Objectives for Today

- Present assumptions used to develop forecasts
- Discuss sensitivities and scenarios to create a forecast range
- Gather feedback on assumptions and for developing sensitivities and scenarios
Forecast and Planning Assumptions

- Welcome and Overview 8:30 - 8:40
- Underlying Forecast Assumptions 8:40 - 9:30
  - Economic Drivers
  - Electricity Price Forecast
  - Weather
- Break 9:30 - 9:40
- Electrification of Transportation Assumptions 9:40 - 9:55
- Distributed Energy Resources Assumptions 9:55 - 10:15
- Break 10:15 - 10:30
- Breakout Session 10:30 - 11:25
- Break to grab a bento 11:25 - 11:45
- Continue Breakout Session 11:45 - 12:35
- Break 12:35 - 12:45
- Report on Breakout Session 12:45 - 1:25
- Wrap-up 1:25 - 1:30
Our forecast is developed in layers

Illustrative example

- Underlying
  - Weather
  - Economic
  - Price
  - Other

- Energy efficiency
- Distributed energy resources
- Electrification of transportation

Sales forecast at customer level

Forecast will be further modified by DR and controllable DER
Our forecast is developed in layers

Illustrative example

Forecast will be further modified by DR and controllable DER
Underlying Forecast Assumptions
Electricity Price
## Electricity Price Forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>Updated Resource Plan for Oahu</th>
</tr>
</thead>
</table>
| 2019 | Install 20 MW West Loch PV Project  
      | Install 109.6 MW Clearway PV Projects |
| 2020 | Install 5 MW CBRE PV (Phase 1)  
      | Install 24 MW Na Pua Makani Wind Project |
| 2021 | Install West Oahu Solar – 12.5 MW PV + 50 MWH Storage  
      | AES deactivated  
      | Install 43.5 MW CBRE PV (Phase 2)  
      | Install Hoohana Solar 1 – 52 MW PV + 208 MWH Storage  
      | Install Mililani 1 Solar – 39 MW PV + 156 MWH Storage  
      | Install Waiawa Solar – 36 MW PV + 144 MWH Storage  
      | Install Stage 2 RFP Projects  
      | (1,300 GWH Annual Renewable Energy)  
      | Install Stage 2 Grid-Charged Energy Storage  
      | (200 MW, 1,200 MWh daily)  
      | Install Demand Response Programs from Grid Services RFP  
      | (Up to 119 MW)  
      | Install synchronous condensers and/or other technologies to enable reliable operation of resource portfolio |
| 2022 | Waiau 3 & Waiau 4 Removal from Service  
      | Install 47 MW Palehua Wind Project |
| 2023 | Install 200 MW of Offshore Wind |
| 2024 | Install 151 MW CC  
      | Waiau 5 & 6 Removal From Service |
| 2025 | Install 151 MW CC  
      | Kahe 5 & 6 Removal From Service |
| 2026 | Install 165 MW 4-hour Load-Shift Battery  
      | Waiau 7 & 8 Removal From Service |
| 2028 | Install 168 MW 4-hour Load-Shift Battery  
      | Kahe 1 & 2 Removal From Service |
| 2030 | Install 168 MW 4-hour Load-Shift Battery  
      | Kahe 3 & 4 Removal From Service |
| 2031 | Install 280 MW of Grid-Scale PV  
      | Install 420 MW 4-hour Load-Shift Battery |
| 2032 | Install 1180 MW of Grid-Scale PV  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2033 | Install 280 MW of Grid-Scale PV  
      | Install 420 MW 4-hour Load-Shift Battery |
| 2034 | Install 1180 MW of Grid-Scale PV  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2035 | Install 1180 MW of Grid-Scale PV  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2036 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2037 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2038 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2039 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2040 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2041 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2042 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2043 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2044 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |
| 2045 | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 1525 MW 4-hour Load-Shift Battery  
      | Install 68 MW ICE (4 x 17 MW) |

### Notes:
- **AES deactivated**: AES, which is a power plant, is deactivated.
- **Grid Services RFP**: Grid Services Request for Proposal.
- **4-hour Load-Shift Battery**: A type of energy storage system.
- **Power Plant Conversions**: Either biodiesel conversion or military generation biodiesel conversion.
Electricity Price Forecast

Illustrative Example of Rates and Year over Year Change

- Average Nominal Residential Rate
- Year over Year % Change
Weather Assumptions
Weather Variables

– One or more weather variables are included in most of the underlying sales models

– Weather variables considered include measures of:
  – Temperature (average temperature, cooling degree days)
  – Humidity (relative humidity, dew point)
  – Combination of both
  – Other

– Focusing on average monthly temperature (°F)
  – Average monthly temperature = Average of daily average temperatures
  – Average daily temperature = Average of daily minimum and daily maximum
Historical Average Monthly Temperature (Degrees Fahrenheit)
2019 Monthly Temperatures vs 20-Yr Average (Degrees Fahrenheit)

Hilo

Oahu

Maui

Kona

Actual AvgTemp  20yrAvg

Actual AvgTemp  20yrAvg

Actual AvgTemp  20yrAvg

Actual AvgTemp  20yrAvg
Weather Forecast Assumptions

– Prior forecasts assumed a historical rolling average for weather variables for Oahu, Maui and Hawai`i Island
– Recognize that we should include some measure of climate change
– Analysis of historical trends by island resulted in a forecast assumption of 0.5 °F increase in average temperature every 20 years applied to the 20-year historical average
– NOAA Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 8. Climate of the Pacific Islands
  - Two future climate scenarios developed for the Hawaiian Islands
  - Includes analysis of average annual temperature in 2021-2050 compared to 1971-1999 base period
  - Both scenarios project a 1-2 °F increase in annual average temperature by 2035

