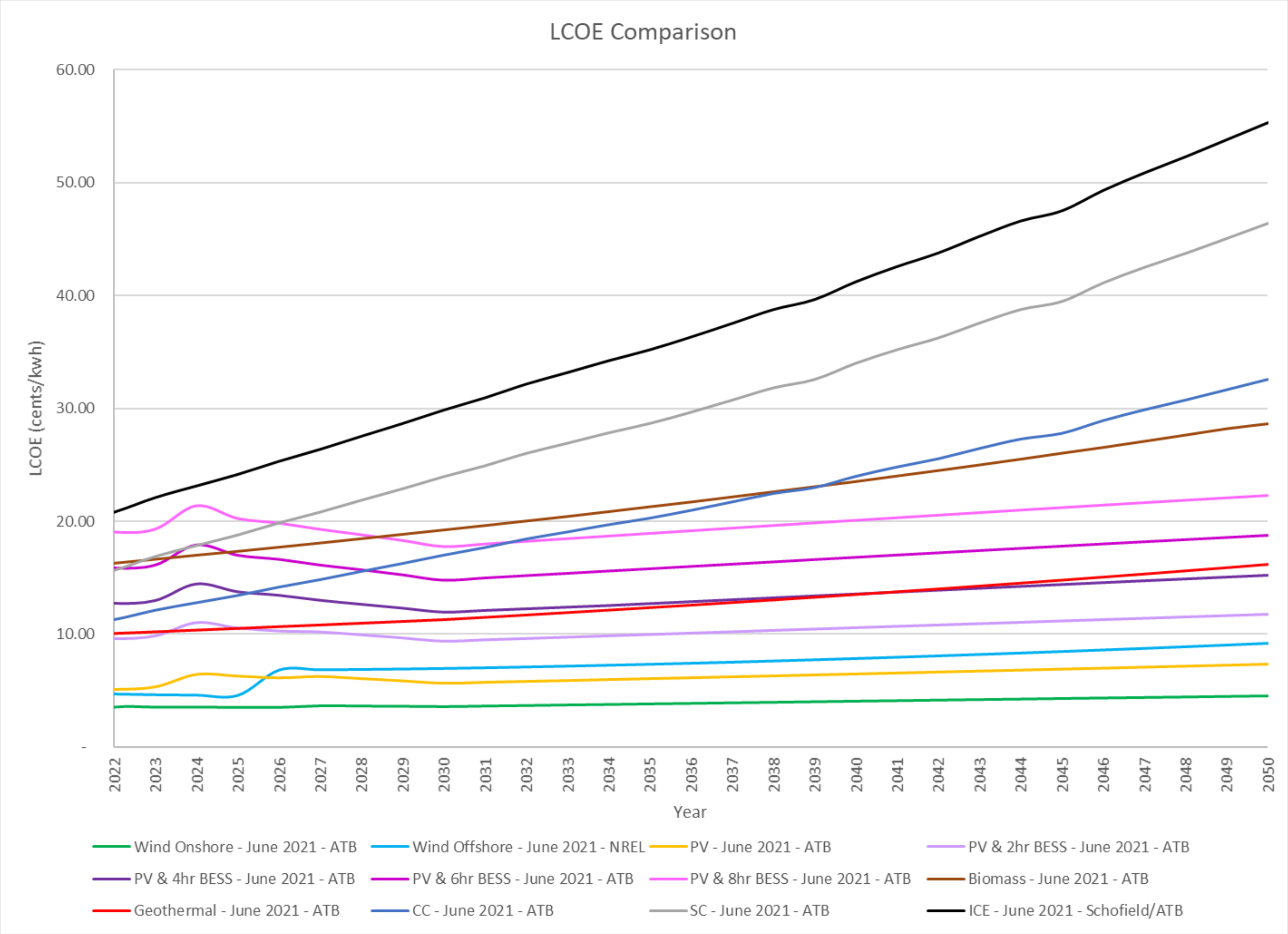
- Current forecast based on ATB forecast for CC
- Previous forecast based on estimate provided by General Electric with ATB trend for CC applied
- ATB provides a flat heat rate of 6.40 MMBTU/MWh
- The ATB CC is assumed to be a 750 MW plant
- What additional public data sources can be used to align the resource cost and heat rate/operating characteristics of a CC candidate resource?

Updated Synchronous Condenser Costs



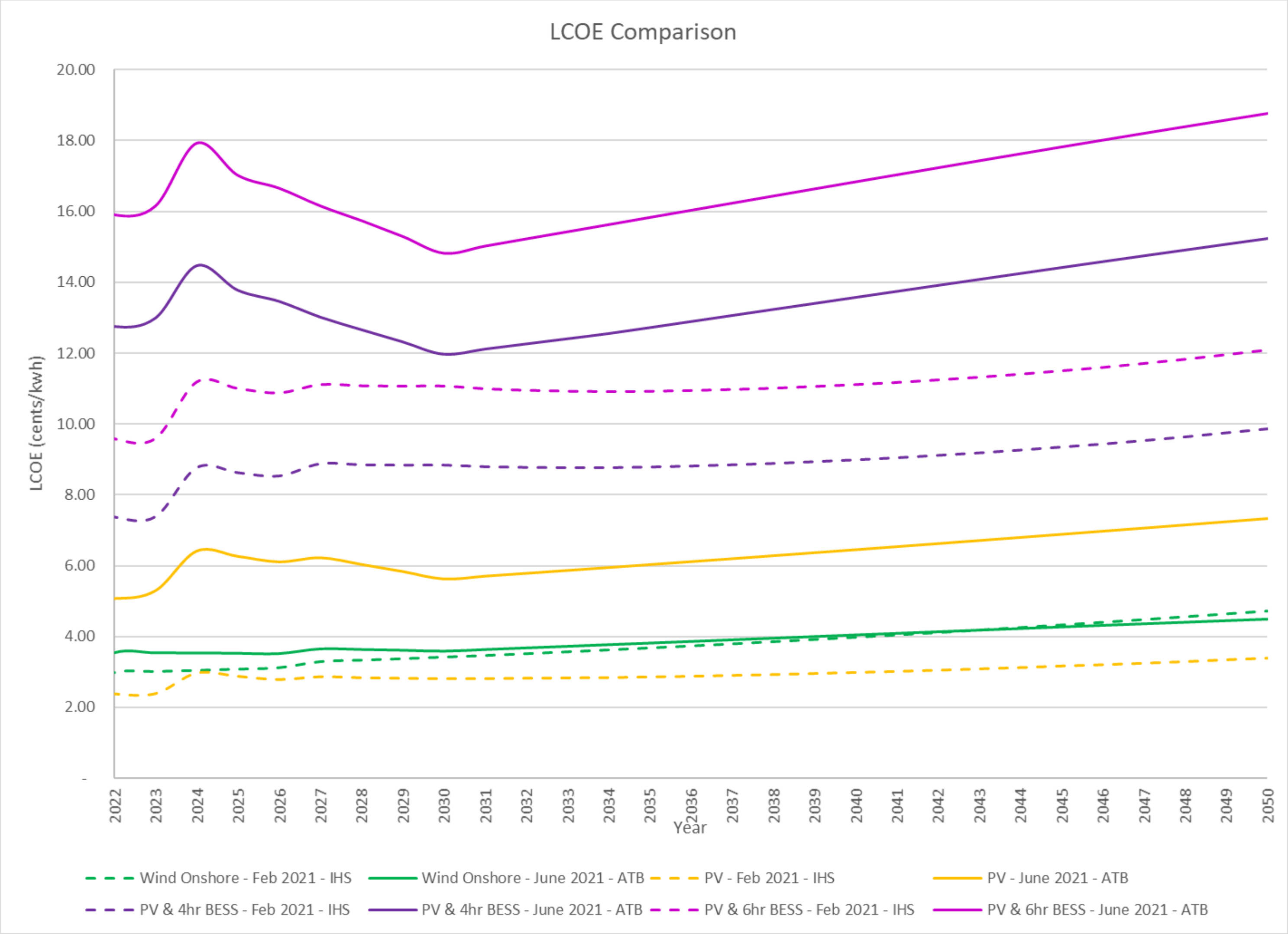
- ATB and EIA do not provide direct forecasts for a standalone synchronous condenser
- Current forecast based on ATB forecast for CT
- Previous forecast based on an estimate from Siemens with ATB trend for CT applied

Levelized Cost of Energy (LCOE) Comparison



- In calculating the LCOE, the following capacity factors were assumed,
  - PV: 25%
  - Onshore Wind: 56%
  - Offshore Wind: 58%
  - Thermal Resources: 70%

LCOE Comparison



February 2021 – Forecast uses publicly available data (ATB, NREL, EIA) and proprietary data (IHS)

June 2021 – Forecast uses publicly available data (ATB, NREL, EIA)

