Meeting agenda

8:30
- Welcome
- Objectives & Agenda
- Process recap

10:30
Electrification of Transportation

11:30
Energy Efficiency Potential Study

12:35
Sensitivities and Scenarios

1:05
Resource Costs

1:35
What's next
Process recap

Overview
Who are our customers?
What are we forecasting?
High level “how”

Gather assumptions
Economic outlook
Behind the meter technologies
Electricity price
Weather...

Present methods
To derive the “layers”
Shaping the forecast
Other utilities

Review assumptions and forecasts
Present assumptions and forecasts
Gather feedback
Refine assumptions
Sensitivities
Update as needed
## Objectives for today

<table>
<thead>
<tr>
<th>1</th>
<th>Distributed Energy Resources, Electrification of Transportation and Energy Efficiency</th>
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<tbody>
<tr>
<td></td>
<td>• Present updated assumptions and preliminary forecasts</td>
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<td>• Propose sensitivities to address uncertainty</td>
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<td>• Gather feedback</td>
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<table>
<thead>
<tr>
<th>2</th>
<th>Resource costs used for planning</th>
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<tbody>
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<td>• Present forecasts and solicit feedback</td>
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</table>
Distributed Energy Resources
Inputs to DER Forecast

**Economic Assumptions**
- PV and battery installed costs
- Incentives
- Electricity price
- Program structure
- Panel degradation, maintenance and replacement

**Addressable Market**
- Residential customers
- Commercial customers

**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
Storage Cost Projections, Real Dollars

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

Cost, $2019/kWh

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost (2019/kWh)</th>
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<tbody>
<tr>
<td>2019</td>
<td>$1,400</td>
</tr>
<tr>
<td>2021</td>
<td>$1,200</td>
</tr>
<tr>
<td>2023</td>
<td>$1,000</td>
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<tr>
<td>2025</td>
<td>$800</td>
</tr>
<tr>
<td>2027</td>
<td>$600</td>
</tr>
<tr>
<td>2029</td>
<td>$400</td>
</tr>
<tr>
<td>2031</td>
<td>$200</td>
</tr>
<tr>
<td>2033</td>
<td>$0</td>
</tr>
</tbody>
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*Res, Paired with PV
*Comm, Paired with PV
Examples of Residential PV+Storage System Costs, Real Dollars

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

- **Federal tax credits**
  - 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

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<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>
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</tbody>
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- **State tax credits**
  - 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

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<tr>
<th></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>Tax Credit Rate</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>
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- **Grid services/demand response**
  - Base assumption: no grid services incentive factored into adoption decision
  - Future consideration: capacity incentives for grid services participants
Oahu

- NEM complete
- CGS fully subscribed, but not built out
- GSP and ISE not fully subscribed
- SIA projects thru 2022
- NMP installations continue thru 2031 with current pace increasing by 10% in 2021 and 2022

- Uptake model accounts for adoption of all future programs and all rate schedules
Hawaii

- NEM complete
- CGS and GSP complete
- ISE complete
- SIA projects thru 2022
- NMP installations continue thru 2031 with current pace increasing by 10% in 2021 and 2022

- Uptake model accounts for adoption of all future programs in R, G and J rates
- *Manual forecast for P rate
Near-term assumptions

- NEM complete
- CGS complete
- GSP and ISE not fully subscribed
- SIA projects thru 2022

Long-term uptake model*

- NMP installations continue thru 2031 with current pace increasing by 10% in 2021 and 2022

- Uptake model accounts for adoption of all future programs in R, G and J rates
- * Manual forecast for P rate

Near-term is informed by experts and recent activity.
Near-term assumptions

- NEM complete
- CGS complete
- GSP and ISE not fully subscribed

Near-term is informed by experts and recent activity

Long-term uptake model*

- Uptake model accounts for adoption of all future programs in R
- * G and J rates forecasted in historical proportion to R
Molokai

Near-term assumptions

- NEM complete
- CGS complete
- GSP and ISE not fully subscribed

Long-term uptake model*

- Uptake model accounts for adoption of all future programs in R, G and J rates
- * G and J rates forecasted in historical proportion to R

