Fight Climate Change (Global Warming) with Solar + Multi-Storage Resilient Island Nano-Grid for 3 Year PayBack and 100% Renewable Clean Energy Today

Dec 12, 2019

John O. Borland

J.O. B. Technologies

98-1204 Kuawa St

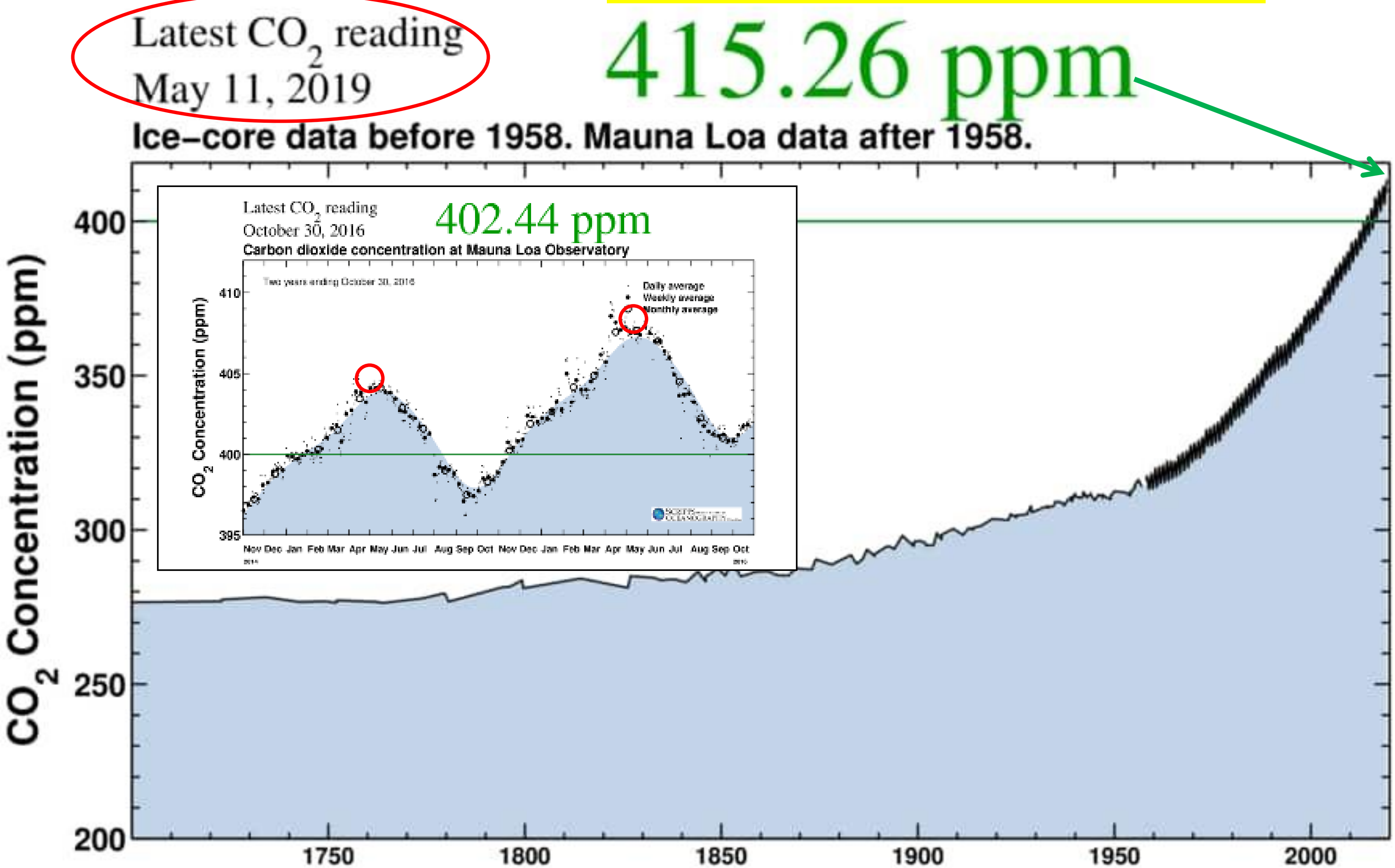
Aiea, Hawaii, 96701

USA

Outline

- Introduction
  - Global Carbon Emissions reach record level of 37.1 B Tons for 2018 and CO_2 peak reached 415PPM on May 11, 2019.
  - Solution: Each person do their part & reduce carbon footprint
    - Home/Building achieving 100% Renewable Clean Energy Today and Not Net Zero Energy! Export to Grid creates Duck Curve problem!
    - Plug-in Electric Vehicles (B-EV & PH-EV) are Not Carbon Neutral! Need Solar PV-powered (PVB-EV) and Battery Swapping (BS-EV)
    - Island Nano-Grid Resilience Saves Lives & Money!
- Start at Home:
- Summary:

2018 CO_2=37.1B tons +2.9%



Solution #1: We must all do our part to fight Climate Change (Global Warming) today by reducing our carbon footprint at home and work with **Solar+Multi-Storage for 100% Renewable Clean Energy**.

Global Carbon Emissions

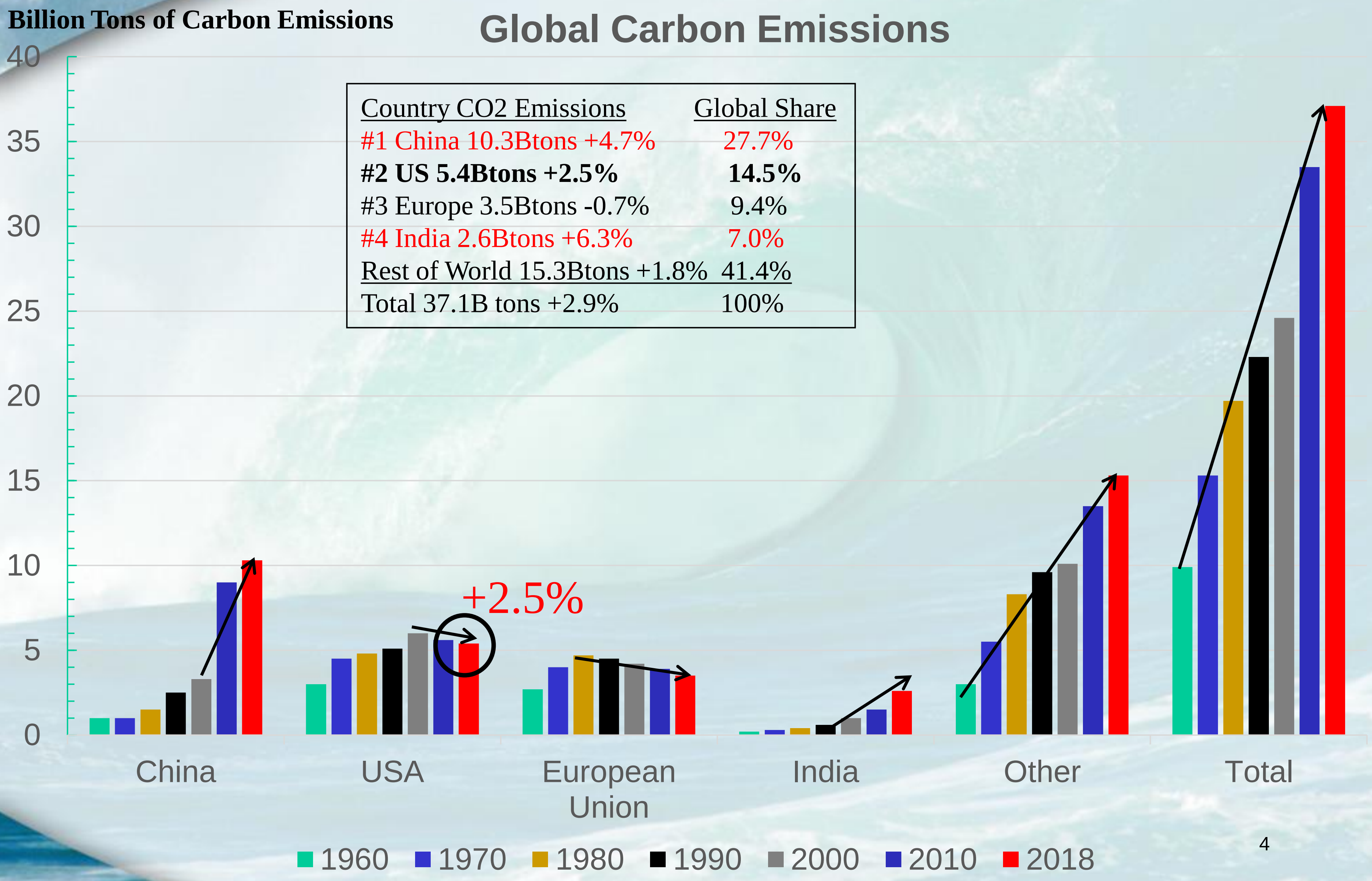
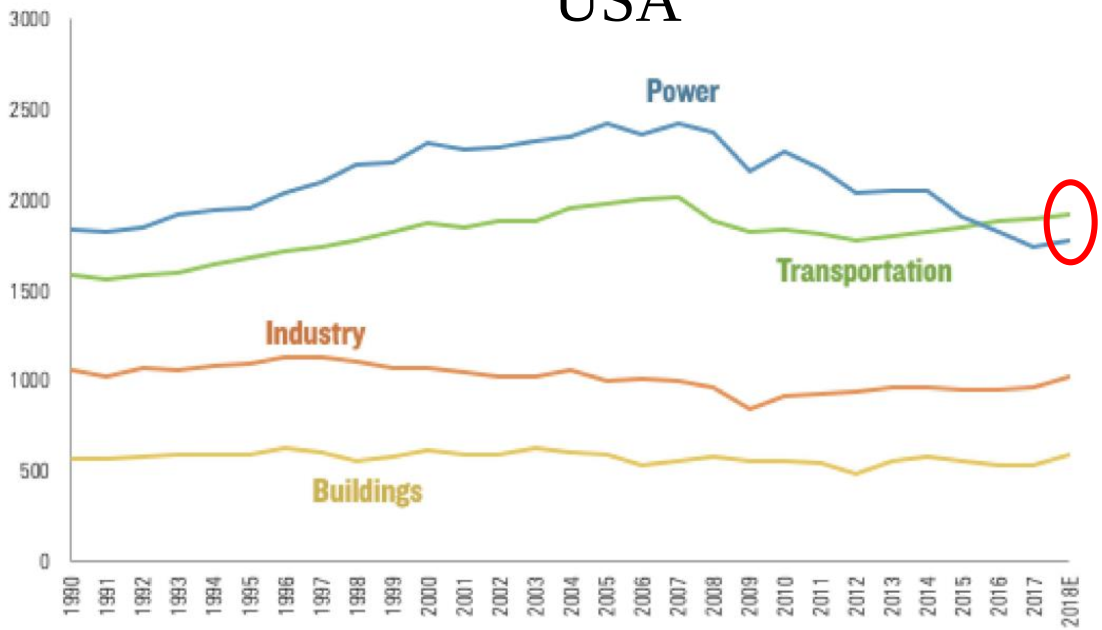


Figure 4: Energy-related CO_2 emissions by sector

Million metric tons

USA

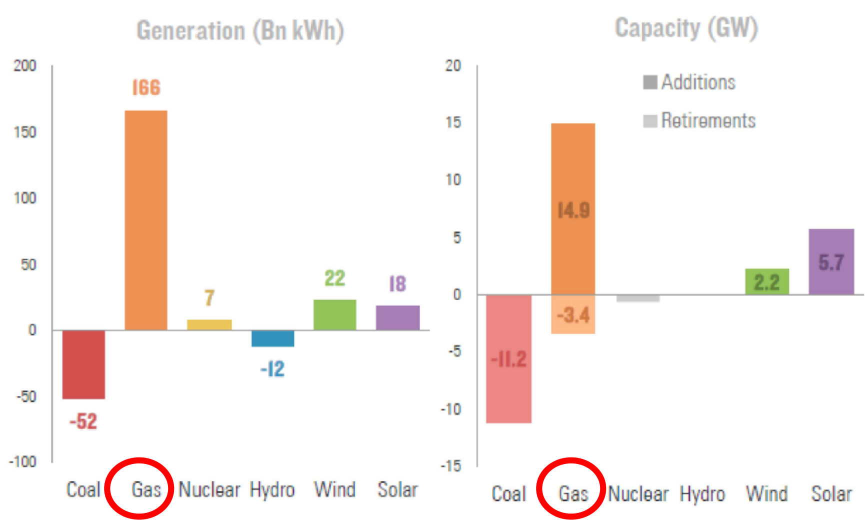


Source: Rhodium US Climate Service

Rhodium Group, Jan 8, 2019.

Figure 2: Change in US power generation and capacity by source, Jan-Oct 2018

Billion kilowatt hours (kWh) (left) and gigawatts (right)



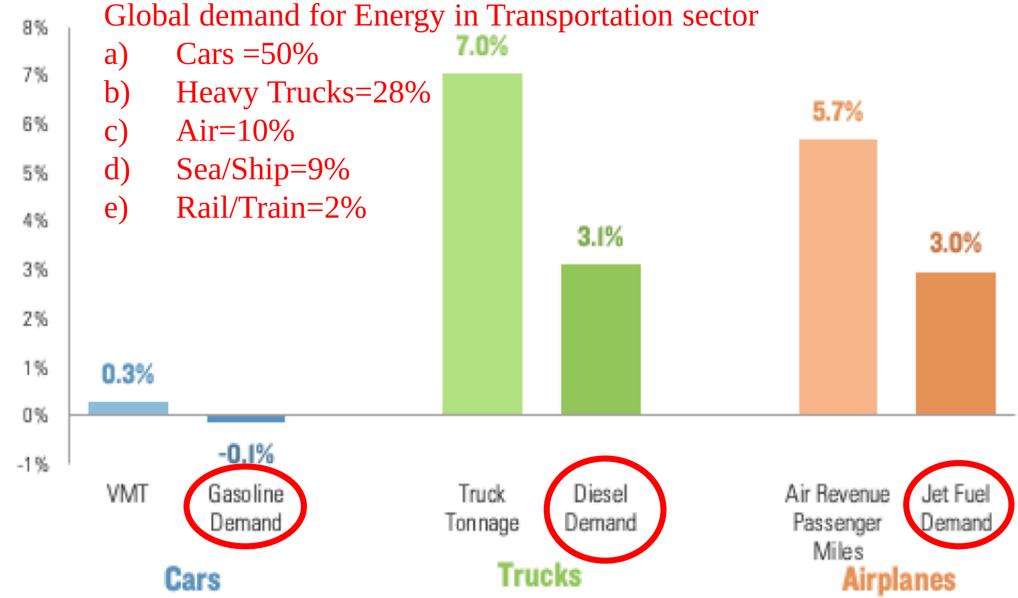
Source: EIA and Rhodium Group estimates

Figure 5: The drivers of transport emissions growth

January-September 2018 vs 2017

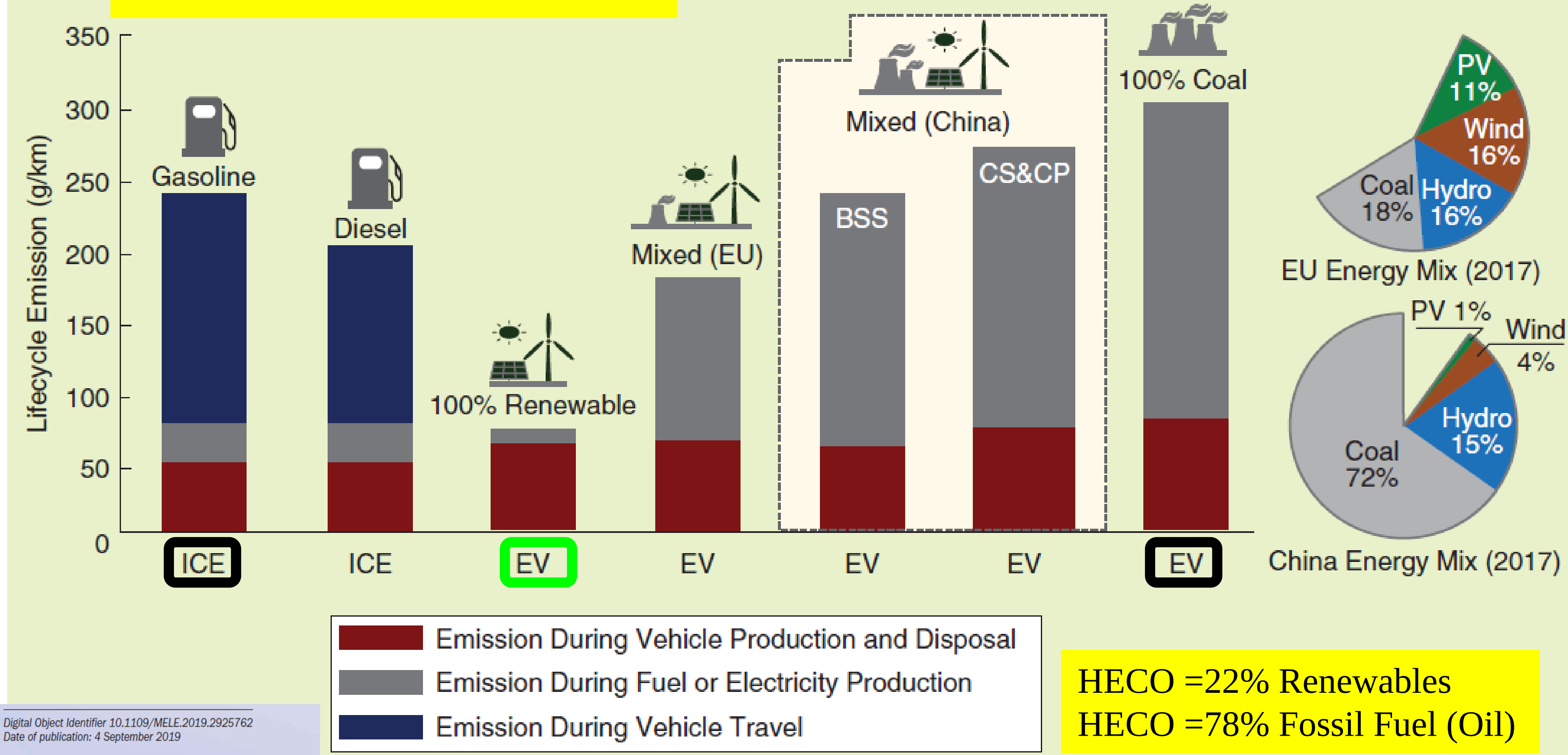
Global demand for Energy in Transportation sector

a) Cars =50%
b) Heavy Trucks=28%
c) Air=10%
d) Sea/Ship=9%
e) Rail/Train=2%



Source: Rhodium US Climate Service, based on data from the EIA and US Department of Transportation

EV Not Carbon Neutral!



Digital Object Identifier 10.1109/MELE.2019.2925762
Date of publication: 4 September 2019

IEEE Electrification Magazine / SEPTEMBER 2019

HECO =22% Renewables
HECO =78% Fossil Fuel (Oil)

Figure 9. The lifecycle emissions associated with different types of vehicles in the EU and China. CS&CP: charging stations and charging piles; PV: photovoltaic; Hydro: hydroelectric.

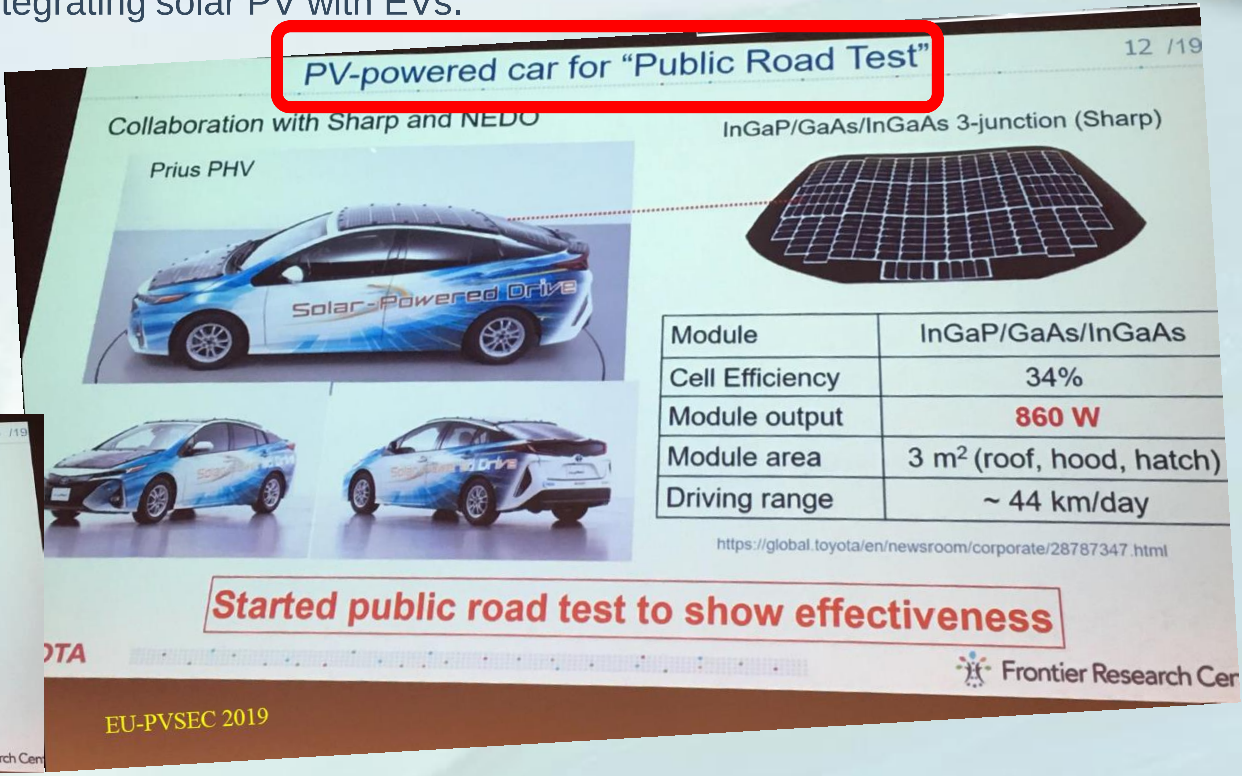
1) 2018 EV sales up 68% reaching 1.98M for total of 5.12M, but EV still <1% of global car fleet.
2) China #1 with 1.0M EVs followed by Europe with 385K then US with 361K.
3) Percentage of EV sales, Norway #1 with 46%, Iceland with 17% and Sweden with 8%. **Hawaii ~6%**

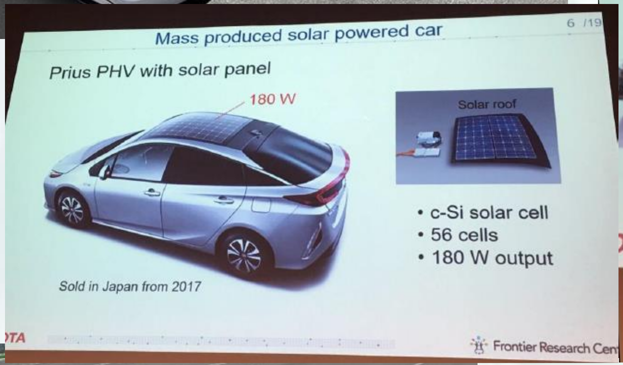
Plug-in Battery Electric Vehicles (B-EV) & Plug-in Hybrid Vehicles (PH-EV) are Not Carbon Neutral! Need PV-powered (PVB-EV)

Hyundai enters the solar car race with new Sonata

Hyundai has unveiled its new hybrid, the Hyundai Sonata, complete with integrated solar cells. The Sonata's unveiling joins Toyota and Lightyear in integrating solar PV with EVs.