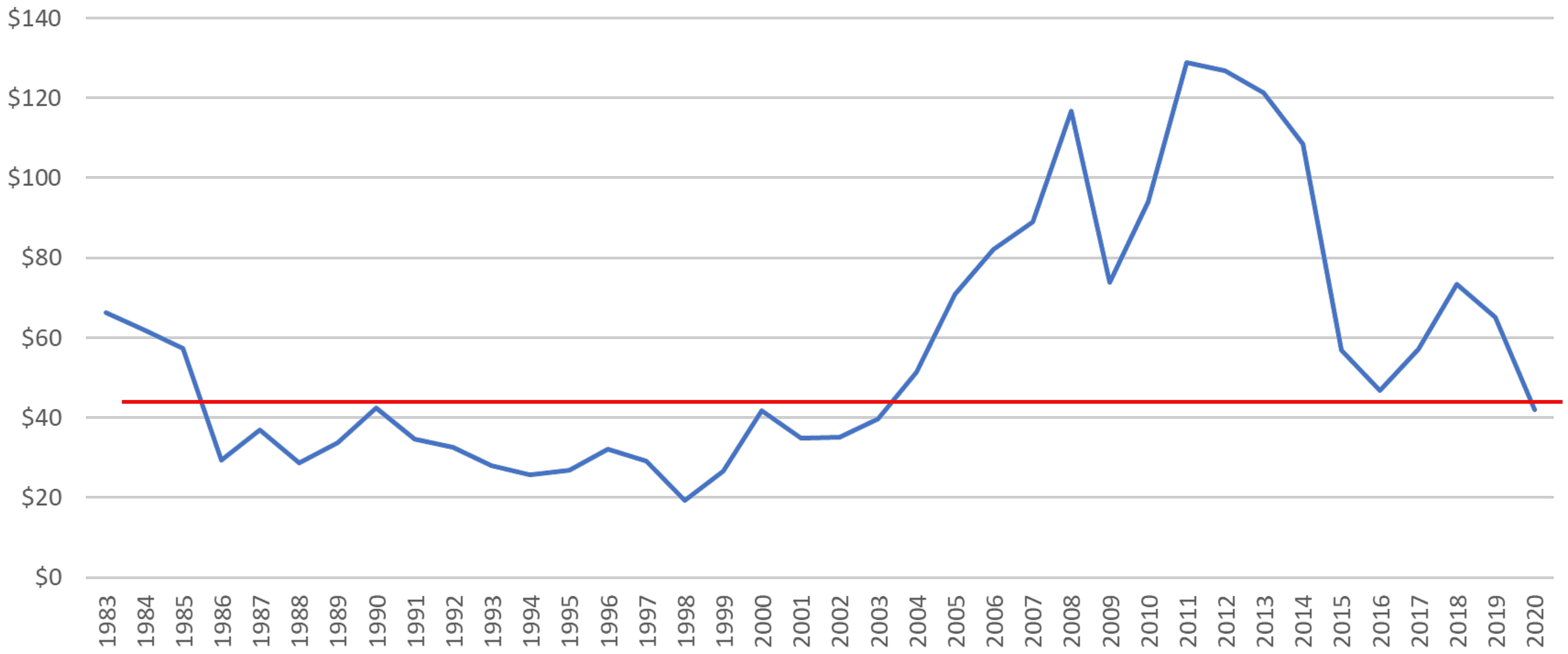
Hawaiian Electric

Fuel Price Projections

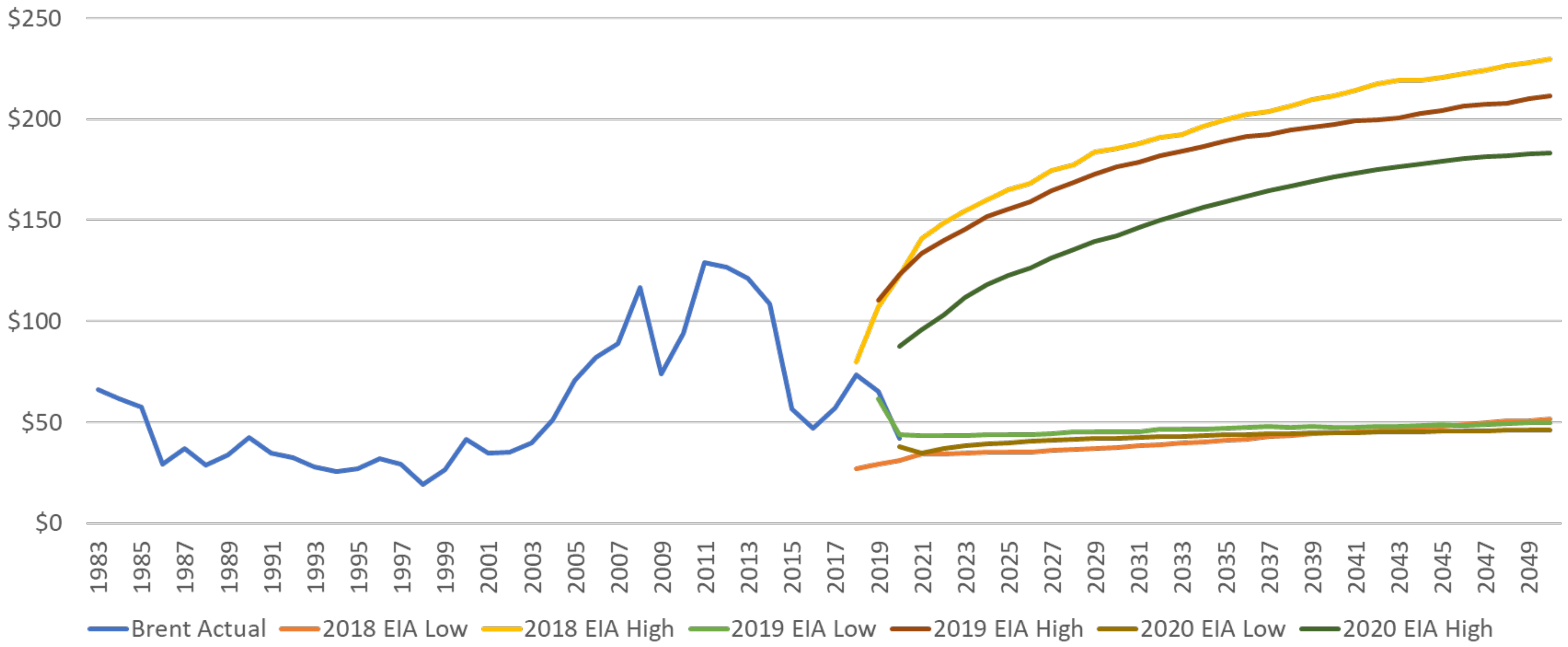
2021 AEO Fuel Price Forecast

- Similar process as the IGP fuel forecast based on FGE. Correlation developed between historical actual fuel prices and Brent North Sea Crude Oil Benchmark (Brent) from 1983-2019.
- R^2 for petroleum fuels > 0.93.
- EIA AEO forecast released in February 2021.

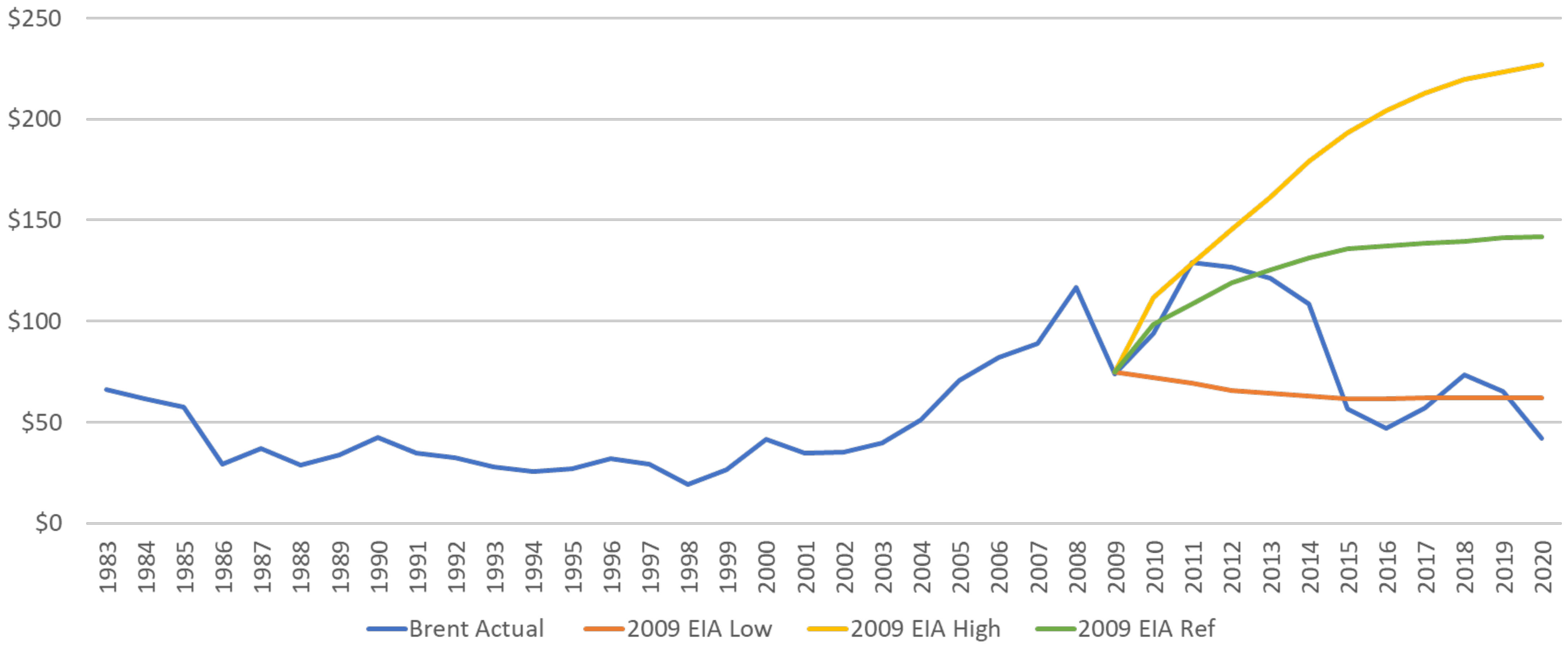
Actual Brent Price By Year in Real 2020 $



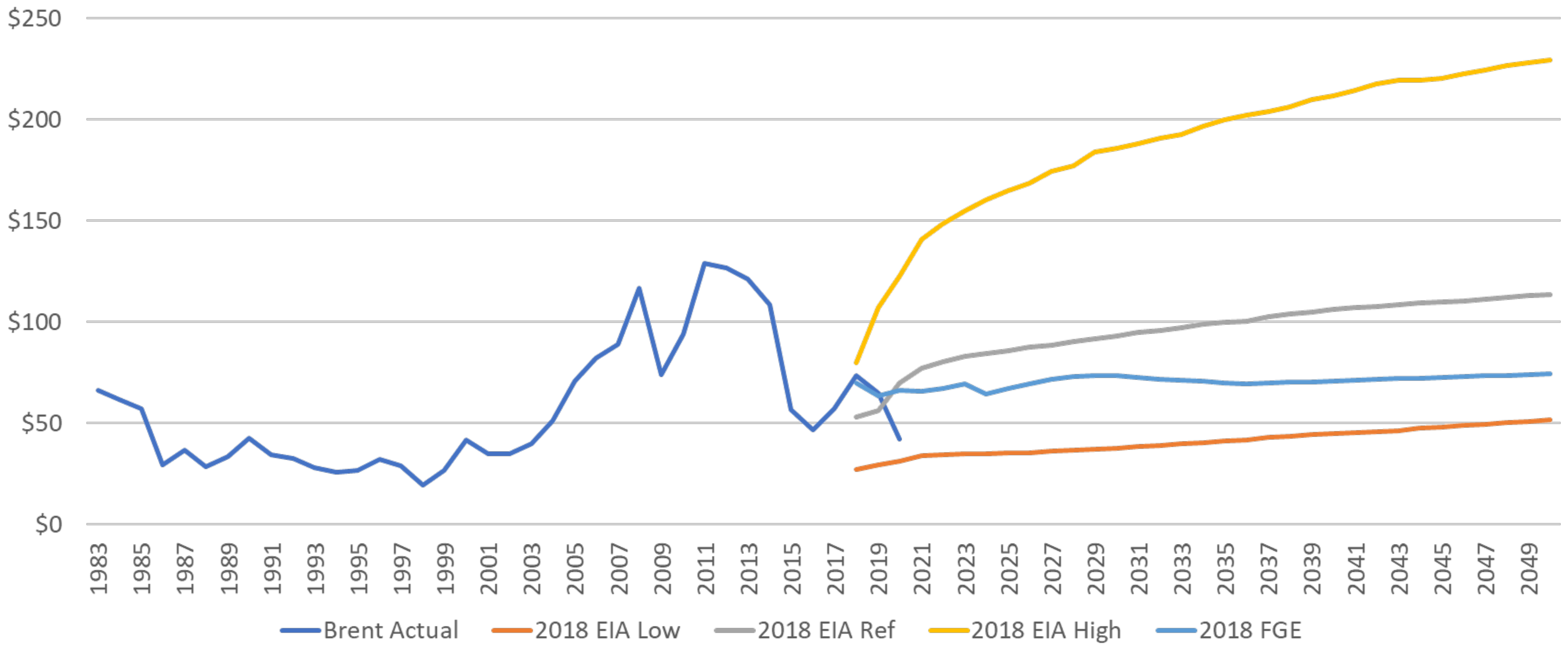
EIA High and Low Fuel Price Forecasts



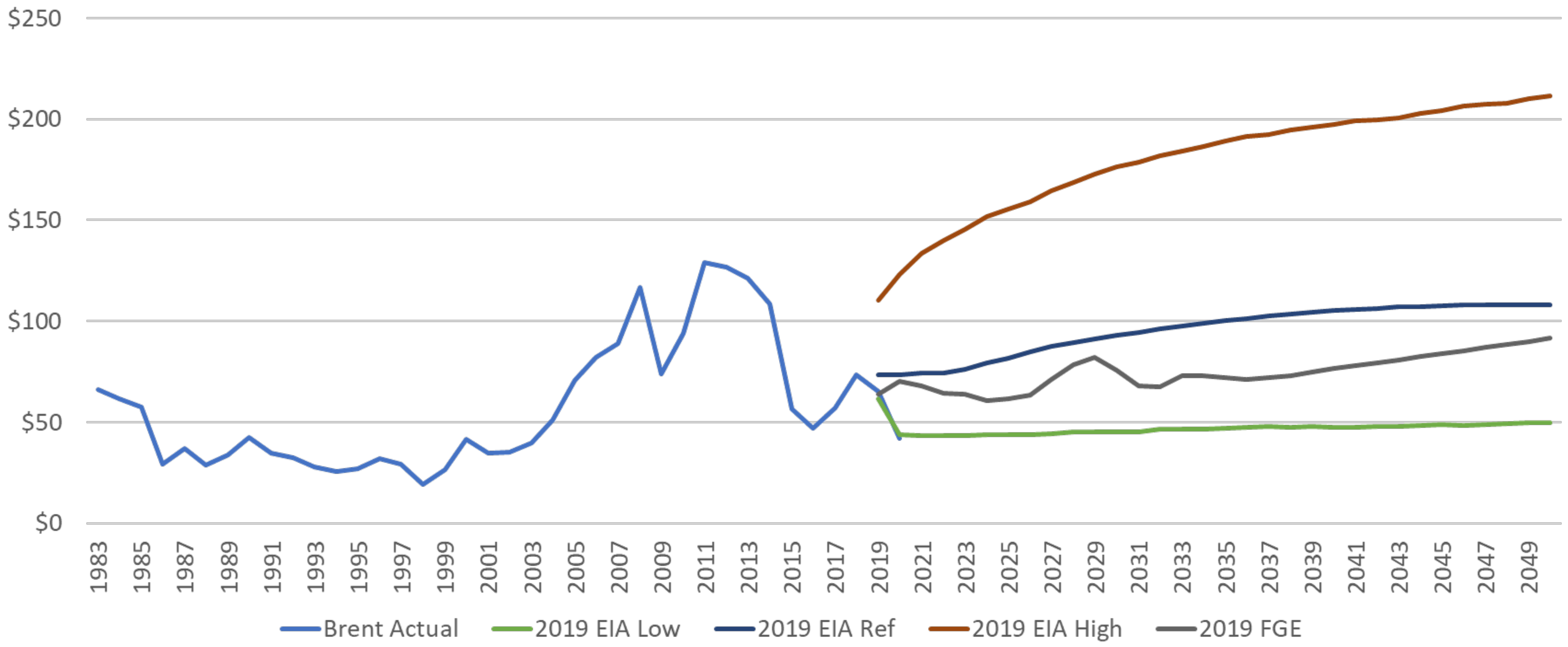
EIA Example


$250
$200
$150
$100
$50
$0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Brent Actual
2009 EIA Low
2009 EIA High
2009 EIA Ref