“The resulting climate conditions are to be viewed as scenarios, not forecasts, and there are no explicit or implicit assumptions about the probability of occurrence of either scenario.”
Oahu Average Temperature Forecast
(Degrees Fahrenheit)
Maui Average Temperature Forecast
(Degrees Fahrenheit)
Hilo Average Temperature Forecast (Degrees Fahrenheit)
How Other Utilities Incorporate Climate Change

- **Base Case**
  - No assumption for climate change
  - Incorporate a rolling historical average calculated annually
  - Utilize a trended normal weather assumption to account for gradually warming temperatures

- **Scenario that includes extreme weather**
Electrification of Transportation
Inputs to the Light Duty Electric Vehicle ("EV") Forecast

- Number of light duty EVs
  - Vehicle Costs
  - Fuel Economy
  - Gas/Electricity Prices
  - Discounts
  - Income
  - PV Installations
  - Number of Charge Ports
- Total light duty vehicles
- Charging profiles
Vehicle Costs ($2018)

Source: Reference case EIA AEO 2019 Forecast
Fuel Economy (mpg/mpge)

EV Fuel Economy

CV Fuel Economy

Source: EIA AEO 2019 Forecast
Gas Price ($/gal)

Source: EIA AEO 2019 Forecast
Electricity Price ($/kWh)
Income ($2018)

Source: UHERO’s 2019 Economic Forecast
PV Installations

Will be updated with new forecast
Total Light Duty Vehicles

Oahu

Hawai‘i Island

Maui County
Inputs to EV Forecast

Annual VMT

Weighted Average Fuel Economy

Annual kWh/Vehicle

Maui
Hawai’i Island
Oahu
E-Bus Assumptions

- Number of buses per bus operator
- Route information/miles traveled
- Location of chargers
- Operating hours
- Technical specs (battery size, charging rate, kWh/mile)
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
Solar PV Cost Projections, Real Dollars

- Installed cost before incentives
- Residential: <20kW
- Commercial: between 20kW and 5MW
- Grid Scale: 20MW
Storage Cost Projections, Real Dollars

- Installed cost before incentives
- Residential: <20kW, 2 hours
- Commercial: between 20kW and 5MW, 2 hours
- Grid Scale: >5MW, 4 hours

Cost, $2019/kWh

2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045

Res, Stand-Alone  Res, Paired with PV  Comm, Stand-Alone  Comm, Paired with PV  Grid Scale
Examples of Residential PV+Storage System Costs, Real Dollars

- 5 kW PV/13.5 kWh Storage
- 7.6 kW PV/27 kWh Storage

Installed cost before incentives

Cost, $2019

Year: 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
Incentives

- **Federal tax credits**

<table>
<thead>
<tr>
<th></th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022 - forward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>30%</td>
<td>26%</td>
<td>22%</td>
<td>0%</td>
</tr>
<tr>
<td>Commercial</td>
<td>30%</td>
<td>26%</td>
<td>22%</td>
<td>10%</td>
</tr>
</tbody>
</table>

- **State tax credits**

<table>
<thead>
<tr>
<th>Tax Credit Rate</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027-forward</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35%</td>
<td>35%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>15%</td>
</tr>
</tbody>
</table>

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

- **Grid services/demand response**
  - Base assumption: no grid services incentive factored into adoption decision
  - Future consideration: capacity incentives for grid services participants
Future Program Structures

- Standard interconnection agreement (SIA) utilized by large commercial customers with load exceeding potential on-site PV generation
- Standard DER Tariff
  - Time-variant compensation for export aligned with system needs
  - Controllable by utility for system stability emergency
- CBRE forecast: Actual project proposals and programmatic targets
- Future consideration: Advanced rate design
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

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

**Island Percent of Customers**

<table>
<thead>
<tr>
<th>Island</th>
<th>Percent of R Customers</th>
</tr>
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<tbody>
<tr>
<td>Oahu</td>
<td>37%</td>
</tr>
<tr>
<td>Hawai`i</td>
<td>40%</td>
</tr>
<tr>
<td>Maui</td>
<td>43%</td>
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**Island Percent of G, J, P Customers**

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<th>Percent of G Customers</th>
<th>Percent of J Customers</th>
<th>Percent of P Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oahu</td>
<td>37%</td>
<td>53%</td>
<td>110%</td>
</tr>
<tr>
<td>Hawai`i</td>
<td>35%</td>
<td>68%</td>
<td>110%</td>
</tr>
<tr>
<td>Maui</td>
<td>41%</td>
<td>63%</td>
<td>110%</td>
</tr>
</tbody>
</table>
Panel Degradation, Maintenance, Replacement

- PV system
  - Output degrades at rate of 0.5% per year
  - No removal or replacement
  - Maintenance cost is 1% of capital investment per year

- Battery replacement after 15 years in service
Solar Resource Unitized Profiles (kWh/kW)

Hawai`i Island
Average of 2014-2018
Annual capacity factor: 19.5%

Oahu
Average of 2015-2018
Annual capacity factor: 21.1%

Maui
Average of 2015-2018
Annual capacity factor: 20.9%

Molokai
Average of 2015-2018
Annual capacity factor: 21.8%

Lanai
Average of 2014-2018
Annual capacity factor: 19.9%
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Mahalo!