AEG
Applied Energy Group

Hawaii Statewide Market Potential Study

Preliminary Estimates

Prepared for HECO FAWG Meeting, January 29, 2020

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Context

AEG is conducting a Market Potential Study (MPS) for the state of Hawaii, sponsored by the HPUC

HECO plans to use the energy-efficiency forecasts developed for the MPS as the basis for its EE forecast

This presentation presents preliminary results from the MPS

- These were shared with the MPS Working Group on January 7
- They will be revised in the coming weeks to reflect feedback from the WG

Topics

This presentation presents preliminary results from the MPS and includes:

- Definitions
- Summary of results
- Overview of study approach
- Market characterization and baseline end-use projections
- Energy efficiency
  - Modeling approach
  - Estimates by sector and island
- Next steps

Levels of Savings Estimates

This study estimates several levels of savings:

- Codes and standards – savings that occur from an upgrade from the minimum level of efficiency available on the market and what is required by standard or code
- Naturally occurring efficiency – savings that occur when customers choose to install an EE measure outside of programs
- Energy efficiency potential:
  - Technical: everyone chooses the efficient option when equipment fails regardless of cost
  - Economic: is a subset of technical potential that includes only cost-effective measures
  - Achievable: is a subset of economic potential that accounts for likely measure adoption within the market

The summary slides below highlight energy-efficiency potential first

- Then we present C&S and naturally-occurring savings estimates

Primarily, savings are quantified in terms of annual energy savings, consistent with EEPS metrics.

In addition, the study will estimate 8,760-hour savings.

In this deck, we focus on annual savings estimates.

Preliminary EE Potential Estimates

Executive Summary: Statewide Look at Potential

Potential Results from Future Interventions

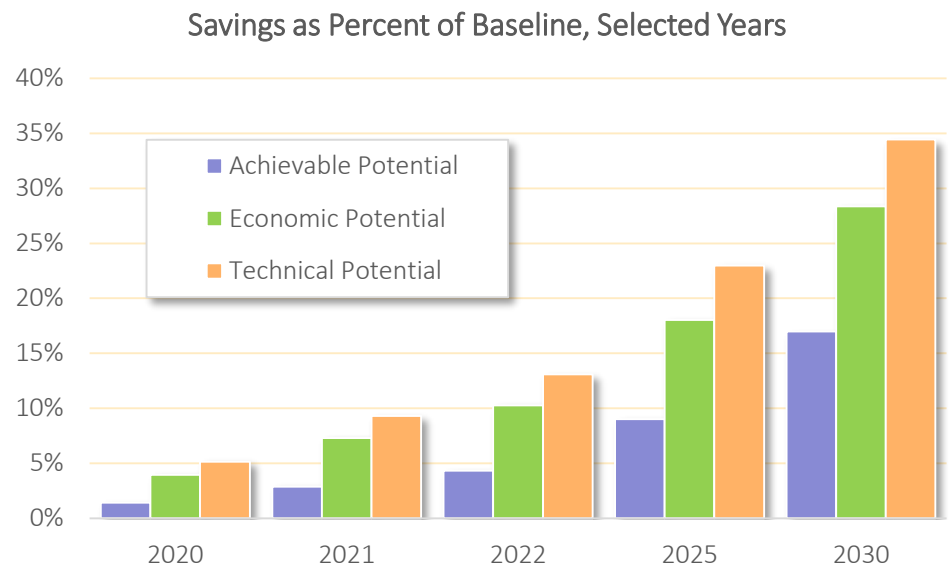
Energy Efficiency Potential Projections, All Islands and Sectors

After accounting for savings from codes, standards, and naturally occurring efficiency, 424 GWh (4.3% of the baseline) of cumulative **achievable** savings are expected over the next three years

- This aligns with Hawai`i Energy's program plans
- It compares favorably with other jurisdictions

By 2030, achievable potential reaches 1,717 GWh (17%)

- There is headroom in economic potential of more than 1,000 GWh



Summary of Energy Savings	2020	2021	2022	2025	2030
Baseline (GWh)	9,811	9,814	9,822	9,853	10,104
Cumulative Savings (GWh)					
Achievable Potential	140	281	424	889	1,717
Economic Potential	388	715	1,008	1,776	2,867
Technical Potential	505	913	1,286	2,263	3,482
Energy Savings (% of Reference)					
Achievable Potential	1.4%	2.9%	4.3%	9.0%	17.0%
Economic Potential	4.0%	7.3%	10.3%	18.0%	28.4%
Technical Potential	5.1%	9.3%	13.1%	23.0%	34.5%

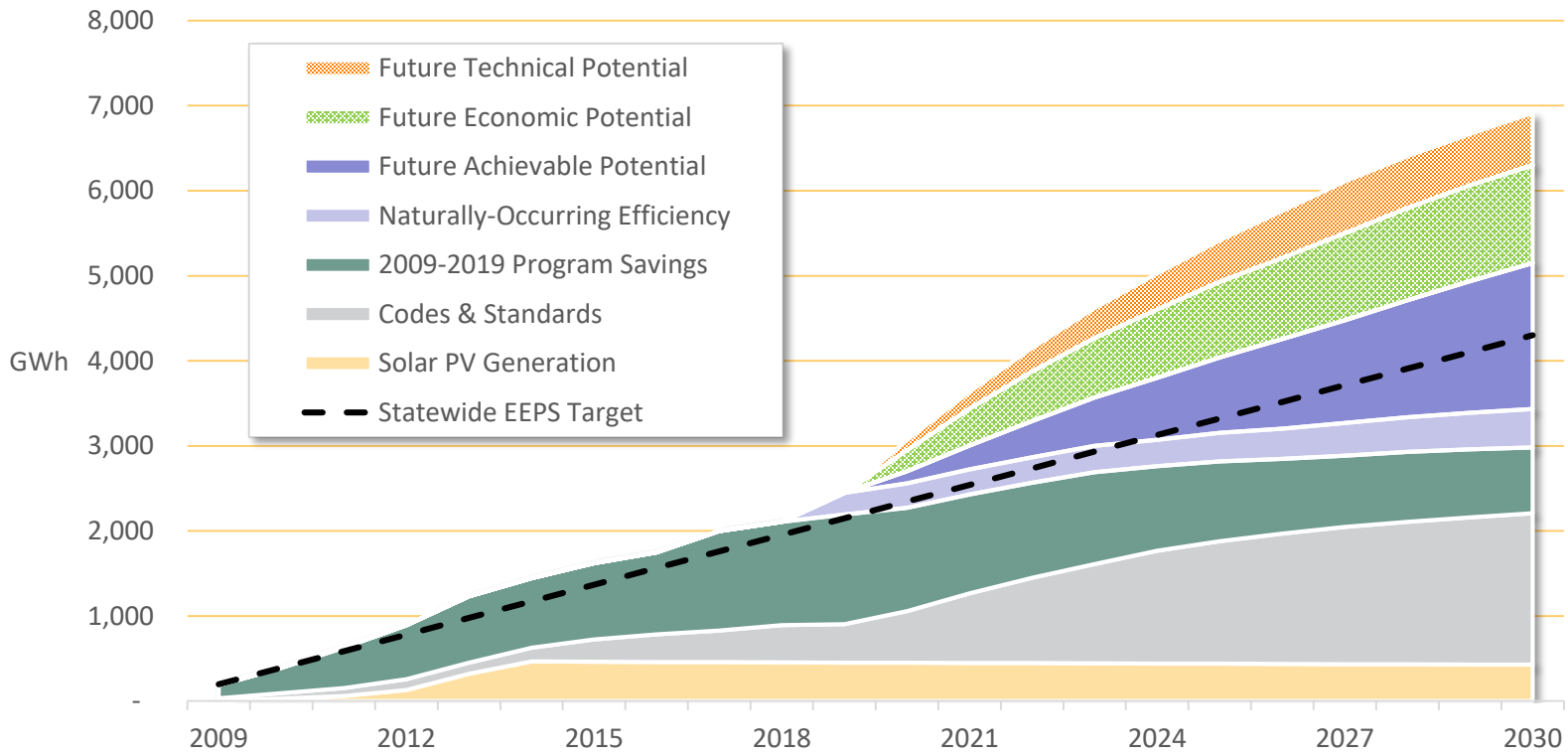
Energy Efficiency Portfolio Standards

EEPS Progress to Date and Future Projections

To assess progress toward the EEPS target (4,300 GWh of savings by 2030), we need to include savings that have been achieved since 2009

Our preliminary analysis indicates that **the EEPS target appears to be attainable**

Cumulative Persistent Energy Savings through 2030, EEPS Perspective

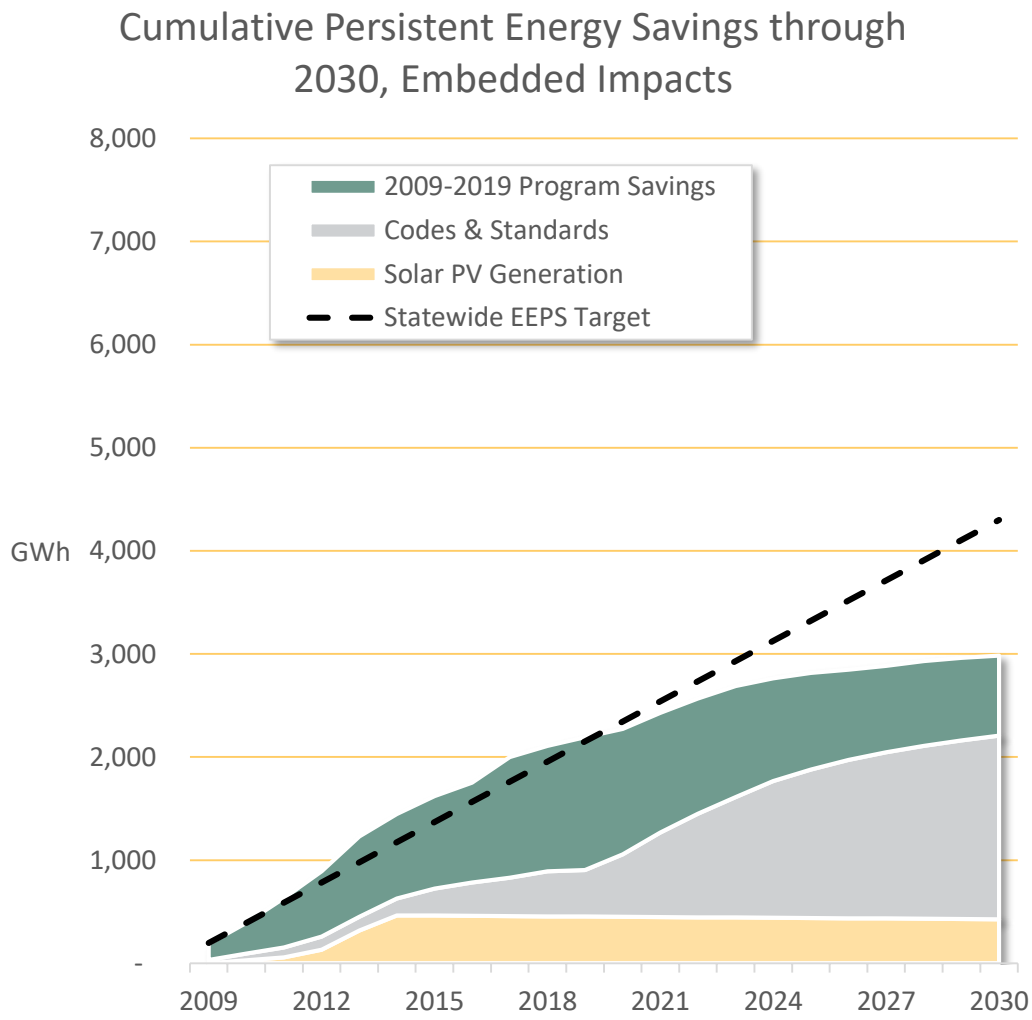


Embedded Impacts, EEPS Perspective

Progress from 2009 Through 2019

Embedded impacts include potential from the following categories of interventions taken before 2020:

