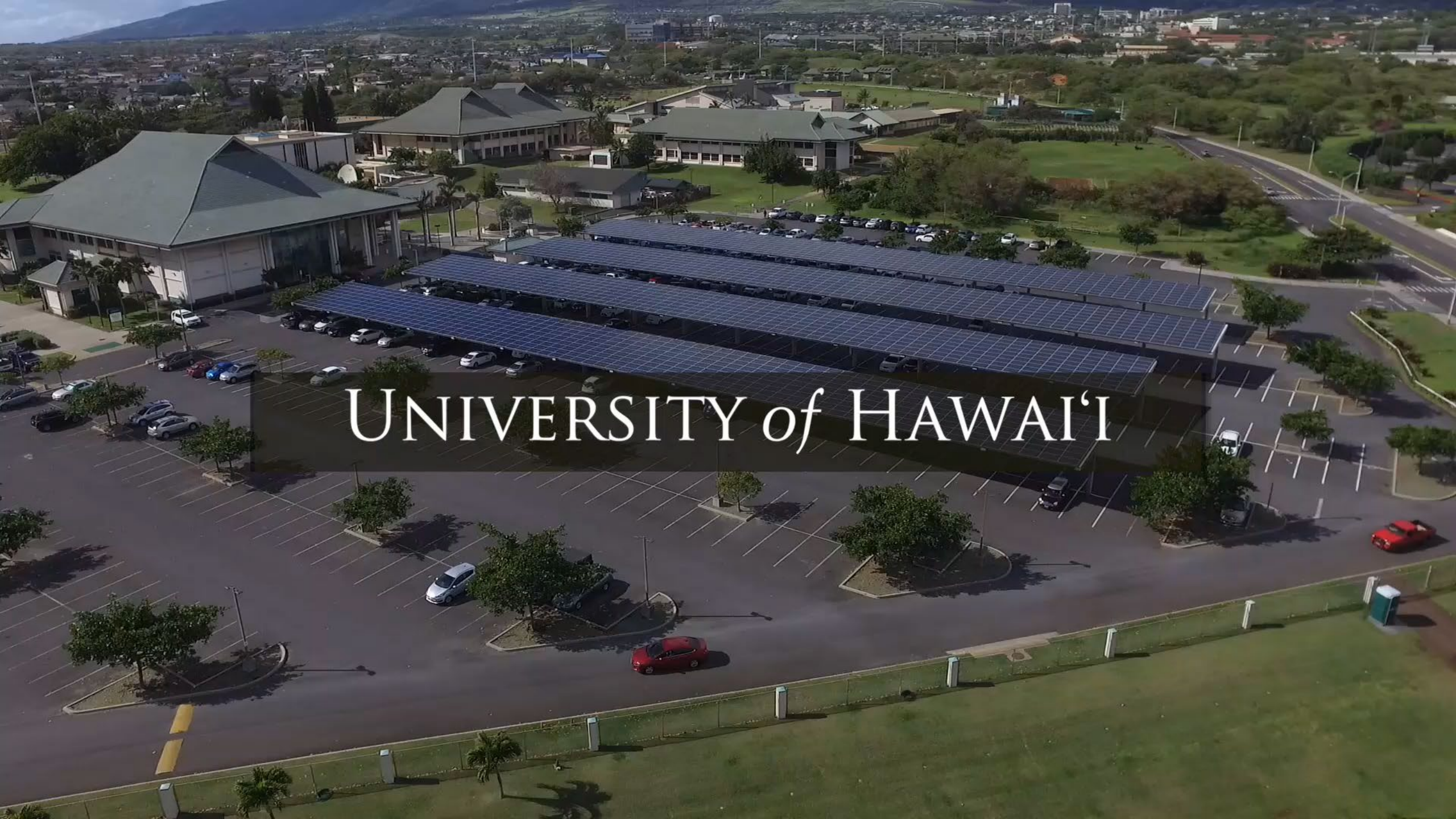
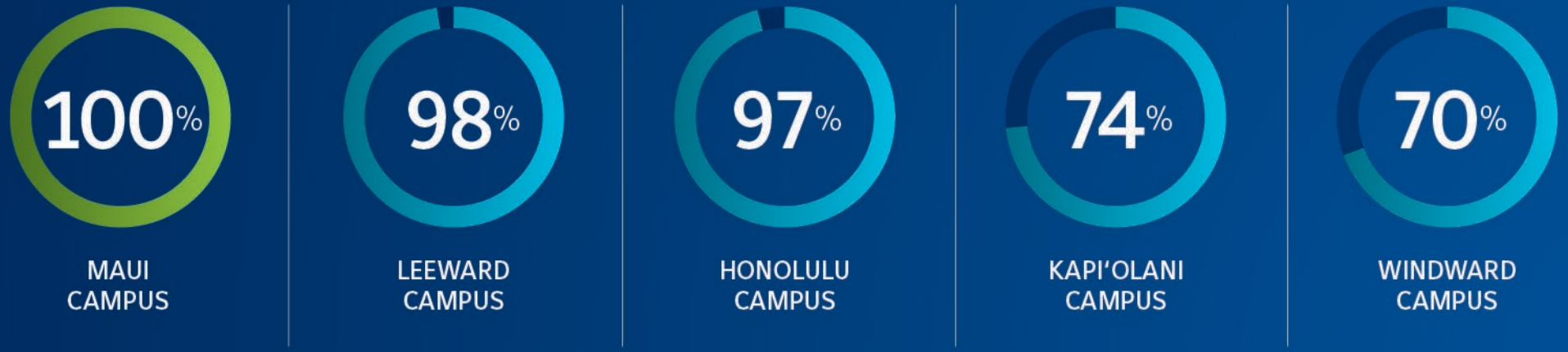

UNIVERSITY of HAWAIʻI

Advancing toward 100 percent renewable energy

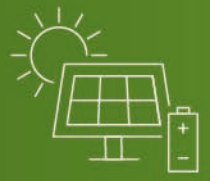
By 2019, the University of Hawai'i (UH) Maui College will be capable of producing as much energy as it consumes. A total of five UH Community College campuses will cut their fossil fuel energy consumption by the following:



Here's how UH is partnering with Johnson Controls to increase energy resiliency and self-sufficiency.

