Distribution Planning
Methodology

JUNE 2020

Hawaiian Electric

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01 INTRODUCTION

1.1 Background

As it strives to provide 100 percent renewable energy by 2045, Hawaiian Electric (Company) faces an unprecedented situation: a comprehensive transformation of its five electric power grids. Attaining the state's renewable energy goals represents uncharted territory for both short-term and long-term resource planning. Performing the analyses necessary to attain this goal is a complicated resource planning process, requiring new tools and new processes: modeling across generation, transmission, distribution, infrastructure, and behind-the-meter resource options. This report describes the distribution planning methodology used to analyze the current state of the grid and its capability to meet future needs. Through this process, grid needs essential to support the transformation to a clean energy future are identified and solution options are explored.

The Company's distribution system is the part of its electric power system that distributes or disperses power to individual customers. The electrical distribution system (commonly referred to as the distribution grid) was originally planned and designed for the sole purpose of delivering electricity to customers from a small number of large power plants. In general, power flowed in only one direction, and it did not have to be flexible or adaptable—just strong and reliable.

Because centralized power plants have provided all of the power for its customers, the Company's traditional distribution planning methodology did not have to consider power generation. Instead, its methodology concentrated only on developing a distribution system that had the capacity to serve customers while maintaining power quality and a high level of reliability. Any deficiencies in the distribution system were solved by upgrades to the existing electrical system, including the installation of more substation transformers, more circuits, larger circuits, or larger distribution transformers.

Today, power plants can be found everywhere, connected to the distribution system in the form of privately owned rooftop solar systems, for example, that send power back onto the grid to serve other customers. The Company recognizes the potential and value of these distributed energy resources (DER) and agrees with the Commission's direction to "include the locational benefits of customer-sited distributed energy resources"[1] in the distribution planning process.

[1] HPUC Docket No. 2018-0055, Decision and Order No. 36288 Ka'aahi Substation, filed May 3, 2019, at 22.

As the power supply and electrical distribution systems transition to an integrated system, the planning processes must also transition. Hence today's distribution planning methodology must ensure the orderly expansion of the distribution system and fulfill the following core functions:

- Plan the distribution system's capability to serve new and future electrical load growth, including electric vehicle (EV) growth
- Safely interconnect DER, such as photovoltaic (PV) systems and energy storage systems that transmit power across the system in a two-way flow, while maintaining power quality and reliability for all customers
- Incorporate the locational benefits of DER in the evaluation of grid needs and system upgrades

The Company has engaged with customers and stakeholders to seek input and feedback on the distribution planning methodology as part of the Distribution Planning Working Group. This has afforded opportunities for stakeholders to collaborate and co-develop the Company's distribution planning methodology for identifying grid needs.

1.2 Scope

The objective of this report is to describe the first three stages of the distribution planning process, particularly the planning methodology that will be used to identify distribution grid needs. The grid needs will be the foundation that drives solution options, including non-wires alternative (NWA) opportunities.

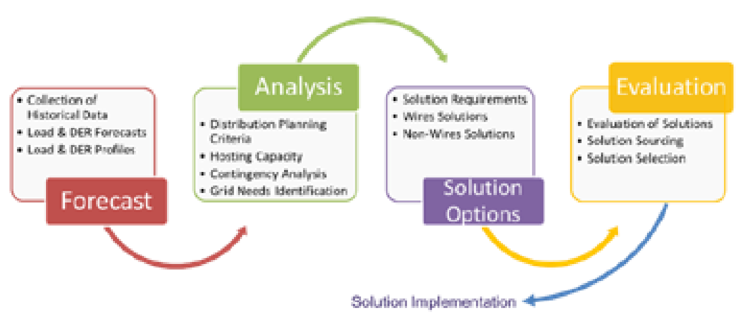
This report is a Distribution Planning Working Group deliverable as described in the Integrated Grid Planning (IGP) Workplan accepted by the Commission. [2]

02 DISTRIBUTION PLANNING PROCESS

2.1 Overview

The distribution planning process occurs annually and includes four stages: forecast, analysis, solution options, and evaluation (see Figure 1). This report focuses on the first three stages, and the fourth stage is described in the *Non-Wires Opportunity Evaluation Methodology* report.[3]

Figure 1: *Stages of the Distribution Planning Process*

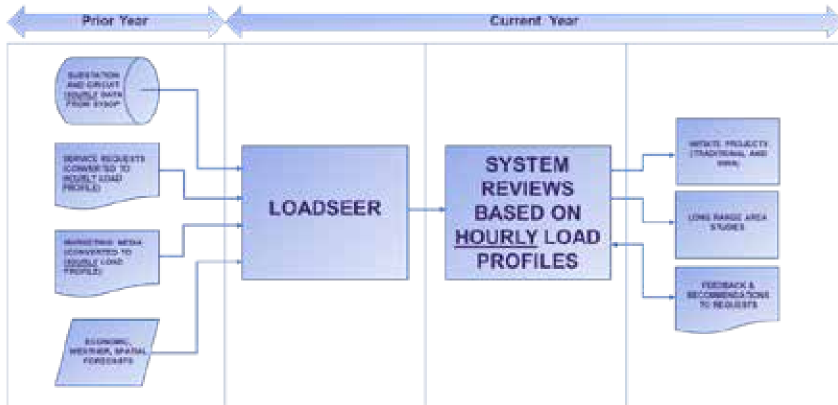


[2] HPUC Order No. 36218, Accepting the IGP Workplan and Providing Guidance, Docket No. 2018-0165.
[3] Hawaiian Electric, *Non-Wires Opportunity Evaluation Methodology*, June 2020.

2.2 Stages

The forecast stage begins at the start of the calendar year when the prior year's data and corporate demand forecast are available for analysis (see Figure 2). LoadSEER, an integrated spatial load forecasting product developed by Integral Analytics, Inc., is used to create circuit- and transformer-level forecasts.

Figure 2: Data from Prior Years used for Current Year Analysis



The analysis stage involves the analysis of the electrical system to ensure that there is adequate capacity and reliability (back-tie capabilities). Planning criteria have been established that provide the basis for determining the adequacy of the electric distribution system. In situations where the criteria are not met, grid needs are identified.

In the solution options stage, requirements to meet the grid needs are determined, and wires and non-wires options are developed. These options are evaluated in the fourth stage of the distribution planning process, which is discussed in the *Non-Wires Opportunity Evaluation Methodology* report.

It is worth noting that during the calendar year, it is expected that new service requests or projects will arise that will require modifications to the circuit- and or transformer-level forecasts. The Company will, therefore, continually evaluate grid needs throughout the year and make decisions on when to address any grid deficiencies identified outside of the forecast and analysis stages.

03 FORECAST STAGE

During the forecast stage of the distribution planning process, the Company develops a corporate demand forecast and uses LoadSEER to create circuit- and transformer-level forecasts.

3.1 Corporate Demand Forecast

The Company develops a corporate demand forecast that will be used throughout the distribution planning process. This forecast is built with layers that include sales, DER, energy efficiency (EE), and EV. The corporate forecast is developed as an 8760 for the Company by layers. The 8760 is named for the number of data points it contains: one for every hour of every day of the year (24 x 365 = 8760). This will include DER (PV), battery energy storage system, EV, electric bus, and EE (8760 EE provided by AEG). For further information on the methodology of developing the corporate forecast, see the Integrated Grid Planning presentation by the Forecast Assumptions Working Group.[4]

3.2 LoadSeer

LoadSEER is recognized as an industry-leading tool for use in forecasting and integrating DER with distribution planning.[5] LoadSEER has been adopted by the Company as a key component to advancing the distribution planning methodology. This electric load forecasting software uses the Company's corporate load forecasts and a multitude of other inputs to create forecasts at the circuit and transformer level.

The objective of LoadSEER is to statistically represent the geographic, economic, and weather diversity across a utility's service territory, and to use that information to forecast how circuit- and transformer-level hourly load profiles will change over the next 30 years. Because of the complexity of the forecasting challenge, LoadSEER employs multiple statistical methods, including hourly load modeling, macro-economic modeling, customer-level economic modeling, and geospatial agent-based modeling, which taken together increase the validity and reduce uncertainty associated with the forecasts.