Near-term is informed by experts and recent activity
### Future Program Structures

| Standard DER Tariff | - Time-variant compensation for export aligned with system needs  
<table>
<thead>
<tr>
<th></th>
<th>- Controllable by utility for system stability emergency</th>
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</thead>
<tbody>
<tr>
<td>Standard Interconnection Agreement (SIA)</td>
<td>- Primarily utilized by large commercial customers with load exceeding potential on-site PV generation</td>
</tr>
<tr>
<td>Future Consideration</td>
<td>- Advanced Rate Design</td>
</tr>
</tbody>
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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

<table>
<thead>
<tr>
<th>Island</th>
<th>Percent of R Customers</th>
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</thead>
<tbody>
<tr>
<td>Oahu</td>
<td>37%</td>
</tr>
<tr>
<td>Hawaii</td>
<td>40%</td>
</tr>
<tr>
<td>Maui</td>
<td>43%</td>
</tr>
<tr>
<td>Lanai</td>
<td>24%</td>
</tr>
<tr>
<td>Molokai</td>
<td>30%</td>
</tr>
</tbody>
</table>
Commercial Rate Classes

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

<table>
<thead>
<tr>
<th>Island</th>
<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>78%</td>
</tr>
<tr>
<td>Hawaii</td>
<td>35%</td>
<td>68%</td>
<td>44%</td>
</tr>
<tr>
<td>Maui</td>
<td>41%</td>
<td>63%</td>
<td>68%</td>
</tr>
</tbody>
</table>
Panel Degradation and Replacement

- PV system
  - Output degrades at rate of 0.5% per year
  - No removal or replacement
- Battery replacement after 15 years in service
PV Paired with Battery Assumptions

- In the near-term, proportion of systems paired with batteries are based on recent application data
- All residential and small commercial have batteries under future programs
- A portion of medium commercial customers have batteries
- For large commercial, include known projects
Solar Resource Unitized Profiles (kWh/kW)

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

Hawaii Island
Average of 2014-2018
Annual capacity factor: 19.5%

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%

Hour Ending
DER Forecast Developed by Island for Each Program
Oahu Incremental
Oahu Cumulative
Oahu BESS Cumulative

Cumulative BESS Capacity (MWh)

Future Programs
SIA *
NMP
ISE
GSP
CSS
CGS
NEM

Cumulative BESS Capacity (MWh)

Years:

Cumulative BESS Capacity (MWh)
Hawaii Island Incremental
Hawaii Island Cumulative
Hawaii Island BESS Cumulative
Maui Incremental
Maui Cumulative
Maui BESS Cumulative
Lanai Incremental
Lanai Cumulative
Lanai BESS Cumulative
Molokai Incremental
Molokai BESS Cumulative
Electrification of Transportation ("EoT")
Light Duty Electric Vehicles ("LD EVs")

- Light Duty Vehicle Forecast
- EV Saturation & EV Count Forecast
- Daily Vehicle Miles Traveled & kWh per Vehicle
- Charging Profiles
- Total Energy Sales
Light Duty Vehicle Forecast

EV Saturation & EV Count Forecast

Daily Vehicle Miles Traveled & kWh per Vehicle

Charging Profiles

Total Energy Sales
Electric Vehicle Forecast Roadmap

**Bass Model**
(Top-Down Model — Macro)

1. Vehicle Cost (EV and ICEV)
2. Vehicle Fuel Economy (EV and ICEV)
3. Number of Charging Ports
4. Discount (Tax Credit/Rebate)
5. Electricity Price
6. Gasoline Price
7. Income
8. Number of PV Installations

**Agent-Based Model (ABM)**
(Bottom-Up Model — Spatial)

1. Innovation Parameter
2. Imitation Parameter
3. Housing Characteristics
4. Commuting Patterns
5. Road Accessibility
6. Energy Consumption