Energy Performance Contract

More than $79 million in savings over 20 years, guaranteed



Solar + Storage

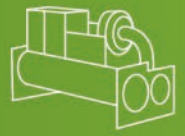
On-site capacity: 2.8 MW of solar PV and 13.2 MWh of battery distributed energy storage at UH Maui College, and 7.7 MW of solar PV and 28.6 MWh of battery distributed energy storage at the O'ahu UH Community College campuses

Smart Controls

Automation to maximize comfort, control and reliability

LED Lighting

Interior upgrades at all campuses



HVAC Enhancements

Replace and upgrade chillers and related equipment

Other Enhancements

Window film installation and new interior transformers at all campuses

Deferred Maintenance

$20 million reduction across two phases, through efficiency projects and savings

Hands-On Learning

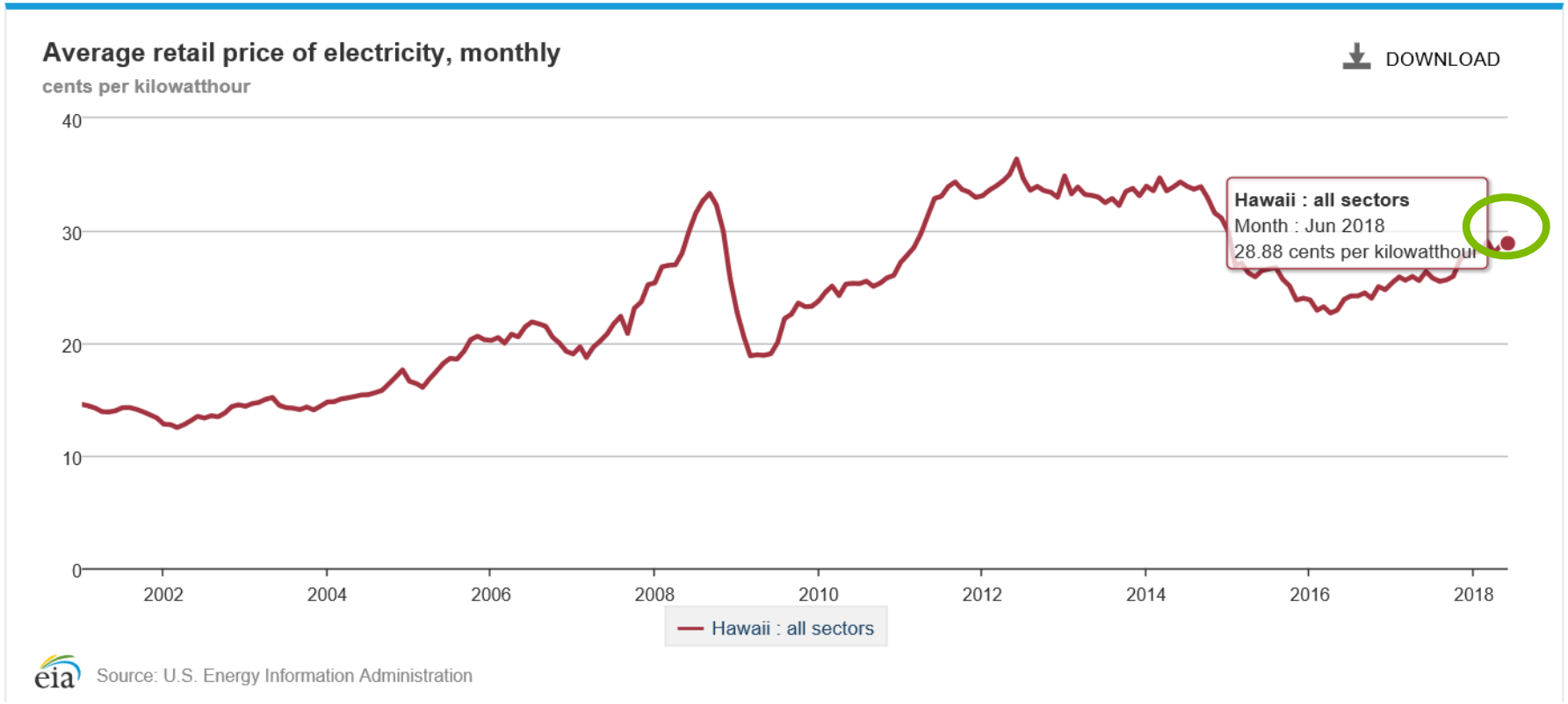
Furthers sustainability education

University of Hawai'i

Johnson Controls

Why do Performance Contracting?
Addresses efficiency & deferred maintenance

2018 **Hawaii** Average Price Per kWh: **28.88** cents per kwh



eia Independent Statistics & Analysis
U.S. Energy Information Administration

Hawaii Average: 28.88 cents /kWh

UNIVERSITY of HAWAI'I®
COMMUNITY COLLEGES

Oahu Campuses

- Kapiolani
- Honolulu
- Leeward
- Windward

2012

AC/ Thermal

Controls

Solar

2015

HRS 304-119 requires UH to become net zero by January 1, 2035

2018

LED lighting

Chiller Controls

Solar + Storage

2020

Grid-Services

Resiliency & Revenue

UNIVERSITY of HAWAI'I®
MAUI COLLEGE

Maui Campus

2012

AC/ Thermal

Controls

Solar

2015

HRS 304-119 requires UH to become net zero by January 1, 2035

2018

LED lighting

Chiller Controls

Solar + Storage

2020

Grid-Services

Resiliency & Revenue

Maui College: Phase 1 (2012)

Performance Contract
Efficiency financing by bond

Backed by Guaranteed Savings stream, 20 year Guarantee

Lighting, AC, Controls

Automation with Smart Controls

More comfort, control, & reliability for areas of campus touched by project

Solar PPA Pricing

Electricity Pricing lower than Utility projections,

20 year term

800kw Solar PV

Clean Solar Energy to the grid

500 KW Energy Storage System

Maui College: Exceeding Guarantee

University of Hawaii Community Colleges Oahu District Energy Savings Performance Contract Summary						
Year	kWh Avoidance	kGal Avoidance	Therm Avoidance	Guaranteed Savings	Verified Savings*	Actual Savings**
1	1,150,443	2,427	744	$391,660	$389,618	$515,868
2	1,578,087	2,427	875	$471,394	$545,243	$666,308
3	1,579,557	2,427	978	$497,713	$598,491	$666,712
4	1,589,472	2,427	862	$525,531	$585,522	$548,185