JULY 25, 2019 PV MAGAZINE





The thin-film manufacturer and Chinese carmaker **Joylong** Automobile applied thin film cells to the roof of a small commercial vehicle which was tested for a month. **Hanergy** says its K-Car could offer an effective **daily range of 50-100km (30-60miles)** without charging.

It's important to remember the equally vital contributions that can be made by private citizens—which is to say, by you. "Change only happens when individuals take action," Aliya Haq, deputy director of NRDC's Clean Power Plan initiative, says. "There's no other way, if it doesn't start with people."

100% Renewable Clean Energy = Zero Carbon Footprint

1. Speak up!

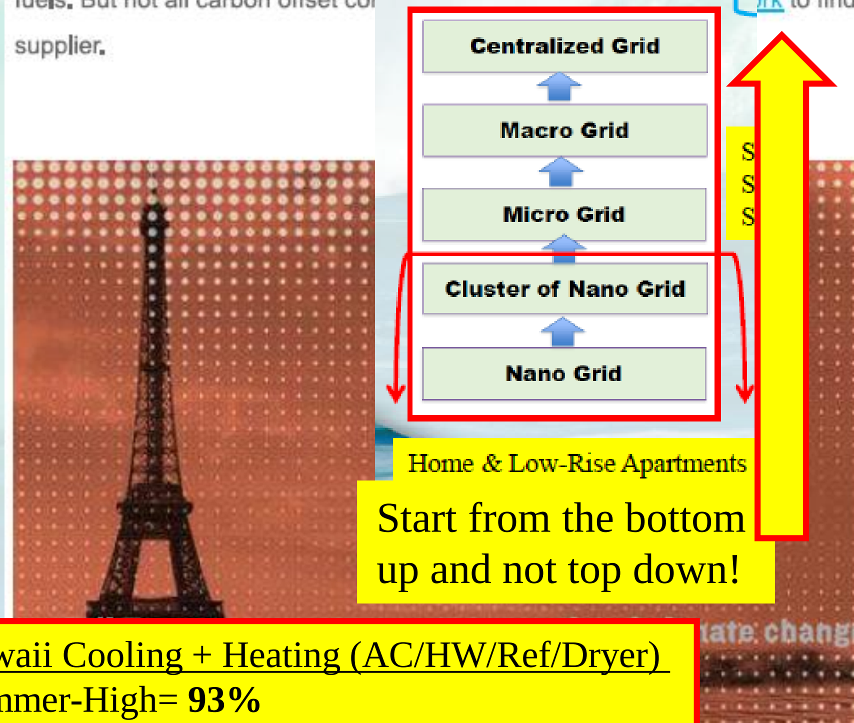
What's the single biggest way you can make an impact on global climate change? "Talk to your friends and family, and make sure your representatives are making good decisions," Haq says. By voicing your concerns—via social media or, better yet, directly to your elected officials—you send a message that you care about the warming world. Encourage Congress to enact new laws that limit carbon emissions and require polluters to pay for the emissions they produce. "The main reason elected officials do anything difficult is because their constituents make them," Haq says. You can help protect public lands, stop offshore drilling, and more here.

12. Shrink your carbon profile.

You can offset the carbon you produce by purchasing carbon offsets, which represent clean power that you can add to the nation's energy grid in place of power from fossil fuels. But not all carbon offset co … rk to find the best supplier.

2. Power your home with renewable energy. Solar + Storage

Choose a utility company that generates at least half its power from wind or solar and has been certified by Green-e Energy, an organization that vets renewable energy options. If that isn't possible for you, take a look at your electric bill; many utilities now list other ways to support renewable sources on their monthly statements and websites.



Home & Low-Rise Apartments

Start from the bottom up and not top down!

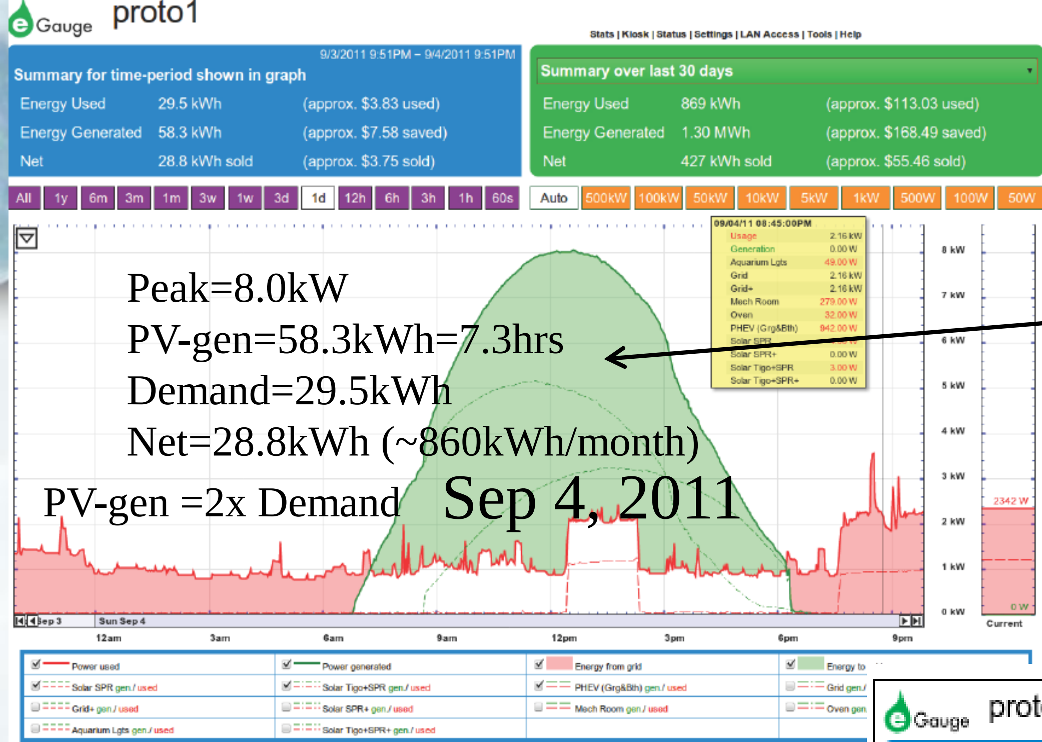
Summertime Air Conditioning use is 60% of Energy!

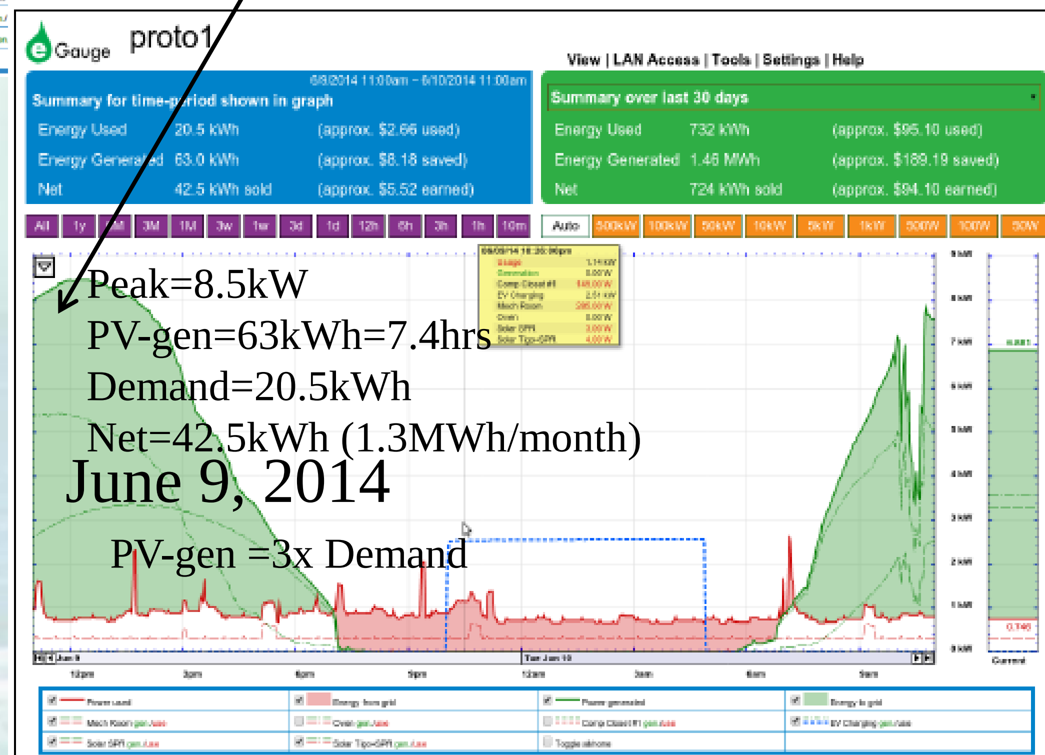
3. Weatherize, weatherize, weatherize.

"Building heating and cooling are among the biggest uses of energy," Haq says. Indeed, heating and air-conditioning account for almost half of home energy use. You can make your space more energy efficient by sealing drafts and ensuring it's adequately insulated. You can also claim federal tax credits for many energy-efficiency home improvements.

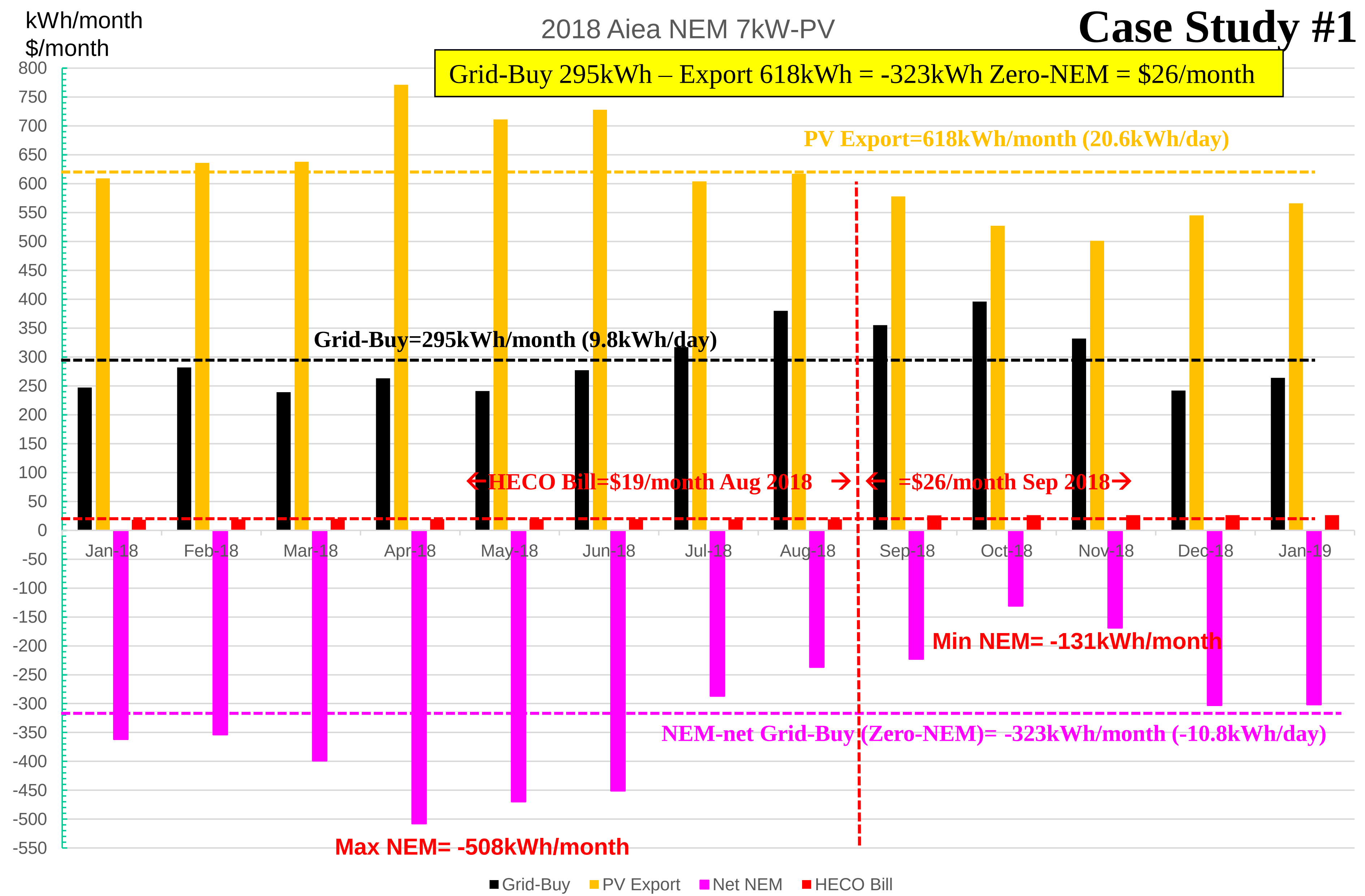
<u>Hawaii Cooling + Heating (AC/HW/Ref/Dryer)</u>
Summer-High= **93%**
Summer-Low= **84.6%**
Winter= **80%**

Severe Over Sizing of Rooftop for Maximum Export Back to Grid with NEM!





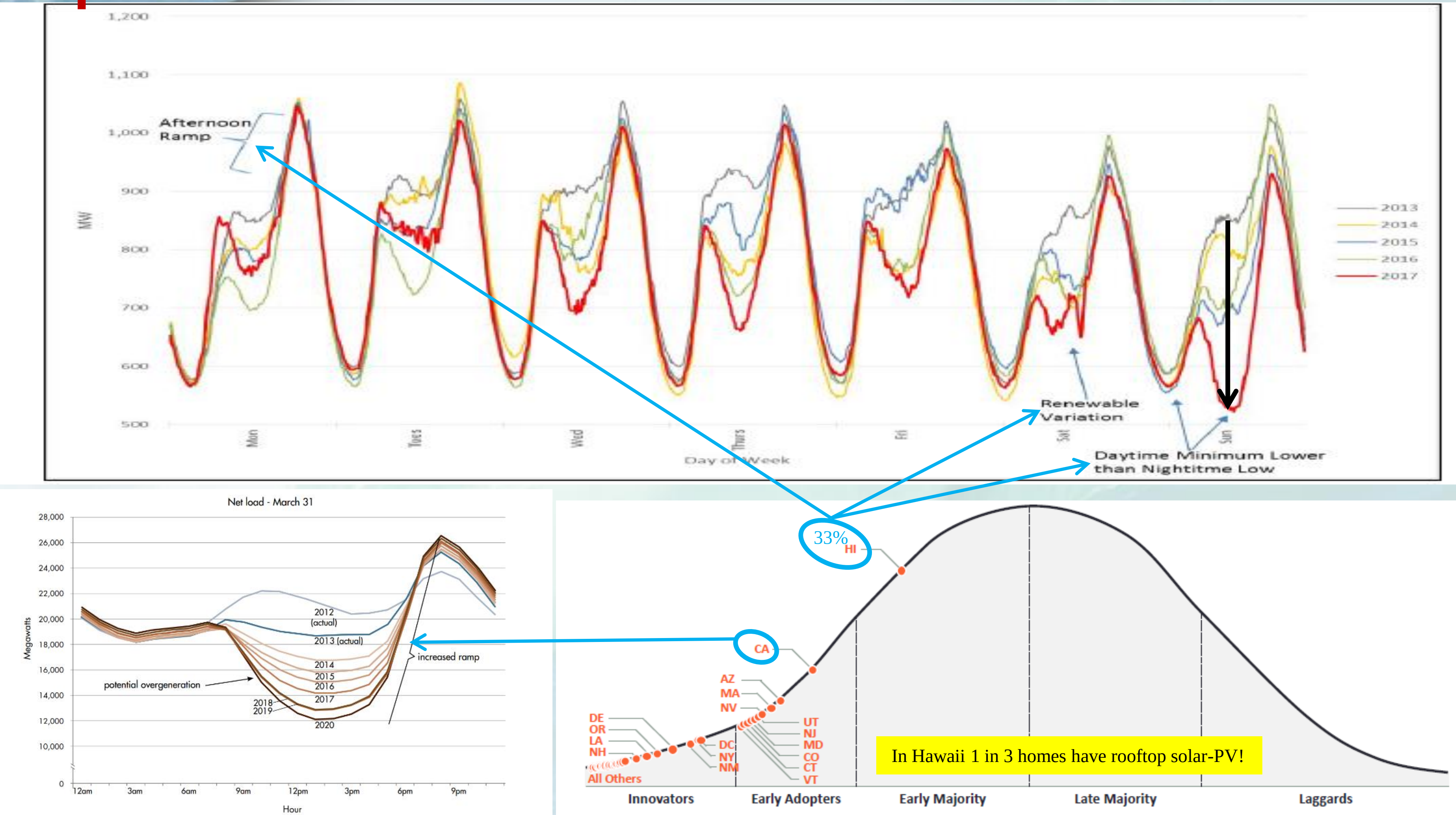
Case Study #1



75% overnight=9.9kWh/night=297kWh/month
25% daytime=3.3kWh=99kWh/month
Total daily usage=13.2kWh/day=396kWh/month
PV-Generation =23.9kWh/day =717kWh/month

Sending 6x daytime excess back to the Grid for a net monthly excess of 323kWh x 30¢/kWh or $96.70/month & $1,162.80/year free to HECO!

Duck Curve Issue in HI & CA Due to Excessive PV Export!



Solution: No More Utility Scale Solar-PV Farms only Battery Storage Farms with Solar-PV Charging for PM Demand! For Residential or Commercial only Self-Consumption not Net Zero Energy with No Export!

How DPVs Impact Bulk Power System Performance in Hawaii

Problem #2

Hawaii is a leader in the deployment of distributed renewables. The Hawaiian Electric Companies (HECO) operate the utilities on the islands of Hawaii, Oahu, Maui, Molokai, and Lanai. Today, 15% of customers across these islands have DPV systems. On Oahu (the most densely populated island), about one-third of single-family homes have DPVs. These high penetration levels have led to technical challenges on the distribution system (e.g., half the circuits are now backfeeding at the substation) and the transmission system; we will elaborate on the latter here.

A key system-level issue regarding DPVs is the degradation of bulk power system reliability. Figure 1 shows the actual frequency response on Oahu resulting from the 2013

Nov 2017

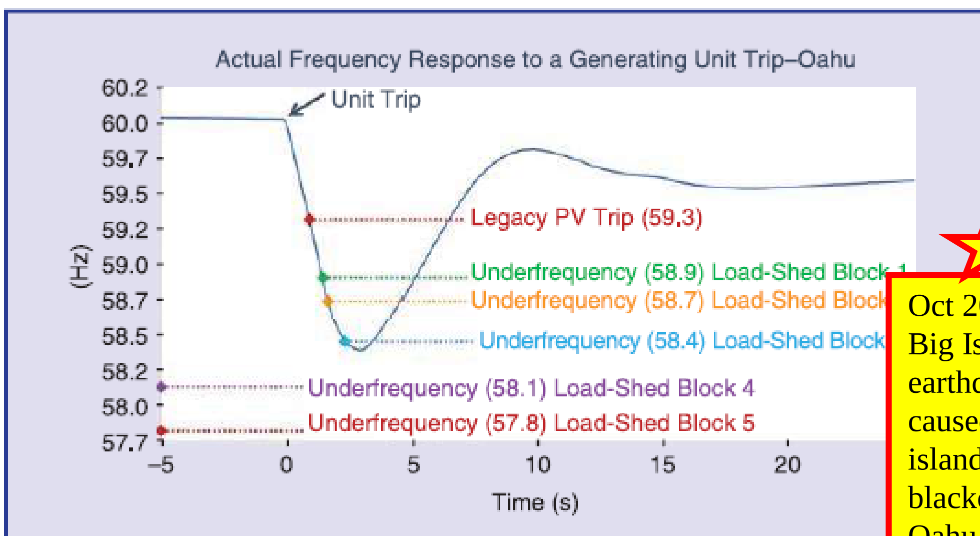


figure 1. The actual frequency response to a generating unit trip on Oahu.

Oct 2006 Big Island earthquake caused island wide blackout on Oahu for 24 hours!

trip of a 180-MW coal unit, the largest conventional generator on the island. When a large generator trip or system fault occurs during a peak PV period, several characteristics of DPV impact reliability.

- ✔ DPV generation displaces conventional thermal generation. While some thermal units are dispatched down, some are decommitted and therefore do not provide inertia to the system. This results in a faster rate of change of frequency (ROCOF), depicted by the slope of the trace after the unit trip in Figure 1. This means the system has less time to respond before UFLS acts.
- ✔ During this frequency decline, PFR from those conventional units still online act to restore frequency, but it takes several seconds for this governor response to increase output.
- ✔ At 59.3 Hz, the "legacy" DPV systems (interconnected in accordance with the IEEE 1547-2003 standard) trip offline. Hawaii's Rule 14H now requires DPVs to ride through low-frequency excursions down to 57 Hz. However, 60 MW of "legacy" DPVs remain that cannot be easily (or inexpensively) retrofitted to ride-through frequency or voltage excursions.
- ✔ At 58.9 Hz, the first block of UFLS is disconnected, which disengages both the load and DPV generation on certain feeders. A block of UFLS is therefore less effective than in the case prior to DPV installation (or at night when there is no DPV output). This reduced effectiveness means that one or two blocks of UFLS are no longer sufficient to restore frequency; rather, three, four, or even five blocks of UFLS are now required. In this particular event, 76,000 customers were disconnected.