- **EE Program Savings** from measures installed between 2009 and 2019 in Hawai'i Energy and KIUC efficiency programs
  - Only cumulative impacts from measures that persist through 2030 are counted
  - Those that expire are counted within the levels of future potential assessed by the MPS
- **Codes and Standards** from impacts enacted and/or in effect between 2009 and 2030
- **Solar PV** generation installed between 2009 and 2014; incorporates degradation over time

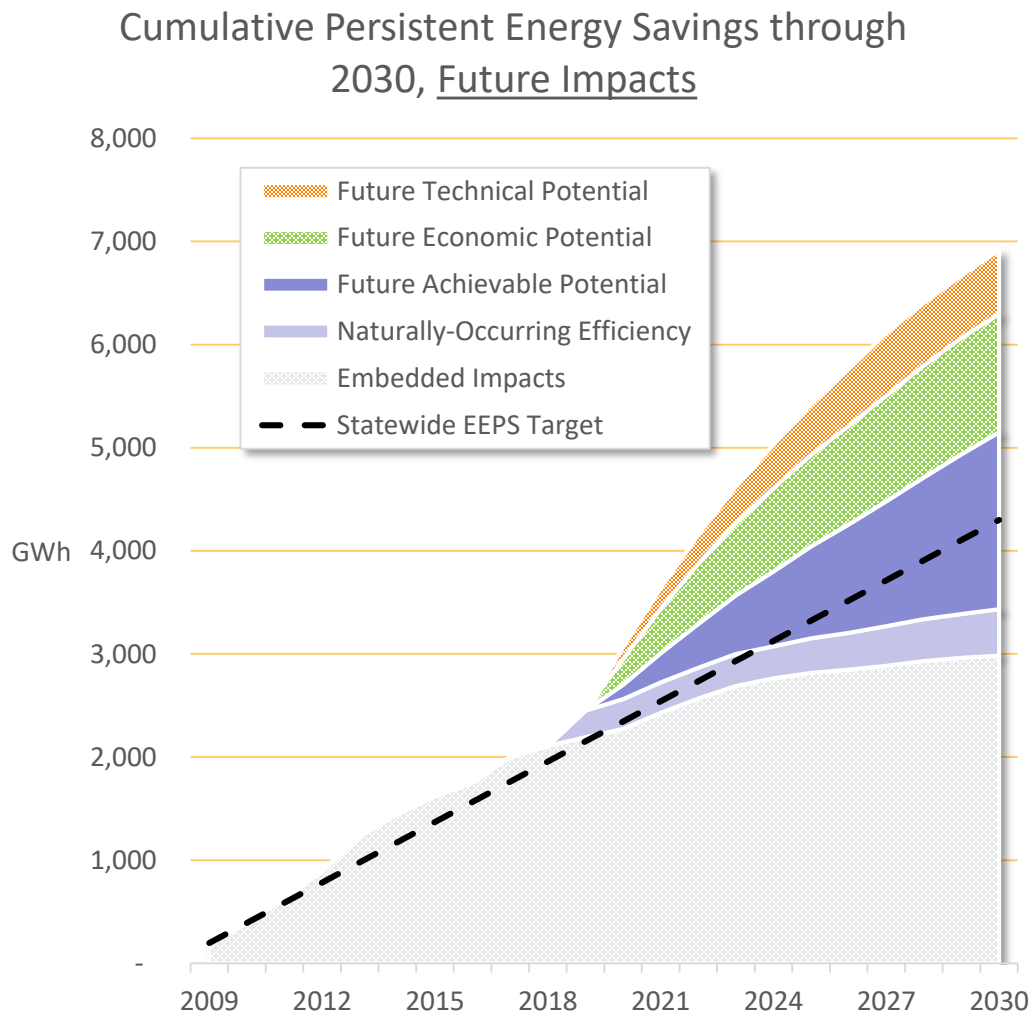


Potential Impacts, EEPS Perspective

Projections of Savings Potential from 2019 Through 2030

Future potential savings may be obtained from new EE interventions (including EE programs, naturally-occurring efficiency, and other possible types):

- **Achievable Potential**: reflects customer adoption of the cost-effective options
- **Naturally-Occurring Efficiency**: savings that occur when customers choose to install EE measures outside of programs
- **Economic Potential**: additional cost-effective potential
  - Based on TRC using PY19 TRM avoided costs
- **Technical Potential**: additional potential from measures that are not (and not expected to be) cost effective



Potential Savings from Future Interventions

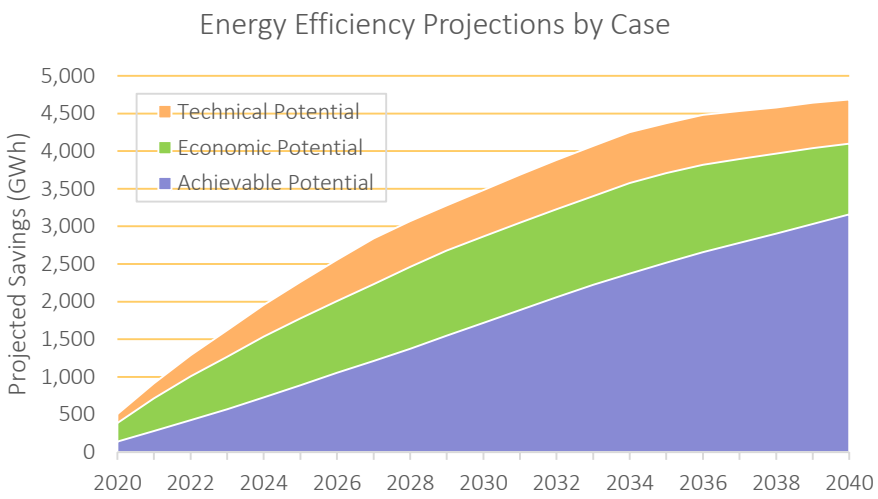
Energy Efficiency Potential Projections, All Islands and Sectors

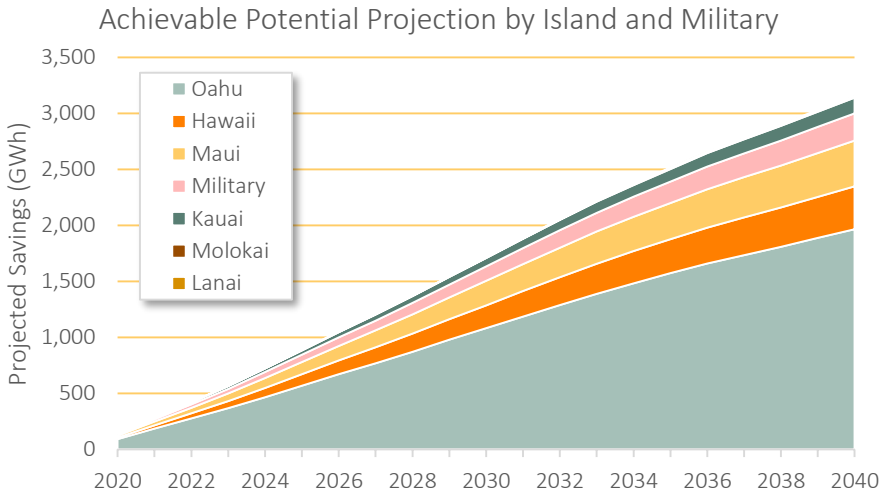
Strong savings potential is expected to continue to 2040

- And, there continues to be additional savings potential beyond 2040

As we might expect, the savings by island mimic the amount of electricity consumption on each island.

Summary of Energy Savings	2020	2030	2040
Baseline (GWh)	9,811	10,104	11,177
Cumulative Savings (GWh)			
Economic Potential	388	2,867	4,099
Energy Savings (% of Reference)			
Economic Potential	4.0%	28.4%	36.7%





Potential Savings from Future Interventions

Summary of Residential and Commercial Sectors

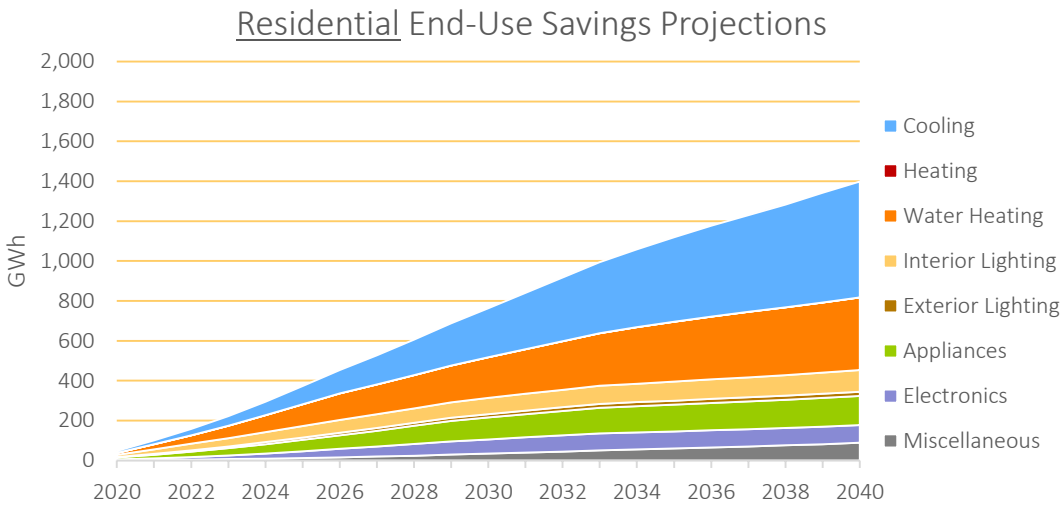
The commercial sector contributes somewhat more savings than residential