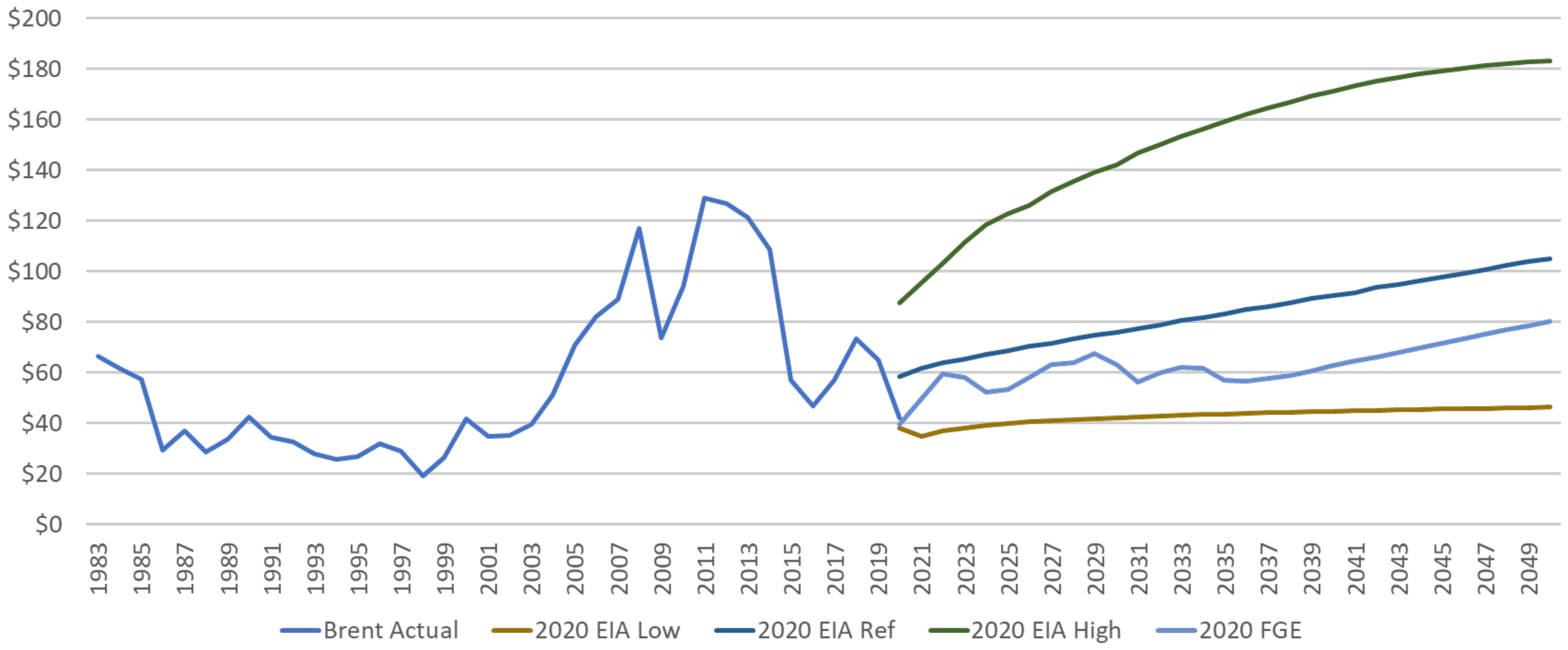
2018 Fuel Price Forecasts



2019 Fuel Price Forecasts



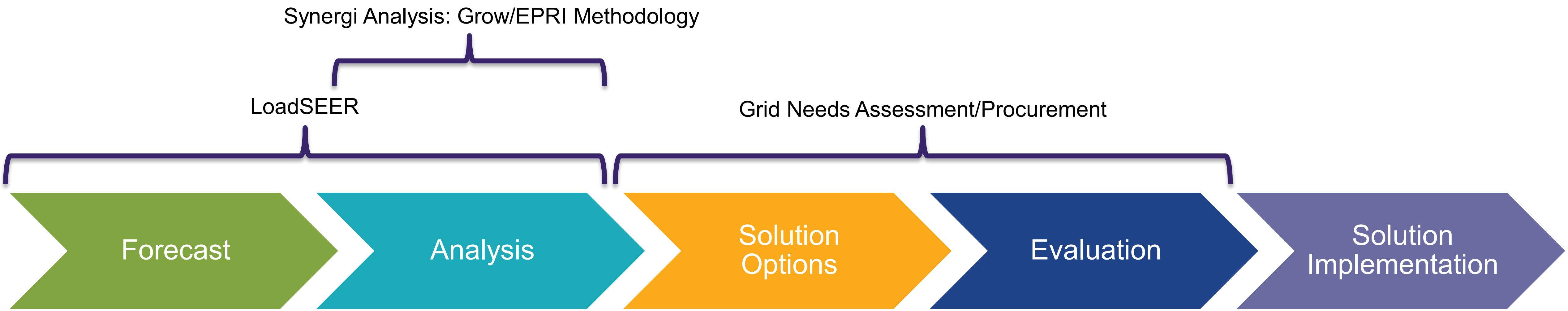
2020 Fuel Price Forecasts



Hawaiian Electric

11:35am: Deep Dive 3A: DER and Load Forecasts – Baseline Inputs and Assumptions

Stages of the Distribution Planning Process



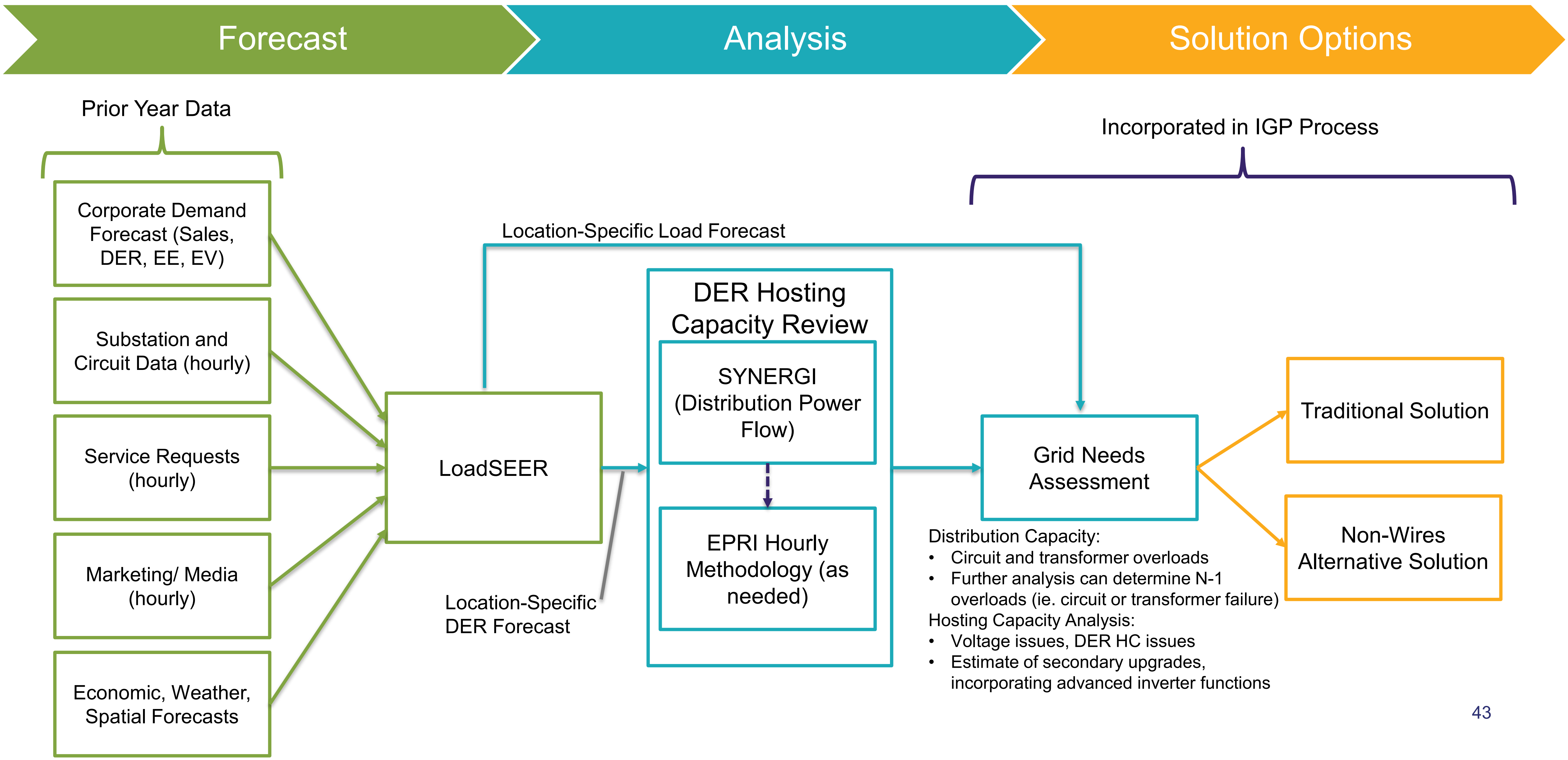
Forecast
- Collection of Historical Data
- Load & DER Forecasts
- Load & DER Profiles

Analysis
- Distribution Planning Criteria
- Hosting Capacity
- Contingency Analysis
- Grid Needs Identification