The Response from Utilities

Problem #2

Time of Use: Peak rate shifting to later in the day

NEM: Selling price decreased to wholesale price

Demand Charge (except HI): kW charge for customer monthly peak

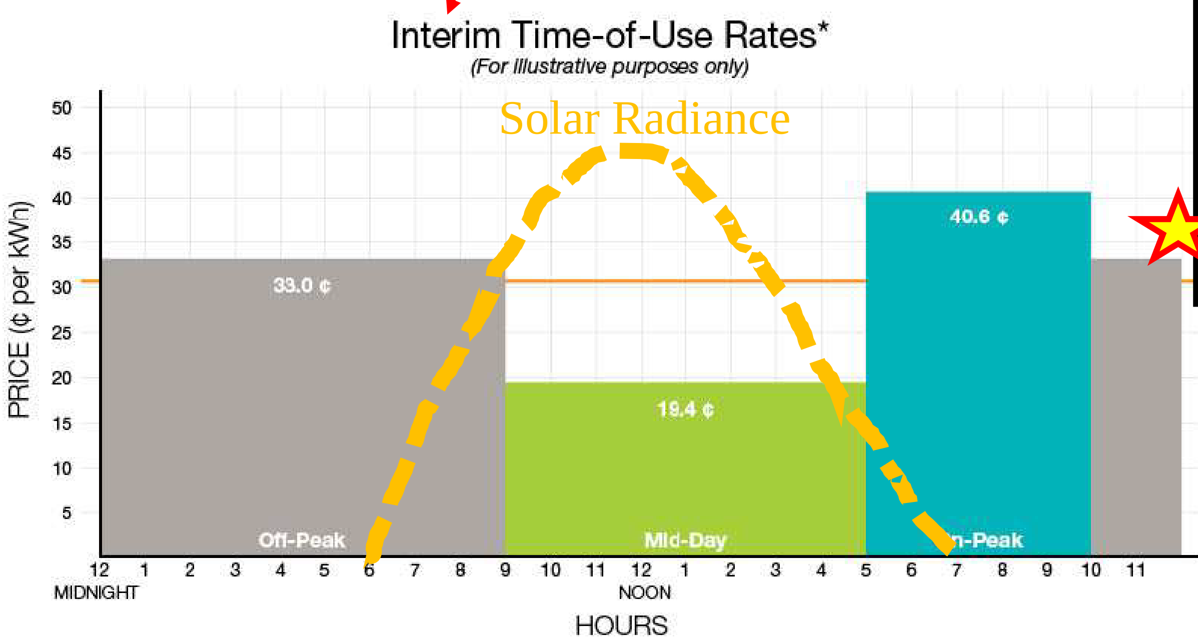
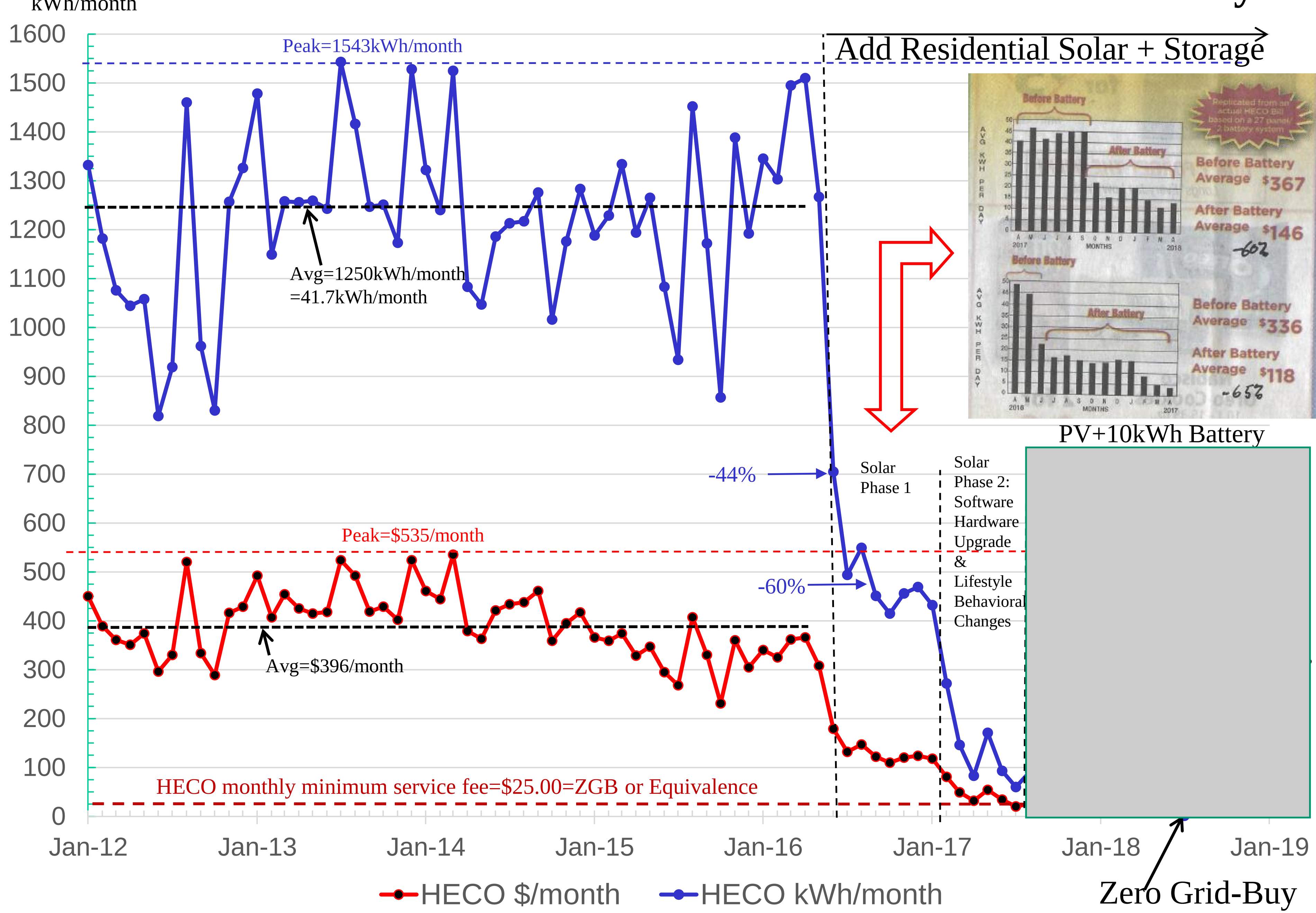


*Illustration reflects November 2018 electric rates with applicable surcharges.

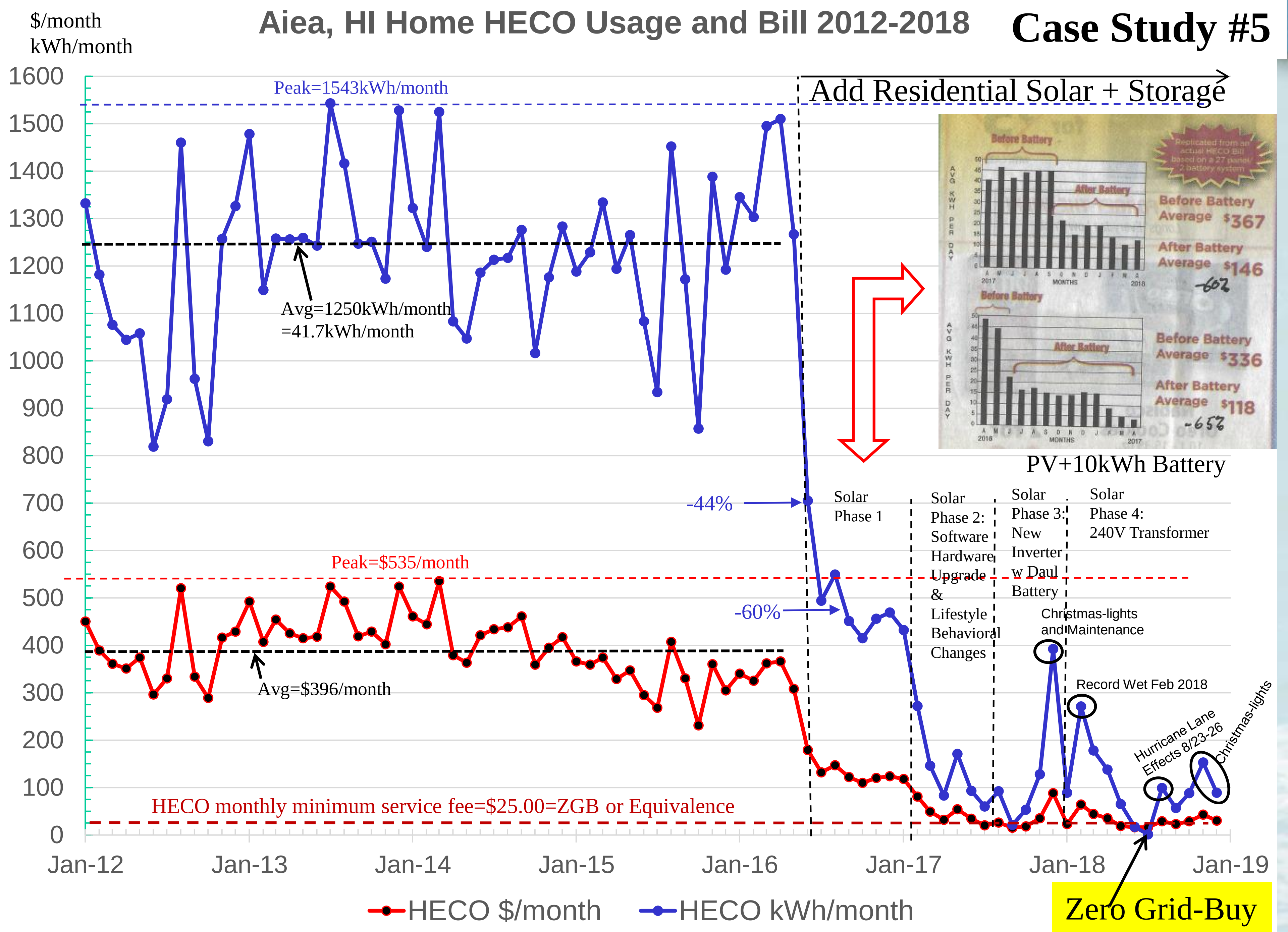
Hawaiian Electric Export Rate
2014: NEM=Full Retail
(35¢/kWh→2016=24¢/kWh→2018=32¢/kWh)
2016: CGS=15¢/kWh
2018: CGS+ =10¢/kWh (wholesale)
But 1kWh credit requires 1kWh Grid-Buy
so Zero Net Energy Metering is possible
but not minimum monthly payment!

Aiea, HI Home HECO Usage and Bill 2012-2018

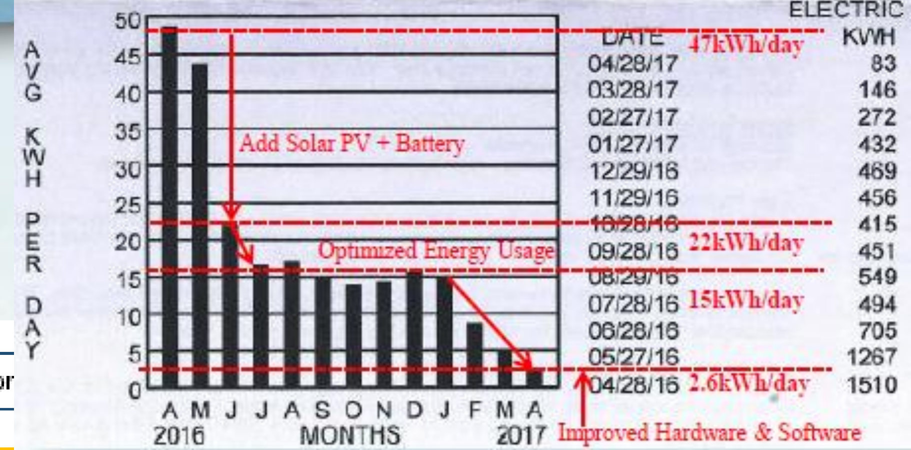
Case Study #5

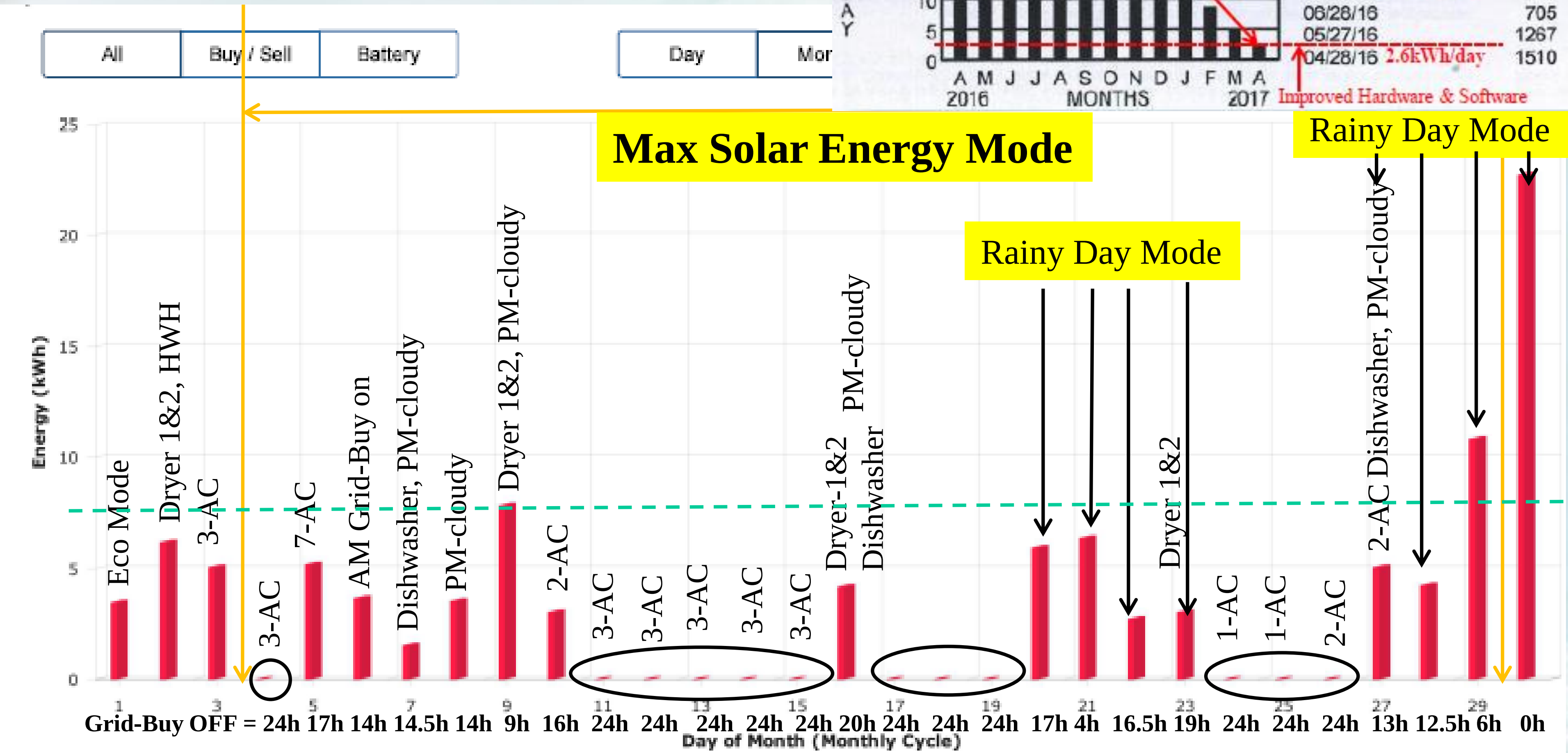


Case Study #5


Aiea, HI Home HECO Usage and Bill 2012-2018
$/month
kWh/month
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Peak=1543kWh/month
Avg=1250kWh/month
=41.7kWh/month
Add Residential Solar + Storage
Before Battery
After Battery
Before Battery Average $367
After Battery Average $146
-60%
Before Battery Average $336
After Battery Average $118
-65%
PV+10kWh Battery
-44%
Solar Phase 1
Solar Phase 2: Software Hardware Upgrade & Lifestyle Behavioral Changes
Solar Phase 3: New Inverter w Daul Battery
Solar Phase 4: 240V Transformer
Peak=$535/month
-60%
Christmas-lights and Maintenance
Record Wet Feb 2018
Hurricane Lane Effects 8/23-26
Christmas-lights
Avg=$396/month
HECO monthly minimum service fee=$25.00=ZGB or Equivalence
Zero Grid-Buy
HECO $/month
HECO kWh/month

April 2017 Grid-Buy: 104.1kWh/month or 3.5kWh/day (Solar Phase2)



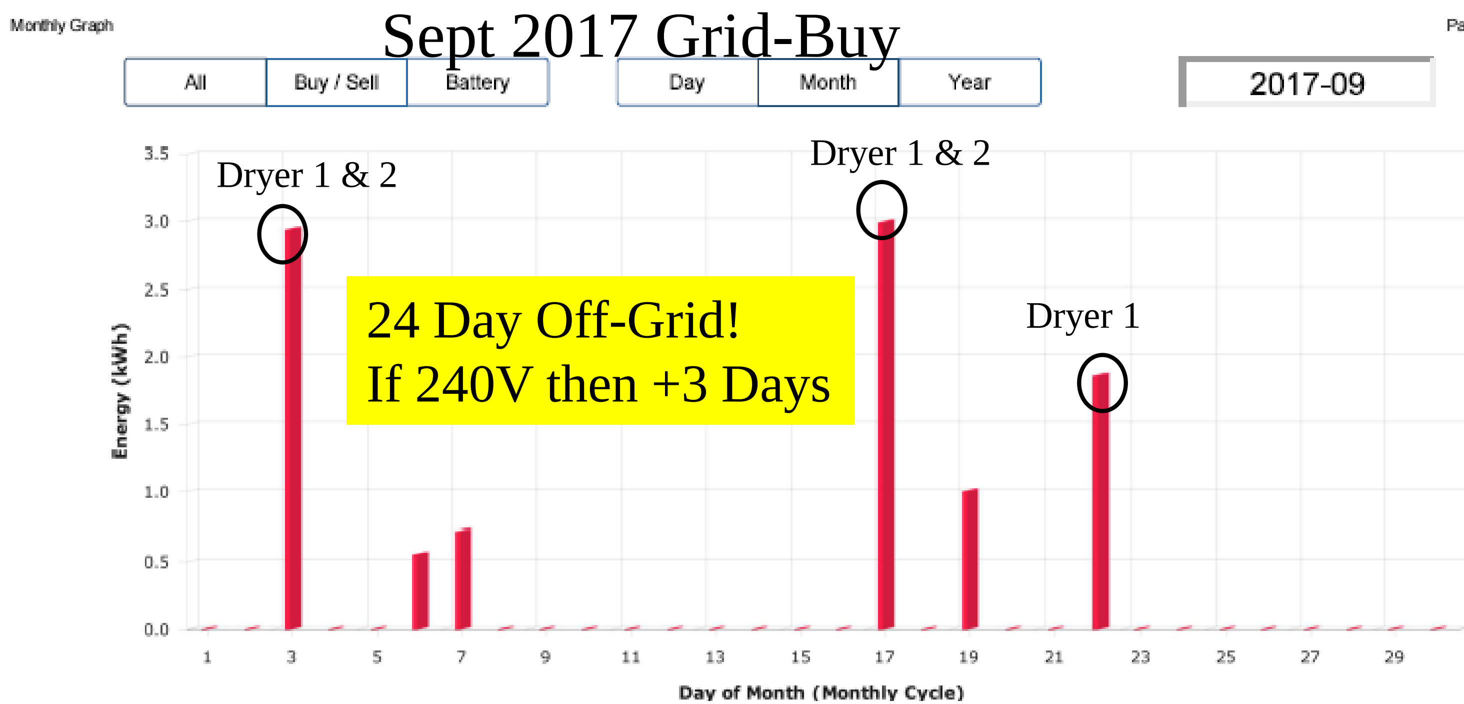


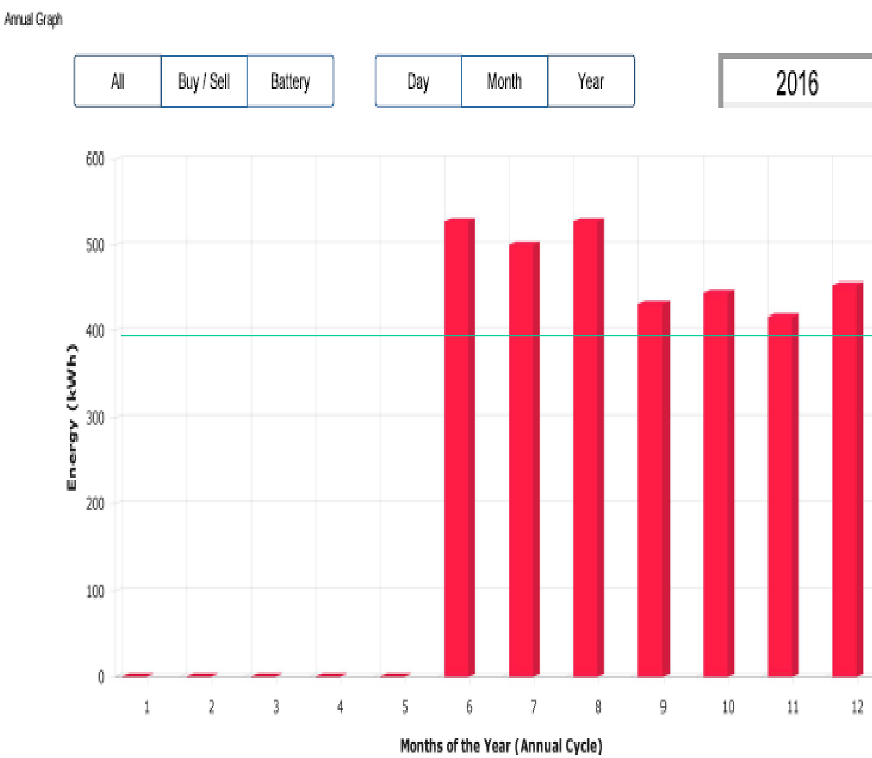
12 Days Off-Grid!