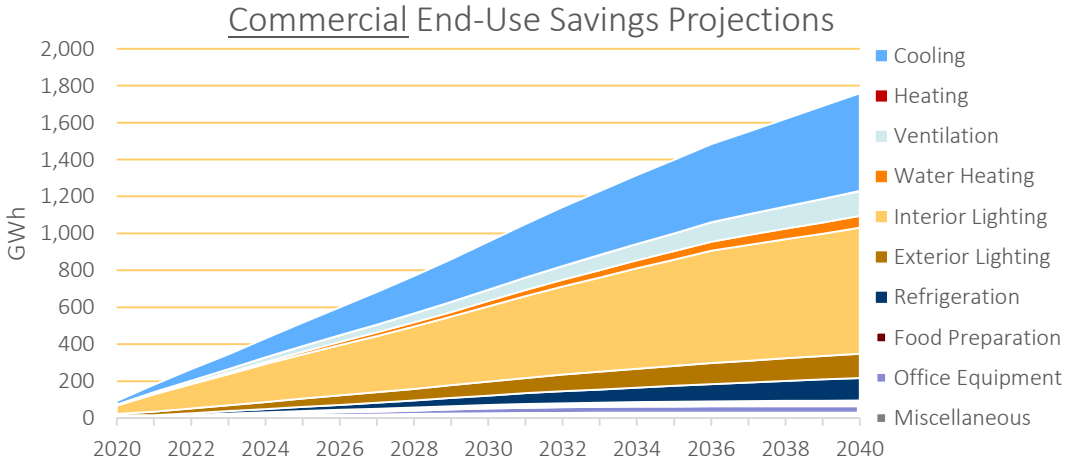
By 2030, the residential sector is expected to achieve 763 GWh

- Cooling and water heating measures account for the majority of savings

By 2030, the commercial sector is expected to achieve 954 GWh

- Substantial savings come from lighting measures followed by cooling

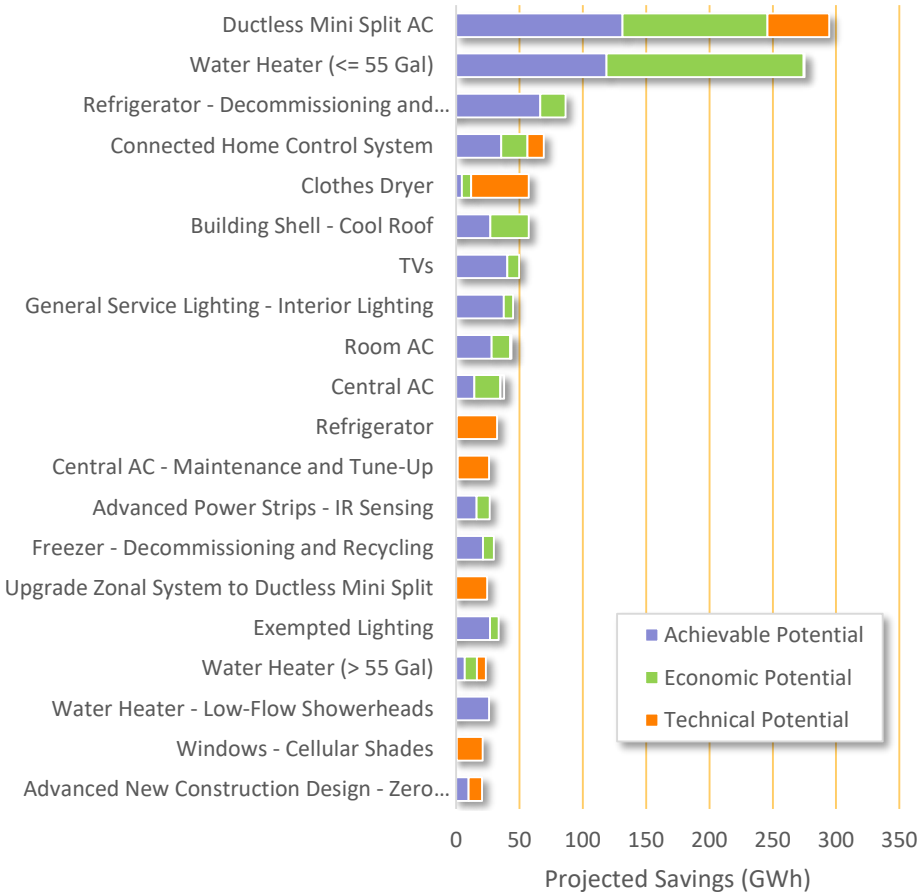




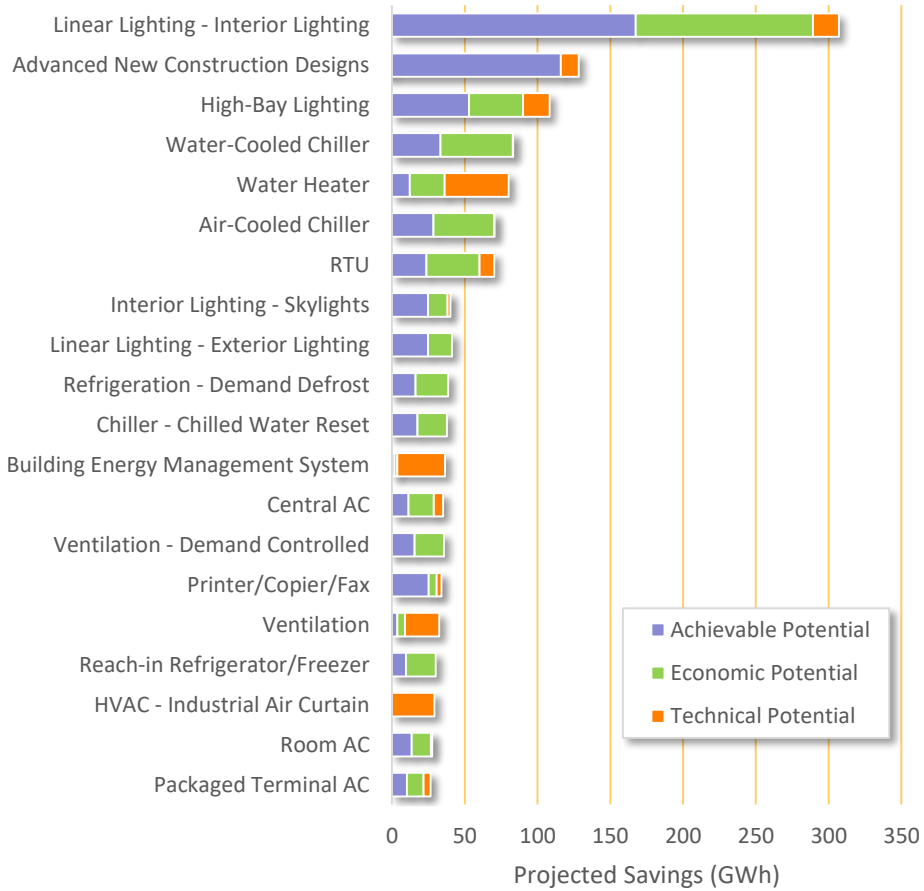
Potential Results by Top Measures and Case

All Islands by Sector

Residential Future Energy Efficiency Savings by Measure, 2030 (GWh)



Commercial Future Energy Efficiency Savings by Measure, 2030 (GWh)



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Approach to Market Potential Study

Statewide Potential Study Objectives

Recap from August Meeting

End-game Goals:

- Quantify the landscape of energy efficiency and demand side management over the next 20 years, including:
- Assess current status with regard to EEPS target and paths to continue to reach goals
- Provide a foundation to consider future programs and other interventions holistically

Specific-Information Goals:

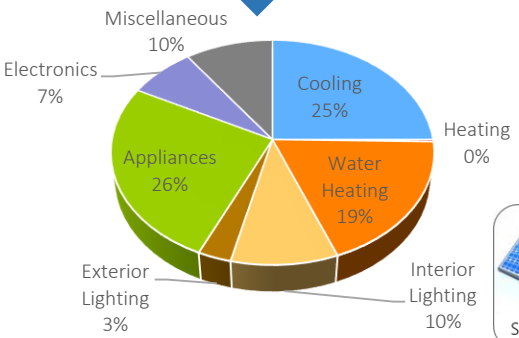
- Annual incremental and cumulative energy savings and hourly impacts by sector, segment, end use, and measure for 2021-2030 and 2031-2045
- Hawaii end-use load shapes to evaluate impacts at an hourly level
- High-level assessment of policy and / or program interventions (including demand-side rates) alongside or in addition to measure savings

AEG's Approach to Market Assessments

AEG Applied Energy Group

- Hawaii data
- Baseline Study
- PY19 TRM algorithms
- Secondary data

Market Characterization



- EE, DR, iDSM, DER, behavioral
- Savings and costs
- Lifetime
- Applicability

Identify Demand-side Resources


Solar + Storage

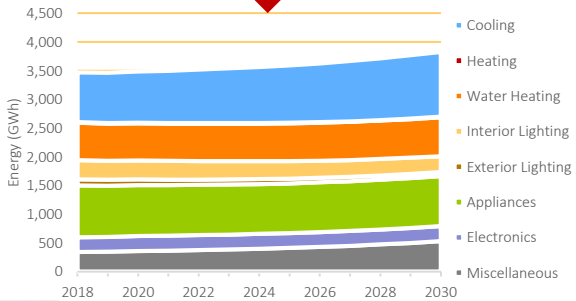
Smart Thermostats


Grid-Connected Water Heaters


Networked LED Controls

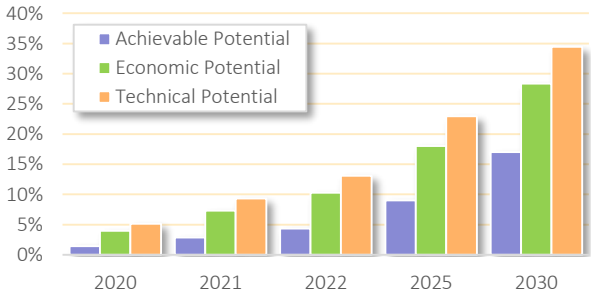
- Forecast drivers
- Appliance standards and building codes
- Generation
- Naturally Occurring

Baseline Projection



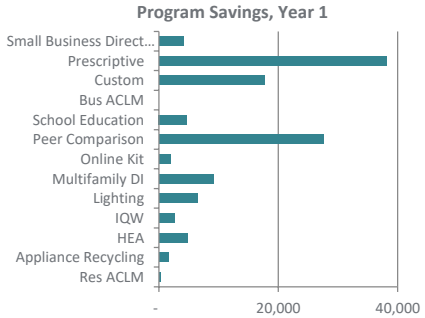
- Avoided costs
- Non-energy benefits
- Discount rates
- Participation rates

Estimate Impacts



- Existing programs
- Best practices
- Budgets

Program Assessment



Key Updates and Background

Potential Study Scope

Although the immediate objective of the MPS is to assess progress towards EEPS in 2030, the study also:

- Estimates potential after EEPS expires (through 2040)
- Incorporates HECO assumptions around new generation and loads (additional PV and electric vehicles)
- Simulates load and potential at the hourly level (EEPS is annual)
- Incorporates Demand Response (DR) and Grid Services (GS) assumptions from the most recent HECO and California DR Potential Studies