Solution Options
- Solution Requirements
- Wires Solutions
- Non-Wires Solutions

Evaluation
- Evaluation of Solutions
- Solution Sourcing
- Solution Selection

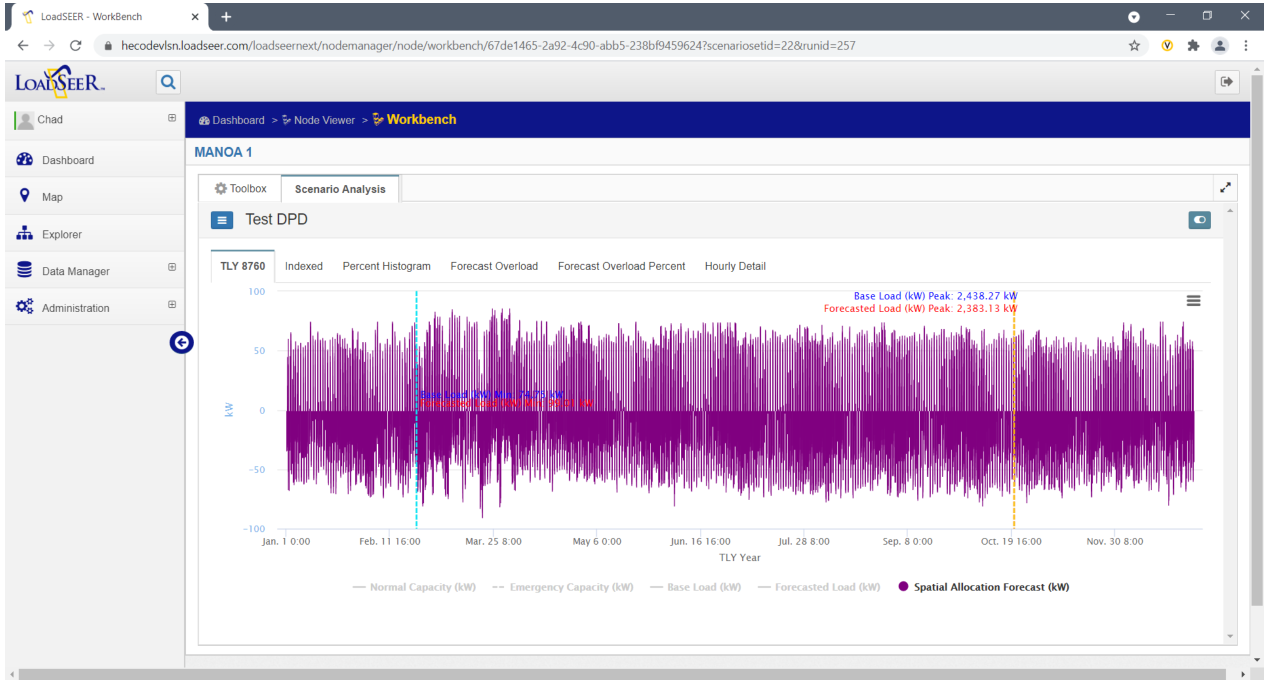
Current Distribution Planning Process



LoadSEER: Start with Historical Data (SCADAScrubber Module)

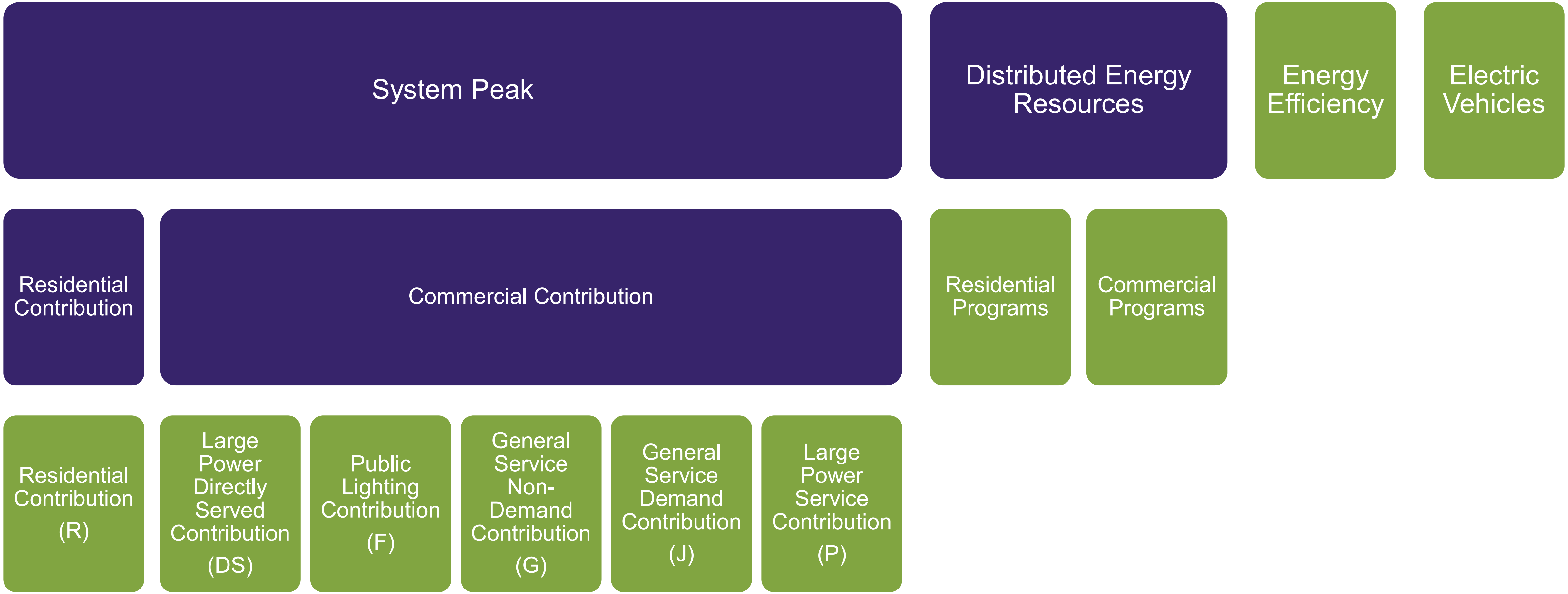
- Importing SCADA data into LoadSEER
- Further cleaning of individual circuit data
- Create Base Load with SCADA data when available
- Applies factor for weather normalization

LoadSEER: Spatial Allocation Forecast



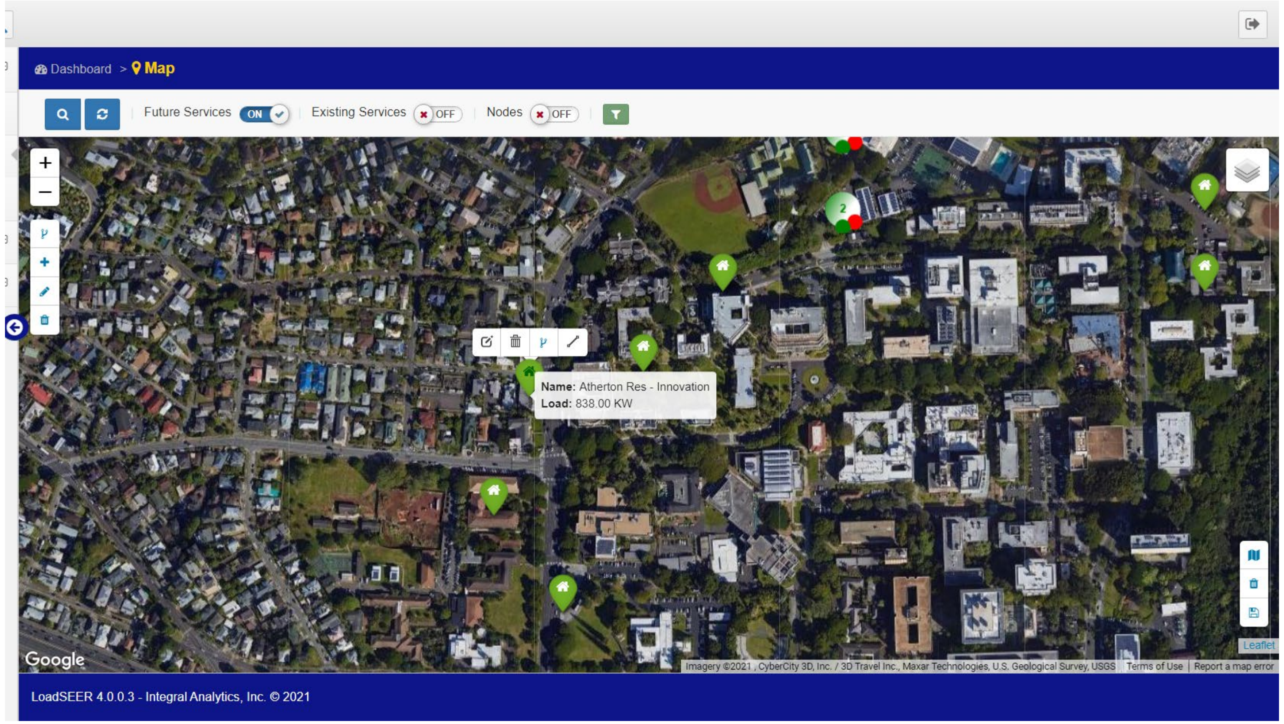
- Each LoadSEER run (ex. Load growth, DER, EE, EV) can be “layered” onto the Base Load

LoadSEER: Disaggregation of Corporate Forecast

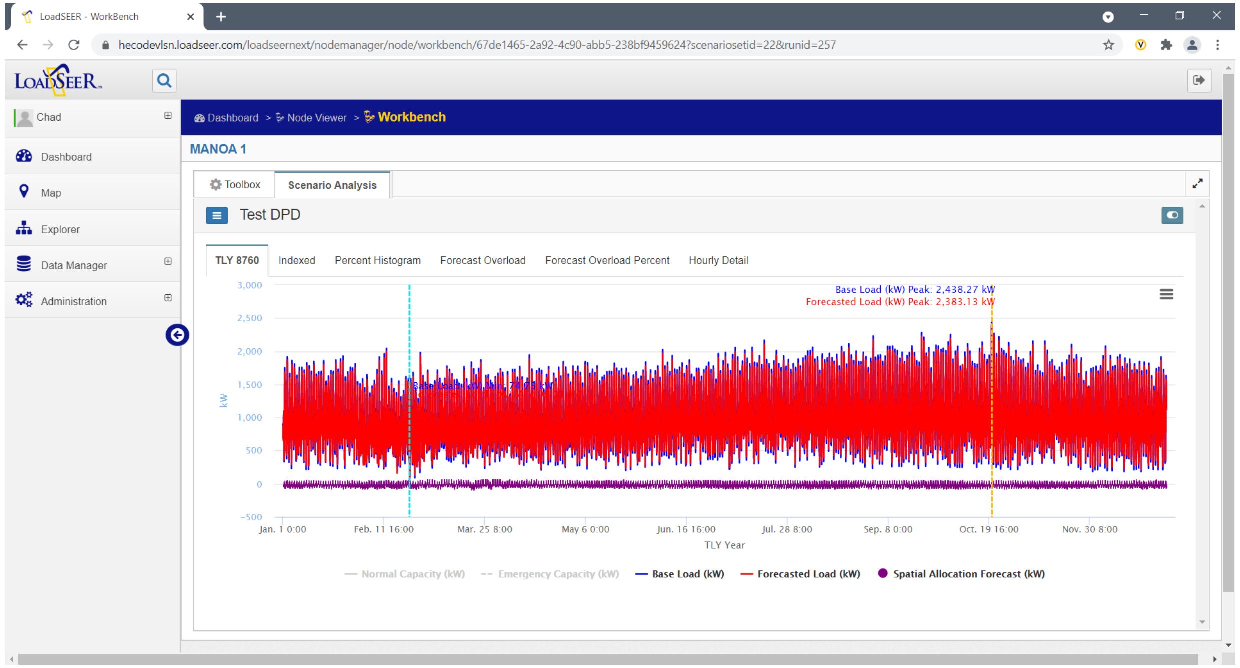


LoadSEER: Map Adjustments

- New Service Requests or known large generation added to map
  - Adds known new spot load/generation **location** to the model
  - Adds known customers and associated **class** load shape types