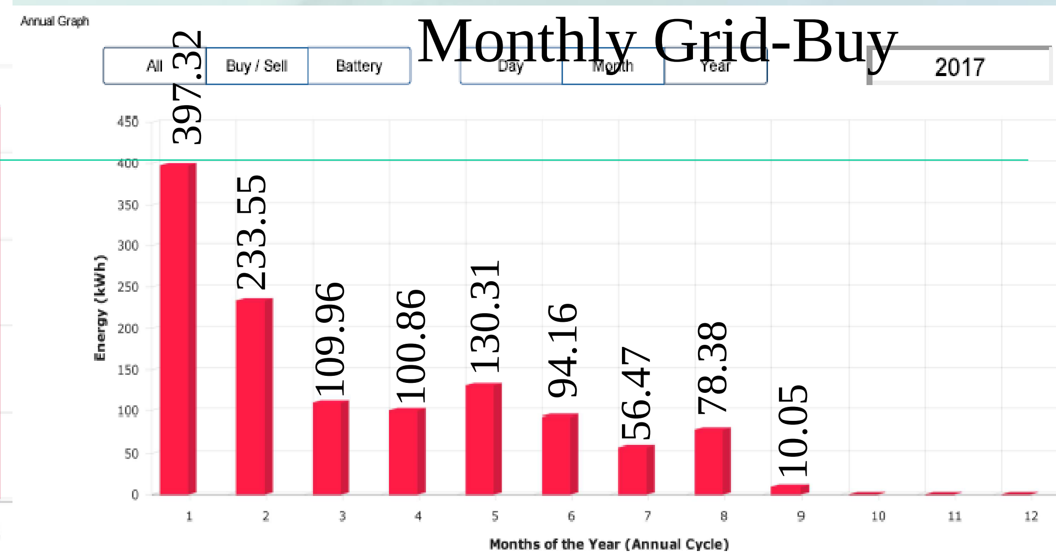
If 2nd Battery (7.5kWh discharge) then +10 Days

If 240V (dryer, hot water, dishwasher pool pump) then +6 Days

Solar Phase 3: Dual Battery 20kWh







Centralized Grid Failure

Problem Statement #2

Utilities with centralized grid, especially with above ground distribution power lines are not resilient to natural disasters that can cut-off power, locally isolating homes and communities for weeks and months!

Puerto Rico Hurricane Sep 2017

Safety: 2,975 lives lost, months without gird power critical life support and health equipment lost generator power overnight

Hawaii Volcano Lava Flow 2018

Security: lost power evacuated homes were looted

CA Earthquakes, Mudslides and Firestorms-2018

Safety: lost power at night could not see how to escape burning homes, 85 lives lost!

- Hokkaido, Japan earthquake (Sep 2018), caused 2 days island wide blackout affecting 2.9M people with 41 lives lost. Many hospitals on emergency backup power had to turn away patients.
- **To save lives** when a natural disaster strikes, it has become clear that true resiliency requires **Zero Grid-Buy (100% renewable energy)** by the creation of **"Island Nano-Grids & Nano-Grid Clusters"**!

Solar Plus Multi-Storage Restores Power to Families in Puerto Rico

May 1, 2018

To Save Lives!!!!! (~3,000 deaths)

RENEWABLE ENERGY WORLD

John Borland and Takahiro Tanaka

Based on my Off-Grid results using **Island Nano-Gird** since April 2017, Tabuchi donated 10 off-grid systems in Oct 2017 to Puerto Rico. Tabuchi has installed 150+ of their systems throughout Puerto Rico — as shown in Fig.1 — with 50 percent initially installed for off-grid operation until grid-tied power could be restored. Fig.2 shows an isolated remote family home installing the Solar + Multi-Storage system for off-grid operation. This is one of the donated off-grid systems that went to a family in remote *Maricao, Puerto Rico*, whose house has been without power for 20 years since hurricane George struck in 1998. The electric power was never restored to their area, according to Tabuchi. Fig.3 is a photo of Edison Rivera standing in his living room with the light on for the first time powered by non-fossil fuel consuming generator since 1998.

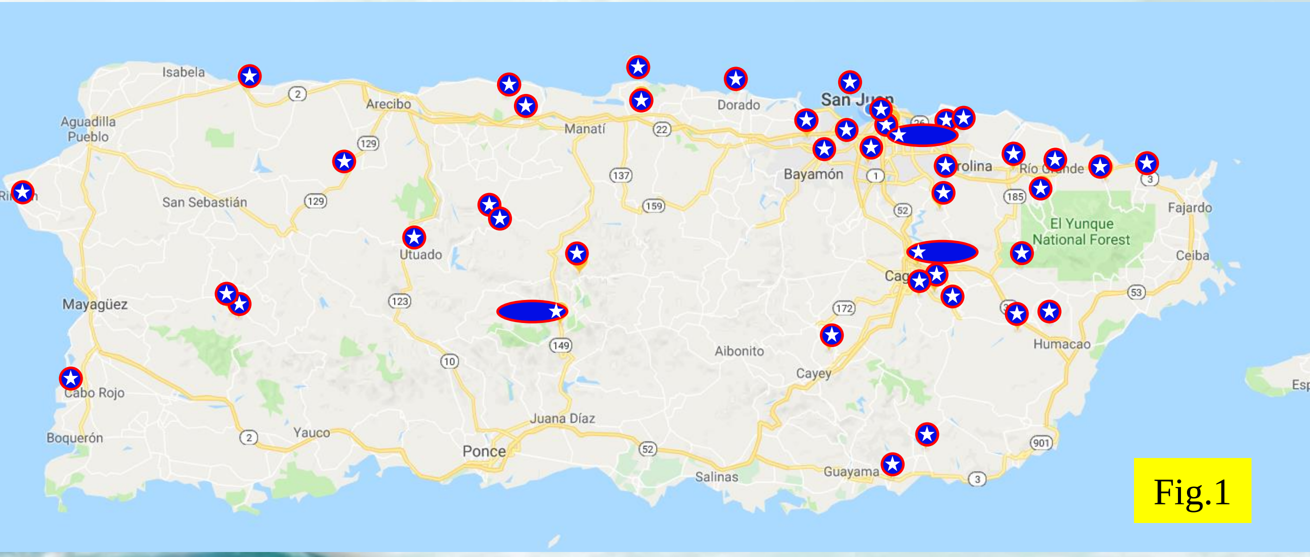


Fig.1

Fig.2

Fig.3

Problem #3

wiliki o hawaii

ENGINEER OF HAWAII

VOL. 53 NO. 10 SERVING 2000 ENGINEERS & LAND SURVEYORS DECEMBER, 2017

Be Proactive Not Reactive to the Next Island Blackout: A Case Study for Achieving 100% RENEWABLE Energy From The sun + Multiple Storage For HAWAII Residences with <3years Payback & Off-grid Operation

The recent September 20, 2017 Puerto Rico hurricane destroyed the centralized utility grid power for months showing the value of 100% renewable energy with optional off-grid operation in Hawaii.

I'm striving to be a catalyst by optimizing my residential clean energy systems to point to the shortest ROI (return on investment) that can be

A side benefit of achieving 100% renewable energy is eliminating HECO's infamous "Duck Curve" by absorbing the excess PV energy in the middle of the day (low back of duck), and using that energy to shave the evening peak (head of the duck).

So rather than requiring new home building energy codes, the state of Hawaii should require homes be constructed with ~5kWh solar-PV + 10kWh battery storage + 80 gallon modified solar thermal/PV/battery/electric water heater with optional home designs for

solar-A/C cold-thermal storage and solar pool pump, leaving only the clothes dryer and oven/stove requiring HECO's electricity.

Future home roofs should be designed for best solar-PV generation. Properly oriented solar panels (facing West & East) can extend solar-PV generation by 1 to 2 hours in the evening and morning and Bifacial panels will generate 20% more energy with generation equal to having a single axis tracker without the added costs.

On June 1, 2016 I installed a Poncho's Solar 7kW rooftop solar-PV + 5.5kW Tabuchi Electric solar inverter control system with a 10kWh Panasonic Li-ion battery for storage post-NEM connection to the grid (no export/selling back to the grid) and a single panel solar thermal hot

87oF to 68oF. The cool carried into the evening and I eliminated up to 12kWh evening consumption. I modified the solar thermal/PV/battery/electric water heater to super charge water to >165oF with storage capacity for 1 full day and eliminated 16kWh evening consumption. By timing my washer/dryer to be used in the middle of the day, I elimnated 10kWh evening consumption. A refrigerator/freezer on/off timer with overnight battery discharge eliminated 7.2kWh/day grid-buy, solar-PV pool pump eliminated 5.8kWh/day grid-buy and overnight battery discharge for night lights eliminated 2kWh/night grid-buy.

In Figure 2, solar phase 1 optimized the HEMS. Solar phase 2 involved inverter control system software upgrade to reduce grid-buy

Like California New Home/Low Rise Solar Mandate May 2018!

Solution #2: Island Nano-Grid and Clusters of Nano-Grid for Resilience

Battery Storage Could Revolutionize Home Health Care: Lessons Learned from Puerto Rico

January 30, 2019

It is time to treat this health issue differently. This is a rare opportunity to combine strategies for clean energy and public health.

Rather than merely putting vulnerable households on utility lists for evacuation, it is time to integrate our clean energy and public health goals to protect the most vulnerable with better, cleaner, and more reliable technology solutions. Dedicated city and utility programs – and third-party providers – should start to offer solar and battery storage (or at least residential battery storage) to protect these communities from ever increasing risks of power outages and non-functioning electric-powered medical equipment.

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

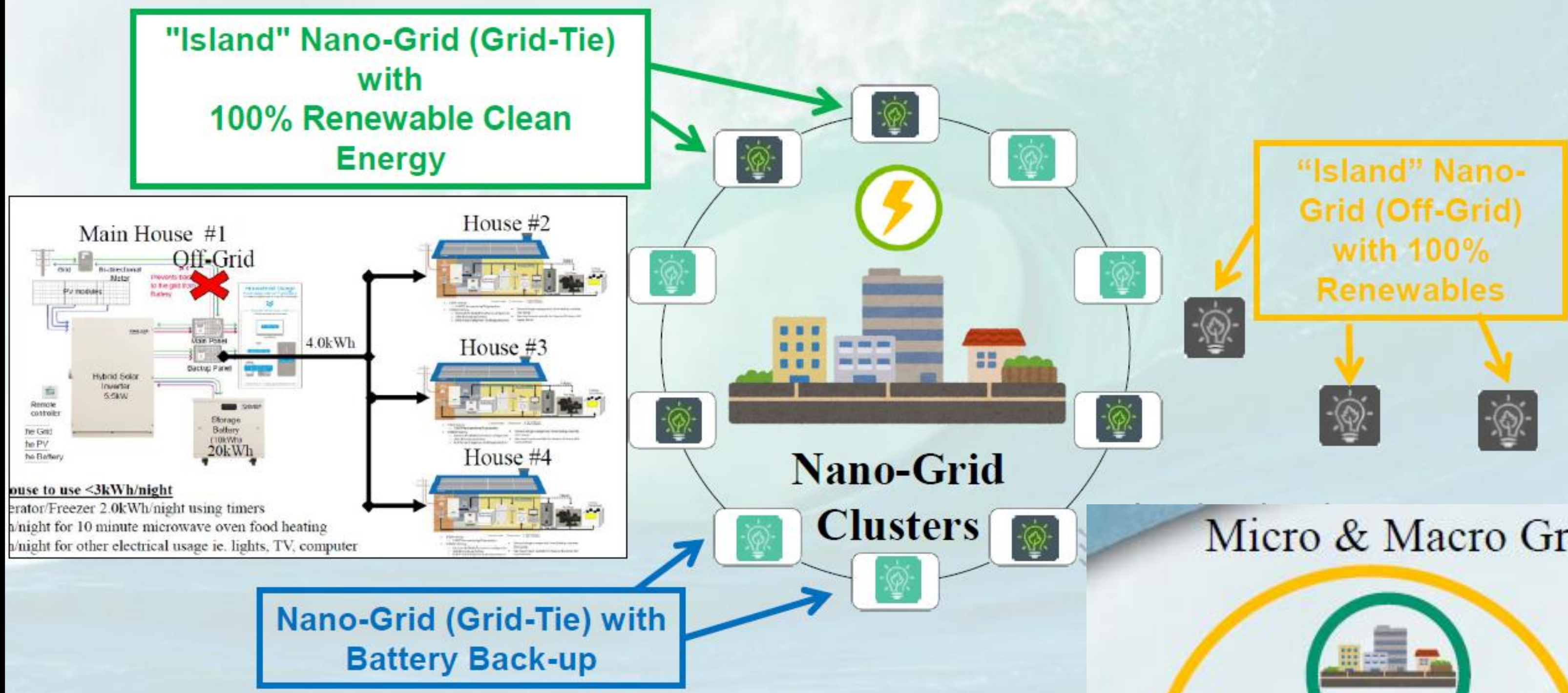
Mortality in Puerto Rico after Hurricane Maria

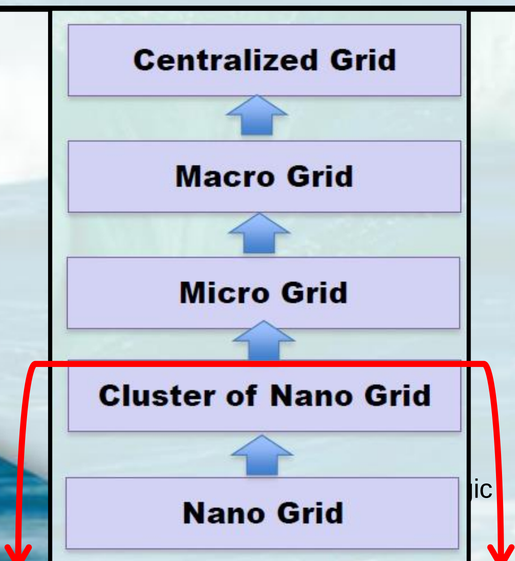
Nishant Kishore, M.P.H., Domingo Marqués, Ph.D., Ayesha Mahmud, Ph.D., Mathew V. Kiang, M.P.H., Irmary Rodriguez, B.A., Arlan Fuller, J.D., M.A., Peggy Ebner, B.A., Cecilia Sorensen, M.D., Fabio Racy, M.D., Jay Lemery, M.D., Leslie Maas, M.H.S., Jennifer Leaning, M.D., S.M.H., Rafael A. Irizarry, Ph.D., Satchit Balsari, M.D., M.P.H., and Caroline O. Buckee, D.Phil. et al.

July 12, 2018
N Engl J Med 2018; 379:162-170

In our survey, interruption of medical care was the primary cause of sustained high mortality rates in the months after the hurricane, a finding consistent with the widely reported disruption of health systems.[37] Health care disruption is now a growing contributor to both morbidity and mortality in natural disasters.[15,38,39] In the United States, this phenomenon has been observed in the aftermaths of Hurricane Katrina, Superstorm Sandy, and more recently Hurricanes Harvey and Irma, in which nursing home residents and those dependent on life-sustaining equipment were disproportionately affected.[40] Growing numbers of persons have chronic diseases and use sophisticated pharmaceutical and mechanical support that is dependent on electricity. Chronically ill patients are particularly vulnerable to disruptions in basic utilities, which highlights the need for these patients, their communities, and their providers to have contingency plans during and after disasters.[41]

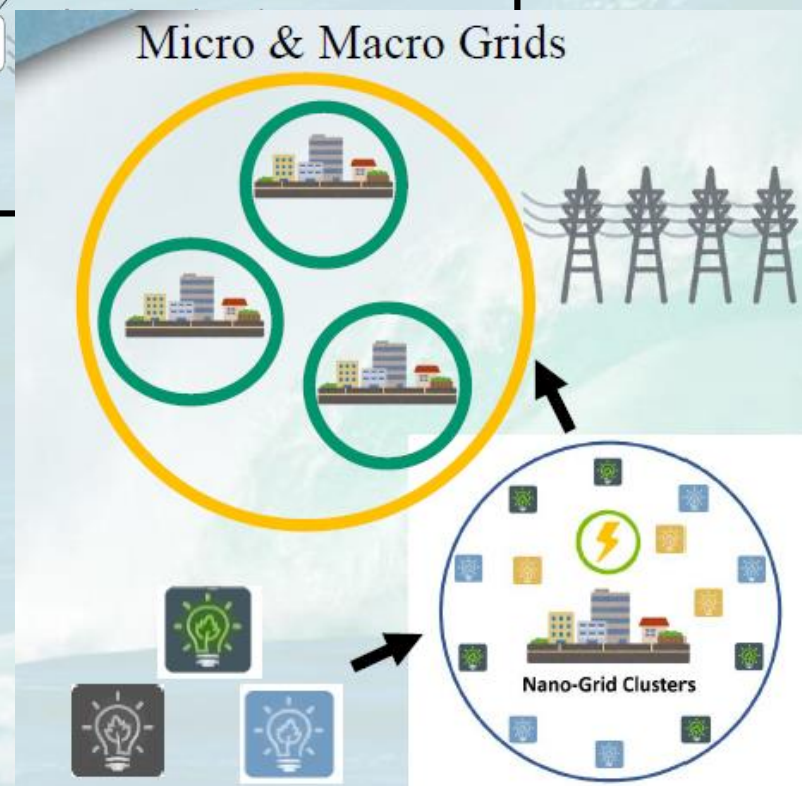
Resilient Grid Connections: “Nano-Grid Clusters”
Start from the Bottom-up with “Island Nano-Grids”





Borland et al., IEEE-PVSC June 2018

Home & Low-Rise Apartments



How To Harden Puerto Ricos Grid Against Hurricanes - IEEE Spectrum

Efraín O'Neill-Carrillo and Agustín Irizarry-Rivera are professors of electrical engineering at the University of Puerto Rico Mayagüez. Nov 2019

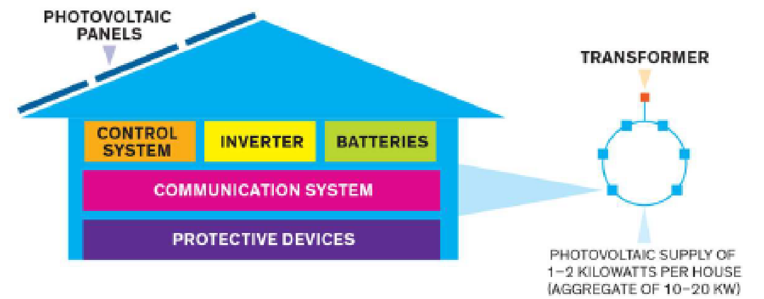
In the weeks and months following the hurricane, many of the 3.3 million inhabitants of Puerto Rico, who are all U.S. citizens, were forced to rely on noisy, noxious diesel- or gasoline-fired generators. The generators were expensive to operate, and people had to wait in long lines just to get enough fuel to last a few hours. Government emergency services were slow to reach people, and many residents found assistance instead from within their own communities, from family and friends.

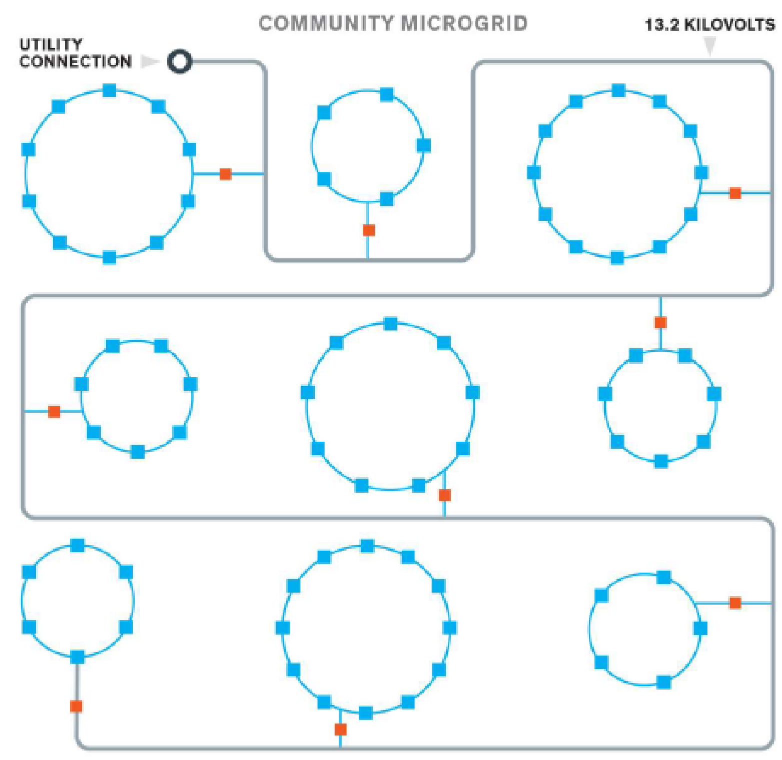
Such a system is called a community microgrid. It is basically a small electrical network that connects electricity consumers—for example, dozens or hundreds of homes—with one or more sources of electricity, such as solar panels, along with inverters, control electronics, and some energy storage. In the event of an outage, disconnect switches enable this small grid to be quickly isolated from the larger grid that surrounds it or from neighboring microgrids, as the case may be.

Each group within the community microgrid would be equipped with solar panels, inverters, batteries, control and communications systems, and protective devices. For the 10 homes in each group, there would be an aggregate PV supply of 10 to 20 kW, or 1 to 2 kW per house. The aggregate battery storage per group is 128 kWh, which is enough to get the homes through most nights without requiring power from the larger grid. (The amounts of storage and supply in our model are based on measurements of energy demand and variations in solar irradiance in an actual Puerto Rican town; obviously, they could be scaled up or down, according to local needs.)

A Grid of Microgrids

Hurricanes are a fact of life in the Caribbean. Installing community microgrids throughout Puerto Rico would greatly improve the island's ability to recover from severe storms and other natural disasters. In this model, groups of homes and small businesses would share rooftop solar power and battery storage. In the event of an outage on the central grid, the entire microgrid would operate in "islanded" mode. Each household would have enough power to operate essential loads, such as a small refrigerator, personal electronics, lights, and fans. Community members would be trained to operate and maintain the microgrid.