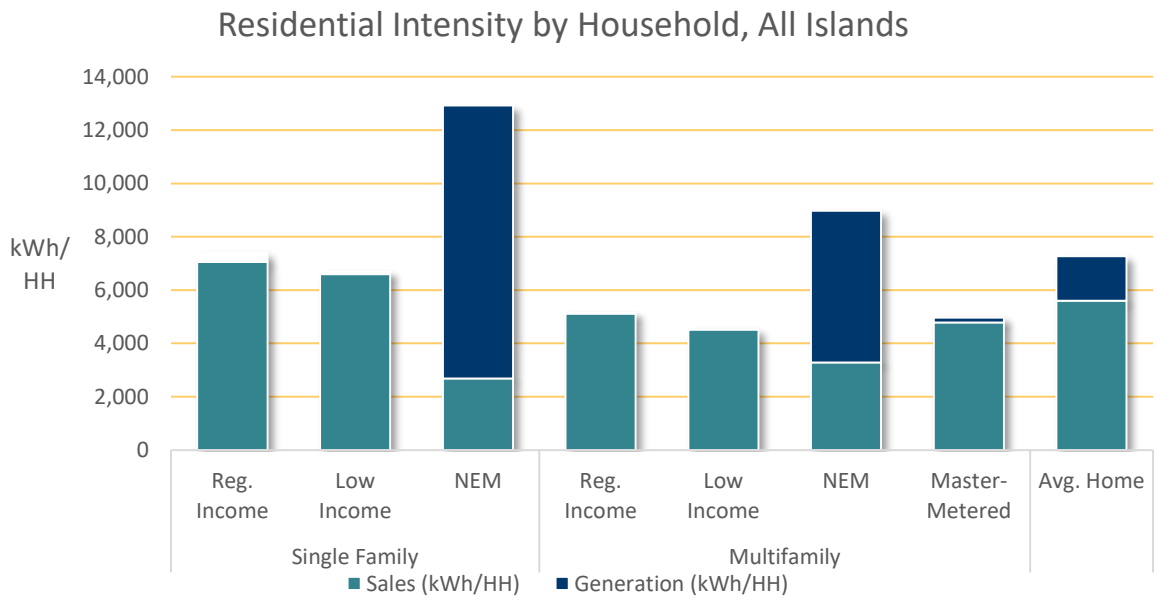
Market Characterization and Baseline Projection

Accounting for Solar PV

Adjusting Utility Sales for Behind-The-Meter Generation

The analysis is grounded in customers' use of electricity, which requires development of consumption estimates

- Estimates of generation impacts were removed from billing data, converting the study baseline from sales to consumption
- Based on 2018 HECO billing and forecast data, this revealed that residential customers in the net-energy metering (NEM) program consume substantially more energy than the average home
  - This adjustment was applied to the commercial models as well, but the difference is less impactful (shown later)

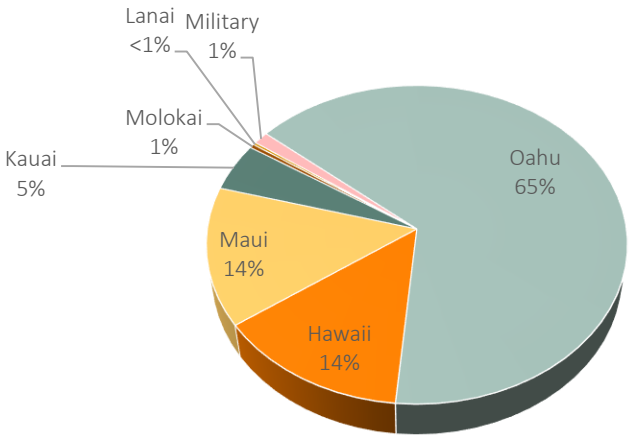


Residential Market Segmentation

The residential market (and potential) are segmented by:

- Island
- Military (when available)
- Housing type
- Ownership
- Income level
- Construction vintage
- Participation in NEM program

Residential Electricity Consumption by Island, 2018



All-Island Residential Segmentation, 2018

Segment	Households	Electric Sales (GWh)	Generation (GWh)	Consumption (GWh)	Avg. Sales (kWh/HH)	Avg. Gen. (kWh/HH)	Avg. Cons. (kWh/HH)
Single Family - Own - Regular Income	149,352	1,052	51	1,103	7,047	340	7,387
Single Family - Own – LMI	66,247	443	5	449	6,691	82	6,773
Single Family - Rent - Regular Income	15,165	108	5	113	7,090	338	7,428
Single Family - Rent – LMI	22,422	142	2	143	6,321	75	6,395
Single Family - Net-Energy Metered	68,602	184	702	886	2,687	10,233	12,920
Multifamily - Own - Regular Income	43,956	229	0	229	5,211	2	5,214
Multifamily - Own - LMI	19,599	90	0	90	4,597	0	4,597
Multifamily - Rent - Regular Income	18,928	93	0	93	4,922	3	4,925
Multifamily - Rent - LMI	32,051	143	0	143	4,452	0	4,452
Multifamily - Net-Energy Metered	3,901	13	22	35	3,282	5,688	8,970
Multifamily - Master Metered	37,351	179	7	185	4,781	182	4,963
Total	**477,575**	**2,676**	**794**	**3,470**	**5,603**	**1,663**	**7,266**

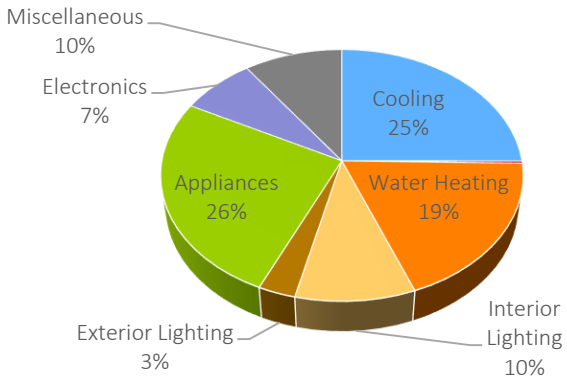
Residential Market Characterization

Incorporates Information from the Statewide Baseline Study

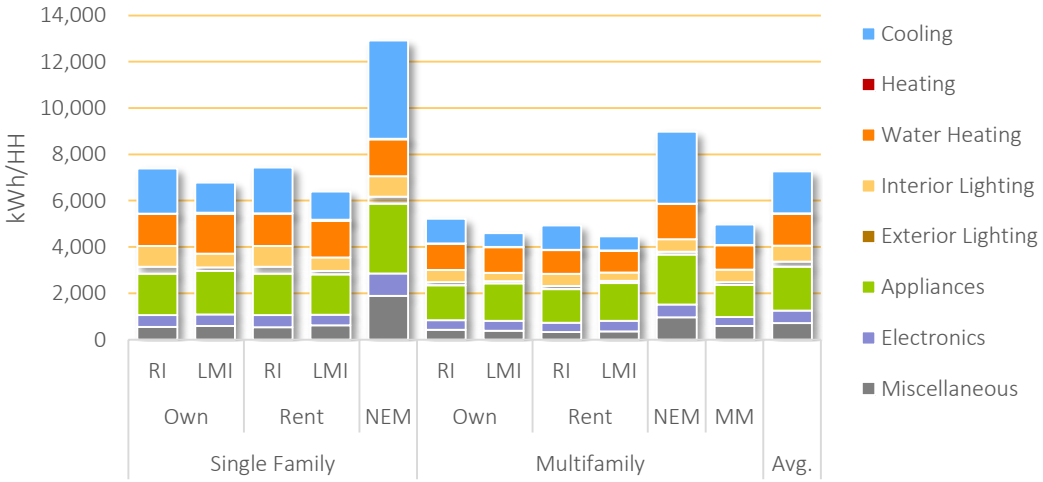
Key Residential Baseline Findings:

- NEM customers have more of everything, including cooling equipment and solar water heating
- End-use composition has changed since 2013
  - Cooling and appliances are now the largest end uses
  - Cooling growth is projected to increase further
  - Adoption of Solar Water Heating lowers average use per customer
- Efficient lighting represents approximately 60% of lamps in the average home
  - 40% are LED
  - 20% are CFL
  - The rest are linear tubes, halogen, or incandescent

Oahu Residential End-Use Consumption, 2018



All-Island Residential Intensity by End Use

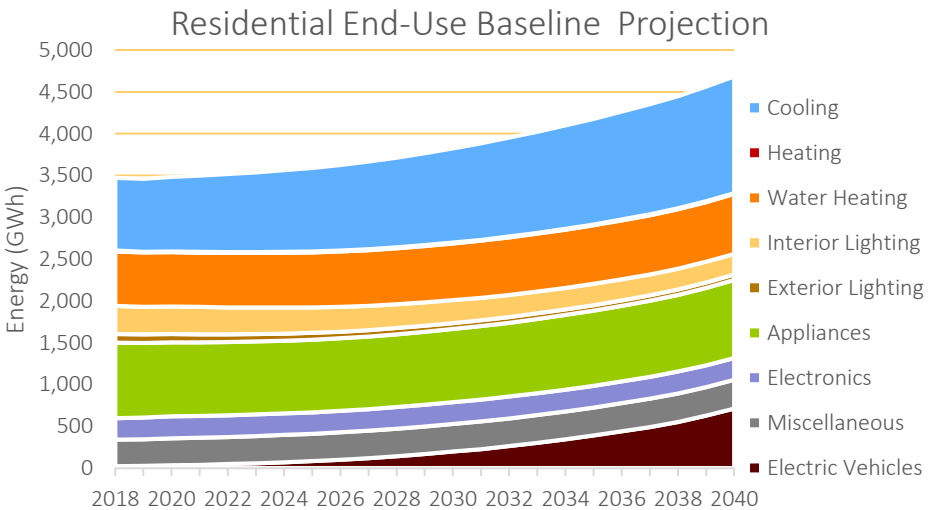


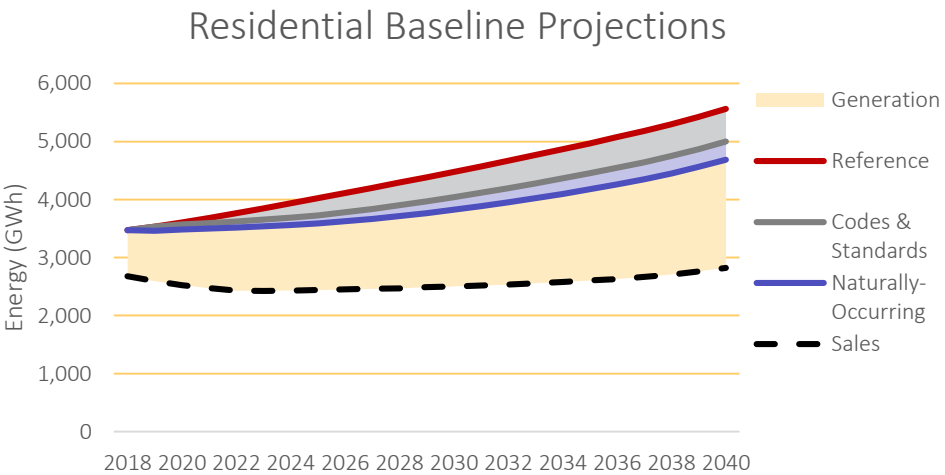
End-use Baseline Projection

Residential Consumption

We developed a baseline end-use projection of consumption that incorporates HECO's generation and EV forecasts and aligns with their sales forecast