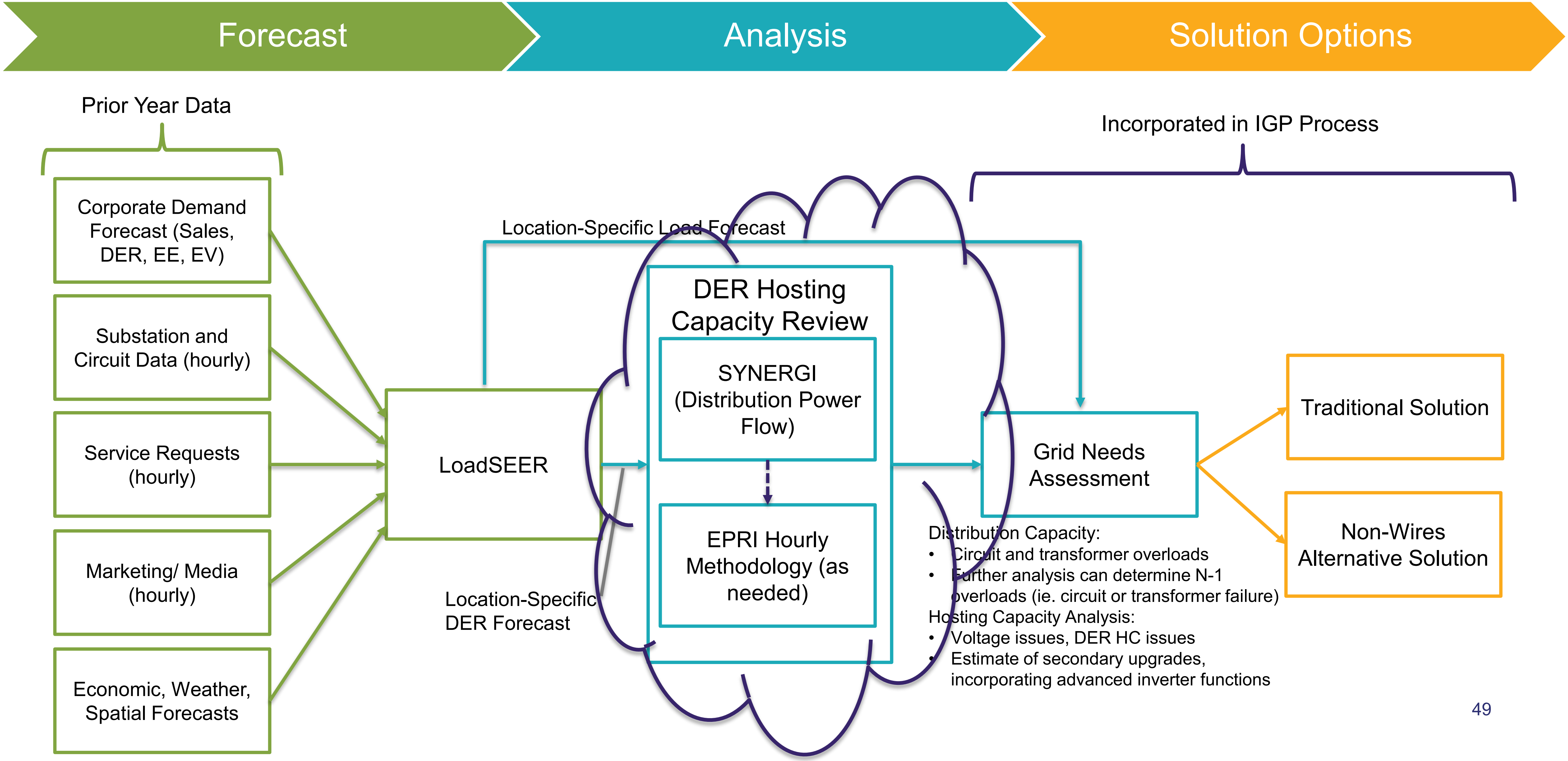


LoadSEER: Circuit Level Forecasts



- Forecasted Load – Base Load, Spatial Allocation Forecast, and Map Adjustments

Current Distribution Planning Process



Hosting Capacity (HC) Update (5-yr forecast)

Analysis to determine if grid needs are required due to local constraints to meet 5-yr DER forecast.

EPRI Analysis/ SYNERGI (Oahu only)

Updates HC based on multiple load flow runs (probabilistic analysis)

- % of circuits HC being evaluated. If DER forecast > HC, grid need identified.

DER Forecast > Hosting Capacity

SYNERGI Analysis

Updates HC based on loadflow analysis

- % of circuits HC being evaluated. Determine if issues can be resolved with setting changes (vs. grid need).

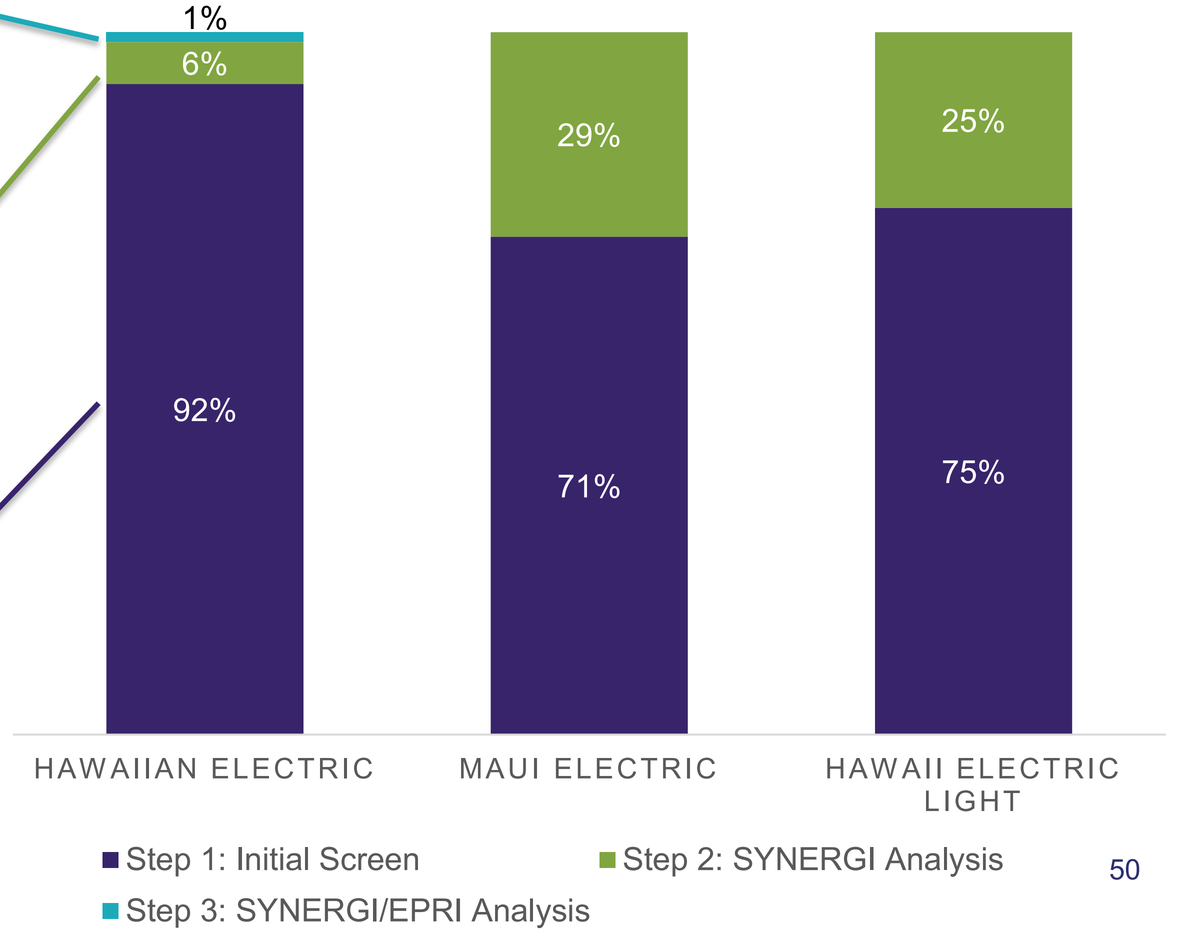
DER Forecast > Hosting Capacity

Initial Screen

Check available HC to meet DER forecast.

- % of circuits that have sufficient HC for the 5-yr forecast. No upgrades needed.

% OF CIRCUITS IN HC ANALYSIS STEPS (CURRENT STATUS)



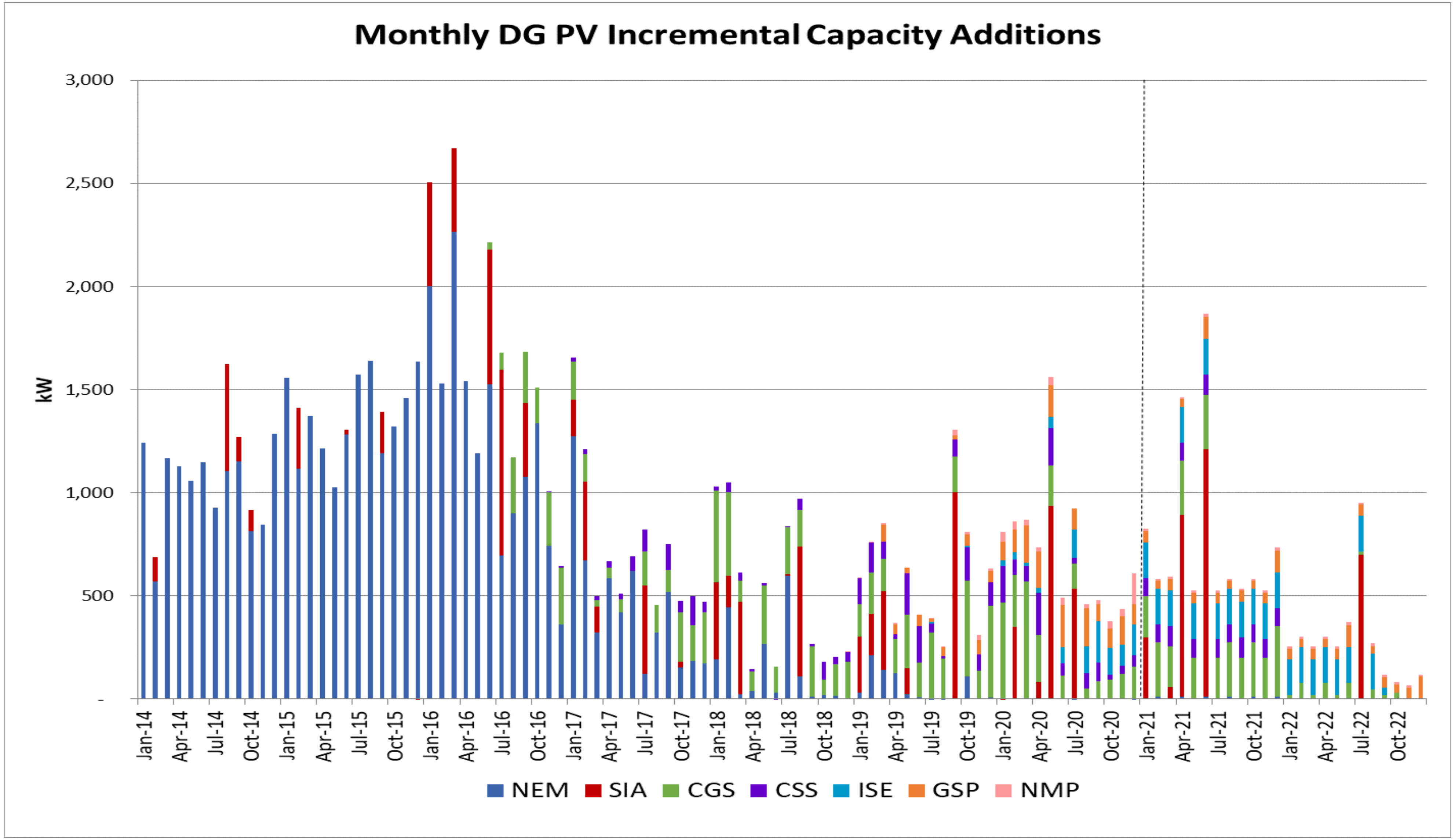
DER Forecast

- Primary focus is behind the meter PV and battery storage
- Other technologies included on ad hoc basis for known projects
- New additions of capacity in each month by island, rate class and program
- Monthly sales impact
- Hourly load impact
- Future capacity on distribution circuits

DER – Methods and Assumptions

- Near term
  - Input from the Customer Energy Resources program administrators
  - Planned projects and build-out of existing programs
  - Recent pace of installations and incoming applications
  - Recent average system sizes with and without BESS
- Longer term
  - Economic choice model considers
    - Installed cost of PV and battery
    - Incentives
    - Electricity price
    - Program structure that affect the economic benefit to the customer
    - Addressable market
- Solar resource
  - Unitized profiles for solar production
  - Monthly capacity factors