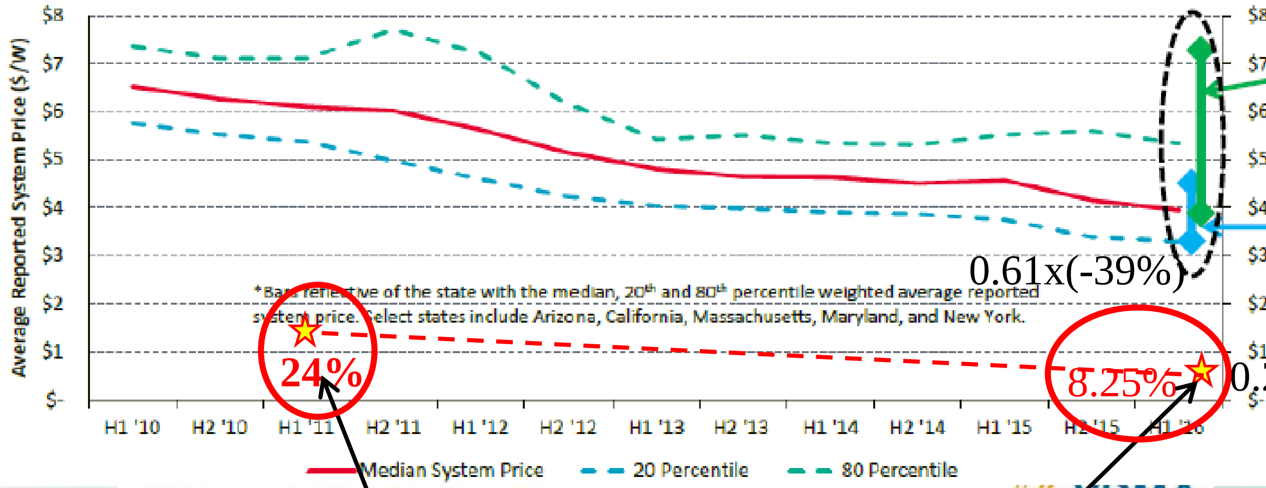
J.O.B. Technologies (Strategic Marketing, Sales & Technology)

Solar PV + Battery Package Costs ROI Analysis

System Pricing from Select States

2.5 kW–10 kW

SunShot U.S. Department of Energy
energy.gov/sunshot



COS=$29.5KK→$51K

Hawaii + Battery Storage
Cost of System (COS) =(+$0.71→+$2.80/W)

Hawaii Solar-PV
Cost of System (COS) = ($3.20→$4.60/W)

<u>COS Rooftop Solar (Sep 2017)</u>
Europe=$1.00/W (64%<USA)
Japan =7%<USA (RTS/Japan)
USA=$2.80/W
→Utility=$1.03/W
→Tracker=$1.11/W

Module Price learning Curve

VDMA

ITRPV

ITRPV-2017

Shipments / avg. price at years end:

2016: 75 GWp / 0.37 US$/Wp
08/2017: 0.35 US$/Wp

o/a shipment: ≈ 308 GWp
o/a installation: ≈ 300 GWp

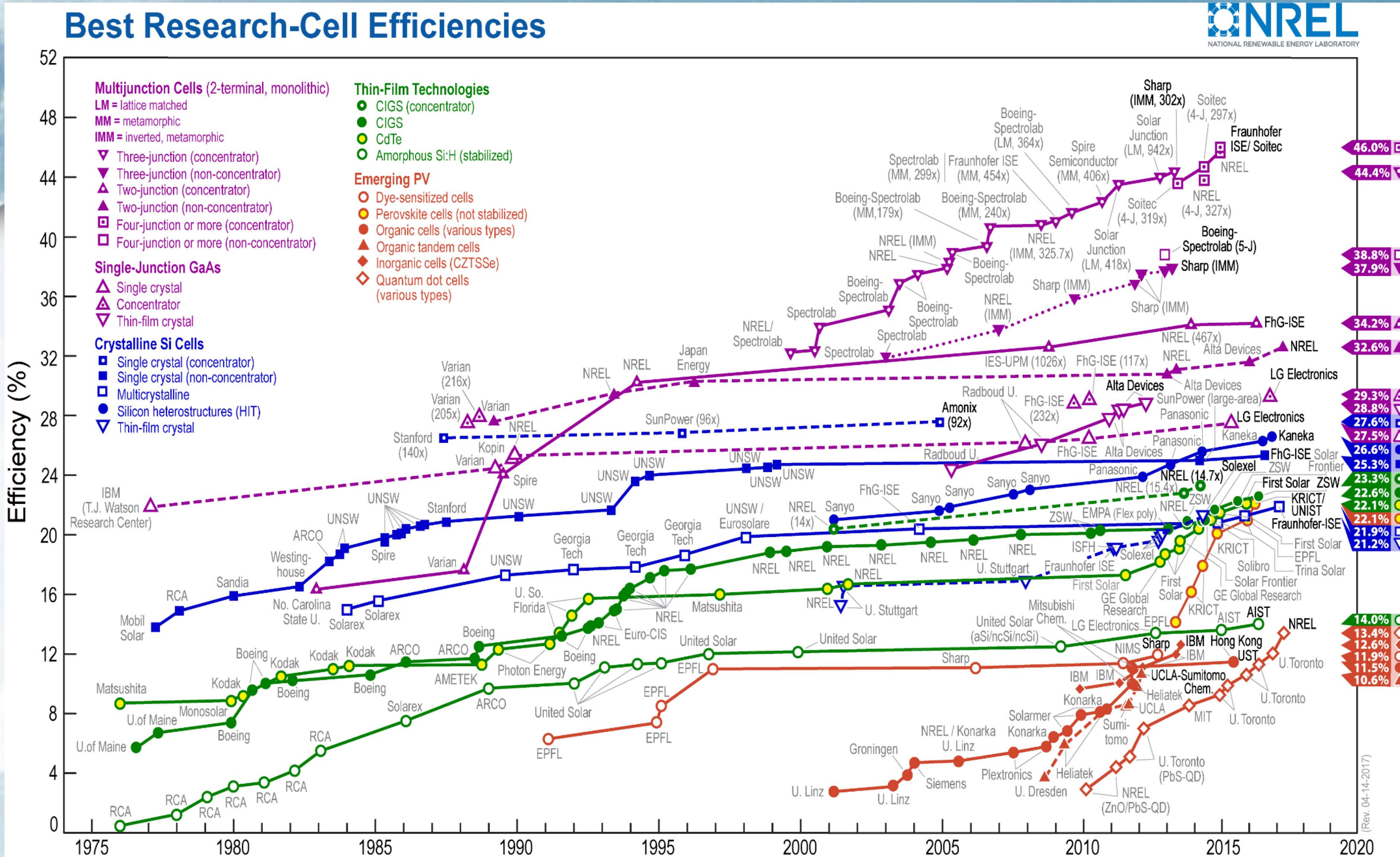
2017expectation: ≈ 380 GWp

300 GWp landmark was passed!

LR 22.5 % (1976 …. E 2016)

dramatic price drop due to market situation
→ Comparable to 2011/2012, but faster

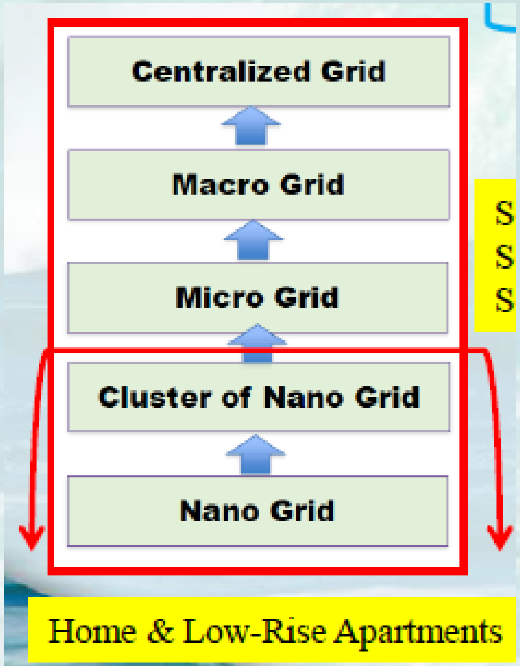
COS (cost of system)
D-COE (Daily-cost of energy)
<u>Solar-PV (7kWh)</u>
COS=$22,400=$3.20/W → TaxCr=$1.44/W
D-COE=7.9¢/kWh/20yrs →TaxCr=3.4¢/kWh
<u>Battery (10kWh)</u>
COS=$7,100=71¢/W → TaxCr=32¢/W
D-COE=32.4¢/kWh/10yrs →TaxCr=14.5¢/kWh
<u>Solar Thermal (16kWh)</u>
COS=$6,000=37.5¢/W → TaxCr=16.9¢/W
D-COE=15.1¢/kWh/10yrs →TaxCr=6.8¢/kWh



New Message at IEEE-PVSC Solar Conference June 6-10, 2016 was "**LCOE Reduction of PV Electricity: Does PV Cell Technology (efficiency) still matter or Climate Optimized Energy Yield**" As a Solar PV End-User my views has changed due to the ~20% PV energy weather & temp LOSS! Lowest cost ($/W install) is more important than highest cell/module efficiency!

Outline

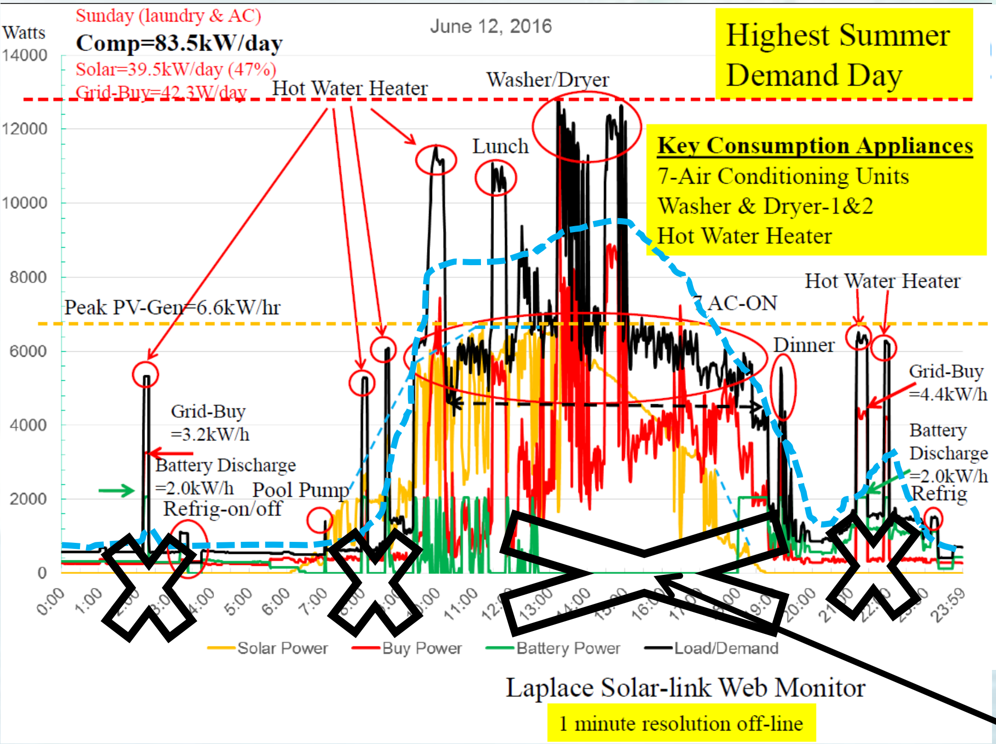
- Introduction
- Start at Home:
  - Solar-PV + Battery Storage → Solar Energy (Light-PV & Heat-Thermal) + Multi-Storage (Battery & Thermal Storage) For 100% Renewable Clean Energy and Resilience
    - Nano-Grid→ Island Nano-Grid (Off-Grid with Grid-Tie Backup)
  - Lifestyle Behavioral Changes and Renewable Energy Conservation Minded Using IoT & Smart Devices for Monitor, Control and Sustainability
- Summary:

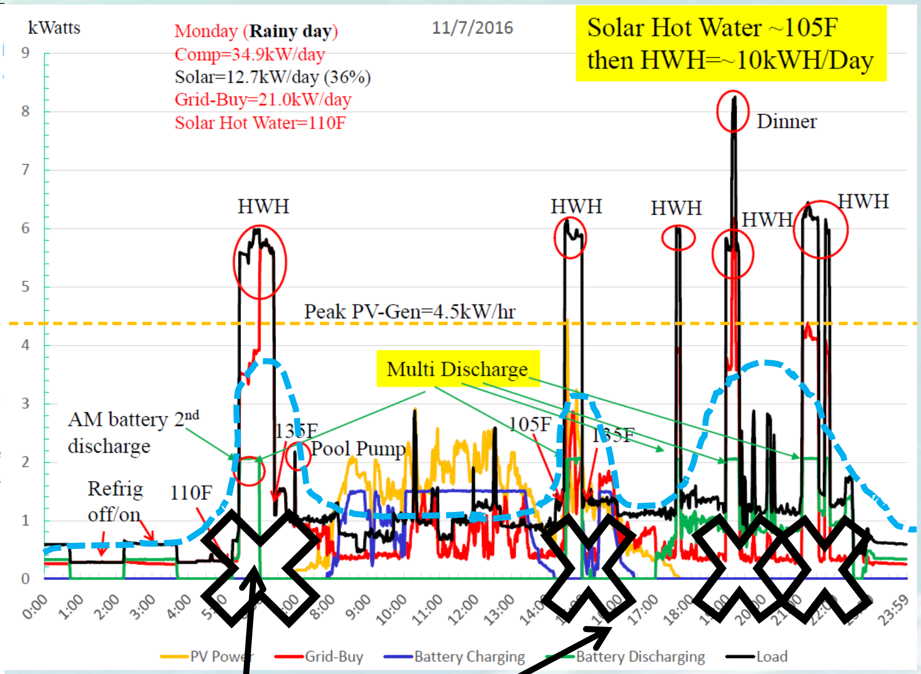


Solar Phase 1

Peak Summer Energy Usage
#1: Air Conditioner= **60%**
#2: Electrical Hot Water= **21%**
#3: Refrigerator/Freezer= **10%**
#4: Pool Pump=4%
#5: Clothes Dryer= **2%**
#5: Other=5%
Total=100%

Winter Energy Usage
#1: Electrical Hot Water= **50%**
#2: Refrigerator/Freezer= **24%**
#3: Pool Pump=10%
#4: Clothes Dryer= **6%**
#5: Other=10%
Total=100%

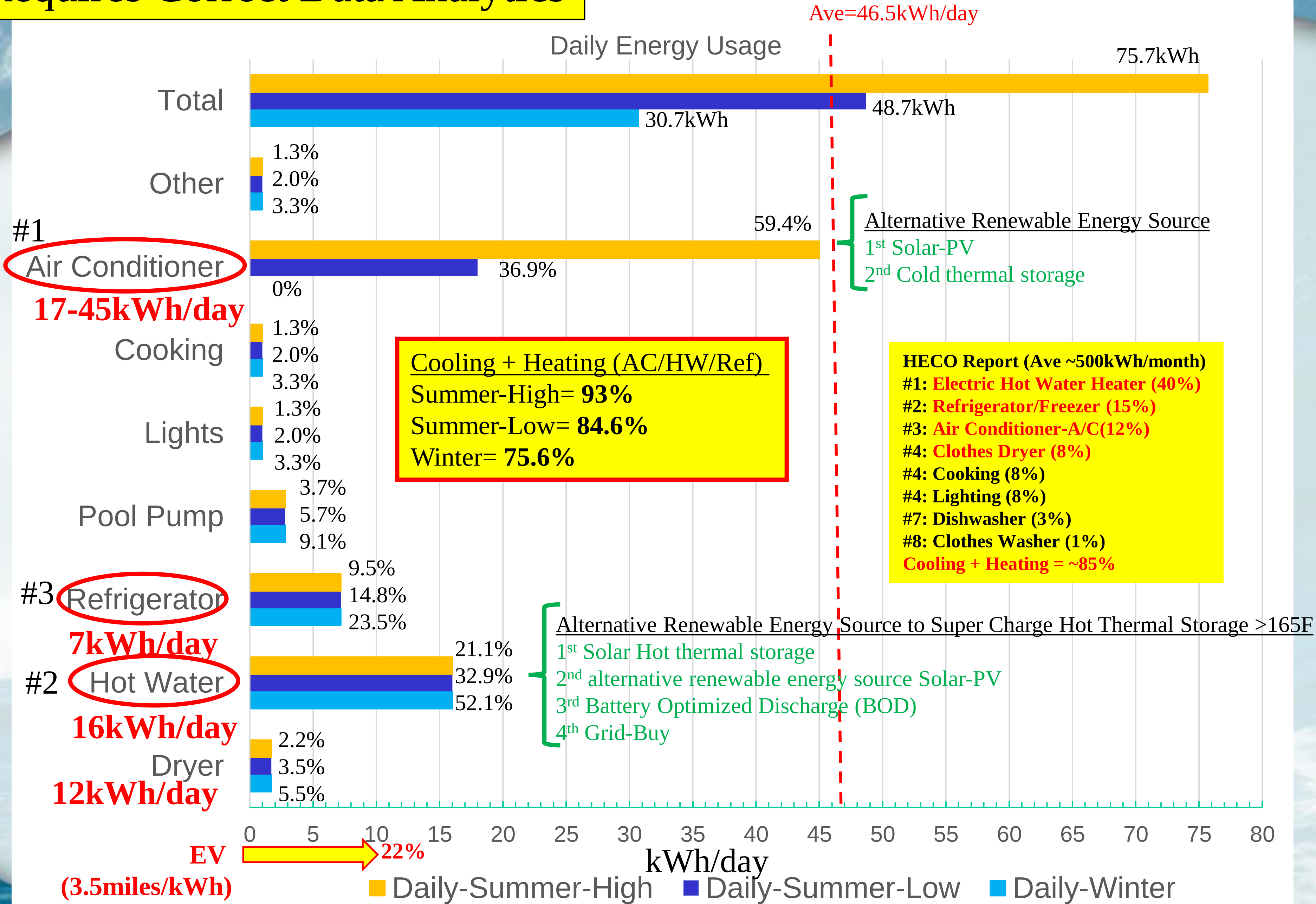




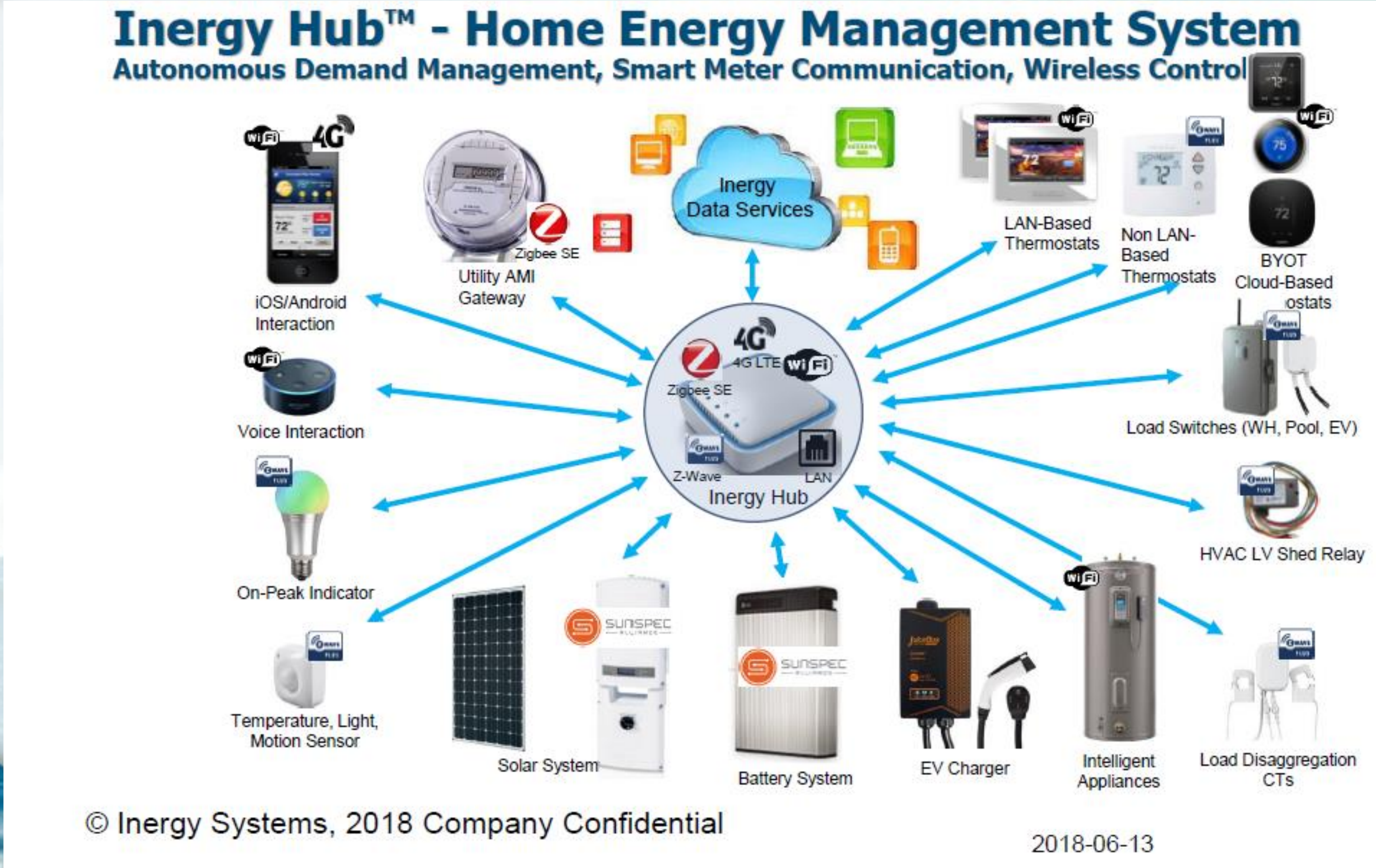
Right Data Analytics Tools

Eliminate Root Cause of Grid-Buy Energy Demand Spikes

Requires Correct Data Analytics



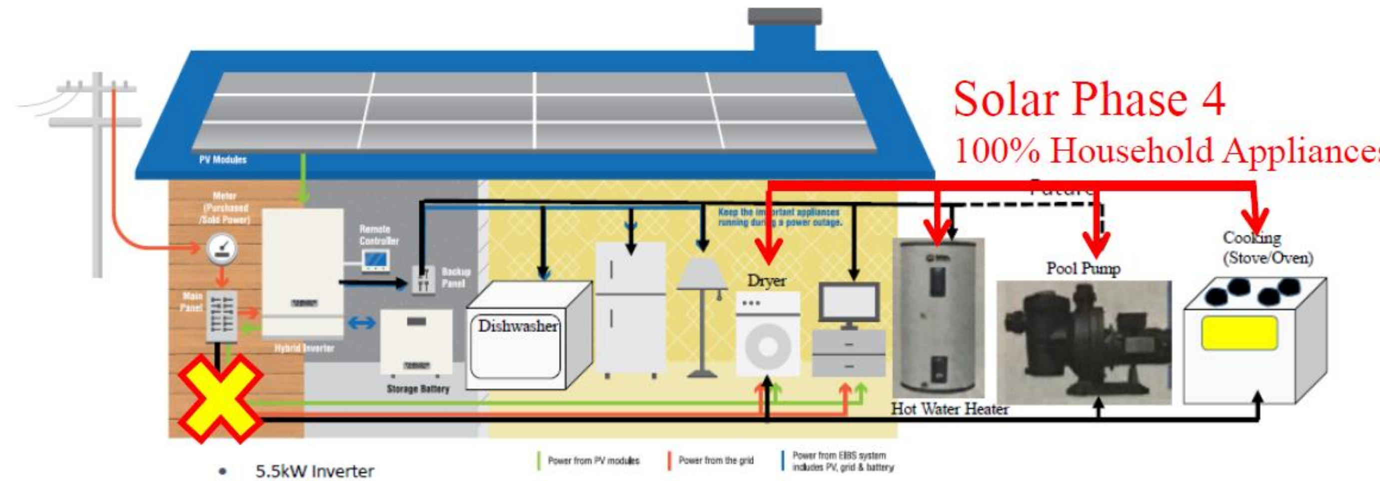
If The Grid Goes Down BIG PROBLEM! All Smart Homes Require Resilient Island Nano-Grid 24/7 For Security & Safety!