- New DG is modeled as "Smart Export" which requires batteries
- Codes & Standards accounts for state and federal C&S taking effect after 2018 (prior years accounted for separately for EEPS)
- Naturally-occurring represents non-program efficiency in the general-service lighting and solar water heating technologies



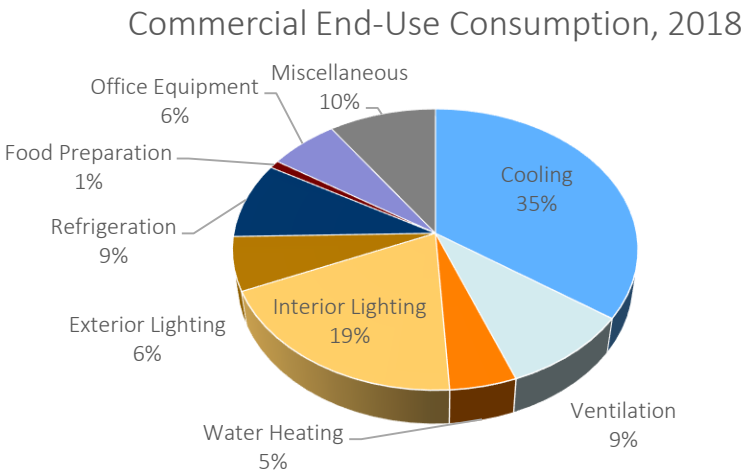


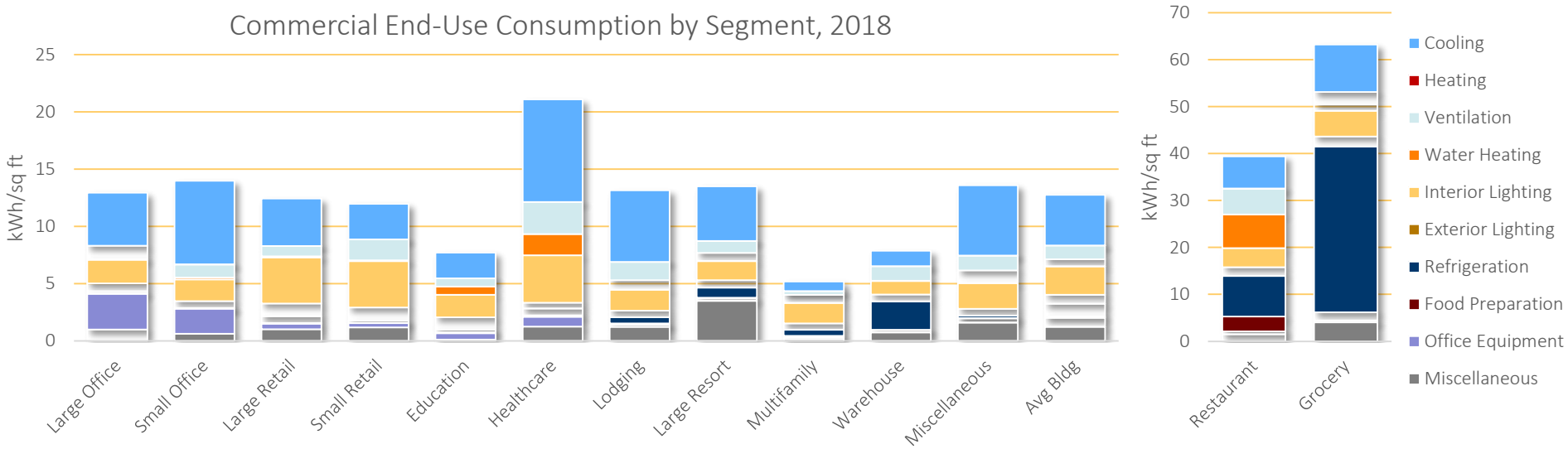
Commercial Market Characterization

Incorporates Information from the Statewide Baseline Study

Key Commercial Baseline Findings:

- Substantial progress has been made in the lighting market since 2013 (reflected in recent-year EE program accomplishments)
- Compared to the residential market, there is less installed solar PV. Market barriers include:
  - Geography: low uptake/feasibility in downtown Oahu
  - Segment: lower PV uptake in lodging and large resorts





End-use Baseline Projection

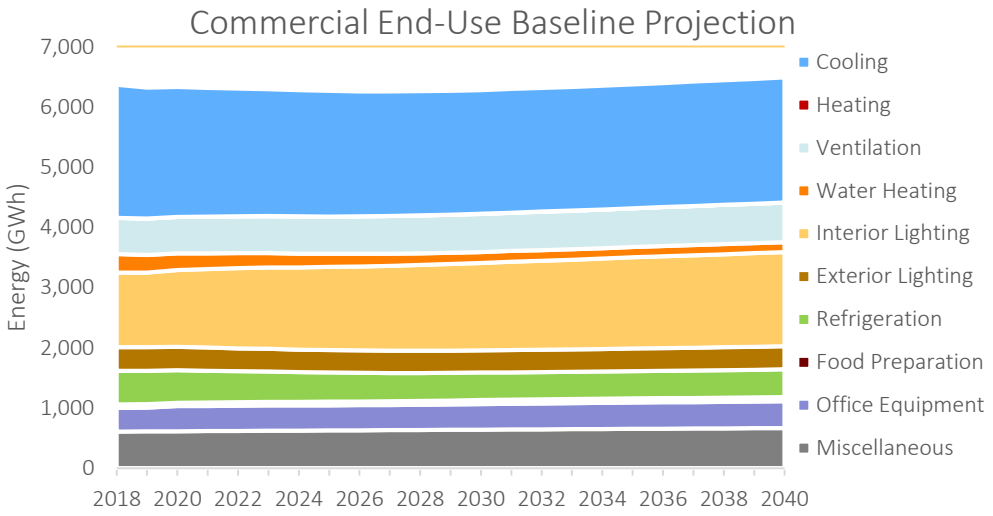
Commercial Consumption

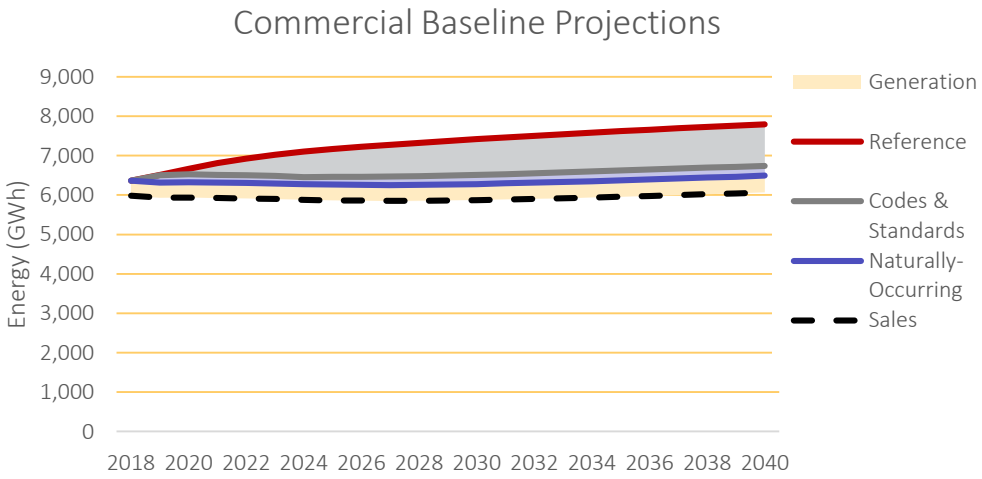
The commercial baseline was developed using a similar methodology to residential

The increase in the Codes and Standards projection is mostly due to the 2020 EISA lighting backstop

- Hawaii has more screw-in lighting than we have seen in other jurisdictions due to large retail, lodging, and resort segments

EV growth is not as prevalent in the commercial sector





Military Modeling Assumptions

Military Facilities

AEG developed military-specific end-use models

- Incorporated data for Joint-Base Pearl Harbor-Hickam provided by the Navy
- Utilized Baseline Study saturation and intensity results

Potential modeling differs from the civilian sector in three ways:

- Incremental measure costs are 25% higher
- Early-year achievability is lower by 25%
- Communication-based controls measures were removed due to energy security concerns

Due to this market's uniqueness, we report military potential separately, alongside the island-level results

Energy Efficiency Methodology and Results

Measure Definitions

Traditional and Emerging Measures

Results in this presentation that count toward EEPS include

- Energy Efficiency
  - This includes both upgrades of energy using equipment and actions or installations that affect how other things use energy
    - E.g., upgrading an air conditioner from SEER 14 to SEER 18 or upgrading to a "smart" thermostat
- Behavioral
  - E.g., Home energy reports

Other interventions that do not count toward EEPS at this time are:

- Demand Response and Grid Services
  - Short-duration curtailments targeting peak periods
  - Flexible response
- Distributed Energy Resources
  - Customer-sited resources including solar PV and battery technologies – we are using HECO's forecast

Solar + Storage

Smart Thermostats

Grid-Connected Water Heaters

Networked LED Controls

Potential Savings from Future Interventions

Energy Efficiency Potential Projections, All Islands and Sectors

Savings in the early years align well with what we see in the industry

High achievability in the later years (up to 85% of economic potential) maintains savings at high levels

Substantial potential is available, particularly in the later years of the projection.