Near-Term Capacity Forecast - Example

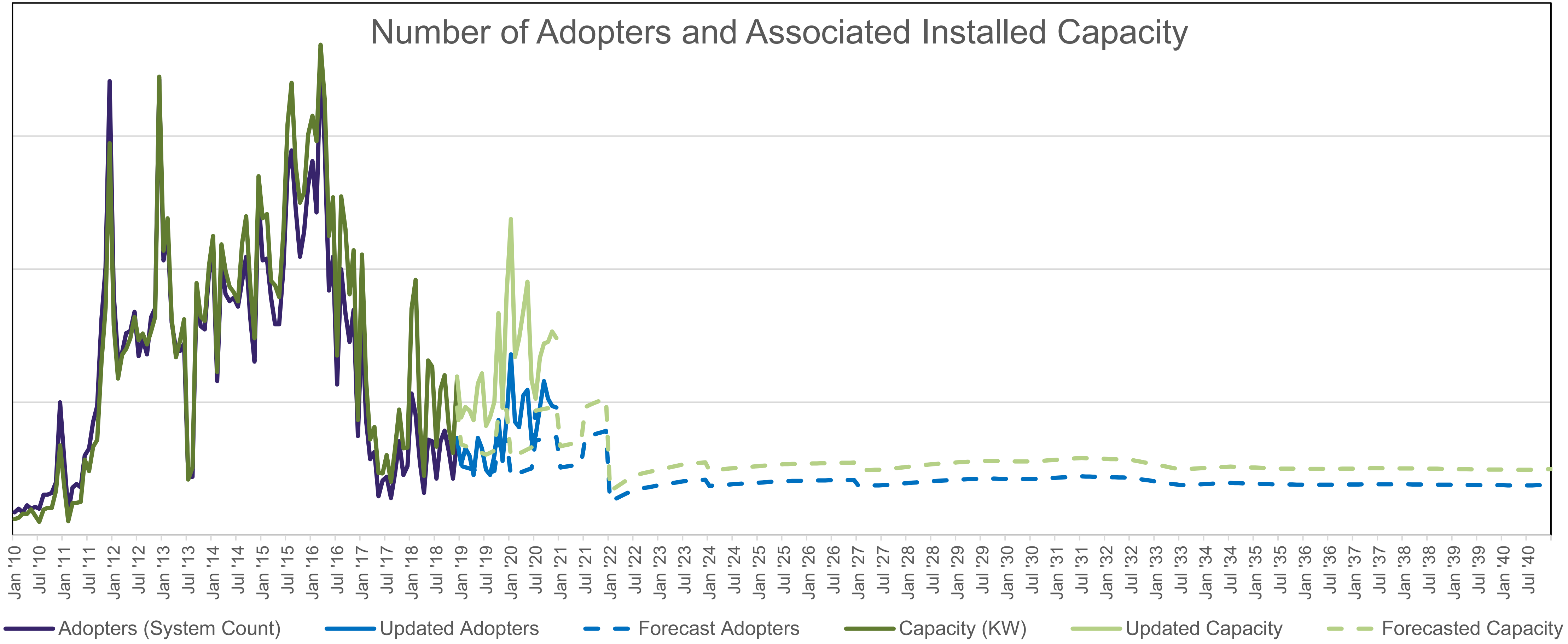


Economic Choice Model

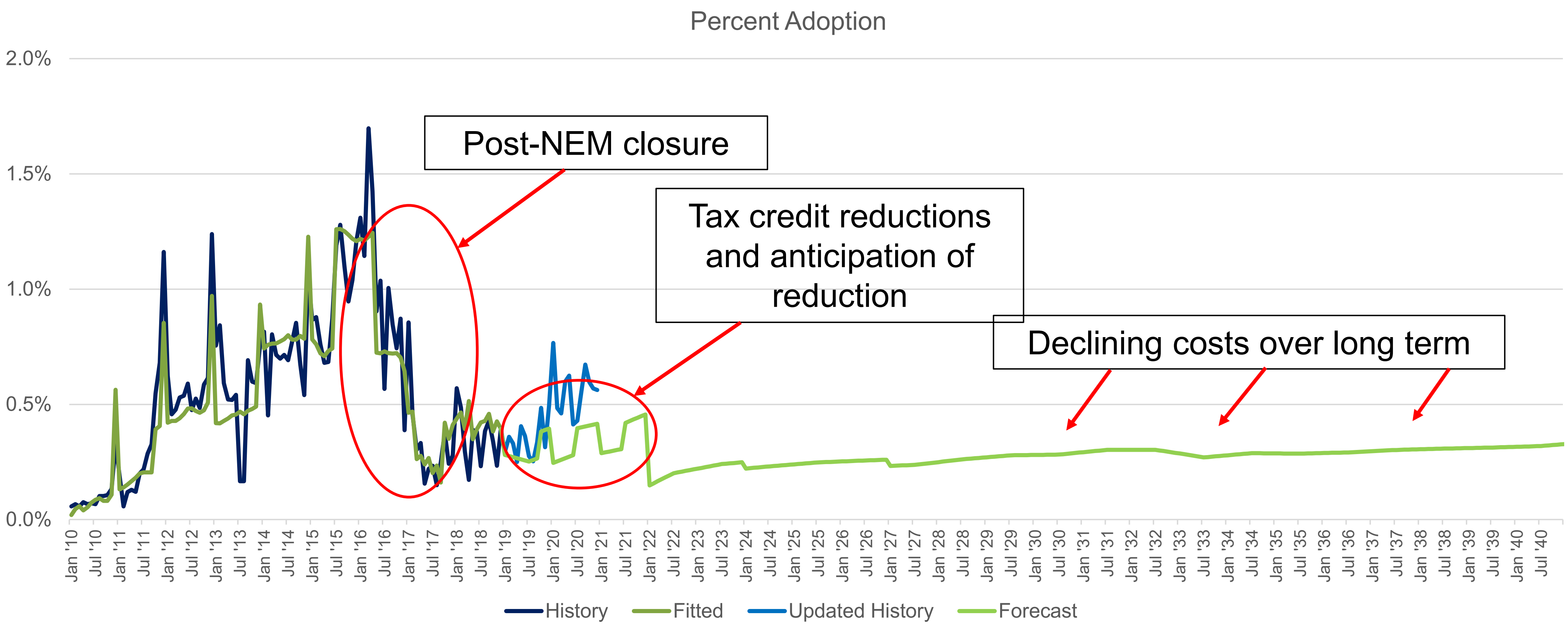
- Analyze historical relationship between adoption rate and economics
  - Dependent variable: Percent of potential PV customers that installed a system
  - Independent variable: Payback time (years)
- New capacity additions derived by incorporating 2 additional key assumptions:

  (% adoption) x (number of potential adopters) x (average system size)

Economic Choice Model

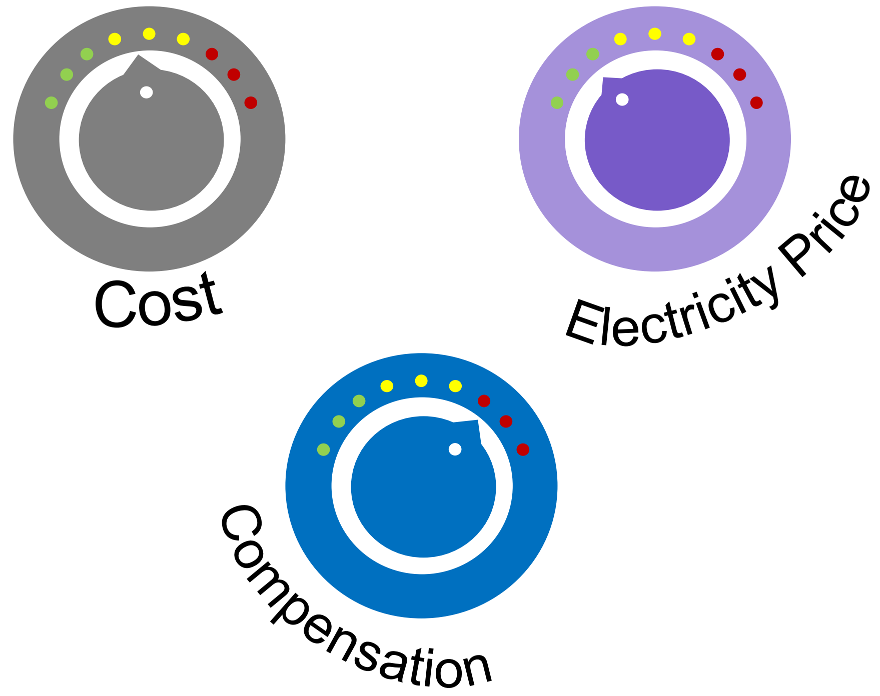


Economic Choice Model



Inputs to DER Forecast

- Economic assumptions
  - PV and battery installed costs
  - Incentives
  - Electricity price
  - Program structure
  - Panel degradation, maintenance and replacement
- Addressable market
- Solar resource assumptions
  - Unitized generation profiles
  - Capacity factors



Addressable Market for Behind-the-Meter DER

- Residential Rate Class
  - Single family and multi-family with maximum of 4 units
  - Owner-occupied
  - Consumption high enough to utilize at least a 3kW PV system

Island	Percent of R Customers
Oahu	37%
Hawaii	40%
Maui	43%
Lanai	24%
Molokai	30%

Addressable Market for Behind-the-Meter DER

- Commercial Rate Classes
  - Private and public ownership
  - Exclude structures with >6 stories
  - Small and medium commercial consumption above threshold

Island	Percent of G Customers	Percent of J Customers	Percent of P Customers
Oahu	37%	53%	78%
Hawaii	35%	68%	44%
Maui	41%	63%	68%

Incentives

- Federal tax credits

	2021	2022	2023	20224 - forward
Residential	~~22~~ 26%	26%	22%	0%
Commercial	~~22~~ 26%	26%	22%	10%

- State tax credits

	2021	2022	2023	2024	2025	2026	2027-forward
Tax Credit Rate	~~25%~~ 35%	25%	25%	20%	20%	20%	15%

  - Cap on residential PV-only systems: $5,000 in all years
  - Cap on residential PV + Storage systems: $5,000 in 2019-~~, 2020~~2021 $10,000 in ~~2021~~2022-forward

- Grid services/demand response
  - To be revised based on future program proposals

Future DER Programs

- Reference DER Docket 2019-0323 for EDR and Long-Term Programs
- Three Sensitivities
  - Market Forecast
  - DER Parties Proposal
  - Hawaiian Electric Proposal
- Assume additional levels of incentives
  - Timeline for incentives
  - Upfront incentive [$/kW or $/kWh]
  - Monthly availability payment [$/kW/month]
  - New export rates [$/kWh]

Stakeholder feedback from June 2, 2021 STWG regarding DER forecasts

- Non-economic factors that may affect uptake
  - For stakeholders: How to quantify these factors to include into the forecasts?
- Technology and installation costs are dropping, citing Ford announcement, DER quick connect, Bill 58
  - For stakeholders: What type of assumptions should be made on system costs? Currently plan to assume NREL ATB costs.
- System size constraints based on limits to export compensation.
  - For stakeholders: What assumptions should be made for export? How should the average system size assumptions change?
- Non-traditional DER adoption
  - For stakeholders: What type of other future programs should be modeled to capture non-traditional DER adoption?

Next Steps and Continued Engagement

- Initiate updates to DER forecast
  - Update Tax Incentives
  - Update DER costs using NREL ATB
  - Incorporate new DER program proposals
- Continue engagement with stakeholders
  - STWG Meeting #3
  - Additional meetings/engagement

Hawaiian Electric

12:40pm: Deep Dive 3B: DER and Load Forecasts – Modeling Different Scenarios and Sensitivities

Sensitivities

- Multiple stakeholder meetings were held across the Forecast Assumptions Working Group, Solution Evaluation & Optimization Working Group, Stakeholder Council, and Technical Advisory Panel to discuss the proposed sensitivity analyses
- A key sensitivity that emerged from those discussions was a proposal to test the bookends of the load forecast. The high and low bookends would evaluate how the resource plan and system cost changes with higher and lower adoption of distributed energy resources, electric vehicles, energy efficiency, and time-of-use rate adoption.
- Because the bookends have been framed as lower and higher customer adoption of certain technologies, a high load sensitivity was also added to test how the resource plan changes when customers primarily adopt technologies that increase load.

Proposed Bookend Sensitivity

- Recognizing feedback from the TAP to conduct bookend analyses to test the sensitivity of the models and portfolios against a range of load forecasts, the Company proposed the following approach for a bookend sensitivity in its March 2021 reply comments on the first review point.