3.2.1 CIRCUIT-LEVEL FORECASTS

The allocation of the forecasts to the circuit level is accomplished by integrating geospatial factors, historian data, historical and forecast weather, and customer billing information. This provides the granular data sets that are required to properly analyze the integration of increasingly dynamic DER.

LoadSEER employs familiar econometric forecasting methods at the circuit level and adds GIS-based spatial forecasting capabilities to aid in the identification of granular pockets of load growth, changes in loads, and load shape alterations that occur over time. Using these forecasting and modeling methodologies, LoadSEER is able to produce circuit-level new load, DER, EE, and EV forecasts.

3.2.2 GRANULAR DATA SETS

Traditionally, non-coincident peak loading was used in the distribution planning process. For instance, the peak load for a new service that was proposed to be energized in year X was added to the peak load forecast for year X to determine the new forecast. If the peak load for the new service did not occur at the same time as the peak load for the circuit or transformer, the resultant peak forecast may be overestimated.

The Company has recognized that this methodology does not properly evaluate the temporal nature of load and, in a similar manner, does not properly evaluate the effect of DER. By using LoadSEER, the annual circuit-level peak load has been replaced by an 8760 hourly load profile as the mechanism for forecasting future load. While traditional planning used one value to plan for a year, this methodology uses a large set of hourly profiles. LoadSEER can convert the large 8760 load profile to a more manageable 576 load profile. The latter profile is composed of a weekday and weekend profile per month [(weekday 24 hours + weekend 24 hours) x 12 months].

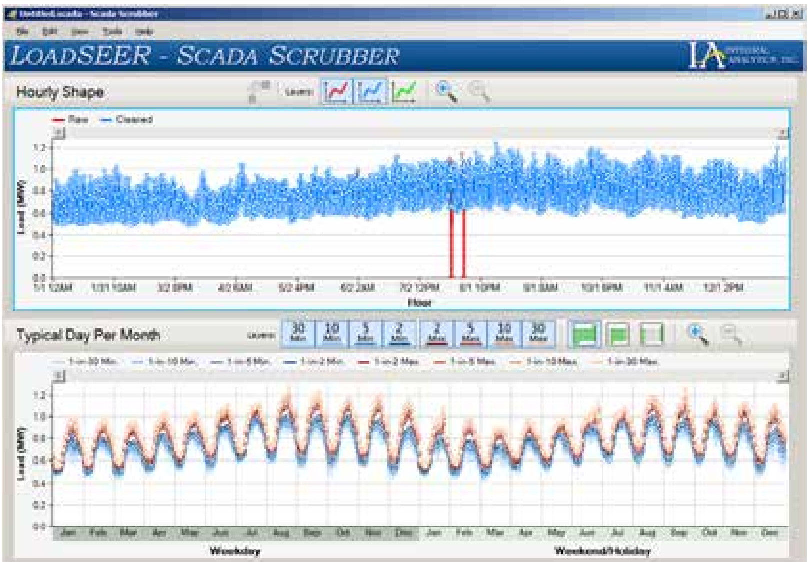
3.2.3 FORECASTING TOOLS

A component of LoadSEER is SCADA Scrubber (see Figure 3). This tool takes the hourly data and analyzes it for trends, which the tool then uses to normalize periods where planned maintenance or system interruptions occurred.

[4] Hawaiian Electric, Forecast Assumptions Working Group Meeting, July 17, 2019 (available at https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/forecast_assumptions/20190717_wg_fa_meeting_presentation_materials.pdf).

[5] See https://www.utilitydive.com/news/how-leading-utilities-are-planning-for-distributed-energy-resources/516260/.

Figure 3: LoadSEER SCADA Scrubber Screenshot



After the data has been "cleaned," 8760 and 576 profiles based on actual data are available to determine the historical peak load and to provide profiles for future year forecasts.

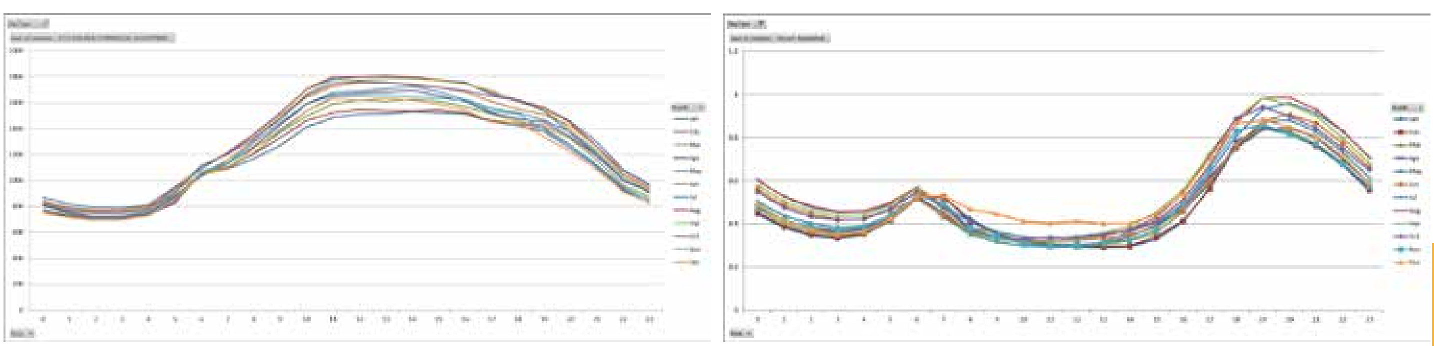
New load requests, DER requests, and marketing and media information of new developments that have been received in the past calendar year are used to refine the forecasts at the circuit and transformer level. Normally, customers who submit new service requests to the Company provide only a peak load estimate and a rough in-service date. As such, LoadSEER has default commercial and residential load profile shapes that are based on the Company's actual commercial and residential load profiles, respectively (see Figure 4). The Company is continuing to explore ways to work with large real estate developers to gain better insight and local knowledge to inform load forecasts, such as, to the extent possible, requiring developers to provide expected load profiles of their developments rather than just a peak megawatt load increase. The Company intends to use additional sensing data as it becomes available to develop customer class profiles by type or sector, which will improve the accuracy of the load forecasts.

These default profiles are used to scale the peak load estimates for the new developments to create a proxy load profile. Similarly, a load profile of an existing, comparable customer could be used in this manner. This local knowledge is a key component because it generally has the greatest impact on circuit-level forecasts.

LoadSEER also has tools to apply various scenarios to the forecasts. For instance, a range of forecasts can be applied to DER, EV, and EE layers to plan for their inherent uncertain nature.

In addition, tools are available to further modify the circuit- and transformer-level forecasts by

Figure 4: Scalable Commercial and Residential Profiles



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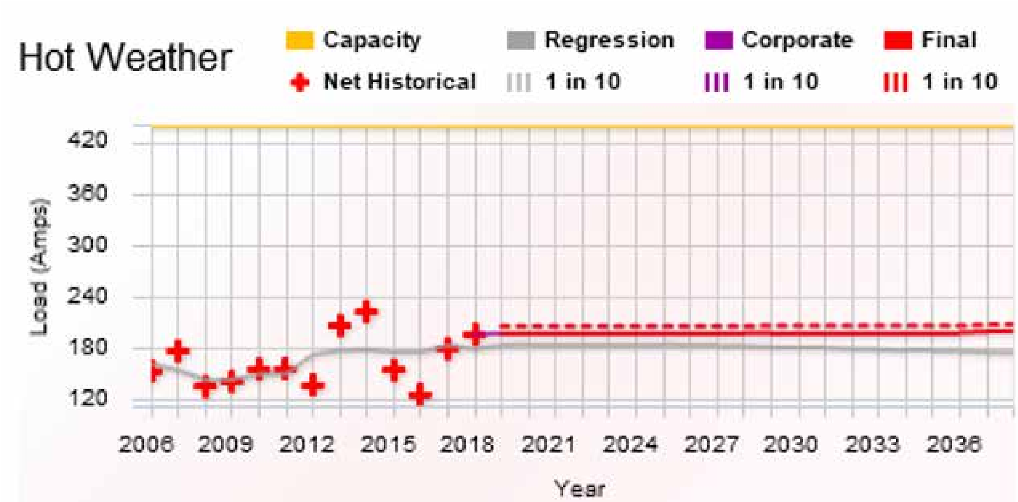
using regression analysis or econometric variables, or a blending of these two methodologies. An example of a feeder forecast is shown in Figure 5.