THE BASIS OF THE GUARANTEE IS IN THE SCIENTIFIC MEASUREMENTS:
KWH, KGAL, TRASH, & THERMS (AVOIDANCE AMOUNT)

Guarantee is…… promised amout X contract rate = **$1,866,298**

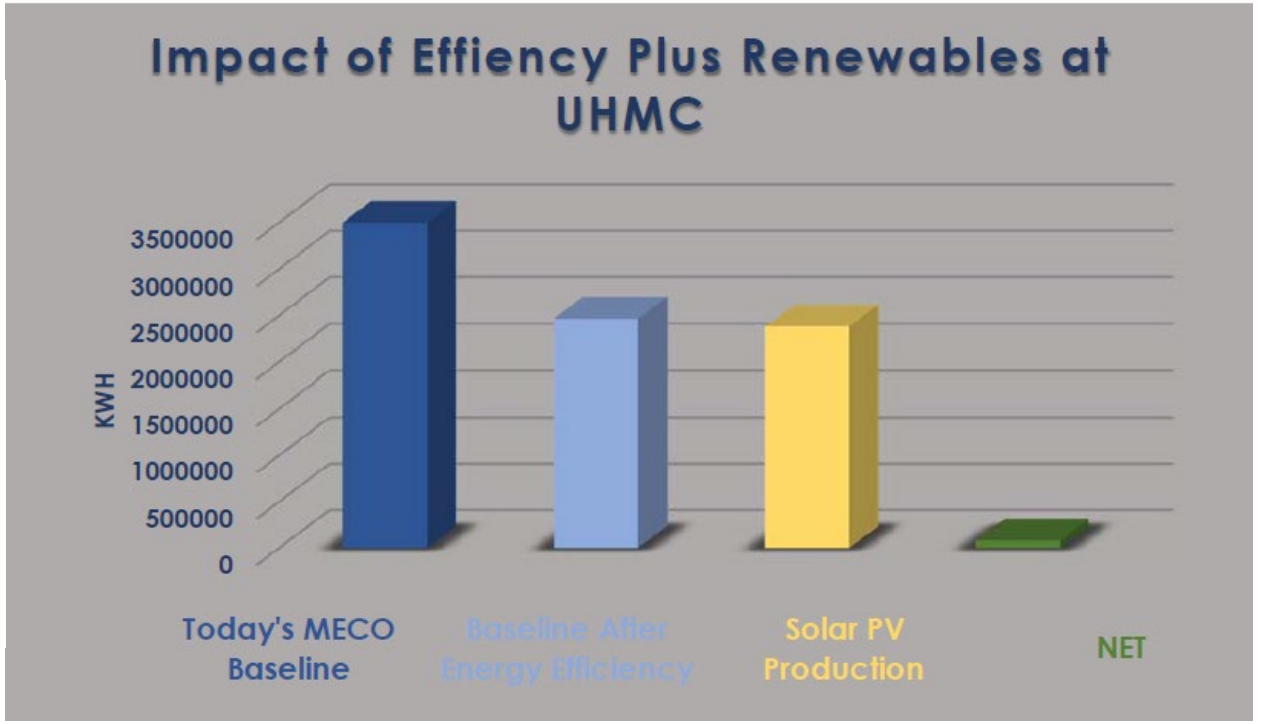
****Actual** is…….. measured amount X HECO rate = **$2,397,073**

Actual amount exceeding Guarantee =

$510,775

Maui College: Phase 2 Efficiency (2019)

ECM #	Recommended Energy Conservation Measures (ECM)	Maui College
1	Interior LED Lighting and Controls	X
2	Replace interior transformers	X
3	Install Window Film	X
4	Replace outdated controls	X
5	Chiller replacements	X
6	Install new BTU submeters	X
7	Install Trash Compactor	X
8	HVAC Modifications	X
9	Roof Mount / Carport / Covered Walkway Solar PV + Energy Storage	X



The Impact of Solar plus Energy Storage

3,499,200 kWh	2,464,764 kWh	2,382,518 kWh	82,246 kWh
Existing Annual MECO Utility Consumption	MECO Consumption After Energy Efficiency Measures	New Solar PV Production	NET
Baseline	30% efficiency	68% solar	98% total

+2 % safety factor

0% remains

Maui College: Phase 2 Solar + Storage

Efficiency financing

Backed by Guaranteed Savings stream 20 year Guarantee

Energy Storage with Smart Controls

Complete storage system

15 year performance guarantee

Solar + Storage PPA Pricing

Demand Savings each year, 20 years

1.57 MW additional Solar PV

Clean Solar Energy stored on campus, 4 hours of storage

Total 13.2 MWHRS

After Net Zero, what next?