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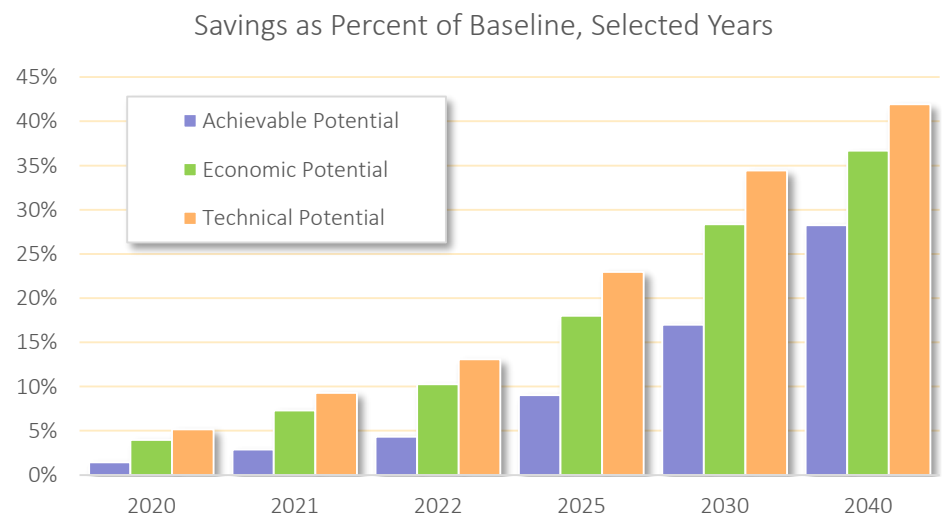
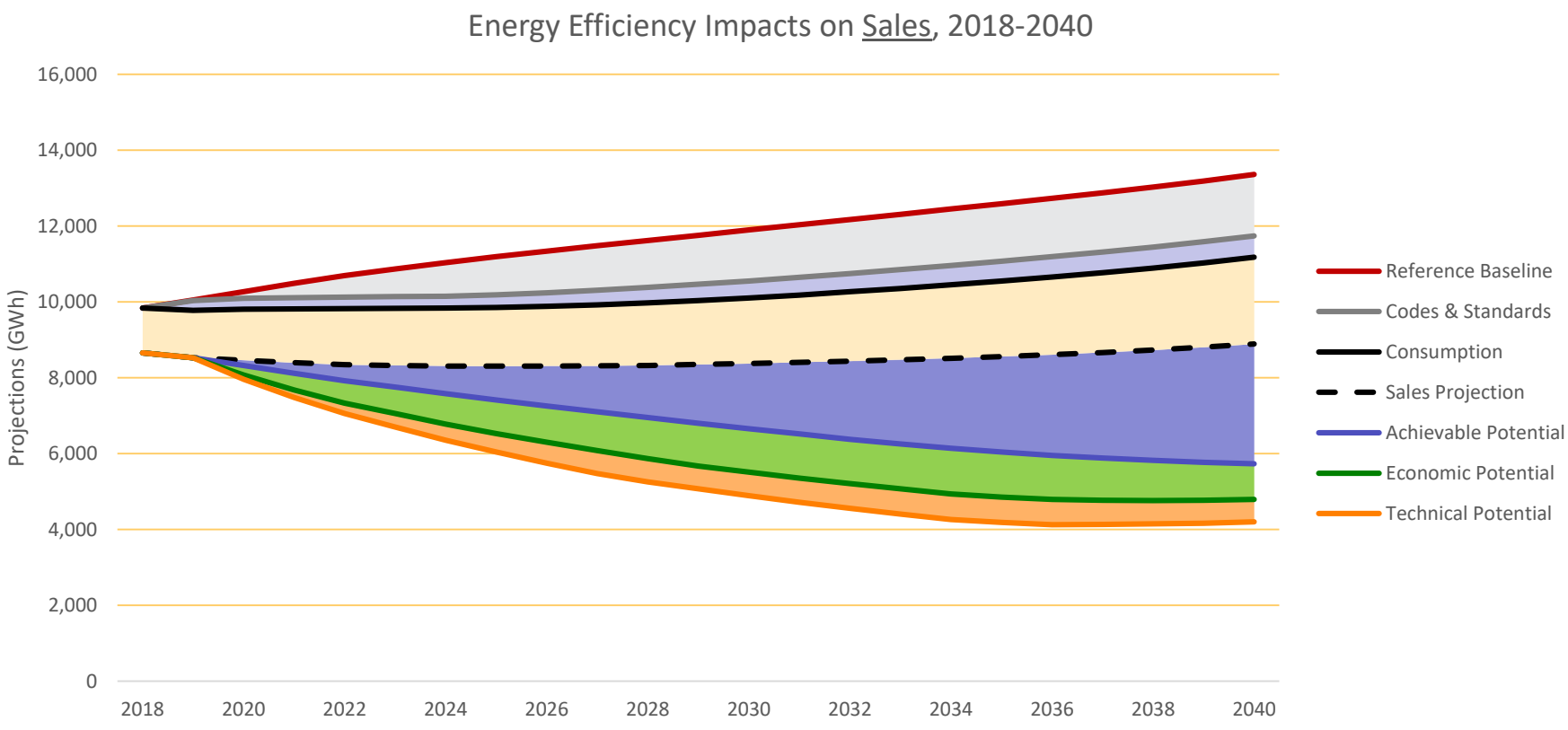


Overall Impacts of Energy Efficiency

Energy Efficiency Potential Projections, All Islands and Sectors

This figure brings all the elements of the analysis together

- The sales projection aligns well with HECO's sales forecast
- Achievable potential could reduce sales substantially over the next 20 years



The Role of Adoption Rates and Summary of AEG's Approach to their Estimation

Adoption rates represent actions customers will take above and beyond compliance with codes and standards and naturally occurring efficiency

- Adoption rates are applied to economic potential to calculate achievable potential

Our approach to developing adoption rates occurs in two steps:

- Align our estimates of technical achievable potential with past program accomplishments (for measures within planned programs)
  - The ratio of technical achievable to technical potential is the near-term adoption rate
  - We imposed a minimum adoption rate of 15%
- Increase achievability over the forecast period to a maximum of 85%
  - This accounts for influences beyond current energy-efficiency programs

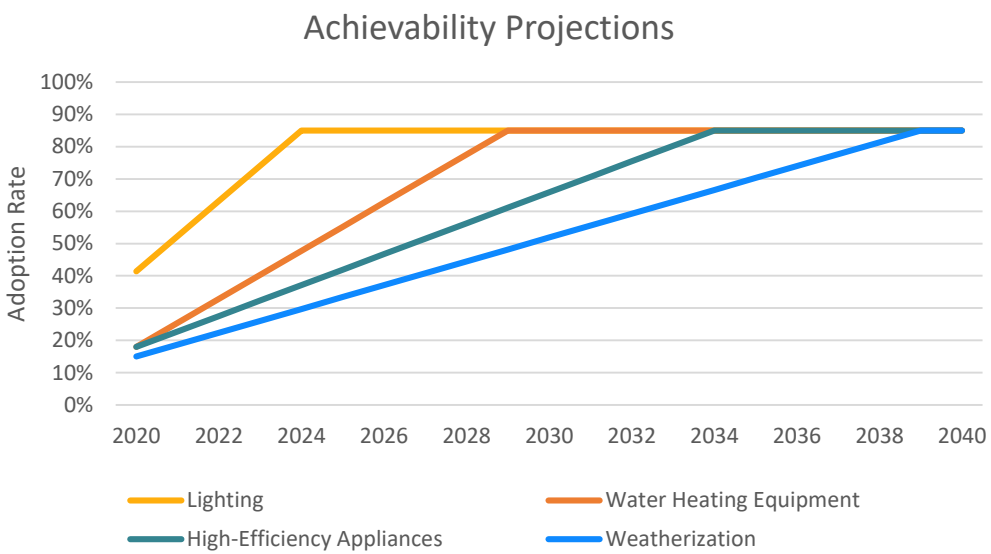
Estimating Adoption Rates
Long-Term Market Transformation

In the longer-term, adoption rates increase, reflecting program maturation and market transformation from a variety of sources

- Expanded programs
- Future (new) state and federal codes and standards
- Future market effects
- Other future interventions

We assumes 85% as the upper limit

- From previous MPS as well as planning guidance in other regions of the country



Potential Savings by Island & End Use

Residential Achievable Potential

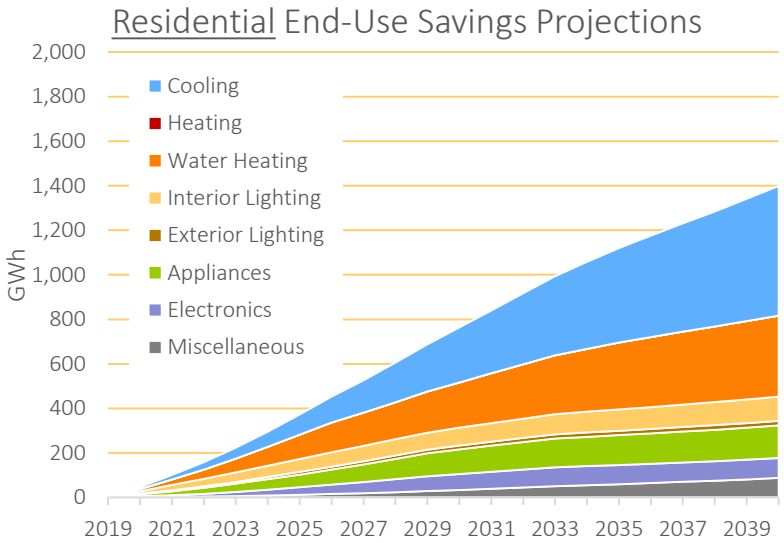
Potential estimates are from a modified code/standard-compliant baseline

- Incorporates naturally-occurring efficiency for general-service lighting and water heating

Cooling and water heating make up most of the savings

- EISA 2020 backstop for lighting shifts substantial potential into the baseline

Military housing only includes non-barracks housing within known on-base communities. Off-base housing is distributed within island-specific markets.



Residential Achievable Potential by End Use and Island, 2030 (MWh)

Segment	Oahu	Hawaii	Maui	Military	Kauai	Molokai	Lanai	Total
Cooling	163,441	30,522	38,647	2,404	9,852	724	594	246,184
Heating	0	0	0	0	0	0	0	0
Ventilation	135,983	26,295	28,962	1,939	9,051	629	677	203,536
Water Heating	48,335	14,322	11,296	1,291	4,703	437	275	80,658
Interior Lighting	10,054	2,907	2,292	266	942	66	46	16,573
Exterior Lighting	77,669	12,421	15,627	991	3,225	60	30	110,023
Refrigeration	45,144	11,792	10,211	917	3,142	315	216	71,737
Miscellaneous	21,644	5,900	5,271	297	1,141	76	57	34,387
Total	**502,269**	**104,160**	**112,306**	**8,104**	**32,056**	**2,306**	**1,896**	**763,096**
Savings as % of Baseline	20.1%	19.8%	20.8%	17.1%	17.5%	16.3%	18.5%	19.9%