Figure 5: Example LoadSEER Circuit Forecast



04 ANALYSIS STAGE

During the analysis stage of the distribution planning process, the Company uses distribution planning criteria to determine the adequacy of the electric distribution system. In addition, the Company assesses DER hosting capacity, conducts a contingency analysis, and identifies grid needs.

4.1 Distribution Planning Criteria

Distribution planning criteria have been established as technical guidelines to ensure that the distribution system has adequate capacity and reliability for the Company's customers. Hence the distribution system is planned and designed to operate under both normal and contingency conditions. In addition, it is important to consider normal and contingency overloads, and thermal and voltage issues.

4.1.1 NORMAL CONDITIONS

The distribution system, or a subset of the distribution system, is operating under normal conditions when all circuits and transformers in the subject area are configured as designed. Under this normal condition, the circuits and transformers are planned to have adequate capacity to serve electrical peak load, and with DER, the circuits and transformers are also planned to be adequate for the backflow of generation caused by the DER.

4.1.2 CONTINGENCY CONDITIONS

The distribution system, or a subset of the distribution system, is operating under contingency conditions when a single circuit or transformer is out of service. This is also referred to as an N-1 scenario. A circuit or transformer may be out of service or de-energized because of equipment failure or planned maintenance. As such, a level of capacity must be available on the circuits and transformers to be available to serve the Company's customers during these N-1 scenarios. For instance, because an adjacent circuit or transformer is often used as a backup source for another circuit or transformer, N-1 scenarios also need to be analyzed to ensure that back-tie capacity is available.

4.1.3 NORMAL AND CONTINGENCY OVERLOADS

Normal overload occurs when the load exceeds the normal equipment rating of distribution circuits or distribution substation transformers under normal operating conditions. Normal overload is identified by comparing the forecasted load with the equipment rating.

Contingency overload occurs when the load exceeds the emergency equipment ratings of a piece of equipment due to other equipment failure or other equipment being out for maintenance. Contingency overload is identified by studying the forecasted load for possible contingency situations.

4.1.4 THERMAL AND VOLTAGE ISSUES

The overload of a circuit or transformer may lead to overheating issues that will damage equipment; hence, overloads are considered thermal issues. In addition to thermal overloads, the Company also ensures that there are no voltage issues. In general, the voltage level must be maintained within 5 percent of the nominal voltage at any point on the distribution system (primary and secondary).

When circuit or transformer loading exceeds the equipment thermal ratings, damage may occur to the equipment. This damage may lead to extended service interruptions and high maintenance expenses. Low or high voltage may lead to power quality issues that could damage customer-owned equipment or cause nuisance electrical issues, such as flickering light or tripping of equipment.

4.2 Equipment Thermal Ratings

Distribution circuit thermal ratings are primarily based on the following factors:

- Conductor size
- Conductor material
- Number of conductors in a duct bank (underground construction)
- Temperature
- Type of insulation
- Conductor configuration

Distribution substation transformer thermal ratings for normal and contingency conditions are primarily based on the following factors:

- Expected hourly loading
- Oil and ambient temperature
- Allowable insulation degradation (loss-of-life limits)
  - A 0 percent loss-of-life factor is the basis for the normal transformer rating.
  - A 1 percent loss-of-life factor is the basis for the emergency rating.

4.3 Grid Analysis and Modeling

Analysis is necessary to identify any violations of the distribution planning criteria. The load forecasts are analyzed under normal and contingency operating conditions to determine the location, cause, and severity of any unacceptable thermal or voltage situations.

Simulations of the various normal and contingency operating conditions are analyzed using LoadSEER as well as Synergi, which is a load flow software developed by DNV-GL. By using LoadSEER and Synergi in concert, the Company determines any existing or forecasted grid needs. Both software products also facilitate the development of solution options for the identified issues.

4.4 DER Hosting Capacity

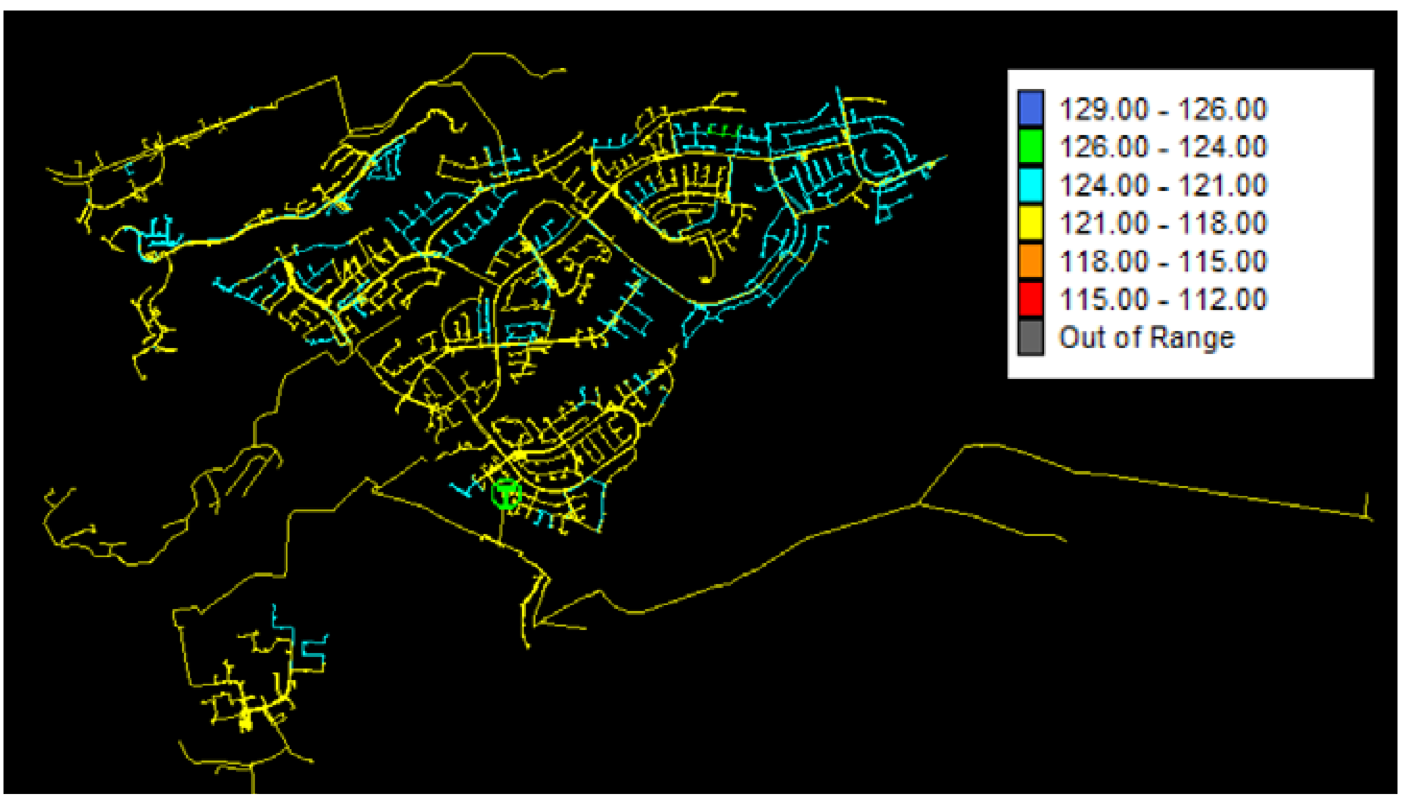
During the analysis stage, DER hosting capacity is assessed to determine any future grid needs required to create capacity for future DER. In general, the hosting capacity analysis involves the use of Synergi circuit models where DER growth is simulated to determine the maximum amount a circuit can host before any thermal or voltage violations occur. The loadflow capabilities of Synergi provide information on the location and magnitude of these issues (see Figure 6).

4.4.1 EXISTING HOSTING CAPACITY METHODOLOGY

Figure 7 illustrates the existing hosting capacity methodology. With today's methodology, DER is added to a circuit according to the location of current DER applicants, and those amounts are grown until a violation occurs. Any violation is a potential grid need.