A. Grid Services & Resiliency for the Community

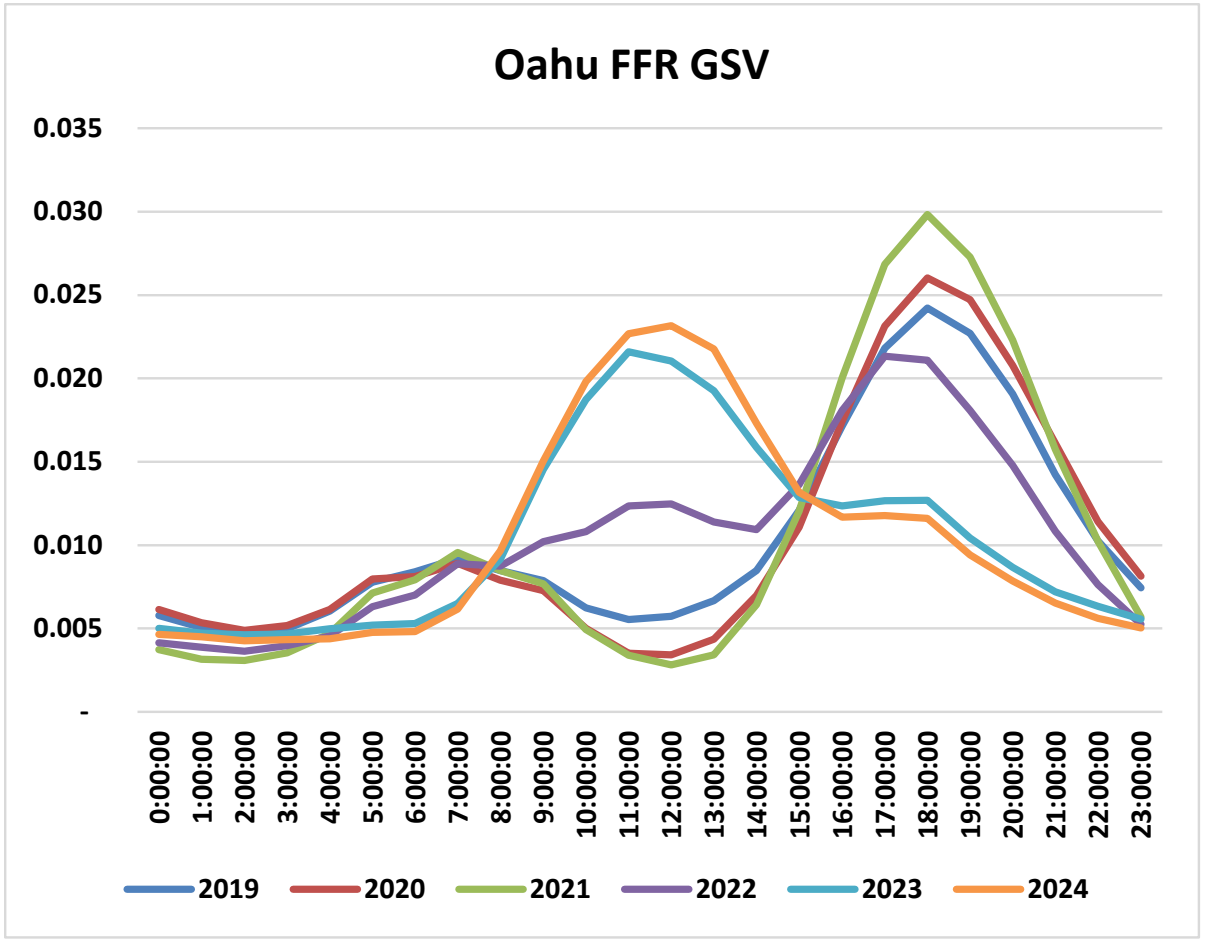
B. Optimize energy assets to create additional revenue for the University

   1. Storage Grid Service: Load Shedding

   2. Storage Grid Service: Fast Frequency Response (FFR)

“the duck curve”
Grid Service Value Ratio

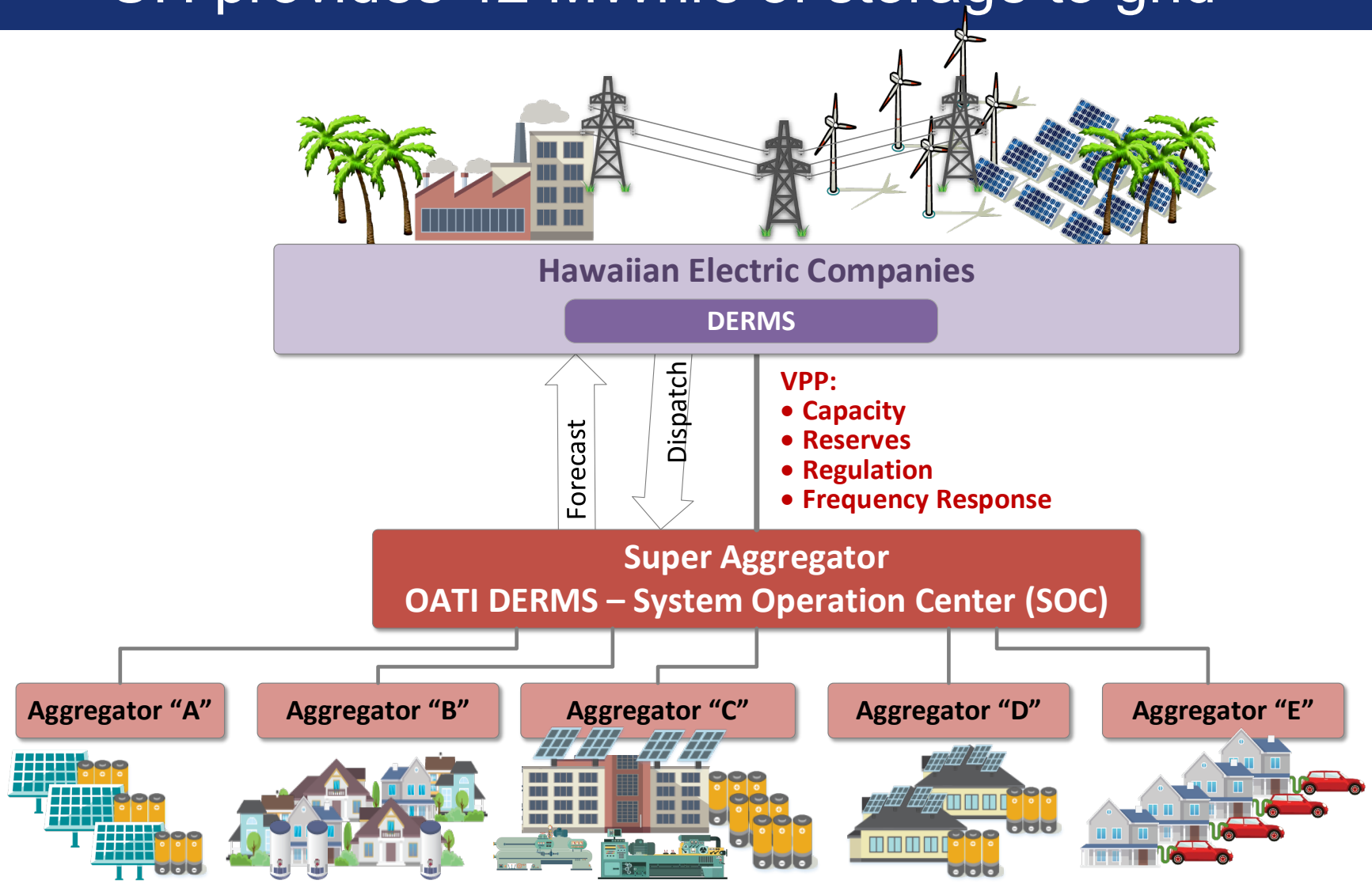
represents the relative value of the services during each day