Smart Home/Building Renewable Energy Management System For Energy Ecosystem Balance

Grid
Electricity

No Export



- 5.5kW Inverter
  - 3 MPPT for maximizing PV generation
- 9.89kWh Battery
  - Optional 19.78kWh/2x batteries configuration
  - 2kW discharge per battery
  - Built-in overcharge/over-discharge protection
- Demand charge management, home backup, maximize TOU savings
- Non-Export mode available for Hawaiian Customer Self-Supply Market

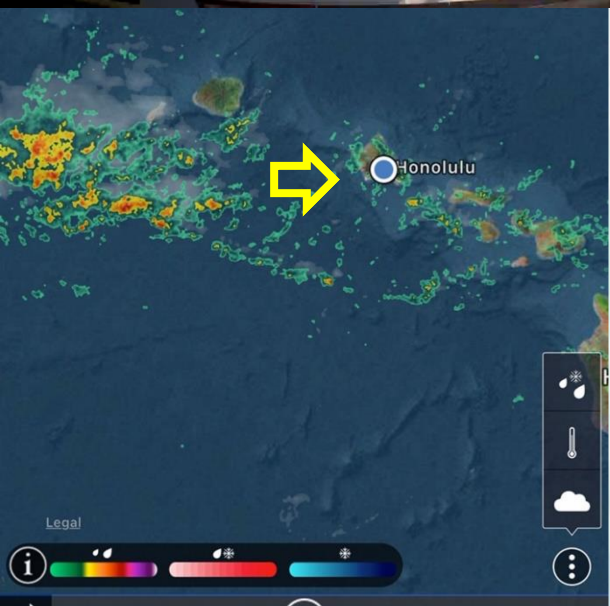
Smart Home Security System
Cameras
Motion Detector
Open/close switches for doors and windows
Smoke Detector
Fire Alarm

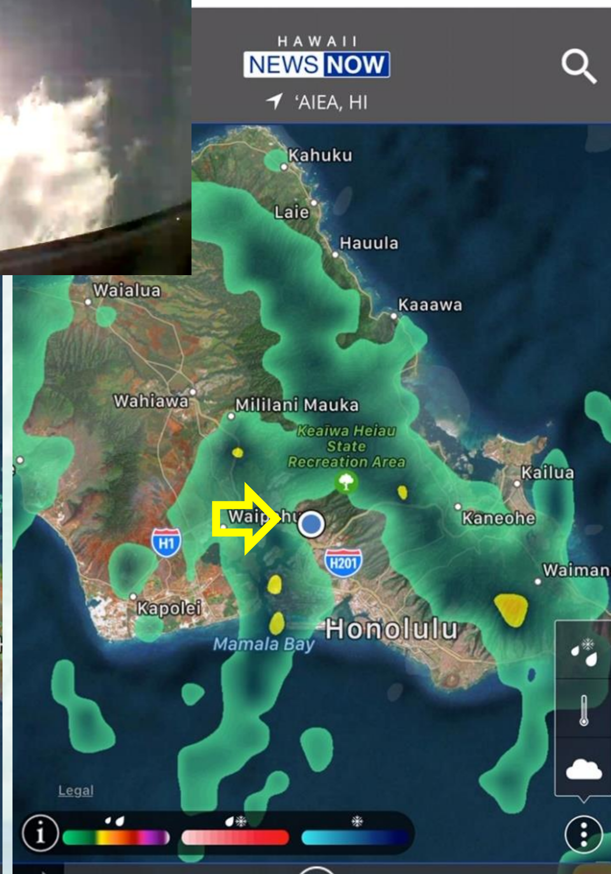
Smart Home Environment Control
Air conditioner
Heater
Hot Water

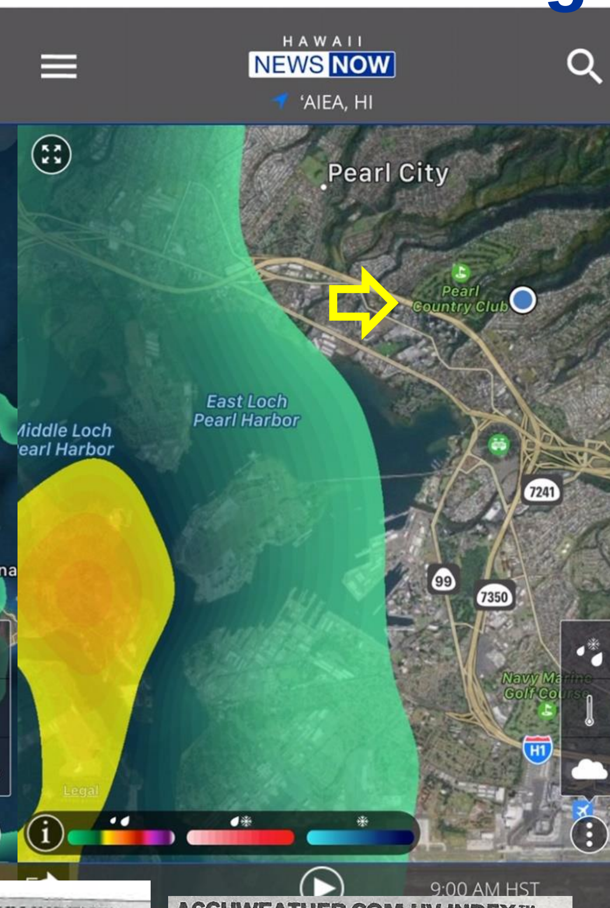
Smart Home Appliance Control
Alexa/Google Home
Pool Pump
Water Pump
Refrigerator/freezer
Dishwasher
Clothes Washer
Clothes Dryer
Lights indoor and outdoor
Entertainment System
Switches

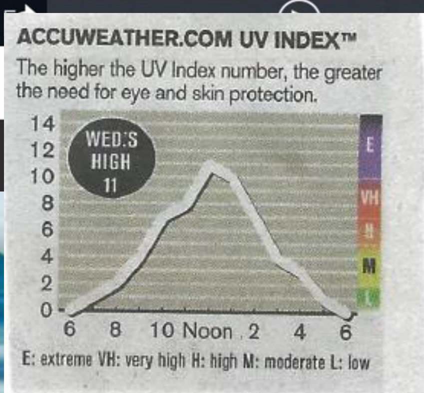
I Have >20 IoT/Smart Home Devices Today!

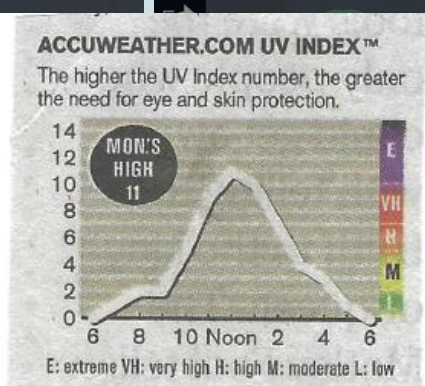
Weather Forecasting: Sky-Cam, Satellite & Radar Local Imaging

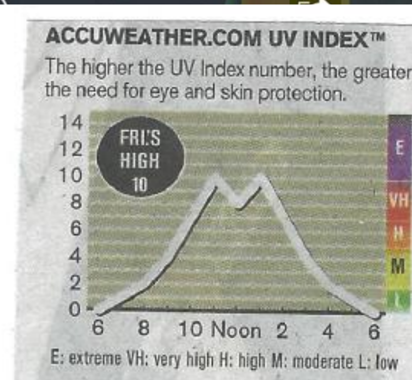


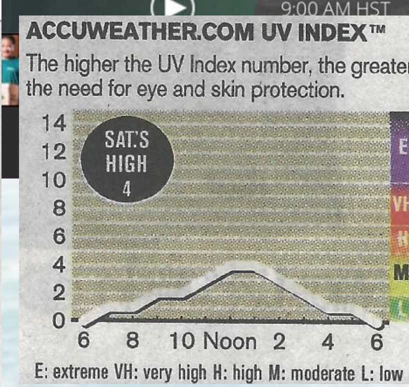




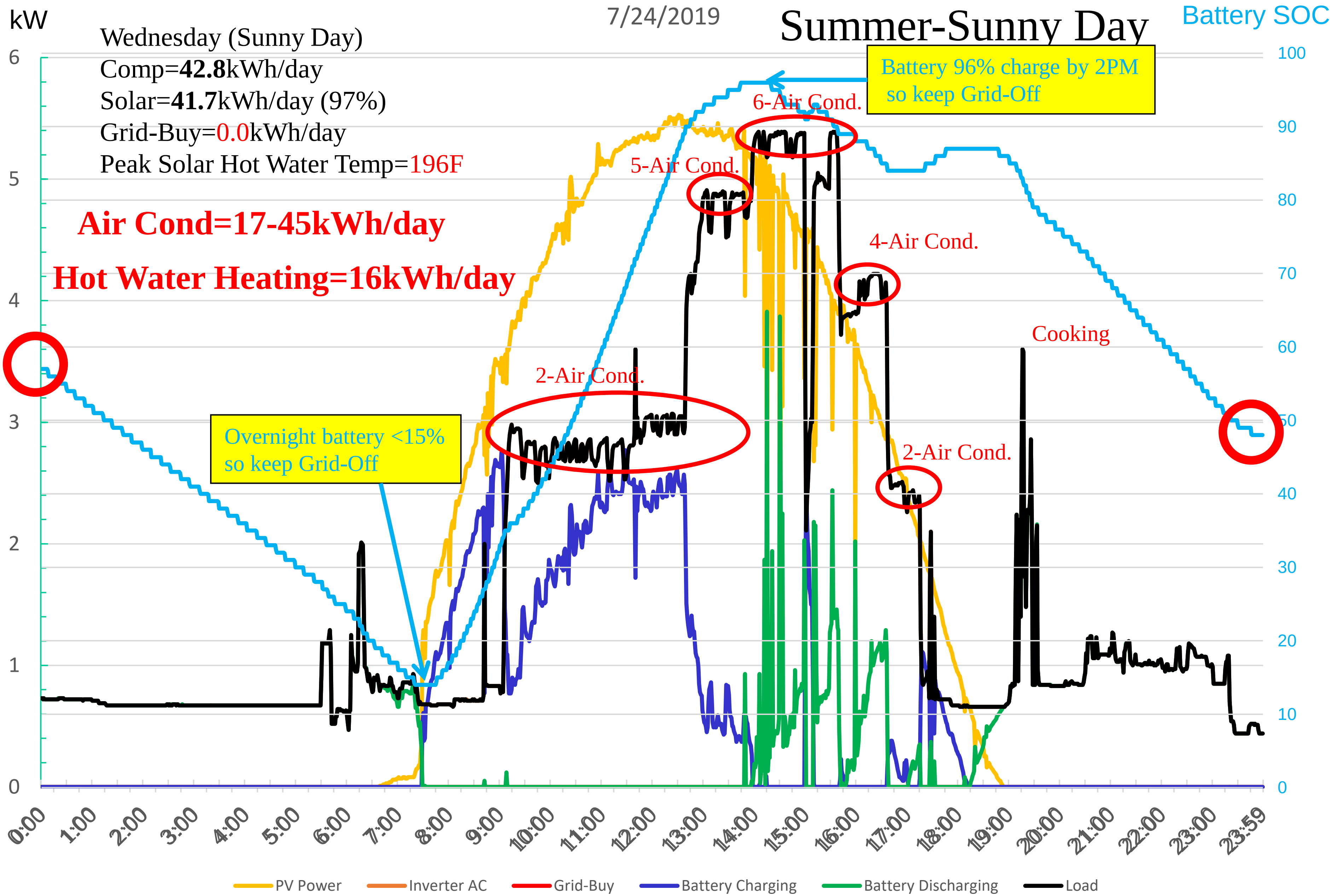








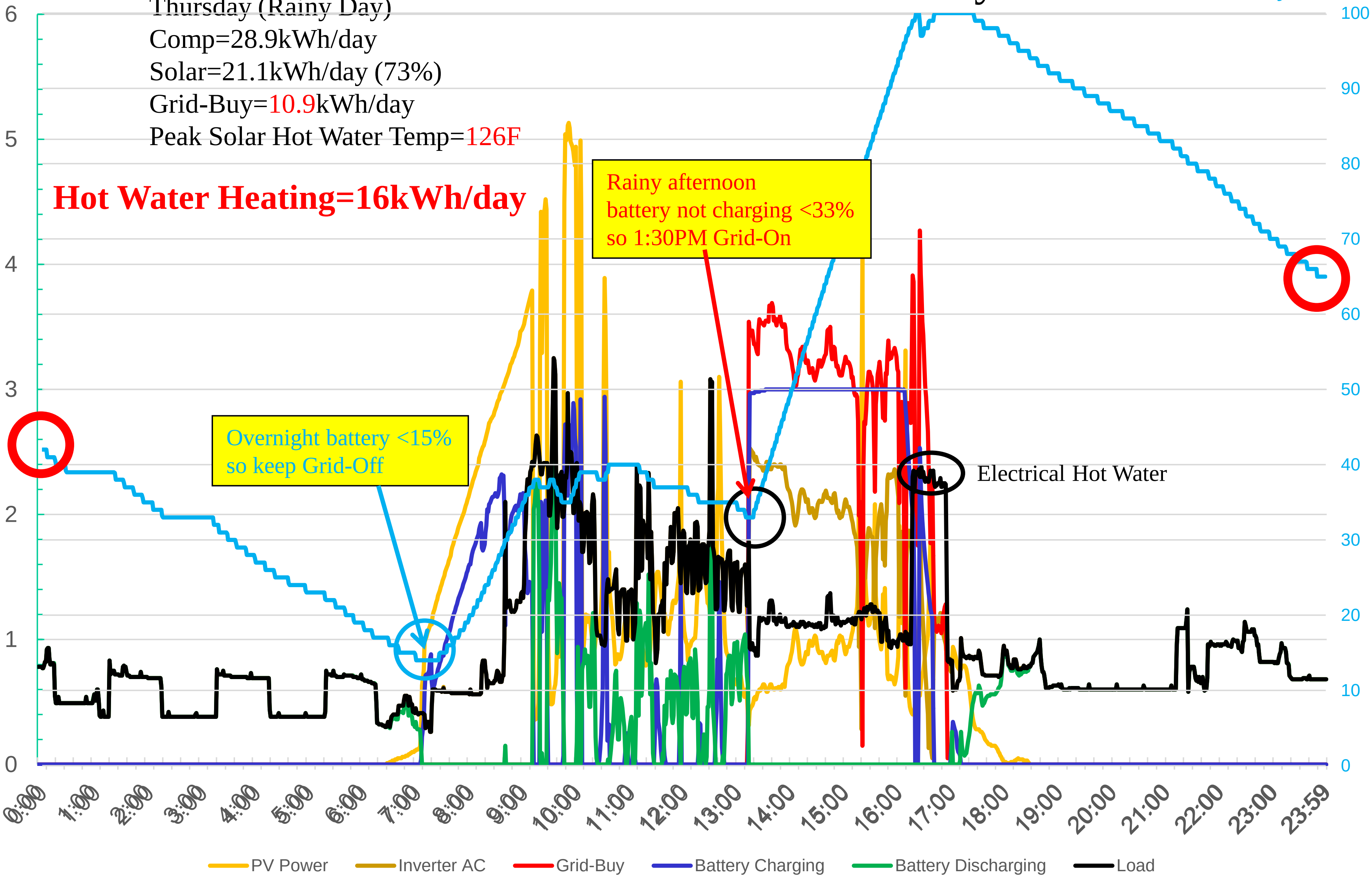
Summer-Sunny Day



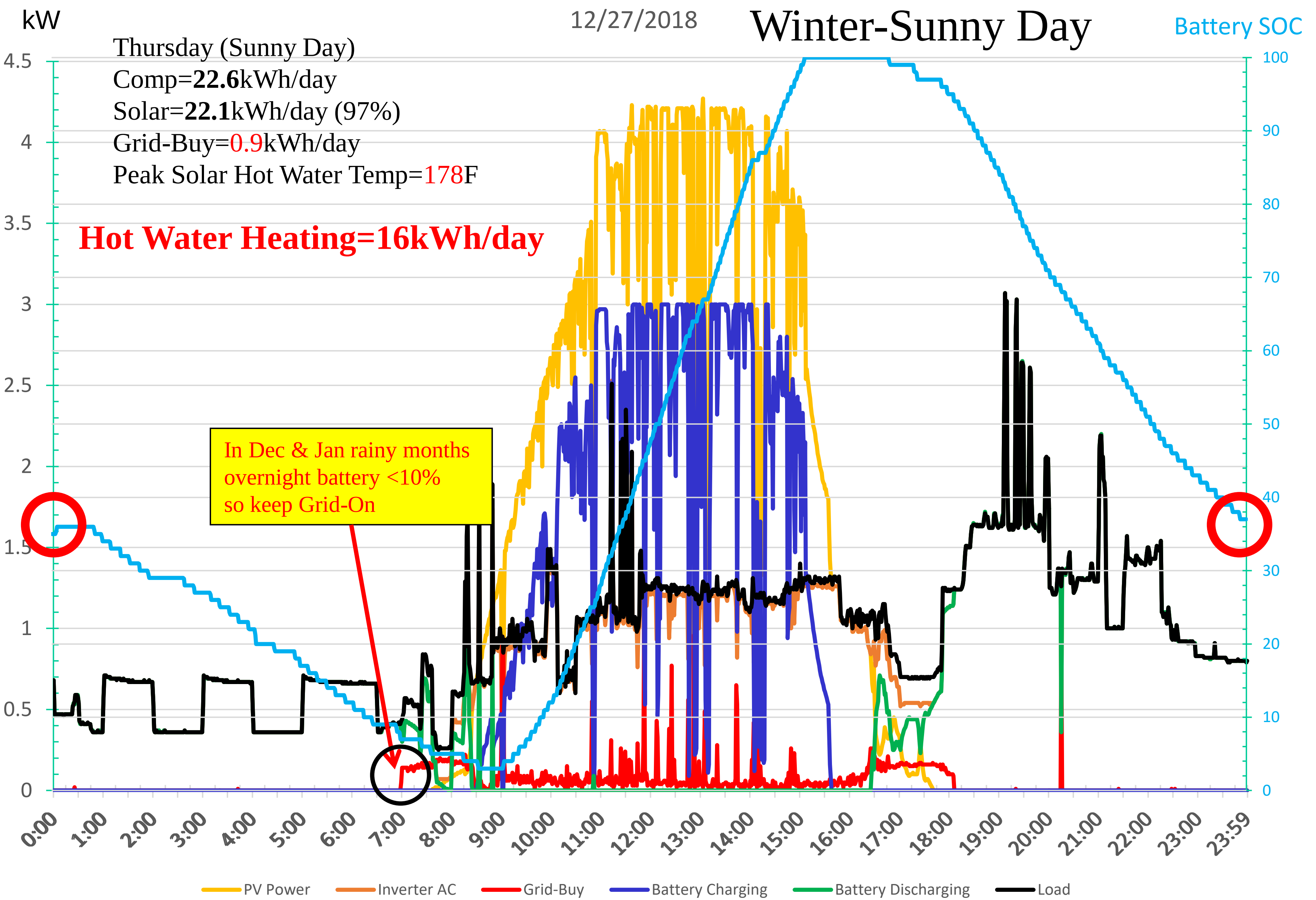
Eliminate Root Cause of Grid-Buy Energy Demand Spikes