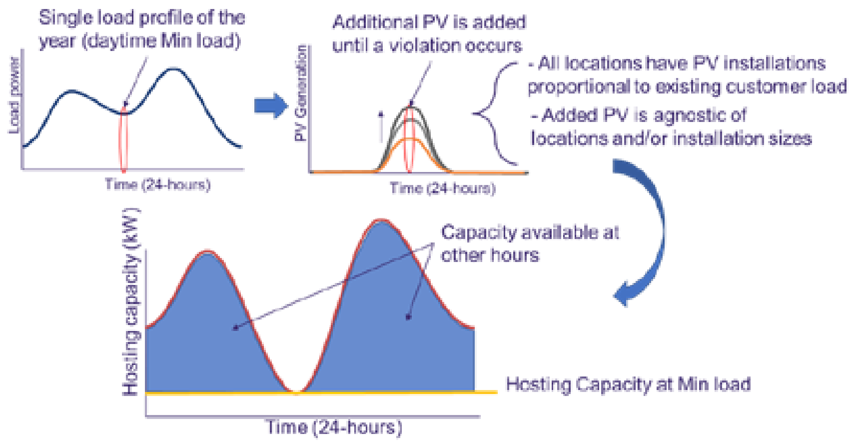
As illustrated, this methodology uses only a single, minimum load profile and does not consider the capacity available during all other hours. Although this does not account for the temporal nature of solar output, this single hosting capacity figure still provides valuable screening thresholds to help determine the circuit's ability to accommodate additional DER without the need for in-depth analysis. If the circuit has reached or exceeded its hosting capacity threshold, then any new DER will require

Figure 6: Synergi Screenshot



more advanced studying until system changes warrant the development of a new hosting capacity threshold.

Figure 7: Existing Hosting Capacity Methodology



4.4.2 FUTURE HOSTING CAPACITY METHODOLOGY

The Company is updating the existing methodology to account for the hosting capacity available during all hours. This can be accomplished only by using time-sensitive profiles of the unique DER programs as well as the modeling of advanced inverters in a time-series analysis. Furthermore, because there are many ways that DER can develop on a feeder, multiple DER growth scenarios need to be studied, applying probabilistic modeling techniques and analysis. A comparison of the existing hosting capacity with the future hosting capacity analysis is shown in Figure 8.

The Company is working with Electric Power Research Institute (EPRI) to refine the hosting capacity analysis.[6] The methodology is scheduled to be developed by the second quarter of 2020. The new DER hosting capacity methodology will be implemented in the distribution needs assessment as part of the transmission and distribution needs assessment step of IGP.

Figure 8: Future Hosting Capacity Enhancements

	Current HECO HC analysis	Future HECO HC analysis
Model Unique DER Programs (Non-Export & Smart Export)	✗	✓
Advanced Inverter (VV/VW)	✗	✓
Time Series (576/8760)	✗	✓
Probabilistic model	✗	✓
Add PV in realistic installation sizes	✗	✓
Add PV in locations that make sense	✗	✓

[6] Hawaiian Electric, Distribution Planning Working Group Meeting, November 18, 2019 (available at https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20191204_dpwg_meeting_presentation_materials.pdf).

The updated hosting capacity methodology being developed with EPRI incorporates several new aspects to determine an hourly circuit hosting capacity profile. The assessment considers the effects of smart inverter functions and the temporal load characteristics of the different Company programs, such as smart-export systems, non-export systems, and storage profiles via time-based analysis. The Company is seeking data from solar installers to help inform the generation output model for these systems.

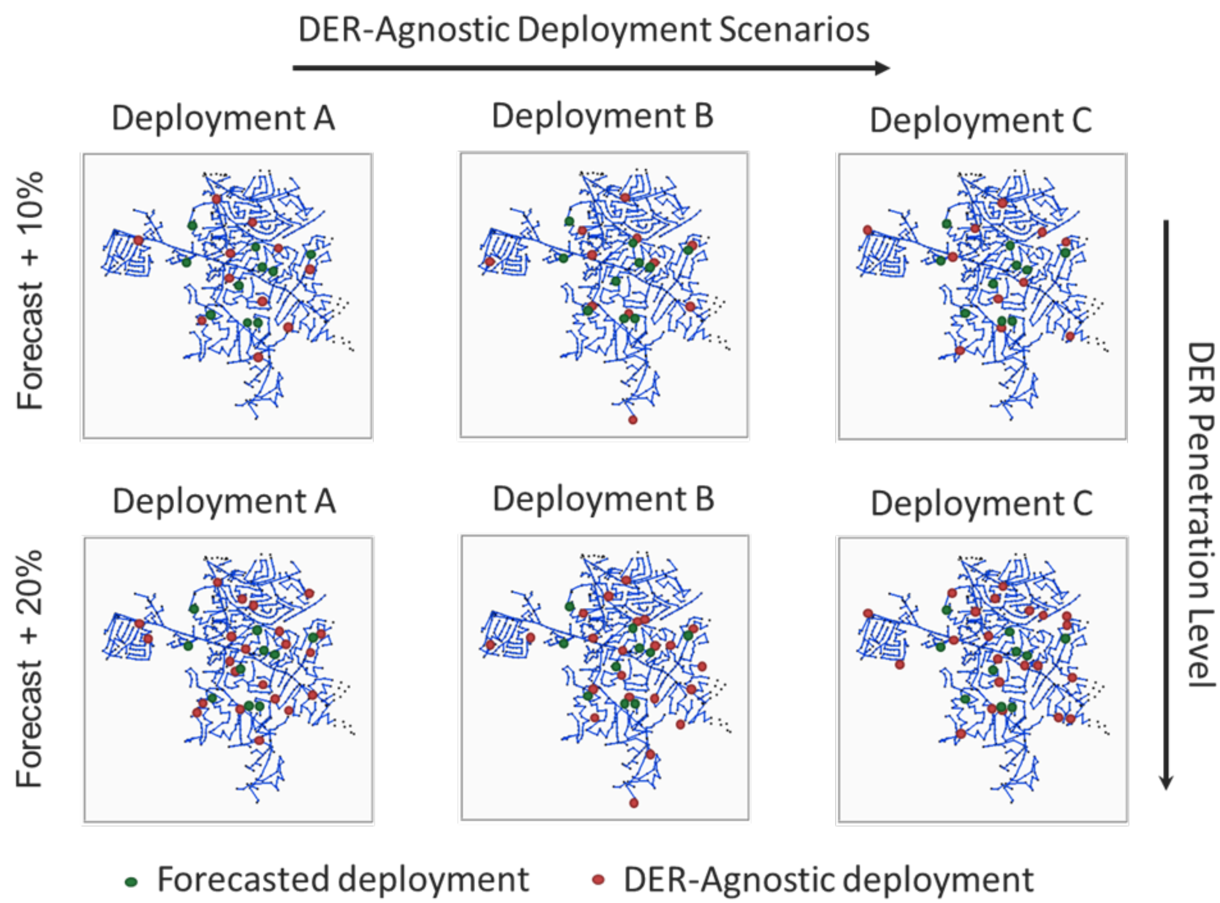
The updated methodology plans to use circuit-level forecasts (for example, circuit load shapes and future DER growth) that are generated from LoadSEER. The Company will use a 576-hour time-series model format that corresponds to 24-hour observations for 24 days. Typically, this represents 2 days for each month. These 2 days are either the peak/minimum load days or the weekday/weekend days of the months. Alternatively, the profile can be expanded to include as many hours as desired, such as a full 8760-hour profile representing all 365 days of the year at a 1-hour resolution.

An additional enhancement is the modeling of future DER deployments. Incorporating user input, the addition of future DER will be modeled in a more realistic manner. The size of each new residential DER is randomly chosen between the bounds defined by the user, allowing flexibility to preserve the prevalent DER size belonging to circuits in unique areas. The user also defines the threshold to identify either a commercial or residential load type.