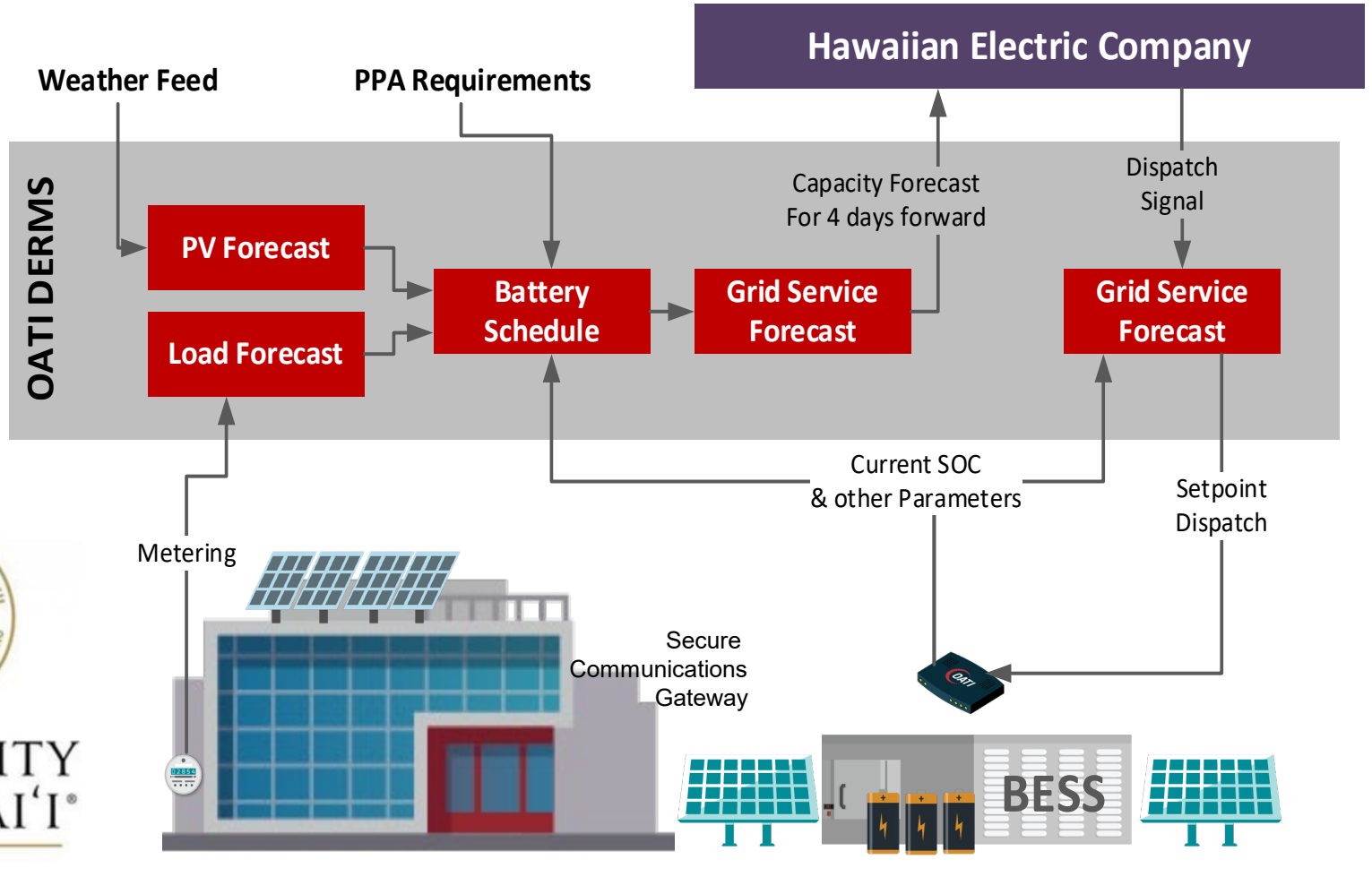
high penetration of PV with no storage during middle of day

shift from 4:30pm to 8:30pm maximizes grid service value

UH Grid Services Participation
UH provides 42 MWhrs of storage to grid



OATI System Operation Center (SoC)