Assumption	Slower Customer Technology Adoption	Base	Faster Customer Technology Adoption
DER	Market Forecast	Market Forecast	+30%
Electric Vehicles	-30%	Market Forecast	+30%
Energy Efficiency	-30%	Market Forecast	+30%
Time-of-Use	None	Managed EV	Managed EV

Proposed Bookend Sensitivity

- Instead of a 30% mark up/down, the slower and faster customer technology adoption bookends can be anchored to certain policies and program proposals that have been discussed in the respective dockets for DER, EV, and EE. A high load sensitivity was also added to further study how the resource plan and system cost changes under this condition.
- Stakeholder input will help to decide the appropriate driver for the level of adoption that is assumed in the low and high bookends and allow the Parties to shape the future uptake that they envision.

Assumption	Slower Customer Technology Adoption	Base	Faster Customer Technology Adoption	High Load
DER	Market Forecast	HE Company Proposal	DER Parties Proposal	Market Forecast
Electric Vehicles	EV--	Market Forecast	EV++	EV++
Energy Efficiency	EE--	Market Forecast	EE++	EE--
Time-of-Use	None	Managed EV	Managed EV	None

Sensitivities

- Additional sensitivities were discussed in the draft Grid Needs Assessment.

Sensitivity	Purpose	Inputs	Status
2. Market DER	Determine the value of the forecasted market uptake DER	Fix DER capacity to 2020 levels in RESOLVE	Modeled as part of the DER Freeze scenarios in the DER docket
3. No Future Transmission Infrastructure	Determine the value of additional DER above the market uptake	Future grid-scale resources allowed to build up to the available transmission capacity DER aggregators will be available as a resource option to meet future grid needs	Planned for IGP as a standalone sensitivity
4. High Energy Efficiency	Determine the value of higher levels of energy efficiency	Increase the assumed energy efficiency in the market forecast	Planned for IGP as part of the bookend sensitivity
5. No State ITC for PV	Understand the impact of removing the State investment tax credit for PV	Adjust the DER uptake forecast and PV resource cost assumptions for the removal of the State ITC	Planned for IGP as a standalone sensitivity
6. No Onshore Development	Determine the value of offshore resources, specifically for O‘ahu, if future onshore grid-scale options are limited	The market uptake of DER will continue as forecasted Only offshore wind will be available as a resource option	Planned for IGP as a standalone sensitivity

See Grid Needs Assessment & Solution Evaluation Methodology, March 2021, Appendix E

Sensitivities

- Additional sensitivities were discussed in the draft Grid Needs Assessment.

Sensitivity	Purpose	Inputs	Status
7. Low Renewable Generation	Understand the impact of low energy production from PV, wind, and PV & wind resources	PV and wind profiles from past weather years Include forecasted forced outage rates and costs to maintain thermal fleet	Planned for IGP as a standalone sensitivity
8. Non Grid-Participating Customer Storage	Determine the value of existing net energy metering customers adopting storage as non-export customer load shift resources	Expand the existing customer storage forecast profiles by adding additional battery capacity	The DER Parties modeled this sensitivity as part of their "Load Shift Scenario" in the DER docket[1]
9. Grid-Participating Customer Storage	Determine the value of additional distributed storage that is able to charge from the grid	Expand paired PV-storage DER resources that can participate in grid services	A version of this sensitivity was modeled in the DER docket as part of the Company's proposal for emergency demand response
10. Unmanaged Electric Vehicle Charging	Understand the value of customers managing their own electric vehicle charging	Load profiles for unmanaged vehicle charging	Planned for IGP as part of the bookend sensitivity
11. Managed Electric Vehicle Charging	Understand the value of electric vehicle charging that is managed by the utility through time-of-use rates	Load profiles for managed vehicle charging	Planned for IGP as part of the bookend sensitivity

[1] See DER Parties Program Track Final Proposal, Appendix D, page 3

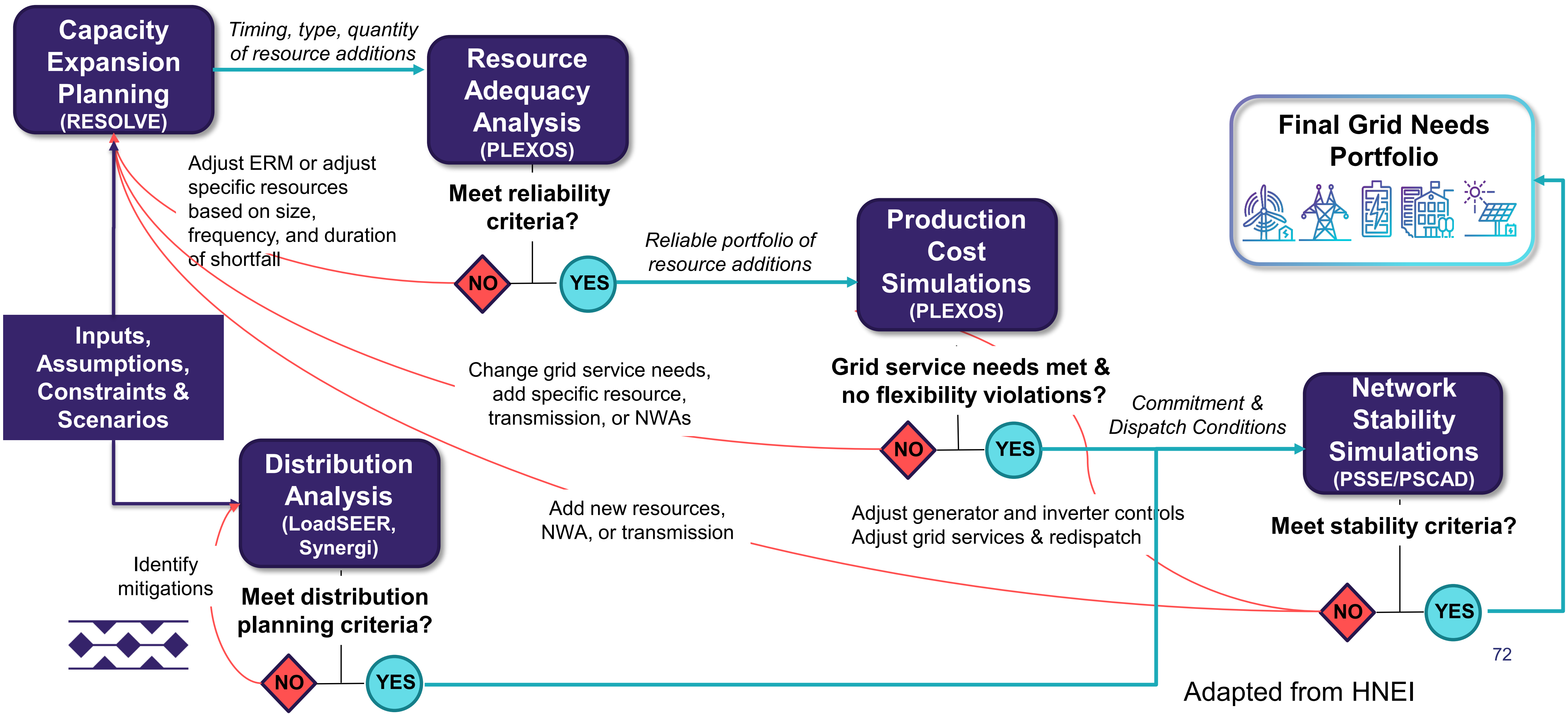
Feedback from June 2, 2021 regarding treatment of DER in the modeling

- Clarifications/questions raised by stakeholders:
  - Is RESOLVE bias toward gird-scale because of fixed cost treatment ("free" resource)?
  - Is DER being modeled to provide grid services?
  - Programs and tariffs should not be excluded in addressing grid needs
  - Separate sensitivities for the DER layers should be standalone
- Company's clarifications:
  - Grid-scale is not a free resource, RESOLVE will optimize resource selection using the cost of the resource
  - DERs can be modeled to provide grid services similar to the modeling work in the DER docket. This includes DER layers in the bookends
  - Bookend scenarios are intended to address uncertainty in future customer adoption. Allows evaluation of a range of max and min of system loads and associated grid needs and costs.
    - Evaluating DER layers in isolation meets a use case that may be better suited to program design (i.e., DER docket)
  - The intent of the grid needs assessment modeling is to identify grid needs that can be fulfilled by programs, pricing, procurements, and different types of technology
    - Grid-scale vs distributed, procurement vs program are less relevant at this stage when determining a portfolio of grid needs. Those discussions can be resolved following the grid needs assessment step as part of solution sourcing

Hawaiian Electric

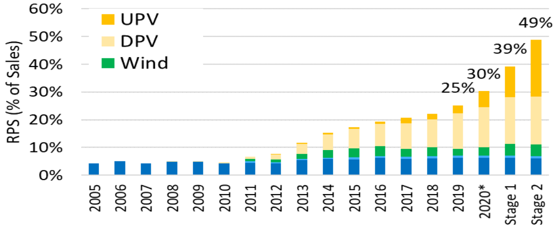
2:00pm: Deep Dive 4: Resource and Reliability Planning Criteria

A suite of tools make up the IGP modeling framework



Adapted from HNEI

Capacity Expansion



Objective:
Screening analysis to determine type, quantity, and timing of utility-scale resource additions across a *range of constraints*

Tool(s): RESOLVE

Key Inputs:
- Cumulative daily load and load shape, including DR, DER, EE, EVs
- Fuel price forecasts
- Candidate technology costs
- Proposed retirement schedules
- Reliability requirement (PRM, ERM)
- Grid service requirements

Key Outputs:
- Timing, type, quantity of utility-scale resource additions, including BESS
- Economic retirements
- Estimated capital and production costs
- Hourly marginal cost for services

Resource Adequacy Analysis

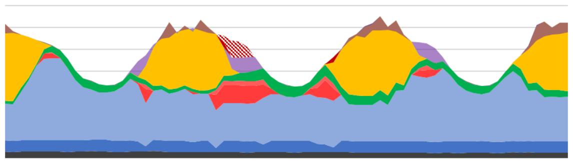
Objective:
Validate resource adequacy of portfolios in selected years to quantify system risk of proposed capacity expansion including timing of *retirements*

Tool(s): PLEXOS

Key Inputs: (additional to previous)
- Resource portfolio, including BESS, DR and DER
- Multiple years of wind, solar, and net load profiles
- Detailed generator outage data

Key Outputs:
- Reliability metrics (LOLE, EUE, etc.)
- Size, frequency and duration of capacity shortfalls

Production Cost



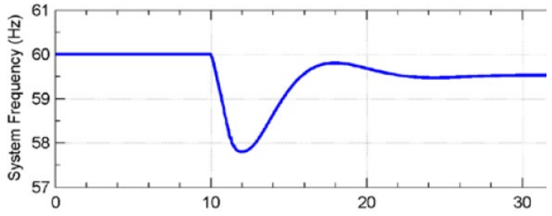
Objective:
Confirm operability of portfolios: reserves, ramp rates, unit commitment, storage schedules.
Quantify *production costs* and *avoided costs*

Tool(s): PLEXOS

Key Inputs: (additional to previous)
- Detailed grid service requirements & capabilities
- Detailed unit operating constraints (ramp rates, heat rate curves)

Key Outputs:
- Production Cost (Fuel, O&M)
- Hourly marginal cost $/MWh
- Curtailment, emissions, storage utilization
- Size, frequency, duration of non-capacity shortfalls

Network Stability Screening



Objective:
Validate *grid stability*, including frequency resp., voltage regulation, and short-circuit strength to determine if transmission upgrades are required.