The DER is then sized according to the load type it is connected to. The size and location of future DER installations are normally unknown variables in hosting capacity analysis. Unlike the existing hosting capacity methodology, which simply scaled up existing DER installations to represent DER growth, the new methodology explores multiple scenarios where DER deployments of different sizes and locations are added to the model to develop a probabilistic hosting capacity. Traditionally, hosting capacity is set by the first DER scenario, causing the first bus/element to have a violation at any instance in time. Probabilistic hosting capacity, on the other hand, allows one to consider additional hours, buses, and/or DER deployments beyond the first violation before the hosting capacity is determined.

The hosting capacity assessment is performed in three primary steps: base case, forecasted DER, and agnostic DER. The base case assessment analyzes the existing circuit conditions for the year. The forecasted DER assessment explores multiple scenarios of adding new DER deployments onto the circuit, totaling the forecasted DER amount for the year of study. The generation profile for the forecasted DER deployments is a function of the DER size, program type, and solar irradiance for the area. Finally, the agnostic DER assessment adds agnostic DER deployments on top of the forecasted DER assessment. Full generation output is considered from each agnostic DER at each hour because it is not known how or when that resource would be online (such as solar plus storage projects), thus providing circuit impact results agnostic to future DER type. The order by which the agnostic DER is allocated is cumulatively split into a number of penetration levels that are independently analyzed so that the impacts from the additional agnostic DER can inform hosting capacity. More penetration levels can be analyzed and will effectively produce finer resolution hosting capacity results because the maximum agnostic DER penetration level scenario

Figure 9: Forecasted and Agnostic DER Deployment Scenarios



is always based on full feeder saturation where all customers have DER. Figure 9 illustrates two penetration levels out of ten, which would take the feeder to 100 percent customer penetration.

After each simulation, power flow data is captured to quantify impacts. This data is used to process the probabilistic hosting capacity depending on time, breadth of the violation, and number of agnostic DER deployments indicating violation. Therefore, the probabilistic hosting capacity is dependent on the number of violated hours, the number of violated locations, and the number of agnostic DER deployments experiencing a violation. In planning studies with so many variables, these probabilistic metrics are more beneficial than planning for the worst-case scenario. The worst-case scenario would identify when the first sampled condition experiences a violation, but it also has the lowest chance of occurrence/risk. The probabilistic hosting capacity allows one to identify a more likely chance of occurrence with slightly increased risk. For example, if the probabilistic hosting capacity is based on 10 percent of the sampled conditions experiencing a violation, the amount of DER that can be accommodated is greater than the conservative worst-case scenario. In this example, this probabilistic hosting capacity defines that 10 percent of the sampled conditions could not accommodate more DER due to more adverse violation, whereas 90 percent of the sampled conditions could still accommodate more

DER. The analysis illustrated in Figure 10 shows the frequency of hosting capacity of a circuit throughout the hours in a day. Figure 11 is its the associated color index.