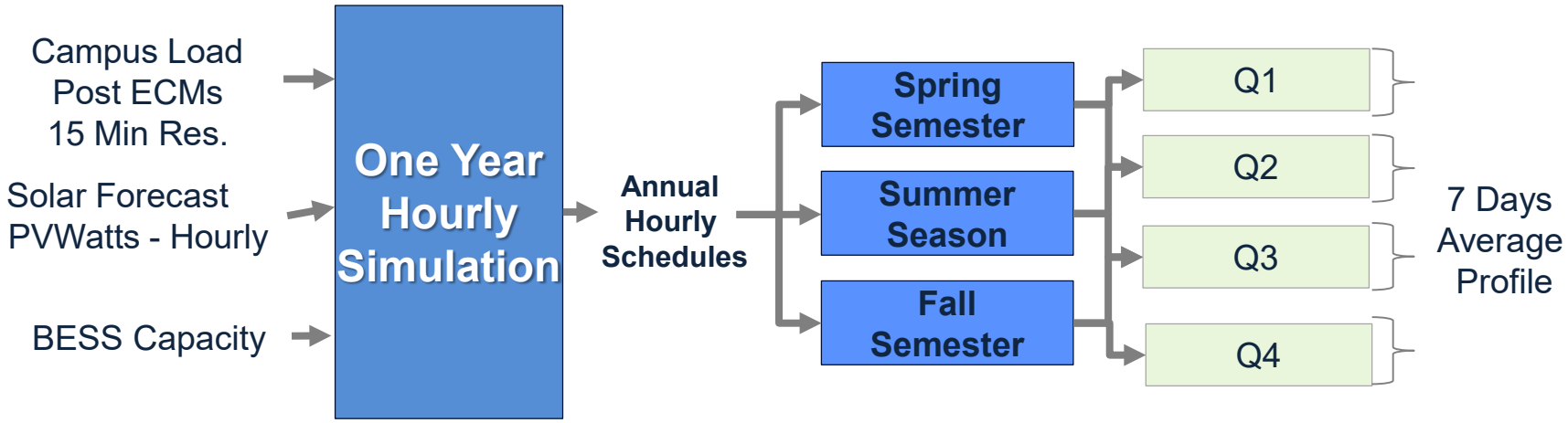


UNIVERSITY of HAWAI'I SYSTEM

Available Capacity Analysis Through Simulations

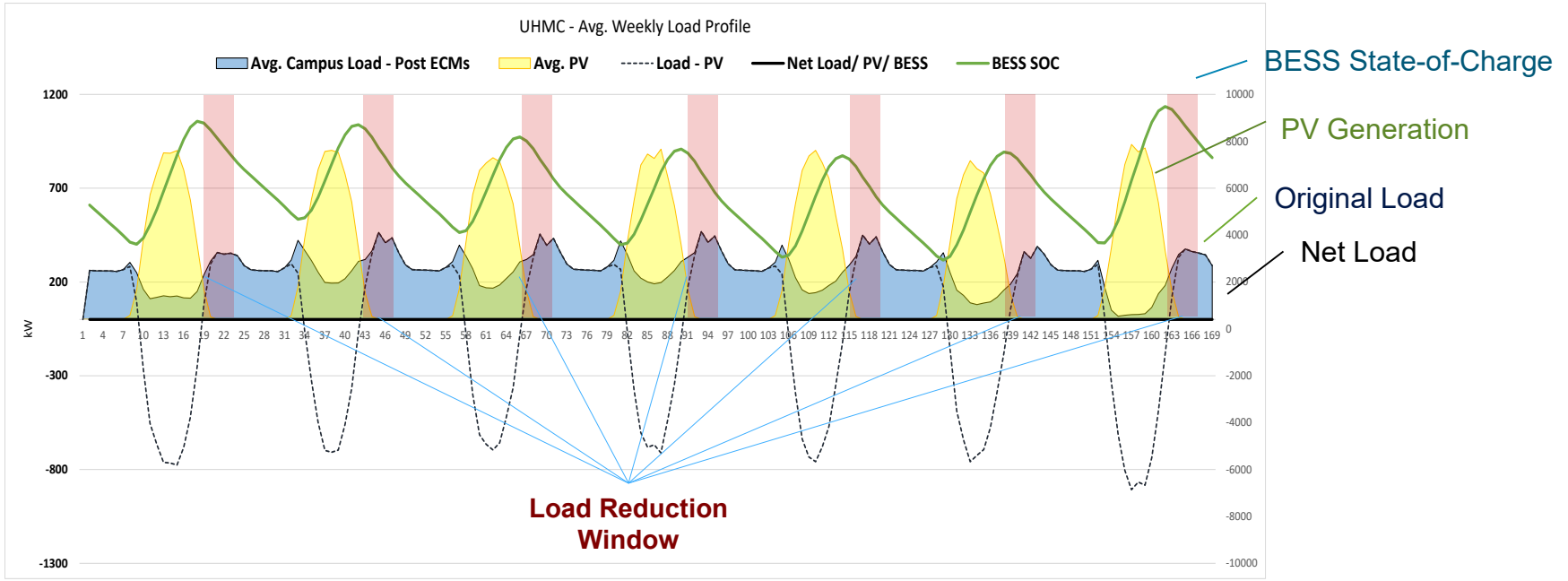
Detailed simulations analysis was performed using:

- One-year, 15-minute load data for each of UH campus
- Hourly Solar PV production forecast for each campus location
- Battery operation simulation per PPA requirements*