**Spatially Distributed Customer Adoption**

% EV Saturation of Total LDVs to 2050

Historic Forecast

Total LDV Forecast

EV Count Forecast

By-product
Light Duty Vehicle (LDV) Forecast

Model Input Updates
- Actual EV counts from DBEDT
- Incorporated new UHERO population forecast

Model Impact
- Econometric models with various drivers including population, jobs, GDP growth, CPI & car loan rates
- Final model utilized population and jobs

LDV Results
- Lower LDV forecast across all islands compared to EoT Roadmap
LDV Forecast – Oahu
LDV Forecast – Maui County

- History
- EoT Roadmap
- IGP
LDV Forecast – Hawaii Island

- History
- EoT Roadmap
- IGP
LD EV Agenda

- Light Duty Vehicle Forecast
- EV Saturation & EV Count Forecast
- Daily Vehicle Miles Traveled & kWh per Vehicle
- Charging Profiles
- Total Energy Sales
Number of EVs per 1,000 Persons

- Oahu
- Hawaii Island
- Maui County

Source: DBEDT
Historical EV Saturation

Source: DBEDT
% EV Saturation of Total LDV by Island to 2050

- Oahu
- Hawaii Island
- Maui County
- Maui Island
- Molokai
- Lanai

- Hybrid F-150
- More EV models
- Autonomous vehicles
- Longer-range EVs (200-400 miles per charge)
- Vehicle Cost Parity
- Battery prices drop > 30%
- Battery prices drop > 70%
- 100% EV conversion of County’s fleet
Number of EVs on the Road

- Oahu
- Hawaii Island
- Maui County
- Maui Island
- Molokai
- Lanai

Molokai/Lanai

Oahu/Hawaii Island/Maui County/Maui Island
EV Forecast Comparison

- Oahu - EoT Roadmap
- Oahu - IGP
- Hawaii Island - EoT Roadmap
- Hawaii Island - IGP
- Maui County - EoT Roadmap
- Maui County - IGP
EV Saturation Scenario Example - Oahu
EV Saturation Scenario Example - Maui

[Graph showing EV saturation scenarios for Maui, with three lines representing High Case, Reference Case, and Low Case, with the Y-axis representing percentage of EV saturation and the X-axis representing years from 2011 to 2050.]
EV Saturation Scenario Example – Hawaii Island
LD EV Agenda

- Light Duty Vehicle Forecast
- EV Saturation & EV Count Forecast
- Daily Vehicle Miles Traveled & kWh per Vehicle
- Charging Profiles
- Total Energy Sales
Daily Vehicle Miles Traveled per Vehicle

- Updated actual VMT by county based on annual DBEDT report

- Incorporates updated Federal Highway Administration’s VMT outlook
  - 20-year annual growth: +1.1%
  - 30-year annual growth: +0.7%
Daily VMT per Vehicle
Comparison to EoT Roadmap
Updated actual EV registration data by county from IHS and utilized the fuel economy by vehicle as determined by the U.S. Dept. of Energy

Incorporates EIA’s updated EV fuel economy forecast and considers following:

- Longer range vehicles (e.g. 300-mile range)
- Larger vehicles (e.g. CUVs, SUVs, Trucks)
Daily kWh per Vehicle
Comparison to EoT Roadmap
Charging Segmentation

Vehicle Ownership (Own/Lease/Rent)

Place of Charging/Charging Options

Types of Charging Profiles

Types of Meters

Rate Schedules

Residential
- Home Chargers
  - Non TOU
  - TOU 9pm
  - TOU Midday
  - Single-metered
  - Master-metered

Commercial
- Public Charging Stations
- Workplace Charging Stations
- Place of Business
  - Fleet Day Operation
  - Fleet Night Operation
  - Fleet 24hr Operation
  - G
  - J
  - P
Charging Profile Updates

- EV count Res/Comm split based on number of PV installations
- Commercial split determined by kW PV capacity installed

- Removed TOU-Midnight profiles and reallocated to Public Charging (75%) and Workplace Charging (25%)
- Generated updated 8760 Commercial and Residential profiles
LD EV Agenda