Figure 10: Daily Hosting Capacity Profile

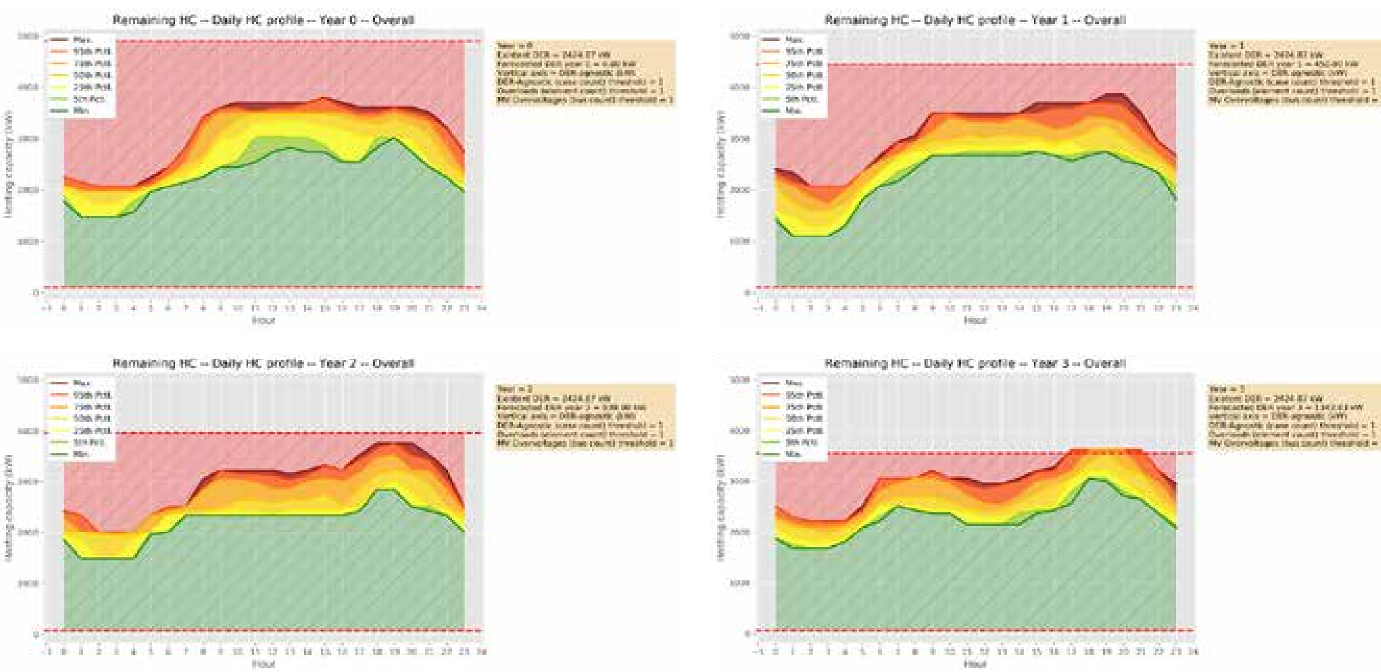


Figure 11: Daily Hosting Capacity Color Code

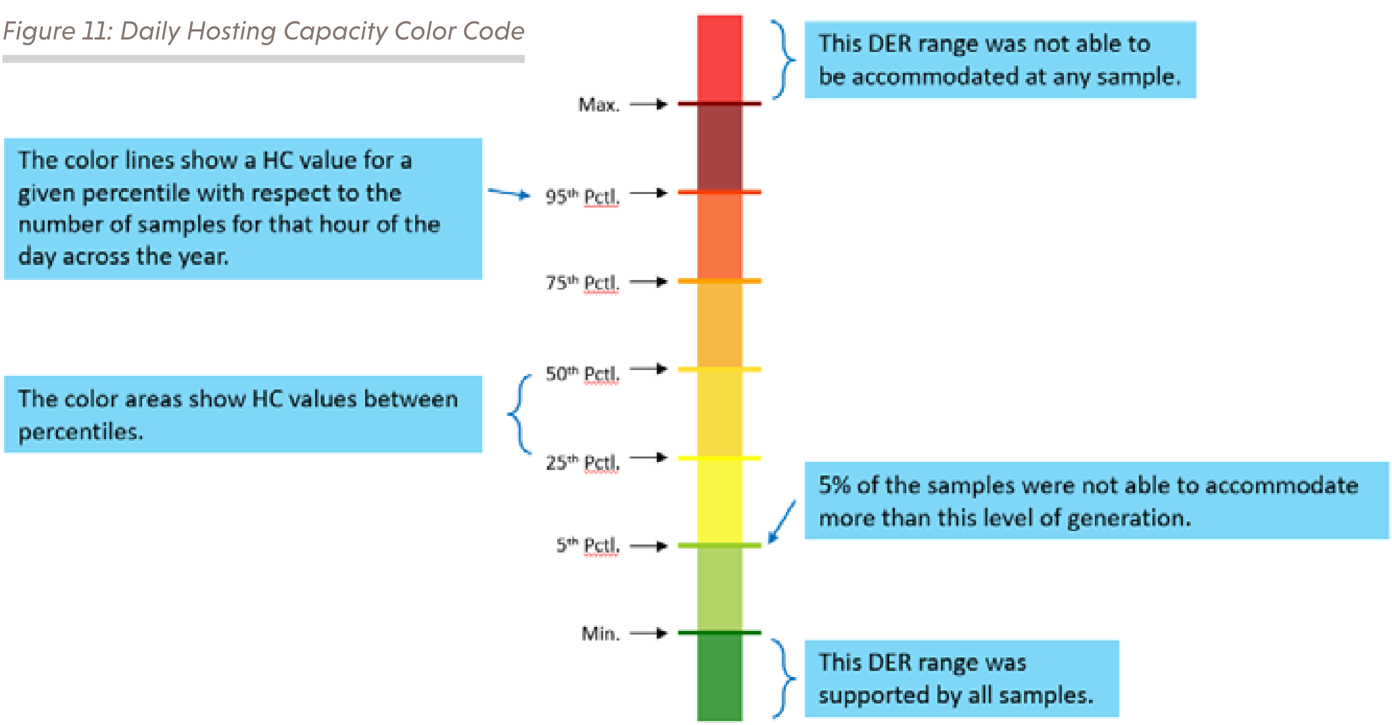
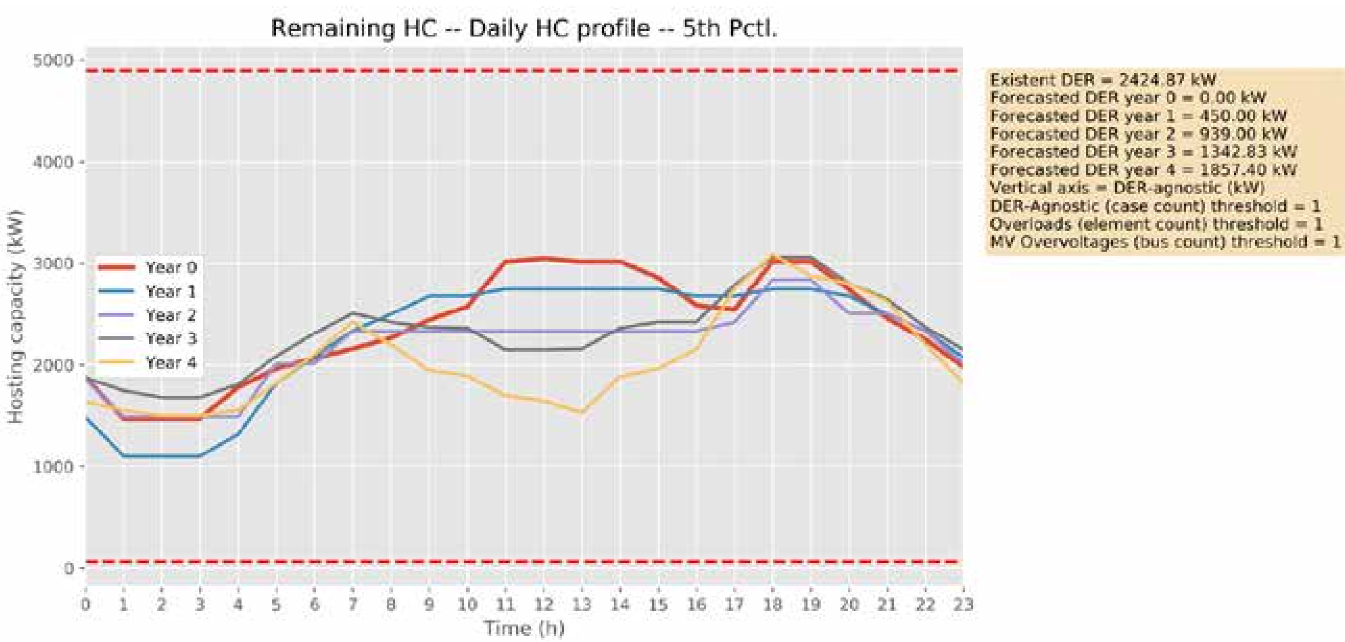


Figure 12: Example Daily Percentile-Specific Hosting Capacity Result



In the example shown in Figure 12, the results of a probabilistic analysis of the fifth percentile shows the daily hosting capacity available forecasted over multiple years on a circuit.

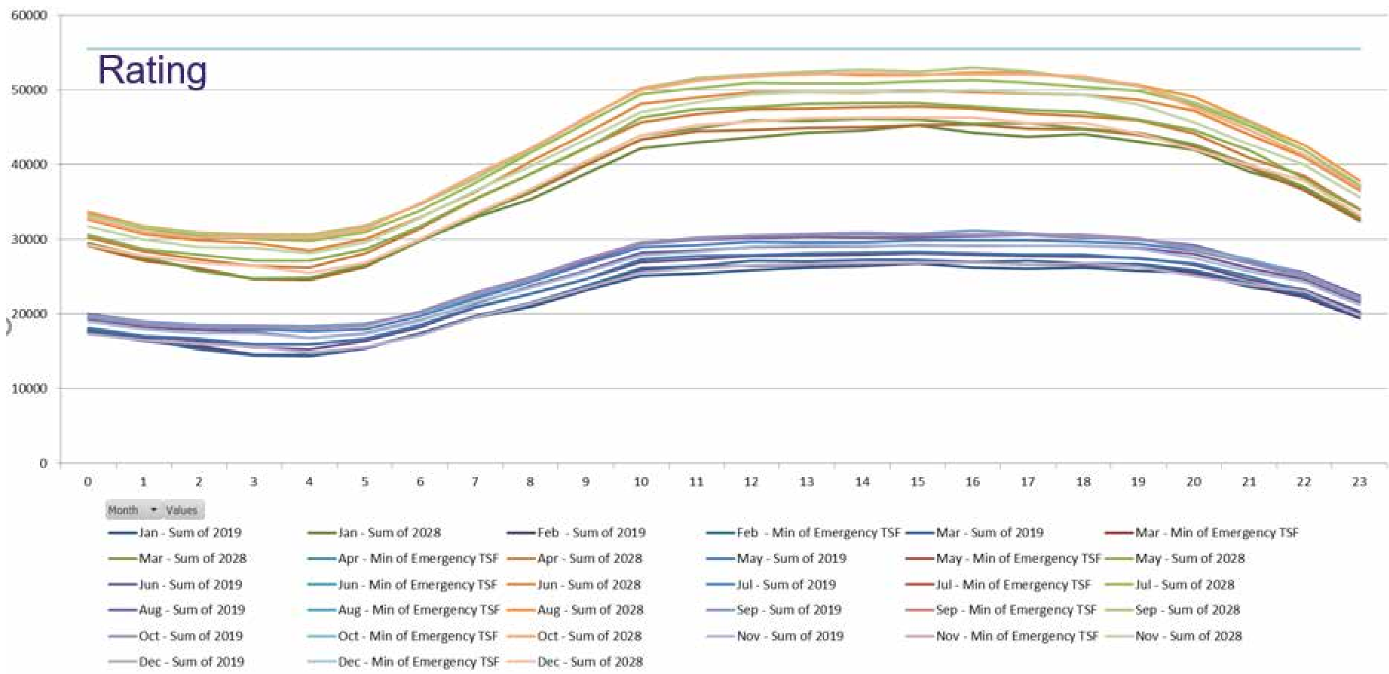
Overall, the Company's updated hosting capacity methodology will be a time-based analysis that takes into consideration the Company's unique programs, the impact of advanced inverter functions, and the two key variables of DER deployment—size and location—that form the core structure for a probabilistic analysis. By considering these new variables, it is expected that the methodology will produce less conservative and more realistic hosting capacity results. The updated methodology is performed in three steps that each provide different objectives: (1) the base case assessment to identify any underlying conditions on the feeder; (2) the forecasted DER assessment to identify underlying conditions due to the DER forecast; and (3) the agnostic DER assessment to identify the remaining hosting capacity. Separating these steps helps the analysis incorporate the information from the Company's forecasting tool and inform its future grid needs assessments.

4.5 Contingency Analysis

For the Company circuits and transformers, LoadSEER produces 576-hour profiles for both normal and contingency (N-1) cases. Furthermore, new developments that have a direct impact on the circuits or transformers that are being analyzed can be added to the profiles created for the various cases.

Figure 13 shows an example of a contingency analysis using the hourly profile from LoadSEER. The darker group of lines represent the forecast loading on a distribution substation transformer for a peak day per month when an adjacent distribution substation transformer fails. The lighter group of lines represents the forecast loading if new large services are energized in the area. The example shows that the forecast for this N-1 scenario does not cause a thermal rating violation.