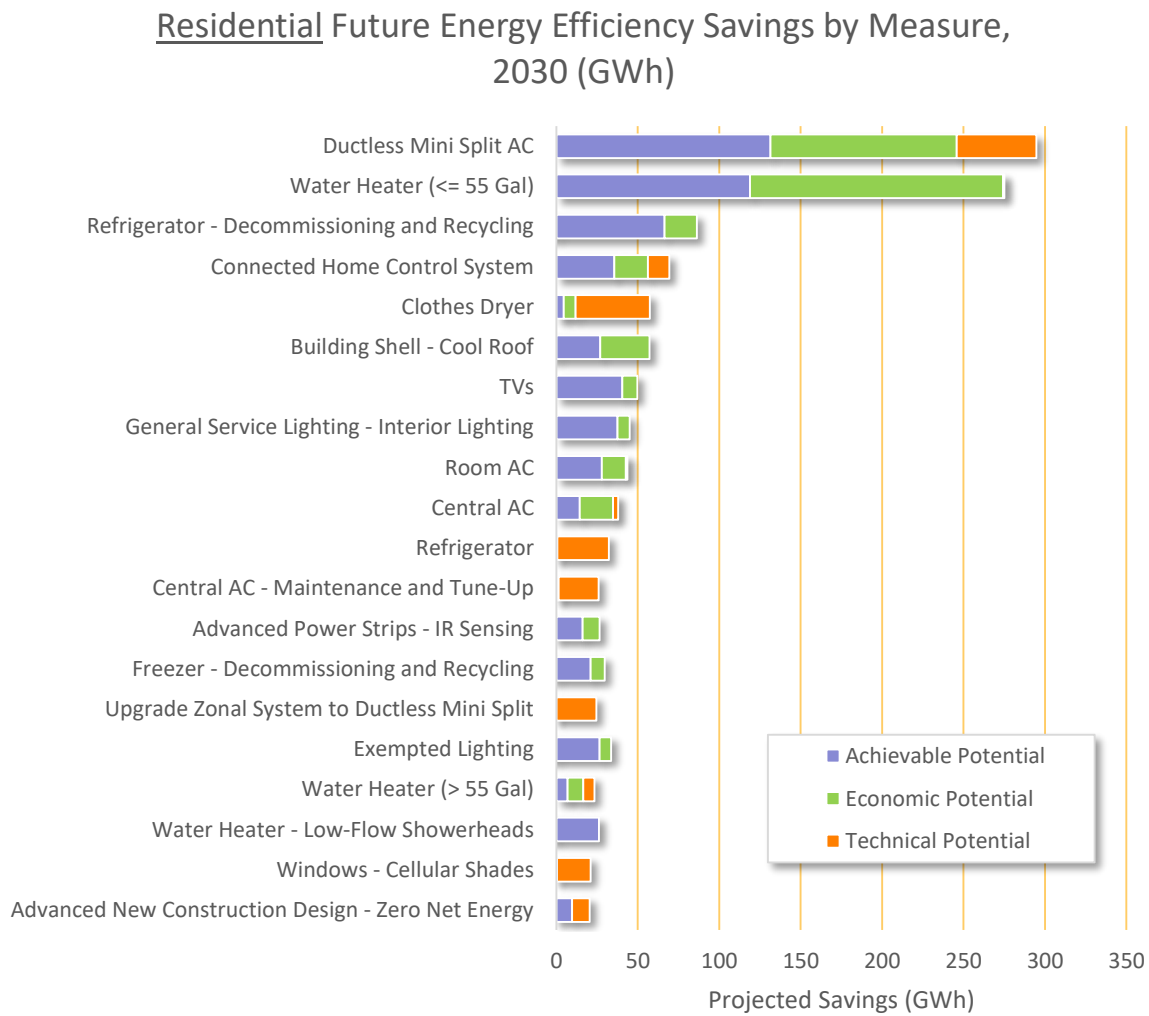
Potential Savings by Top Measures and Case

Residential Potential, All Islands

High growth in baseline cooling saturations are driving HVAC potential

- All but the most efficient ductless AC's pass cost-effectiveness
- Connected home control systems include connected thermostat savings and are cost-effective in most applications

Solar water heaters (**measure #2**) pass cost-effectiveness in 2020 even though the federal tax credit is phased out over time



Potential Savings by Island & End Use

Commercial Achievable Potential

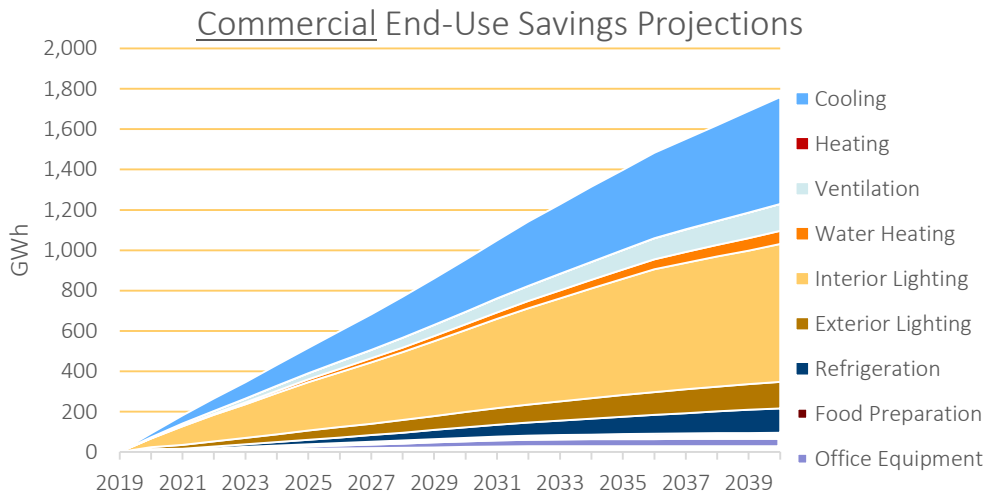
Cooling and lighting comprise a majority of the savings

- Lighting savings occur earlier in the forecast compared to cooling

Potential estimates reflect a modified code/standard-compliant baseline

- Incorporates naturally-occurring general-service lighting efficiency

Potential is largely distributed to islands by size/annual consumption



Commercial Achievable Potential by End Use and Island, 2030 (MWh)

Segment	Oahu	Hawaii	Maui	Military	Kauai	Molokai	Lanai	Total
Cooling	159,441	26,396	28,265	31,912	11,280	598	675	258,566
Heating	0	0	13	0	130	0	0	143
Ventilation	34,762	5,974	10,346	5,763	4,532	136	148	61,661
Water Heating	17,080	3,020	3,478	3,875	1,246	77	95	28,871
Interior Lighting	258,511	45,865	41,737	42,693	16,315	883	1,053	407,057
Exterior Lighting	44,067	7,862	10,267	9,131	4,407	165	198	76,097
Refrigeration	27,829	4,881	5,031	11,080	2,085	124	142	51,171
Food Preparation	5,584	981	885	1,123	361	25	30	8,988
Office Equipment	25,631	4,465	4,747	8,323	1,973	112	133	45,385
Miscellaneous	7,399	1,158	1,238	5,770	662	28	32	16,287
Total	**580,304**	**100,602**	**106,007**	**119,669**	**42,991**	**2,147**	**2,506**	**954,226**
Savings as % of Baseline	16.0%	15.9%	16.6%	11.1%	16.0%	13.3%	13.1%	15.2%

Potential Savings by Top Measures and Case

Commercial, All Islands

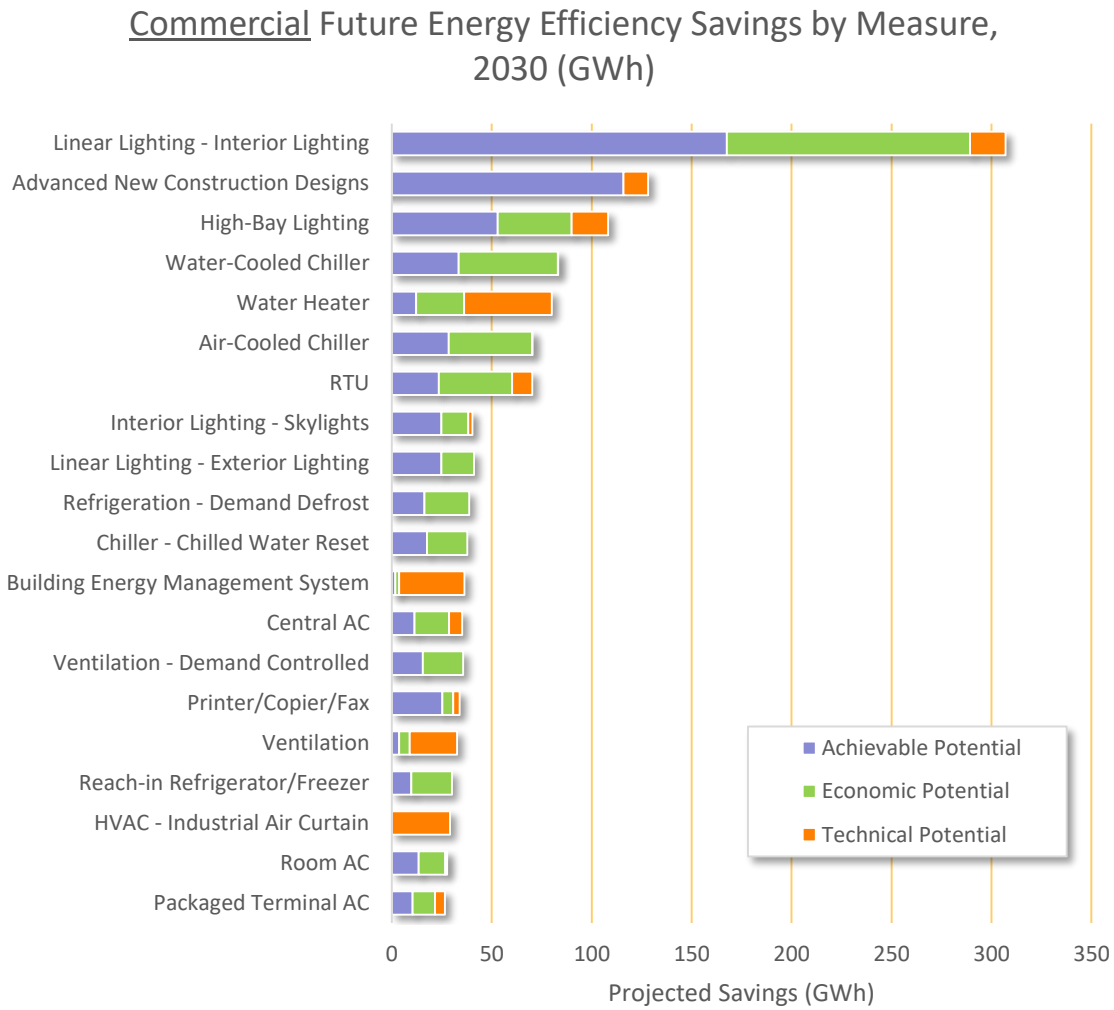
High hours of use drive lighting to be the top-saving end use

- Linear and high bay lighting savings include networked lighting controls in some segments

Substantial HVAC potential in chiller and roof-top unit (RTU) upgrades

- However, long equipment lives slow adoption

Building energy management systems are not cost-effective when installed for EE reasons alone



End-use Load Shapes and Hourly Impacts

Preliminary Results

End-use Load Shape Development Approach

End-use and measure load shapes will be used to estimate hourly impacts

AEG is developing end-use load shapes by sector, end use and island using

- Energy Plus simulation data for HVAC
  - Island-specific EnergyPlus simulations by AEG and NREL
- Results non-HVAC and electric vehicles for southern California from the California Energy Commission's recent load shape study
- Solar PV: Simulations from NREL PVWatts
- Calibrated Energy Market Profiles: end-use consumption data from the MPS calibrated to the HECO peak-hour forecast for 2018

Since the load shapes represent sales, solar generation is incorporated, which is why residential load goes negative at times