- Light Duty Vehicle Forecast
- EV Saturation & EV Count Forecast
- Daily Vehicle Miles Traveled & kWh per Vehicle
- Charging Profiles
- Total Energy Sales
MWh Sales – Comparison to EoT Roadmap
MWh Sales – Comparison to EoT Roadmap

- Oahu - EoT
- Oahu - IGP
- Hawaii Island - EoT
- Hawaii Island - IGP
- Maui County - EoT
- Maui County - IGP
Electric Bus Forecasting
Method

**Collaborative discussions** to gather preliminary assumptions on future state of EV Bus fleets.

**Data analysis and forecasting** to determine potential impact to sales and hourly load demands.

Generate ideas between partners to develop charging rates to align impact to customers’ bills with grid needs.
Assumptions

- Route Information
  Miles traveled

- Location of chargers
  (bulk/opportunity)

- Operating Hours

- Technical Specifications
  (Battery size, charging rate, kWh/mi.)
E-Bus Forecast
Oahu

Source: HECO Electrification of Transportation
E-Bus Forecast
Maui

Source: HECO Electrification of Transportation
E-Bus Forecast
Hawai`i

Source: HECO Electrification of Transportation
E-Bus Charging Profile

- **Shift starts**
- **State of battery updated every hour** (efficiency & duration/distance)
- **Bus charges on an available charger.**
- **State of battery evaluated (i.e., does the battery need to be charged or the shift is completed?)**
- **Bus is pulled in for charge in a queue.**
All buses are charged by 2-3AM

Buses start regular routes. (start-of-day; morning rush)

Buses start queuing for charge. (end-of-day)

Buses mainly on road with some interval charging.

Most buses on road. (evening-rush)

Buses pulling in to depot and will charge in early morning hours. (end-of-day)

No buses charge during TOU hours.
A “typical” week charging profile
Energy Efficiency
Sensitivities
Sensitivities for discussion

- Develop high/low adoption forecasts around the “layers” – DER, light duty EVs and energy efficiency for all islands
- Resource plan modeling sensitivities
Modeling Sensitivities

Several modeling sensitivities have been proposed by stakeholders in the Solution Evaluation & Optimization Working Group.

These sensitivities can be characterized as:

• Constraining future transmission and limiting grid-scale renewable buildout
• Considering new customer behaviors related to EV charging, load shifting
• Freezing DER at current levels
Forecast Iteration

1. Various planning sensitivities will be modeled in RESOLVE.
2. The model results will be used to inform a DER forecast iteration.
   - Grid service needs that are met with grid-scale resources may instead be met with DER, assuming that the DER can provide equivalent services.
   - The timing and quantity of the DER that is adjusted in the forecast will depend upon the results of the sensitivity analyses.
Resource Cost Forecasts
Assumed Sizes of Source Data

- Grid - Scale PV – 20 MW
- Grid – Scale Wind – 20 MW
- Wind On-Shore – 20 MW
- Wind Off-Shore – 600 MW
- Distributed Wind – 21 – 100 kW
- MSW – 50 MW
- ICE – 50 MW
- Pumped Storage Hydro – 50 MW
- Geothermal – 30 MW
- Simple Cycle CT – 100 MW
- Combined Cycle CT – 702 MW
- Biomass – 50 MW
Assumed Sizes of Source Data

- Grid-Scale Storage – 20 MW
• Grid-scale paired resources assume 4-hour storage.

• Does not include interconnection cost.
Next Steps
Deliverables and feedback

Assumptions
• Presentation material
• Assumptions will be posted to the website

Forecasts
• Presentations – January 29 and February 26
• Forecasts will be posted to the website

Feedback
• Provide feedback on today’s meeting material by February 12
• Provide feedback on February 26 meeting by March 12
What's Ahead

2019
- Economic Outlook Meetings
- Assemble Working Group
- Kick-Off Meeting March 13
- Panel Discussion on DER, EE, EoT, May 22 and 23

2020
- Forecast Assumptions August 27
- Receive Updated Economic Forecast
- Preliminary Forecasts Meeting #1 January 29
- Preliminary Forecasts Meeting #2
- Update Forecast as Needed
Mahalo!