Figure 13: N-1 Example



4.6 Planning Criteria Violation

The analysis stage of the distribution planning process should identify existing or forecasted thermal or voltage issues on the Company's circuits and substation transformers. Issues may also be identified through data provided directly by devices installed throughout the Company's system that record voltage and current. These devices include advanced meters and OptaNode Grid2020 units.

Regardless of the manner in which an issue is identified, any situation where planning criteria are violated will need further review to determine the grid needs and the associated solution options.

4.7 Grid Needs Identification

To identify grid needs, the Company develops a demand forecast, a demand forecast by load type, a grid needs assessment, and an hourly grid needs summary, as discussed in the following sections.

4.7.1 DEMAND FORECAST

As part of the distribution grid needs documentation,[7] the Company will submit a demand forecast that will list the grid assets and show the net peak forecast (including DER layers) for these assets over the next 5 years. The data to be provided for this demand forecast is described in Table 1.

Table 1: Demand Forecast

SPECIFICATION	DEFINITION
Facility type	Circuit or transformer
Facility name	Circuit or transformer identifier
Equipment rating (MW)	Equipment's rated capacity
Year XXXX peak load (MW)	Peak load forecast for year XXXX
Year XXXX+1 peak load (MW)	Peak load forecast for year XXXX+1
Year XXXX+2 peak load (MW)	Peak load forecast for year XXXX+2
Year XXXX+3 peak load (MW)	Peak load forecast for year XXXX+3
Year XXXX+4 peak load (MW)	Peak load forecast for year XXXX+4

4.7.2 DEMAND FORECAST BY LOAD TYPE

The Company will submit a demand forecast by circuit by load type per year (5 years of forecasts). The data that will be included is described in Table 2.

Table 2: Demand Forecast by Load Type

SPECIFICATION	DEFINITION
Circuit name	Circuit identifier
Year XXXX residential load (MW)	Residential load forecast for year XXXX
Year XXXX commercial load (MW)	Commercial load forecast for year XXXX
Year XXXX EV	EV load forecast for year XXXX
Year XXXX DER	DER load forecast for year XXXX
Year XXXX EE	EE load forecast for year XXXX

[7] IGP Workplan at 26 (avaliable at https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/dkt_20180165_20181214_igp_workplan.pdf).

4.7.3 GRID NEEDS ASSESSMENT

A grid needs assessment will be performed to identify situations where planning criteria are violated based on the per circuit or transformer forecasted net demand described in Section 4.7.1. In addition, a traditional solution will be defined for each grid need identified, as discussed in Section 6, Solution Options. The data that will be included in the grid needs assessment is described in Table 3.

Table 3: Grid Needs Assessment

SPECIFICATION	DEFINITION
Substation	Transformer asset identification
Circuit	Feeder asset identification
Distribution service required	Distribution capacity or distribution reliability (back-tie) service
Primary driver of grid need	Whether the identified grid need is primarily driven by DER growth, demand growth, other factor(s), or a combination of factors
Operating date	The date at which traditional infrastructure must be constructed and energized in advance of the forecasted grid need to maintain safety and reliability
Equipment rating (MW)	Equipment's rated capacity
Peak load (MW)	Peak loading on asset for given year
Deficiency (%)	Deficiency divided by the rating for each of the forecasted years
Traditional solution	Traditional solution identified, as discussed in Section 6, Soution Options
NWA qualified opportunity	Whether the grid need is a qualified opportunity for further evaluation based on technical requirements and timing of need

Note: A qualified opportunity has passed "Step 1" as outlined in the *Non-Wires Opportunity Evaluation Methodology* report and will proceed to "Step 2," where it will be further analyzed and prioritized.[8]

[8] Hawaiian Electric, *Non-Wires Opportunity Evaluation Methodology*, June 2020, Section 4.

4.7.4 HOURLY GRID NEEDS SUMMARY

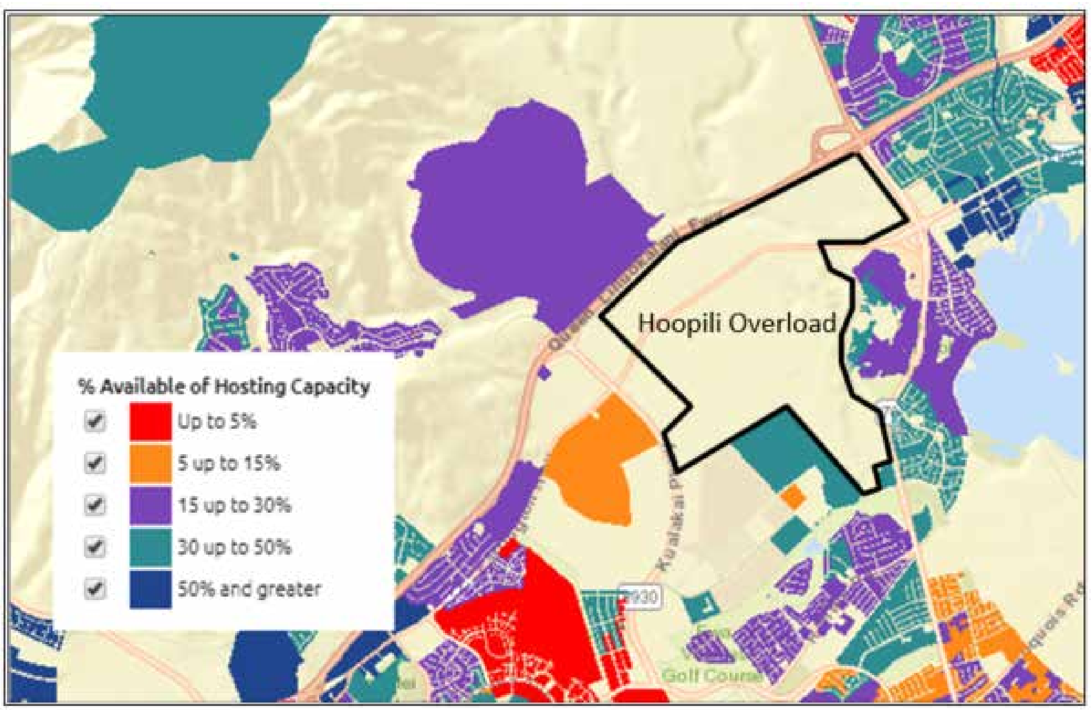
For the grid needs determined to be qualified opportunities, solution requirements will be defined in technology-neutral terms, such as the amounts of energy, time(s) of day, and days of the year. This hourly grid needs summary will be provided as described in Table 4.

Table 4: Hourly Grid Needs Summary

SPECIFICATION	DEFINITION
Substation	Transformer asset identification
Circuit	Feeder asset identification
Capacity (MW)	Amount of power required to mitigate the grid need
Energy (MWH)	Amount of energy required to mitigate the grid need
Delivery time frame	Months/hours when the planning criteria violations occur
Duration (hours)	Length of time of the grid need
Maximum Number of calls per year	Maximum number of days in the year requiring mitigation

During the NWA opportunity evaluation, as outlined in the *Non-Wires Opportunity Evaluation Methodology* report, each NWA opportunity assigned to Transmission and Distribution Action Plan Track 1 or Track 2 will have an associated map of the general area of need overlayed with available hosting capacity. An example of this integrated map for the Ho'opili area is provided in Figure 14.