These load shapes will be used to estimate hourly EE and DR/GS impacts

The following slides show selected load-shape results

End-Use Load Shapes
Customization for Hawaii

Peak estimates are calibrated to the peak hours for each island

- Each island peaks at a different time
- Peaks should not be summed across islands

Peak data is presented in net sales

- This substantially affects the peak, pushing it later in the day and year

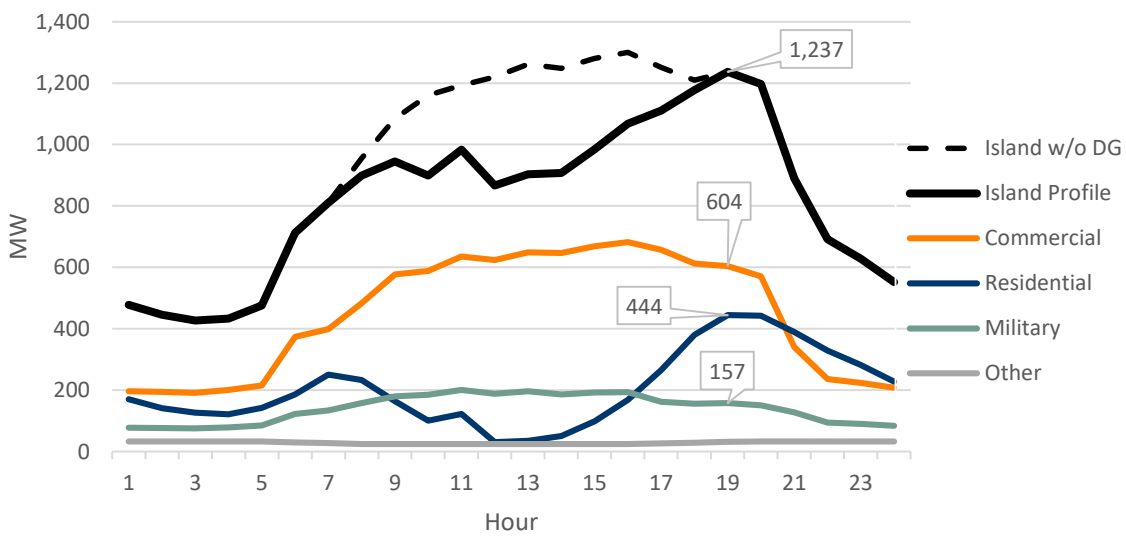
The graph to the right shows the sales peak by market sector, driven by:

- Nighttime reduction in PV
- Evening activity in homes
- Commercial segments that stay open into the evening (retail, lodging, resorts, etc.)

Island-Level Peak Estimates

Island	Island Peak (MW)	Month of Island Peak
Oahu	1,237.0	October
Hawaii	190.4	November
Maui	199.1	October
Molokai	5.8	November
Lanai	5.8	November
Kauai	80.8	October

Oahu Sector-Level Load During Island Peak, 2018



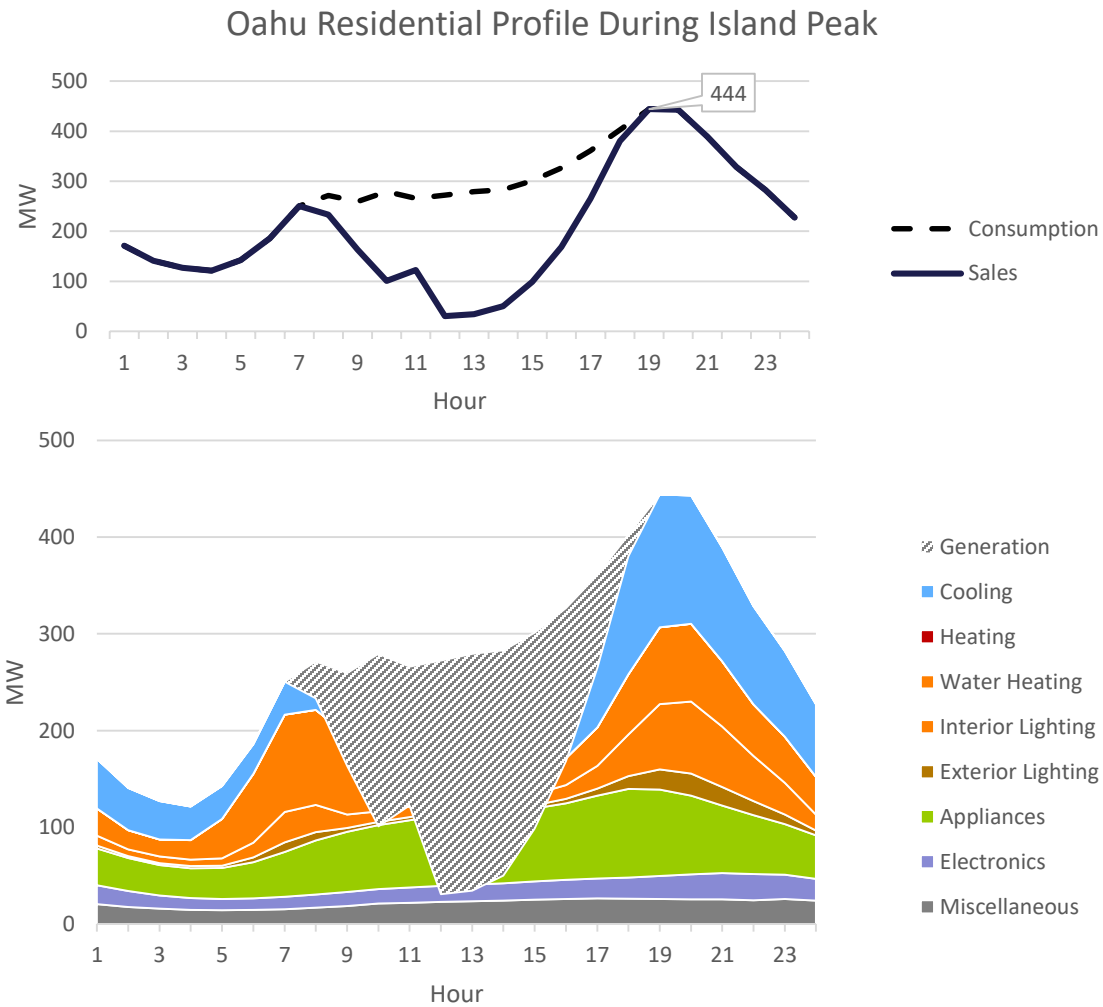
End-Use Load Shapes

Residential Results

Residential peak day shape exhibits the traditional "duck" curve for consumption and sales

However, sales still peak in the evening based on household occupancy patterns

- Water heating and lighting are in use while occupants are home (morning and night)
- This outweighs the cooling required during the traditional afternoon peak
- Appliances behave mainly as a "base load" but their high end-use share results in a noticeable peak impact



End-Use Load Shapes
Commercial Results

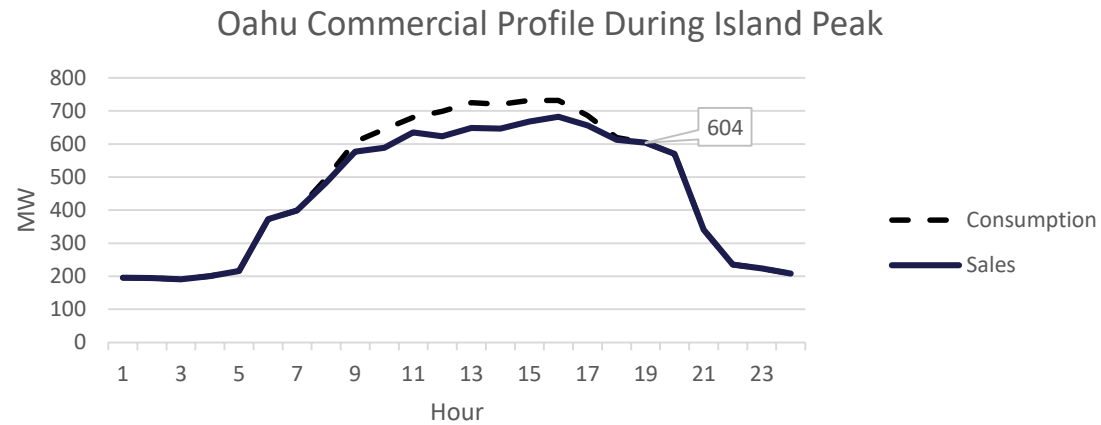
Commercial load peaks during the early afternoon

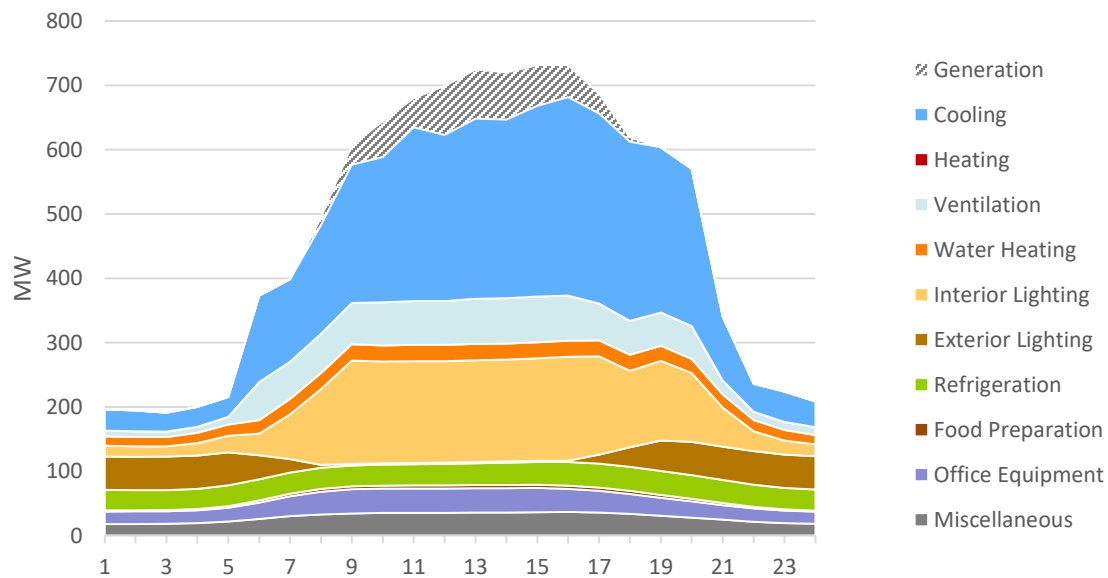
- Lower PV penetration does not substantially change the peak

Cooling and ventilation are the main drivers of the peak, followed by interior lighting

Building types have different occupancy schedules resulting in the "blockiness" exhibited in the profiles to the right

- Lights for an office might turn off around 5, but a restaurant, retail store, or resort may stay on illuminated late into the evening





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Next Steps

Next Steps

Incorporate feedback from the Working Group

Develop hourly estimates of potential impacts

Present final estimates at TWG meeting in late February

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Thank You!