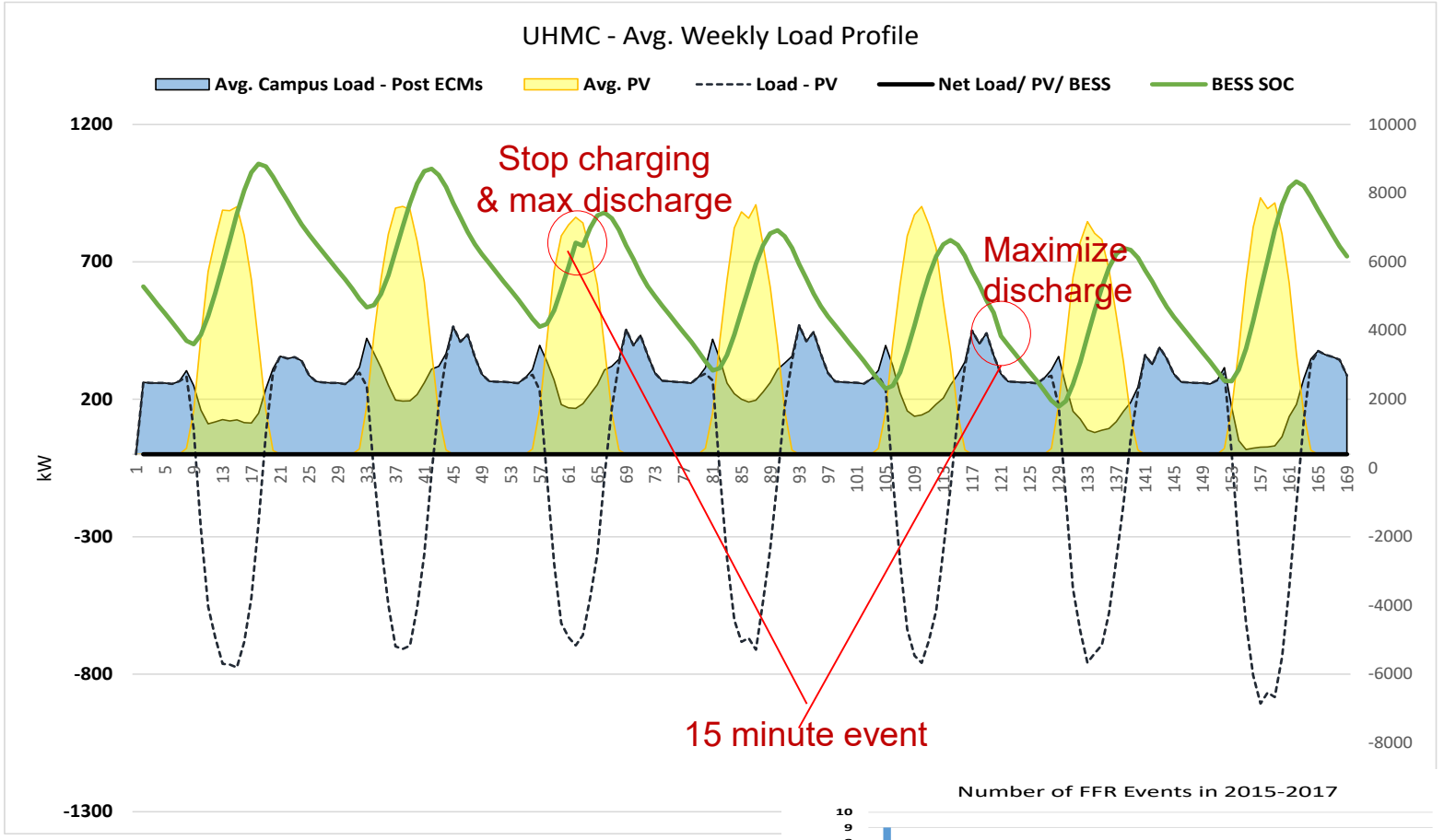


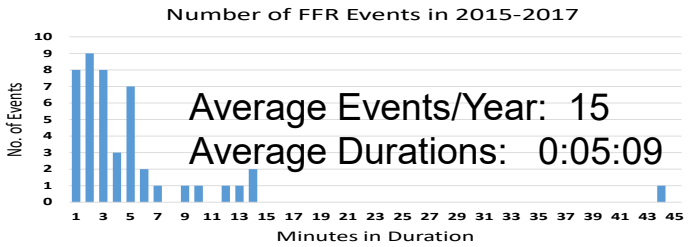
Capacity Reduce Grid Service

- Load reduction dispatch for up to 4 hours from 5:00-9:00 p.m.
- Dispatch notice is issued from 24 hrs to 10 minute in advance of an event



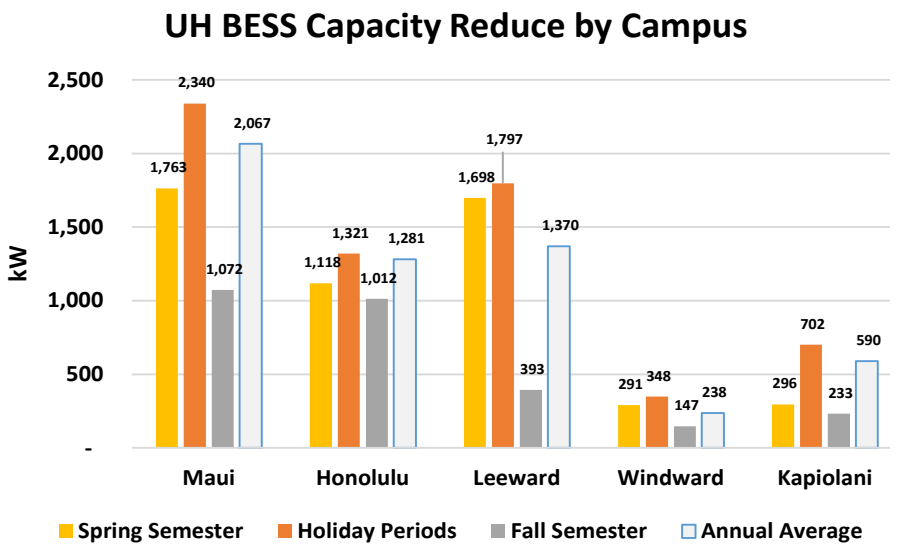
Fast Frequency Response Deployment
Trigger at 59.7 Hz
An autonomous inverter-based operation