7/4/2019

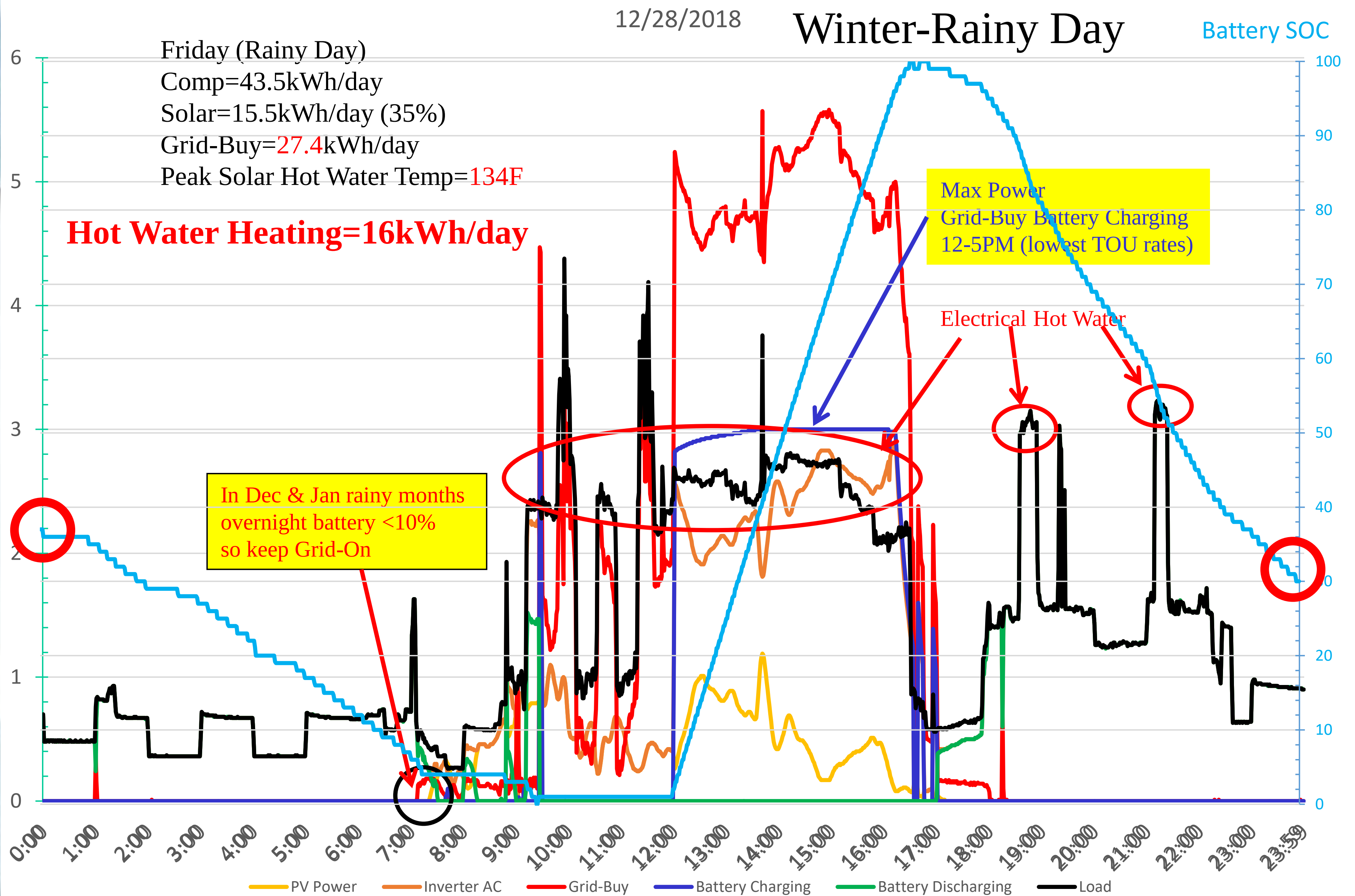
Summer-Rainy Afternoon



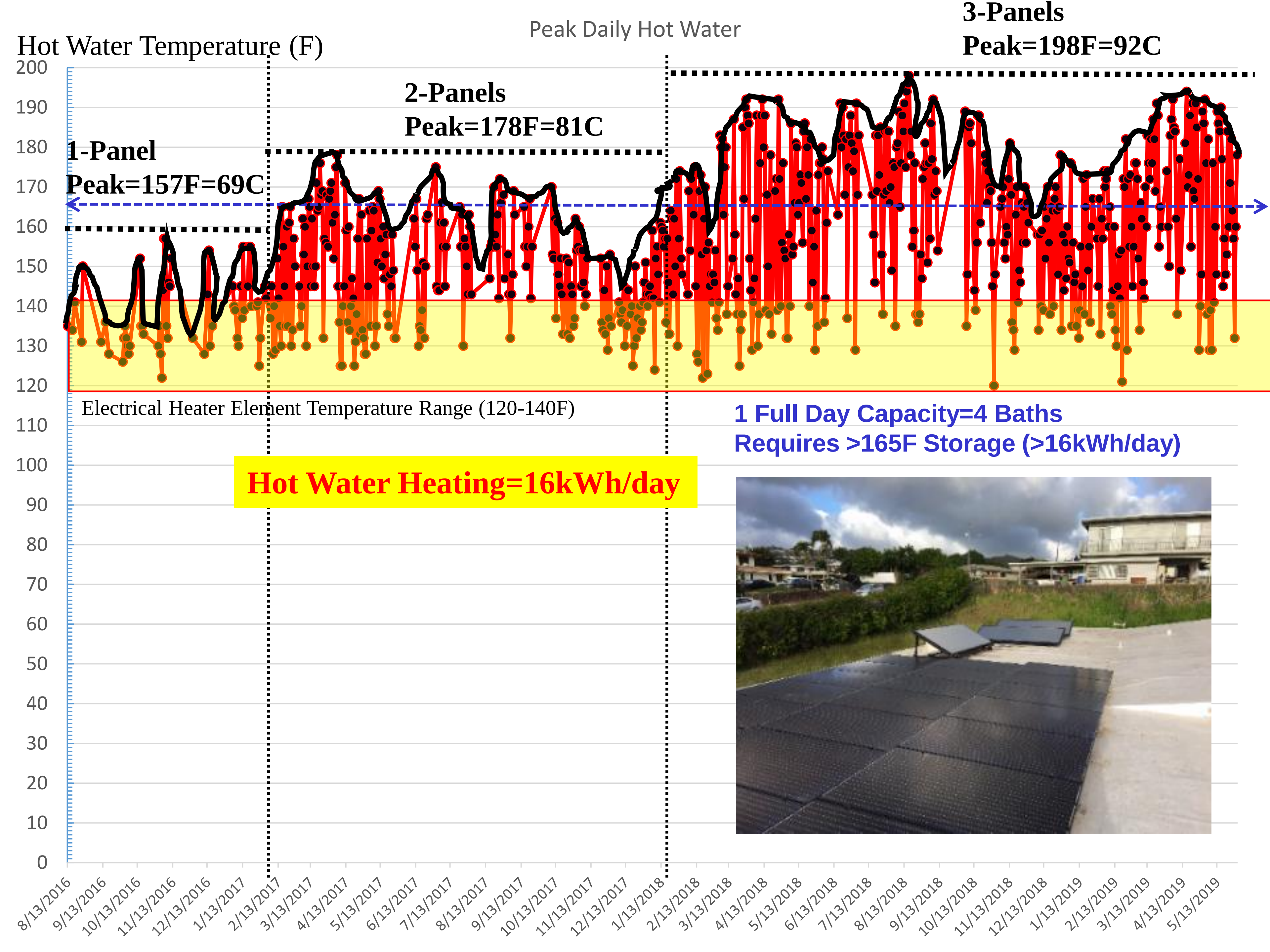
Eliminate Root Cause of Grid-Buy Energy Demand Spikes



Eliminate Root Cause of Grid-Buy Energy Demand Spikes



Eliminate Root Cause of Grid-Buy Energy Demand Spikes



Peak Daily Hot Water
Hot Water Temperature (F)
1-Panel
Peak=157F=69C
2-Panels
Peak=178F=81C
3-Panels
Peak=198F=92C
Electrical Heater Element Temperature Range (120-140F)
1 Full Day Capacity=4 Baths
Requires >165F Storage (>16kWh/day)
Hot Water Heating=16kWh/day
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
8/13/2016
9/13/2016
10/13/2016
11/13/2016
12/13/2016
1/13/2017
2/13/2017
3/13/2017
4/13/2017
5/13/2017
6/13/2017
7/13/2017
8/13/2017
9/13/2017
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9/13/2018
10/13/2018
11/13/2018
12/13/2018
1/13/2019
2/13/2019
3/13/2019
4/13/2019
5/13/2019

Strategy 4:
Grid-Interactive Water Heating (GIWH)

- Acts as a low-cost "battery"
- Stores a full day's supply
- Provides ancillary services to the grid
- **NOT:** simple timers.

Hot Water Heating=16kWh/day

U.S. Water Heaters by Region (×1,000)	US	North-east	Mid-west	South	West
Total	115,745	21,085	25,896	42,893	25,871
Electric ☆	48,607	5,149	8,005	28,363	7,090
Market Share ☆	42%	24%	31%	66%	27%

Strategy 4:
Control Electric Water Heating

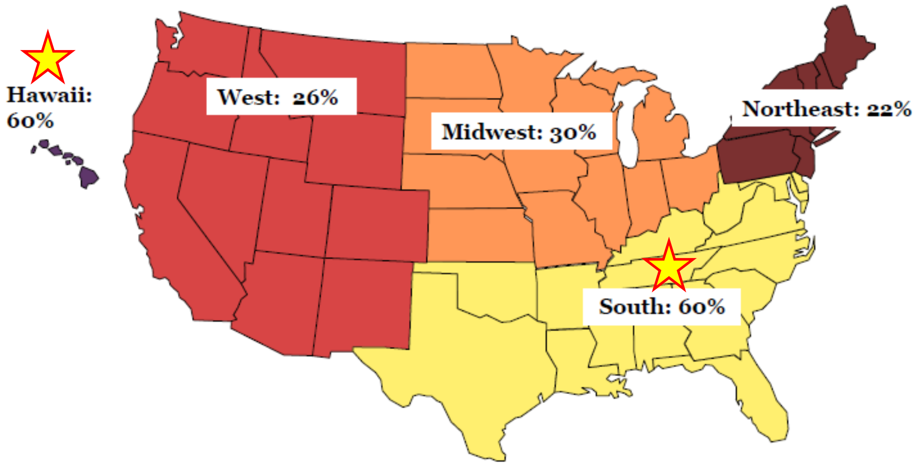
Install grid control of electric water heating;

Supercharge to 140F – 170F during low-cost hours.

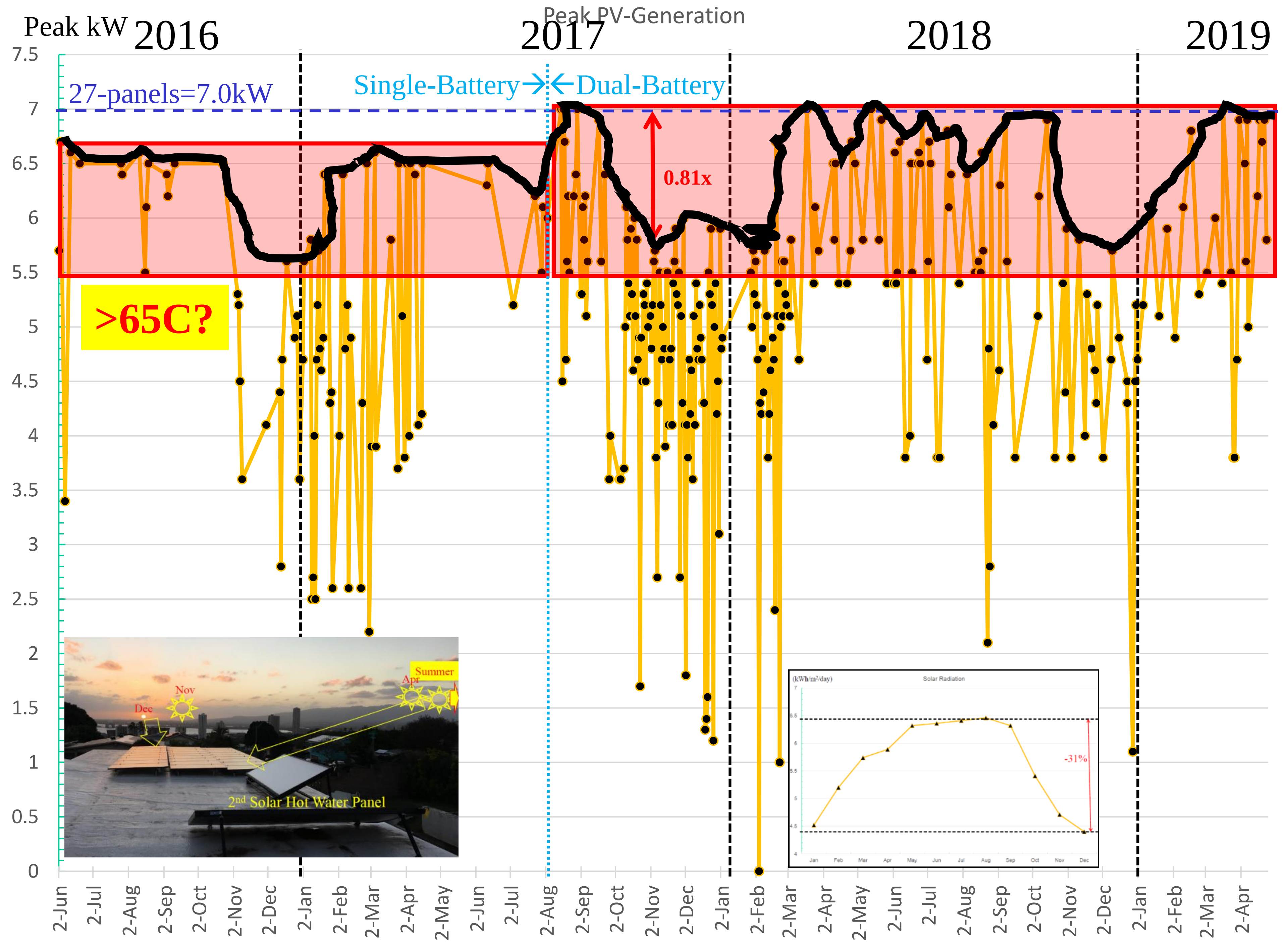
45 million electric water heaters in the U.S.

Each can provide balancing for ~2 kW of wind or solar.

45 Million Electric Water Heaters



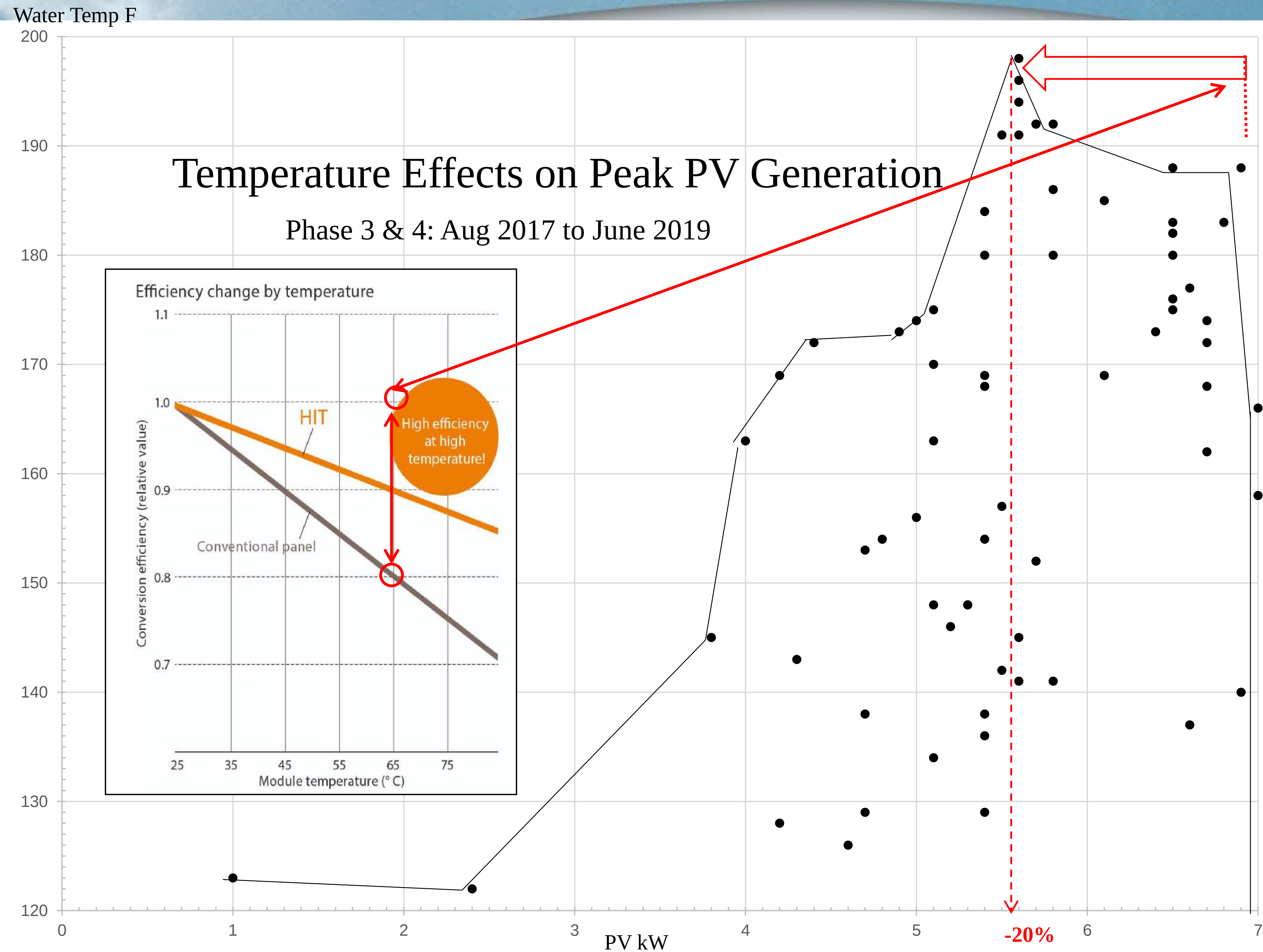
Census Housing Survey Table 2.5 (2010)



Peak PV-Generation
Peak kW
2016
2017
2018
2019
27-panels=7.0kW
Single-Battery→
←Dual-Battery
0.81x
>65C?
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2-Jun
2-Jul
2-Aug
2-Sep
2-Oct
2-Nov
2-Dec
2-Jan
2-Feb
2-Mar
2-Apr
2-May
Dec
Nov
Apr
Summer
2nd Solar Hot Water Panel
(kWh/m²/day)
Solar Radiation
-31%

Temperature Effects on Peak PV Generation

Phase 3 & 4: Aug 2017 to June 2019



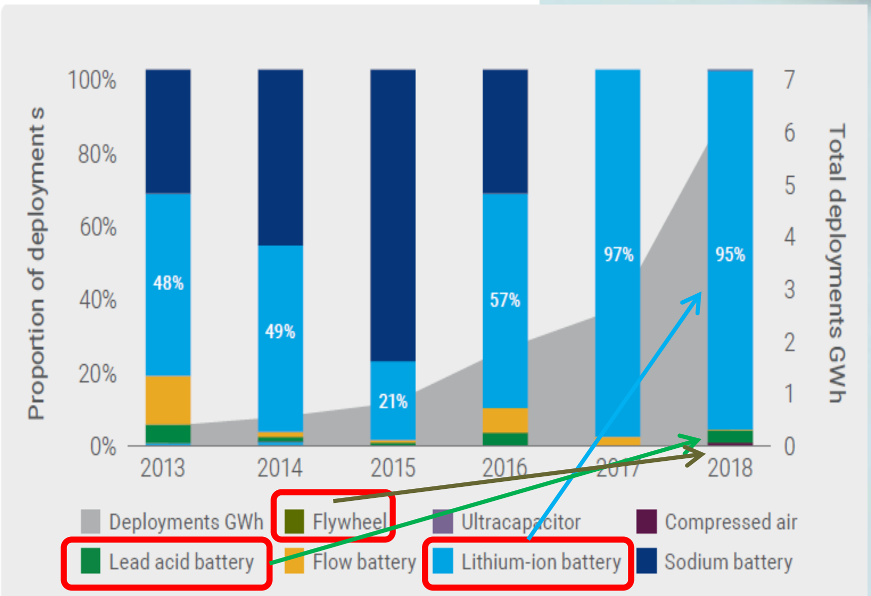
Li-Ion Advantages over Lead Acid

Greater Power Density + **Increased Performance/Reliability**

- ~3X less weight vs lead acid
- ~3X less space vs lead acid
- Less footprint taken up by battery – more space for IT
- No Need for structural reinforcement to support lead acid

- Reduced Maintenance and Coolin[g] needs
- Creates less heat load for HVAC
- 10-15 year service life of li-ion. Vs 3-6 of Lead Acid[2]
- 10x or more cycle life for li-ion
- Integrated Battery Management System provides keys indicators o[f] battery performance and health.