Figure 14: Integrated Grid Needs Map Example



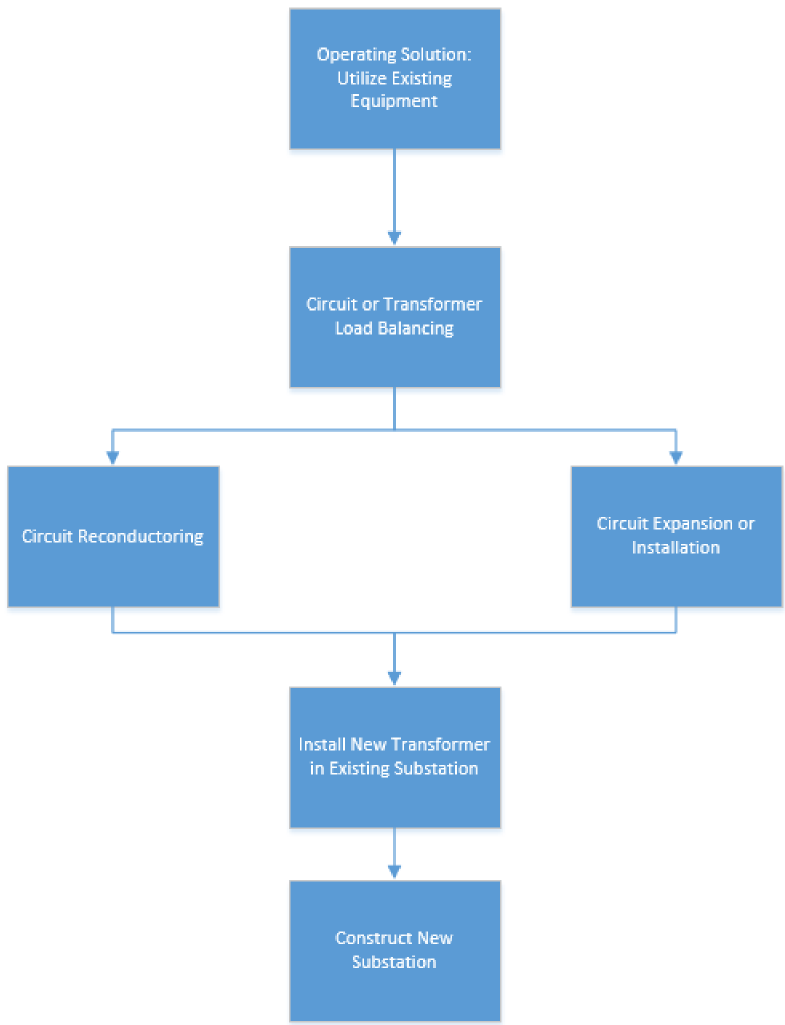
05 SOLUTION OPTIONS STAGE

During the solution options stage of the distribution planning process, the Company determines solution requirements and develops wires and non-wires solution options.

5.1 Solution Requirements

An identified grid need is the foundation of a solution's requirements. There may be other requirements, including some unique to the specific opportunity, that will provide additional constraints that solution options must meet. Examples of additional requirements may include a minimum level of reliability or physical/economic constraints. While factoring the solution requirements, a project scope for solution options will be developed that may involve the creation of work plans, such as planning single-line diagrams for wires solutions or time-based capacity requirements for non-wires solutions.

Figure 15: Wires Solution Development Steps



5.2 Wires Solution Development Process

To develop the scope of a wires solution, the simplest solution will be analyzed first, followed by solutions of increasing complexity. Once a solution is identified that fulfills the grid need, any additional, more complex solutions will not be analyzed. In general, the more complex the solution, the more expensive the solution. LoadSEER or Synergi, or both, will be used to analyze the solutions. The general process flow is shown in Figure 15.

Once the least complex solution is identified, a project scope is typically developed in the form of a planning single-line diagram. This diagram is a sketch that provides sufficient information for design engineers to develop a project scope and cost estimates, and if necessary, to provide the guidance to develop drawings and specifications used by construction personnel to execute the work. The project scope and cost estimates will inform the avoided cost that will be used in the NWA screen and will be evaluated as described in the *Non-Wires Opportunity Evaluation Methodology* report.

5.2.1 OPERATING SOLUTION: USE EXISTING EQUIPMENT

It is possible that a particular grid need can be satisfied by a simple reconfiguration of the existing distribution system. For instance, existing switches could be operated to resolve overload conditions, and the recalibration of the settings for existing voltage regulation devices could be employed to increase hosting capacity.

In this solution scenario, no cost estimates would be developed, and the Company would proceed without any further wires or non-wires analysis.

5.2.2 CIRCUIT OR TRANSFORMER LOAD BALANCING

If the existing electrical system cannot be simply reconfigured using existing equipment, the next type of solutions to be analyzed involves circuit or transformer load balancing. Load balancing can often resolve capacity issues. For instance, new switches may be installed on existing overhead circuits to provide circuit sectionalization to balance circuit loading (that is, reduce capacity on one circuit but increase capacity on another). Also, taps on overhead circuits could be cut and tapped elsewhere to change the configuration and loading on circuits. Similarly, cuts and taps (new splices) can be made in manholes of existing underground distribution systems to balance underground cable loading.

The taps of individual distribution transformers could also be modified to balance the loading among the three electrical phases. This type of balancing is referred to as phase balancing and is a method that can increase hosting capacity.

5.2.3 CIRCUIT RECONDUCTORING OR CIRCUIT EXPANSION/INSTALLATION

The next type of solutions, in terms of complexity and cost, to be analyzed involve upgrades to the distribution circuits. One type of upgrade is the reconductoring of existing overhead conductors or underground cables. In general, this involves the removal and replacement of the existing lines with larger-sized lines. This will directly increase the available capacity on the circuit.

For overhead systems, it may not only involve changing the conductors but also may require installation of new poles because the existing poles may not be strong enough to carry the weight of the larger-sized conductors. Similarly, for underground systems, the existing underground infrastructure (handholes, manholes, conduits) may not be large enough to accommodate physically larger-sized cables. Therefore, reconductoring of underground cables may also involve installation of new underground infrastructure.

Another type of upgrade on a distribution circuit involves the expansion of the circuit. In this situation, new overhead conductors or underground cables are installed where existing equipment does not exist. For instance, a new pole-line consisting of new wires and new poles may be constructed between two existing circuits to create back-tie capacity. For underground systems, new cables can be installed in existing spare conduits to create new underground ties or to balance underground circuits.

Circuit reconductoring and circuit expansion are considered in parallel because the complexity and, therefore, the cost is highly dependent on physical conditions. For example, for the same physical distance, reconductoring is typically cheaper than new construction. However, if reconductoring involves changes in the existing infrastructure, as noted previously, new construction could potentially be less complex to execute and more cost effective.

5.2.4 NEW TRANSFORMER IN EXISTING SUBSTATION

The Company's substations are typically designed to accommodate more than one substation transformer. If grid needs cannot be fulfilled with distribution circuit line work, the next solution option is to analyze installation of new transformers at existing substations. This solution involves the installation of a new substation transformer and associated circuits.

5.2.5 NEW SUBSTATION

The last wires solution to analyze is the construction of a new substation.

5.3 Contingency Plans and Schedule

The lead times to engineer and execute wires solutions is highly dependent on the required permitting and approvals. In general, the least complex solutions, as shown in Figure 15 and discussed in Section 5.2, have the shortest lead times. The following lead times will need to be incorporated into any contingency plans, as described in the *Non-Wires Opportunity Evaluation Methodology* report:

- Operating solution: 1 month
- Circuit or transformer load balancing: 18 months
- Circuit reconductoring or expansion (infrastructure upgrades not required): 24 months
- Circuit reconductoring or expansion (infrastructure upgrades required): 36 months
- New transformer (existing substation): 36–48 months
- New substation: 48 months

Except for operating solutions, deferral of capital expenditures opportunities may exist for the type of solutions listed above. However, as described in the *Non-Wires Opportunity Evaluation Methodology* report, the economic assessment and lead times will be taken into account when determining the path forward on non-wires solutions, if any.

5.4 Wires and Non-Wires Solution Options

Examples of wires and non-wires solution options are provided in Table 5.

Table 5: Example Wires and Non-Wires Solution Options

ISSUE	TRADITIONAL (WIRES SOLUTION)	TECHNOLOGY (NON-WIRES SOLUTION)
Distribution capacity	• Overhead and underground conductor upgrades to relieve capacity overloads from excess load or generation • Distribution transformer and secondary conductor upgrades to relieve equipment overloads during peak load or generation periods • New substation transformer or circuit installation	• Energy storage or export during peak generation or peak loading periods, respectively • Power electronic devices that regulate volt-amperes reactive (increase hosting capacity)
Distribution reliability (back-tie)	• All of the above • Circuit reconfiguration to help rebalance loads and generation between circuits to maintain the N-1 planning criteria and operational flexibility	• All of the above • Advanced inverter DER controllability to allow system operators to manage the resources during abnormal conditions, similar to grid-scale projects that allow system operators to control active power output when safety and reliability are at risk

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