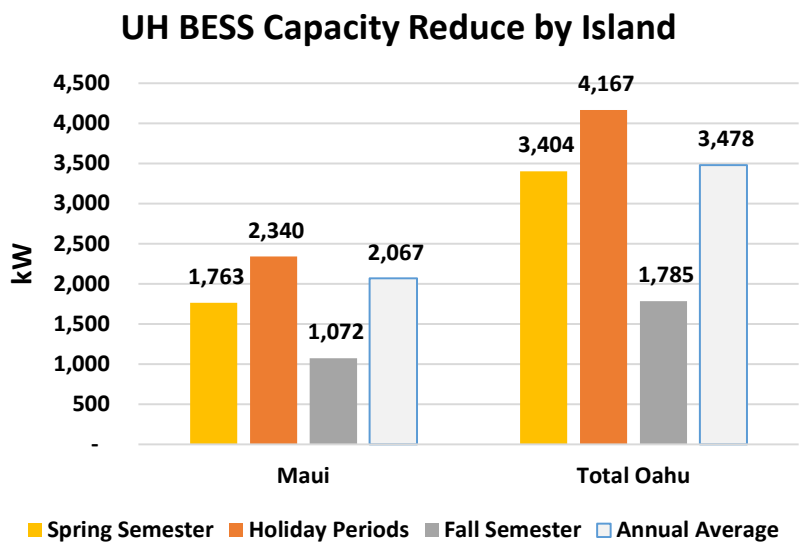




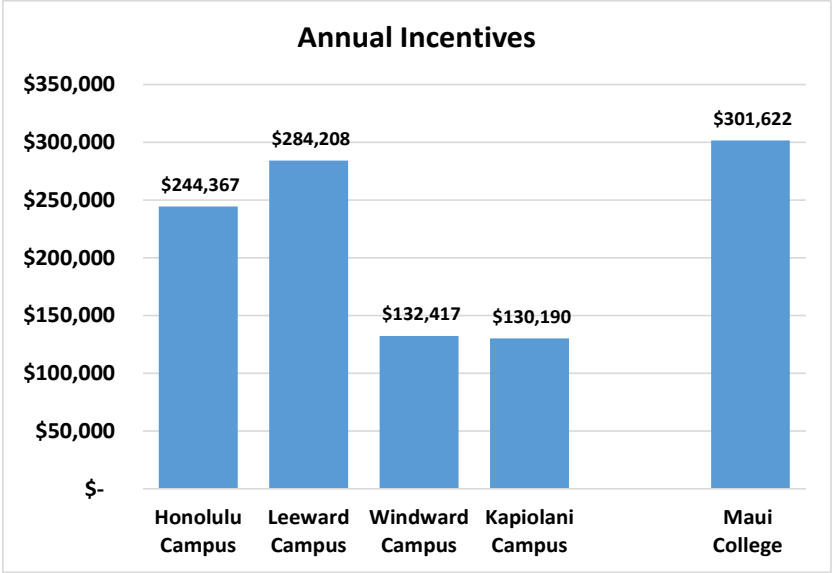
Summary of Capacity Reduce Grid Service

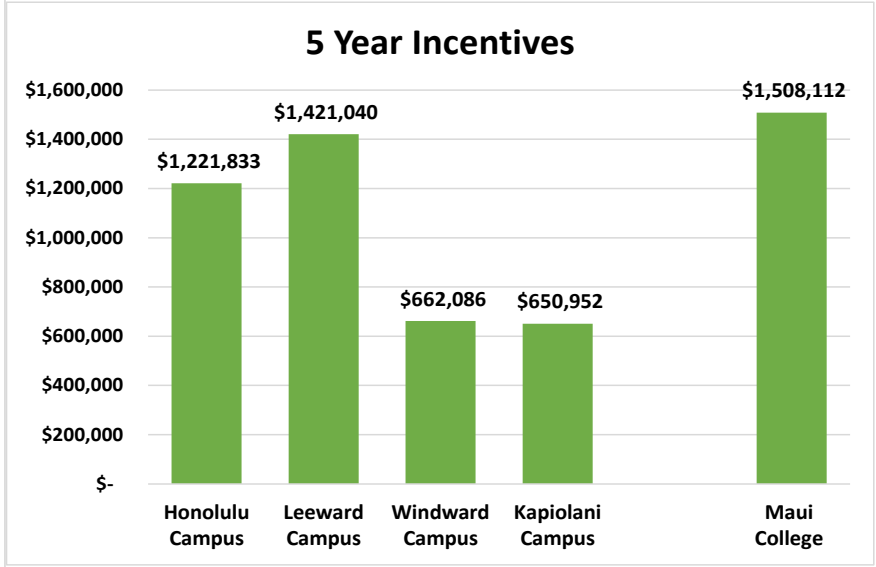
	UH BESS Capacity Reduce Estimates (kW)							
	Maui		Honolulu	Leeward	Windward	Kapiolani	Total Oahu	
Annual Average	2,067		1,281	1,370	238	590	3,478	
Holiday Periods	2,340	13%	1,321	1,797	348	702	4,167	20%
Fall Semester	1,072	-48%	1,012	393	147	233	1,785	-49%
Spring Semester	1,763	-15%	1,118	1,698	291	296	3,404	-2%

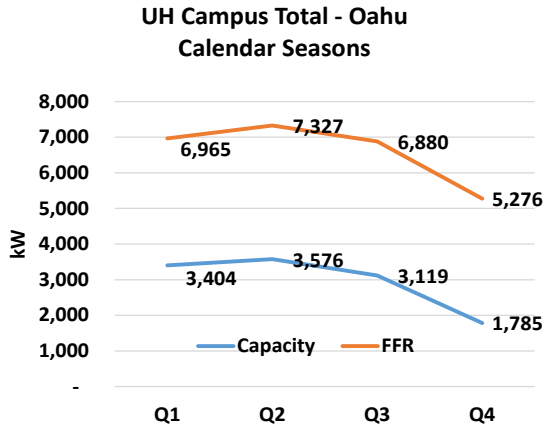


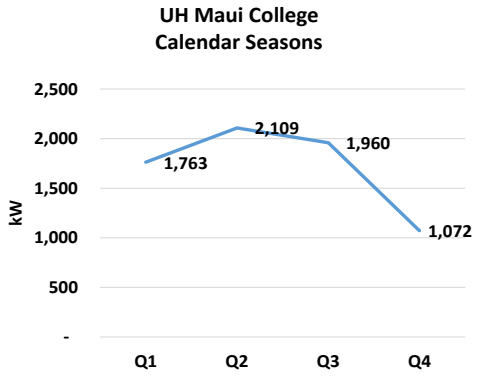


Total UH Incentives: $5,464,023*









* Is a function of the actual kW/kWh services provide throughout the GSPA period

Total UH Incentives: $5,464,023*

GSPA Incentive Structure		O'ahu	Maui
Capacity Build	$/kW/Month	$3.00	$5.00
Capacity Reduce	$/kW/Month	$2.00	$5.00
	$/kWh	$0.1497	$0.1441
FFR	$/kW/Month	$5.00	N/A

UH BESS Incentives	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Honolulu Campus	$ 244,367	$ 244,367	$ 244,367	$ 244,367	$ 244,367	**$ 1,221,833**
Leeward Campus	$ 284,208	$ 284,208	$ 284,208	$ 284,208	$ 284,208	**$ 1,421,040**
Windward Campus	$ 132,417	$ 132,417	$ 132,417	$ 132,417	$ 132,417	**$ 662,086**
Kapiolani Campus	$ 130,190	$ 130,190	$ 130,190	$ 130,190	$ 130,190	**$ 650,952**
Maui College	$ 301,622	$ 301,622	$ 301,622	$ 301,622	$ 301,622	**$ 1,508,112**
Total UH Campuses	$ 1,092,805	$ 1,092,805	$ 1,092,805	$ 1,092,805	$ 1,092,805	**$ 5,464,023**

Sustainable Life & Practice (SLP)

Learning from the sustainable life & practices of Hawaii

Picture: Hokule'a, Polynesian Voyaging Society

$264,738 per month

$8,644 per day

Amounts paid towards utilities
to be re-directed to
Facility improvements
at Maui campus
+ all 4 Oahu campuses

Mahalo

Transforming Campus Infrastructure to Improve Sustainability and Energy Efficiency

UND
Mr. Mike Pieper

CampusEnergy 2020

University of North Dakota

The Challenge

- Century-old coal plant at the center of campus needing immediate replacement

The Innovative Solution

Public-Private Partnership

Design, Build, Finance, Operate, Maintain

- Natural gas-fired steam plant, moved to edge of campus
- Central quad developed
- Intelligent lighting infrastructure
- Building controls upgrades
- HVAC & mechanical equipment

- **200 building campus, 6.5M sq. ft.**
- **40-year public-private partnership**
- **Consortium members include:**
  - Affiliated Engineers
  - AE2S
  - JLG Architects
  - Odney Public Affairs
  - Obermiller Nelson Engineering (ONE)
  - PCL Construction