Tool(s): PSS/E and PSCAD

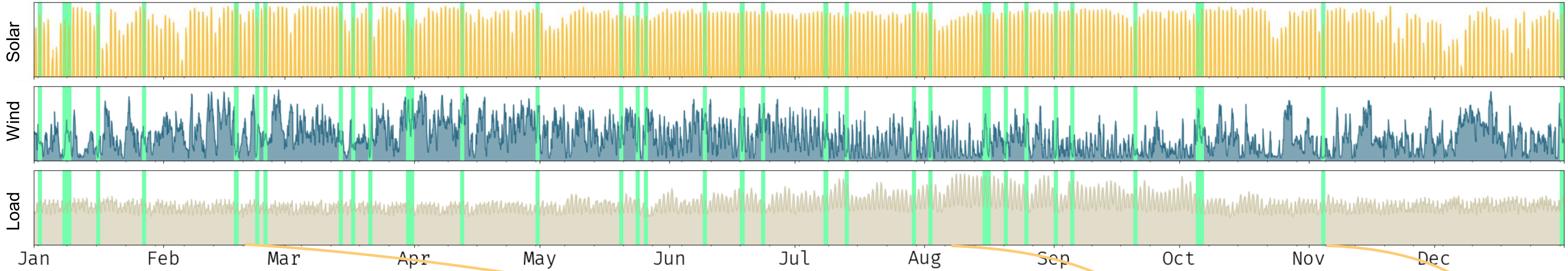
Key Inputs: (additional to previous)
- Transmission topology
- Selected unit commitment & dispatch
- Thermal unit performance: governor response
- Inverter settings & performance

Key Outputs:
- Transmission overloads
- Frequency and voltage violations
- System dynamic performance after a disturbance
- Enabling technologies or inverter control changes to mitigate stability concerns

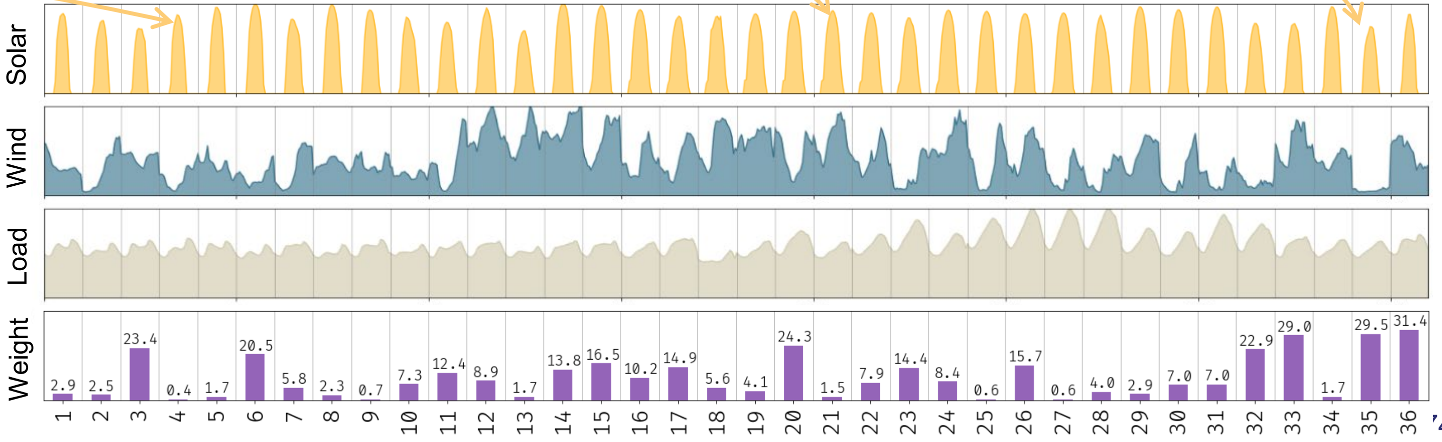
Adapted from HNEI

RESOLVE Day Sampling

- RESOLVE uses statistical sampling to downscale annual data to 30 representative days



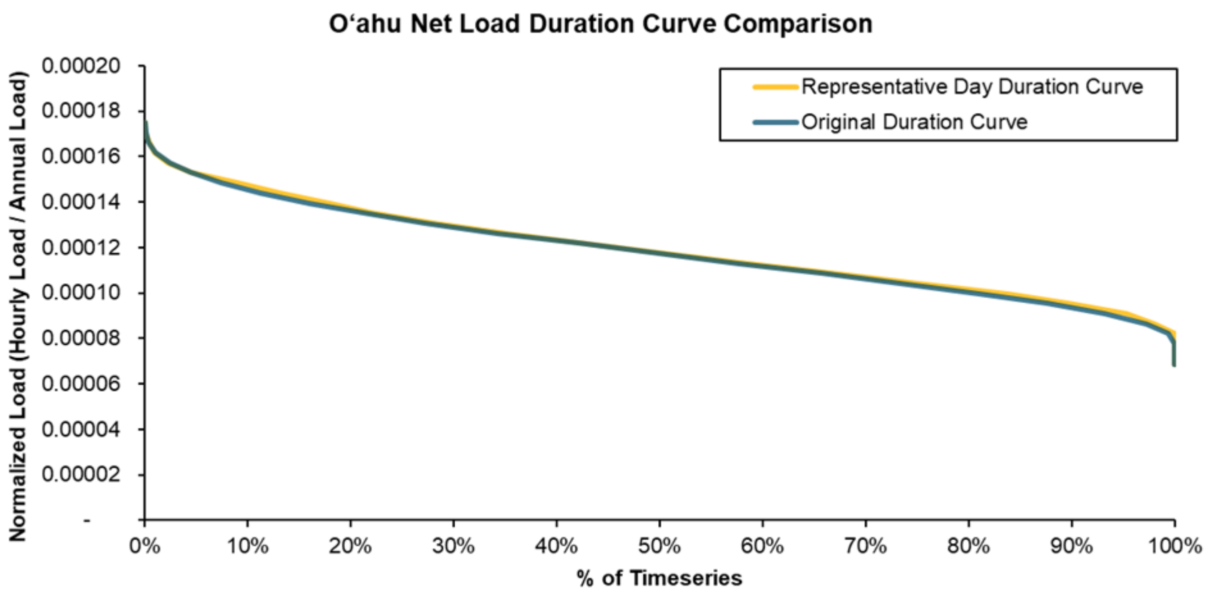
RESOLVE representative dispatch days are **downsampled and weighted** based on historical data to accurately estimate operational costs under most conditions

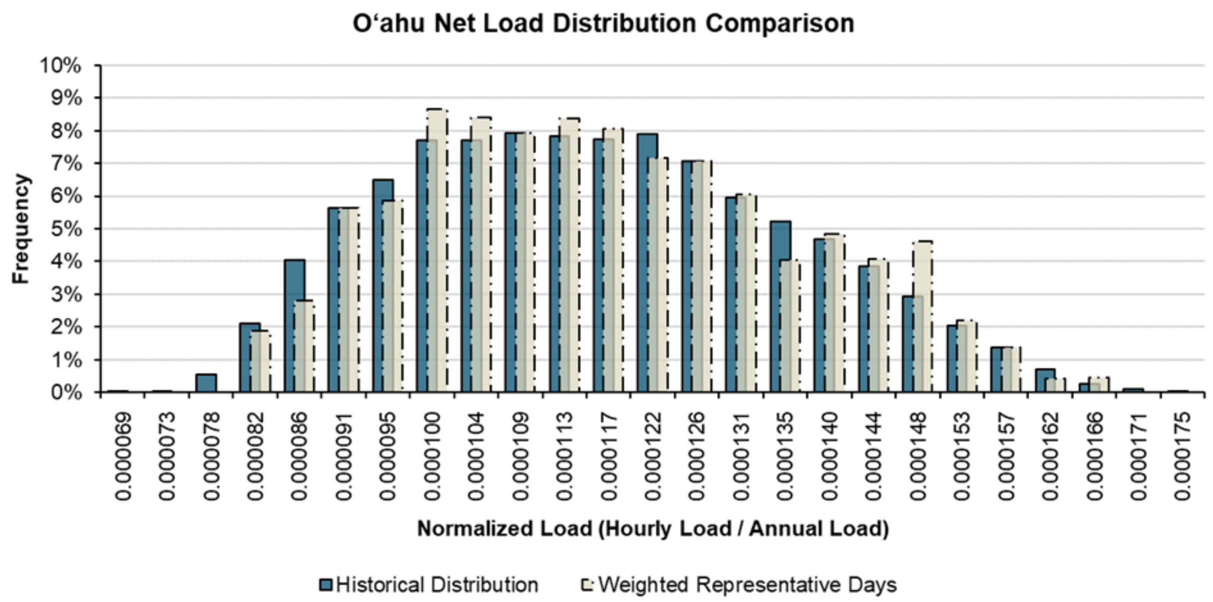


RESOLVE Day Sampling

- A model selects a sampled number of days using historical or synthetic timeseries data to find a subset of days that are representative of long run distributions of load, wind, solar, and hydro
- The model minimizes error between the overall distribution of data and the sampled distribution for the selected days
- 30 sampled days are selected for each month’s weekday, weekend combination, summer peak, winter peak, and an additional 4 days to reduce overall error
- 30 days are representative of most days from an operations perspective and allows the model to run in the span of a few hours
- A greater number of days will increase the model complexity and run time

RESOLVE Day Sampling





- Sampled days are verified against their historical duration curves and historical distributions to ensure a reasonable fit.

Four Ulupono Modeling Methods

Issue	Recommendation
1. Allow RESOLVE to optimize the amount of storage needed for both standalone and paired with solar PV sites, rather than requiring exactly four hours of storage with utility scale solar	1. Paired PV with 2, 4, 6, and 8 hour duration battery systems will be available in RESOLVE as candidate options.
2. Use alternatives to the proposed Energy Reserve Margin calculation or adopt a reserve margin in later years that is tied to a reliability analysis	2. The Company will test lower Energy Reserve Margin target percentages in RESOLVE and evaluate the impact on the resulting resource plans in PLEXOS. A sensitivity will also be performed to remove the Hourly Dependable Capacity assumption for variable renewables and instead consider the full production profiles. The Company is also open to having HNEI test the reliability of the various resource plans generated from RESOLVE at different ERM levels using their stochastic resource adequacy methodology.
3. Assume batteries and curtailed renewables will be able to provide virtual inertia when needed	3. Further study is warranted. The Company will test the provision of inertia from batteries and curtailed renewables in RESOLVE to assess the cost and impact on the resource plan. To mitigate near-term stability issues in 2023-2025, where inverter-based resources are expected to make up 95-100% of the dispatched resources for certain hours of the year, the Company will minimize synchronous condenser investments based on stability studies in PSS/E and PSCAD and repurpose generation assets to synchronous condensers to minimize costs and risk of stranded assets due to future technological advancements.
4. Assume 30-year contracts as the life of the Solar PV system or assume 20-25 with 5-10 year extensions at lower costs	4. New PV and wind resources will assume a 30-year term. Stage 1 and 2 RFP projects will be extended at their current lump sum costs for a total term of 30 years. Existing PV and wind resources will continue to be removed from service at the end of their contract term.

TAP's independent review of planning criteria

- While TAP recognizes that engineering judgement can reduce the requirement for the full process to be used for all iterations, TAP recommends that solutions be vetted by the full process before proceeding to the procurement phase.
- TAP agreed that additional analysis in RESOLVE to estimate optimal battery sizes should be conducted but identified some issues to be considered.
  - The TAP stated that the estimation of alternative storage sizing using RESOLVE should be considered an "estimation," recognizing that more detailed reliability, cost and stability analysis should be conducted to guide decision making.
  - Overbuilding capacity might make sense for a limited duration (a year or two) to ensure reliability but might not be appropriate if the intent is to solve a 2040 problem with today's storage. There needs to be engineering and operational judgment looking at all aspects of the problem.
- TAP agrees that HECO is correct to identify a need to change the conventional planning reserve margin used in previous planning efforts with a new methodology that evaluates all hours of the year and chronological operations of the grid
  - The TAP recommends that a) a more complete description of the determination of the current ERM values be developed and made available for review as soon as possible and b) analysis conducted to determine the relationship between ERM and detailed resource adequacy analysis.
  - The TAP generally agrees with this approach with the recommendation that all parties be involved in the design of the scenarios to be used for this analysis.
  - The TAP does not agree with this statement, that the worst weather day be modeled in RESOLVE
- TAP agrees that, in the relatively near future, more inverters providing services such as inertia and/or FFR will become available. A major question remains as to how this will be implemented.
  - At this point in time, TAP sees high risk in relying exclusively on inverters for inertia required by the Hawaiian grids. Synchronous condenser conversions are a reasonable and realistic short-term bridge as the inverter technology matures.

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.
- The schedules are intended to be initial assumptions that may be iterated upon through the IGP modeling process.

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		