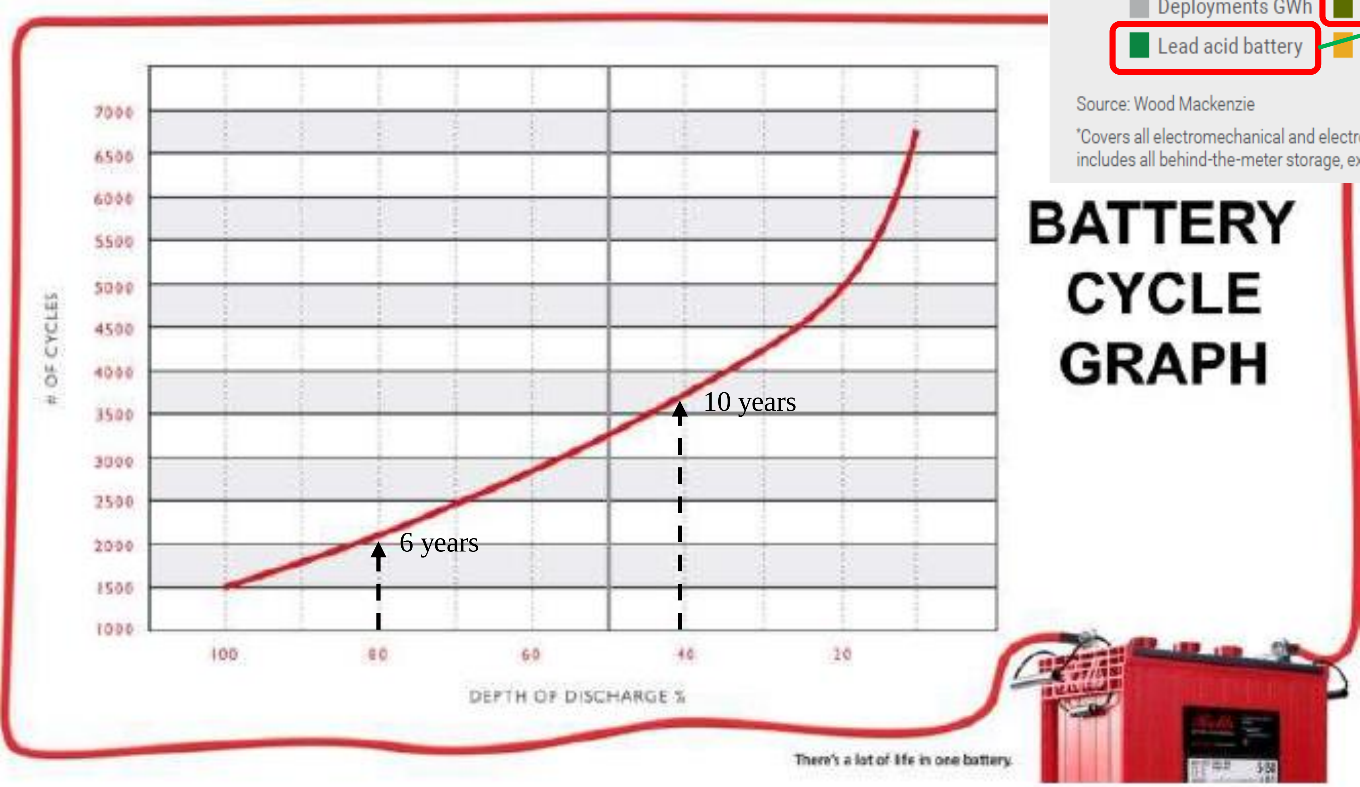
SPI-2018



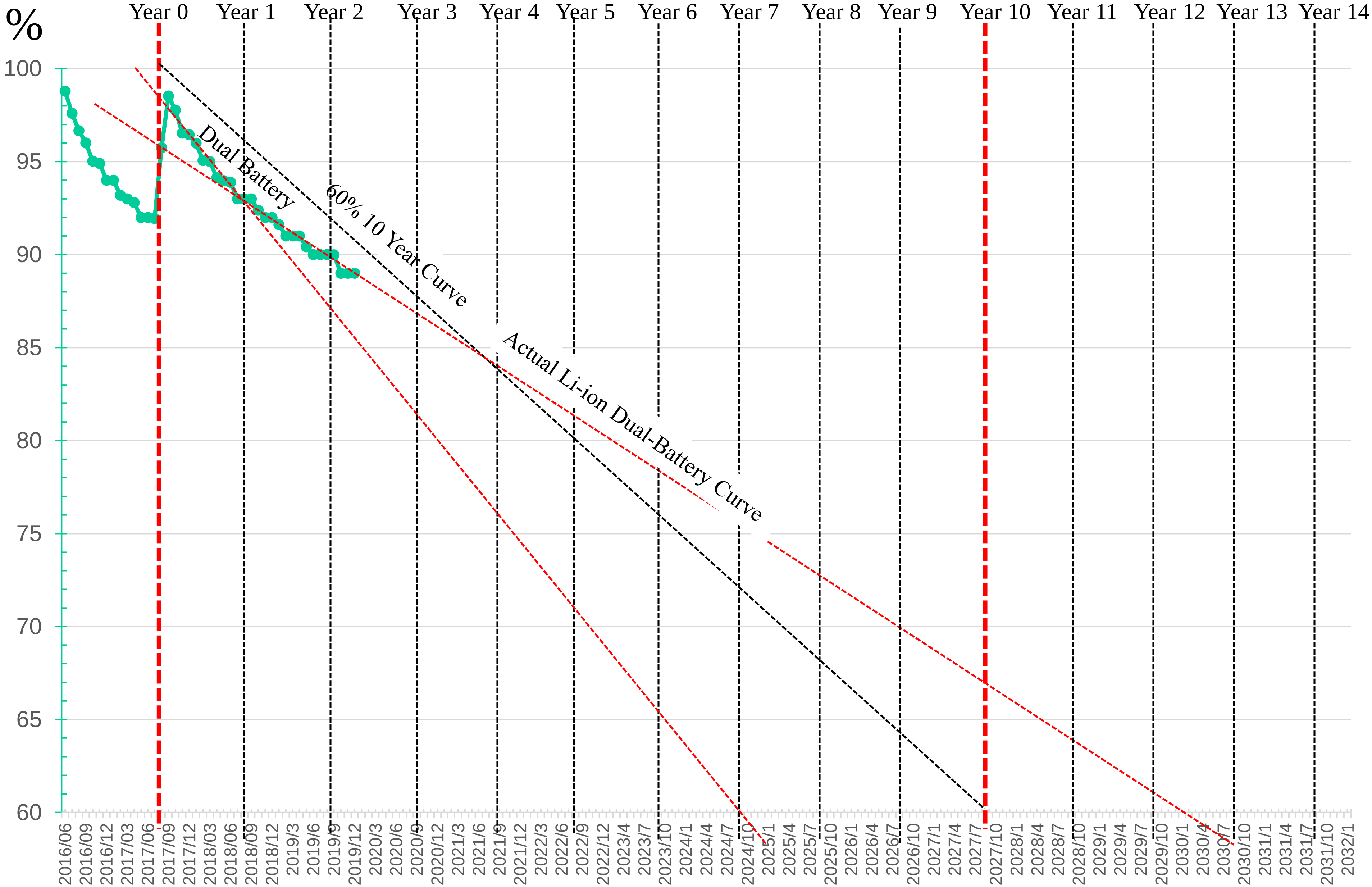
Source: Wood Mackenzie

*Covers all electromechanical and electrochemical energy storage except for pumped hydro. Total deployed capacity includes all behind-the-meter storage, except for UPS, mostly lead acid but this is also changing.

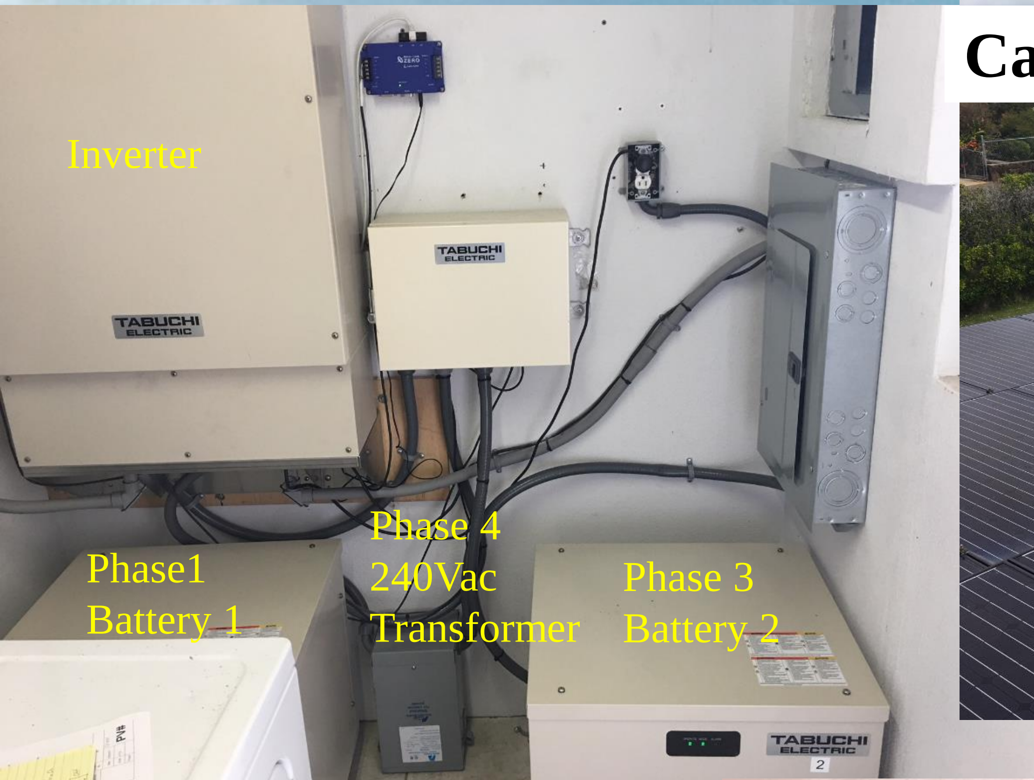
2017/07/20/bloomberg-data-center/



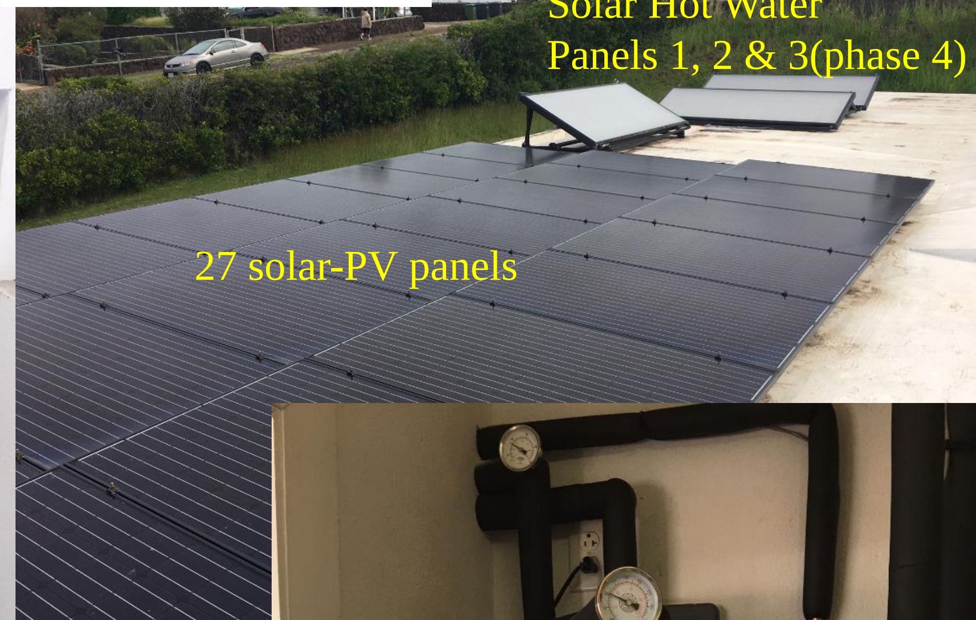
Battery Capacity Degradation



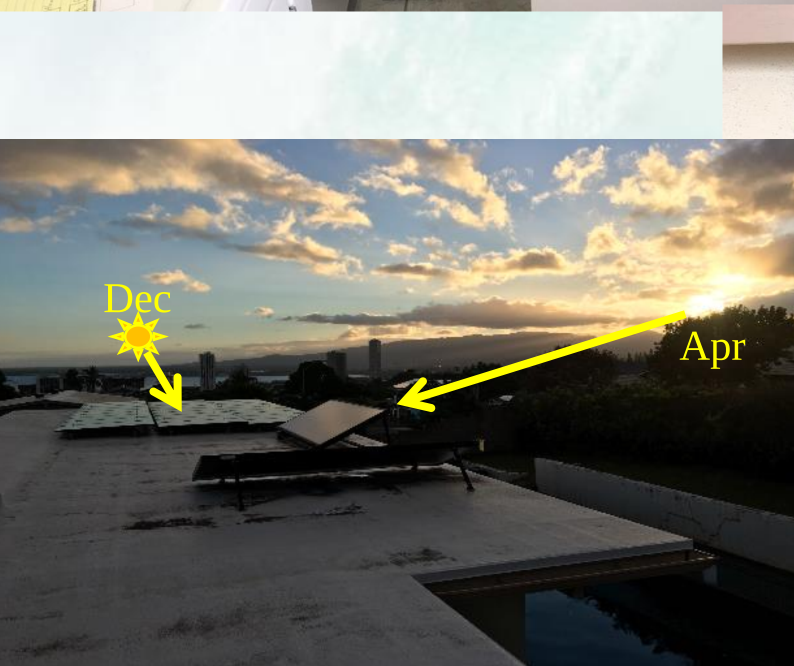
Case Study #5



Inverter
TABUCHI ELECTRIC
Phase 4
240Vac
Transformer
Phase1
Battery 1
Phase 3
Battery 2



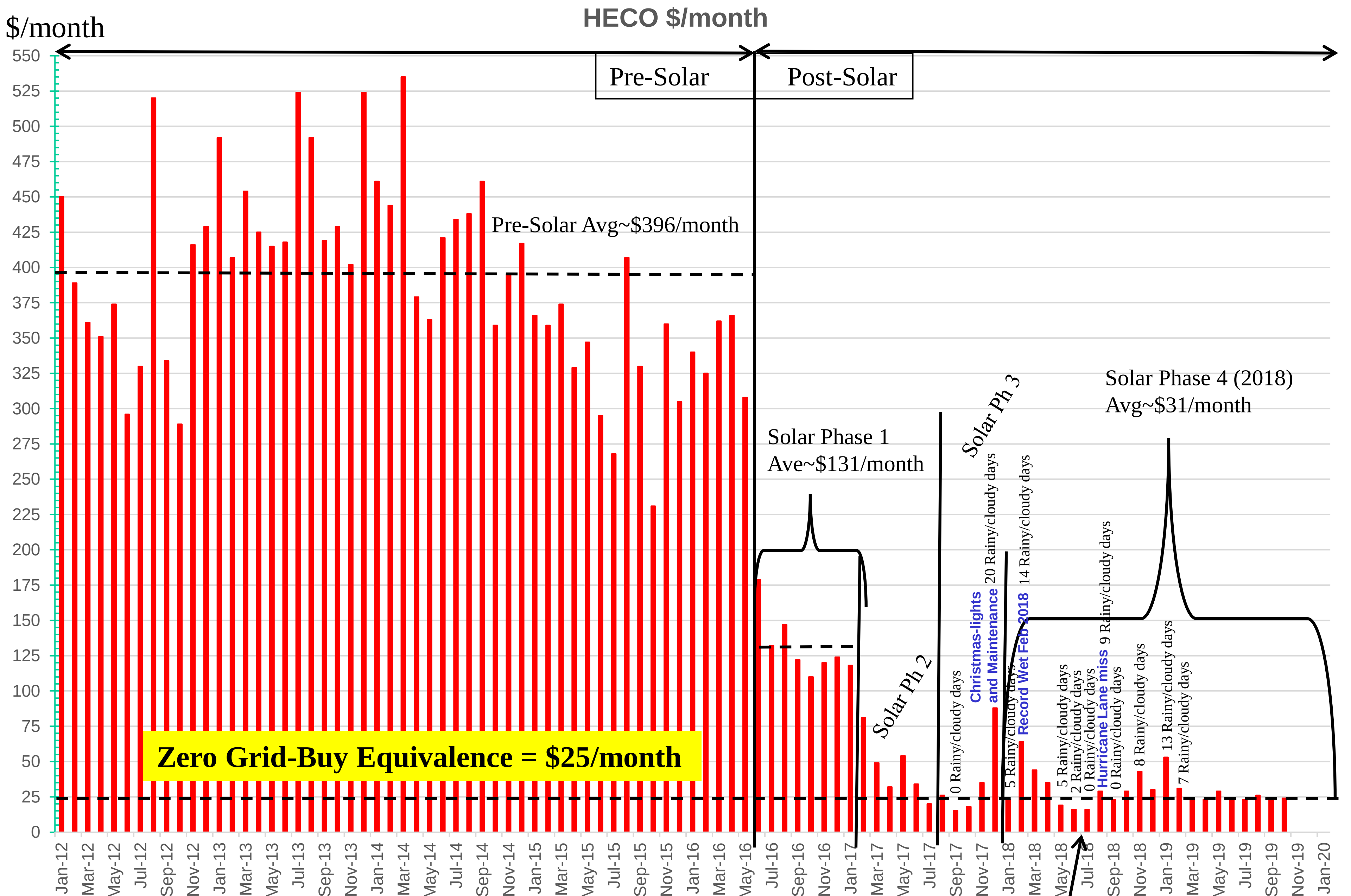
Solar Hot Water
Panels 1, 2 & 3(phase 4)
27 solar-PV panels



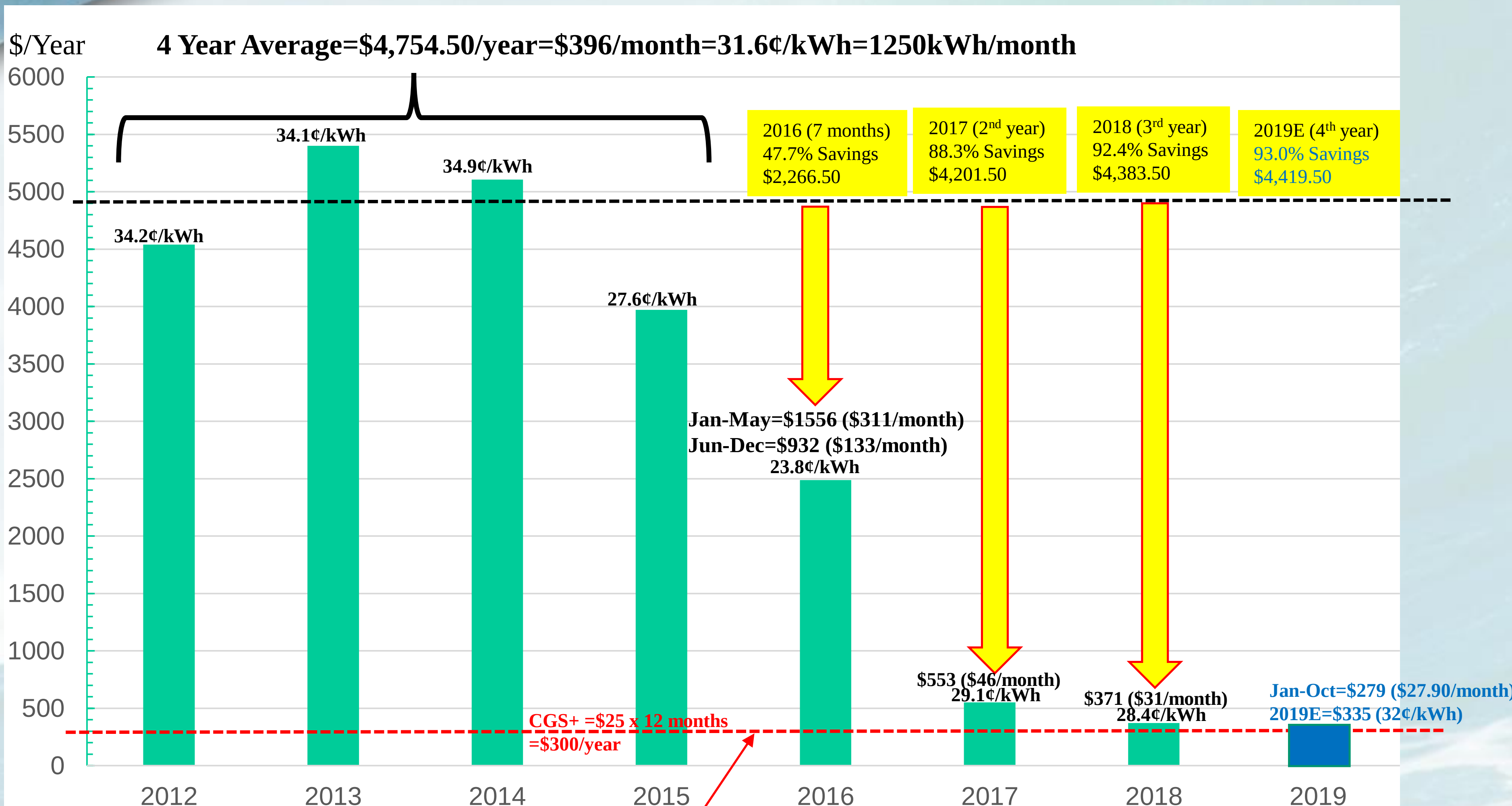
Dec
Apr

Phase 2
40 gallon

Phase 1
80 gallon
Phase 4
Digital Temp Sensor



HECO $/month
$/month
Pre-Solar
Post-Solar
Pre-Solar Avg~$396/month
Solar Phase 1
Ave~$131/month
Solar Ph 2
Solar Ph 3
Solar Phase 4 (2018)
Avg~$31/month
Zero Grid-Buy Equivalence = $25/month
0 Rainy/cloudy days
Christmas-lights and Maintenance
20 Rainy/cloudy days
14 Rainy/cloudy days
5 Rainy/cloudy days
Record Wet Feb 2018
5 Rainy/cloudy days
2 Rainy/cloudy days
0 Rainy/cloudy days
Hurricane Lane miss
9 Rainy/cloudy days
0 Rainy/cloudy days
8 Rainy/cloudy days
13 Rainy/cloudy days
7 Rainy/cloudy days
Zero Grid-Buy

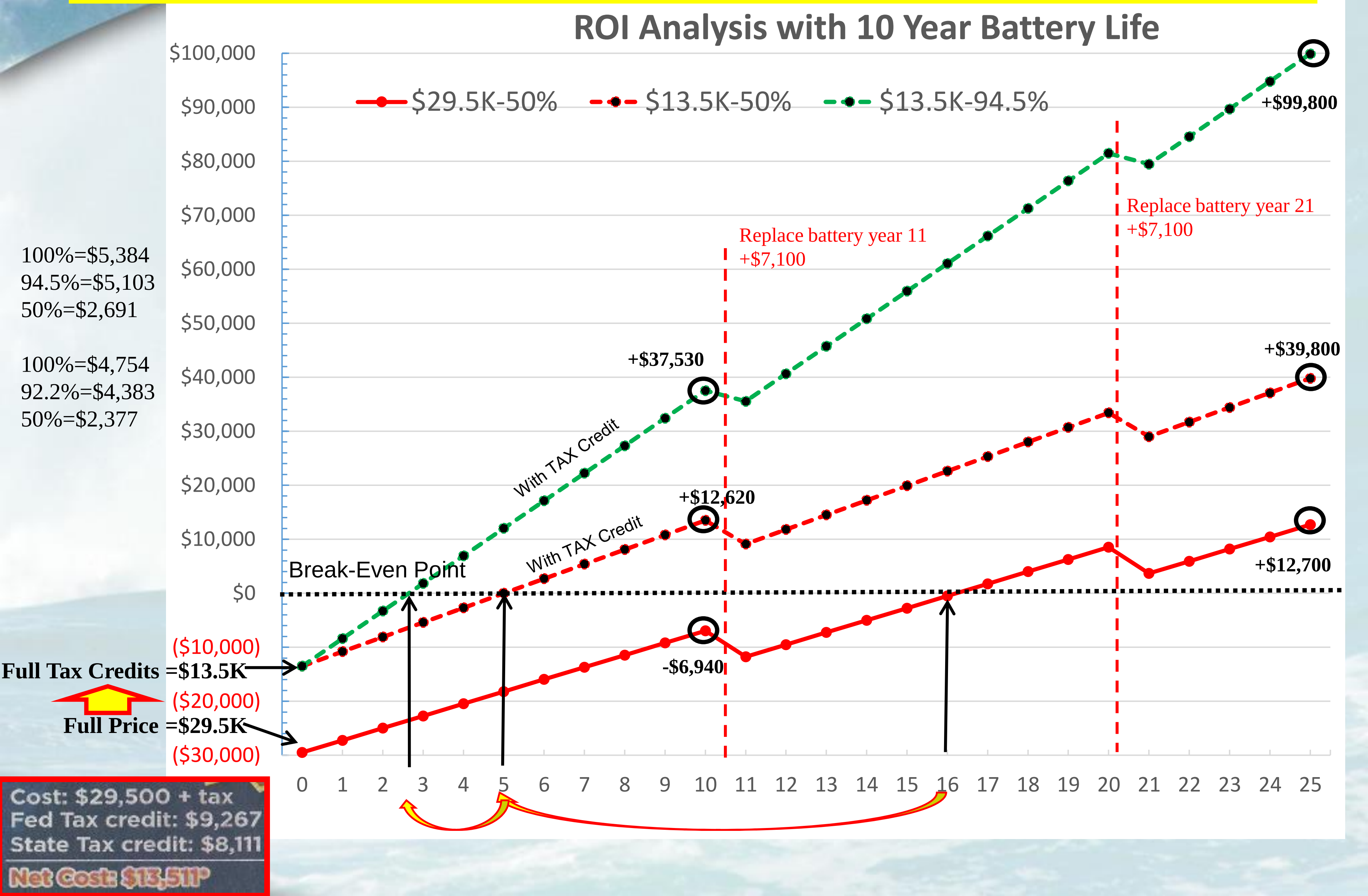


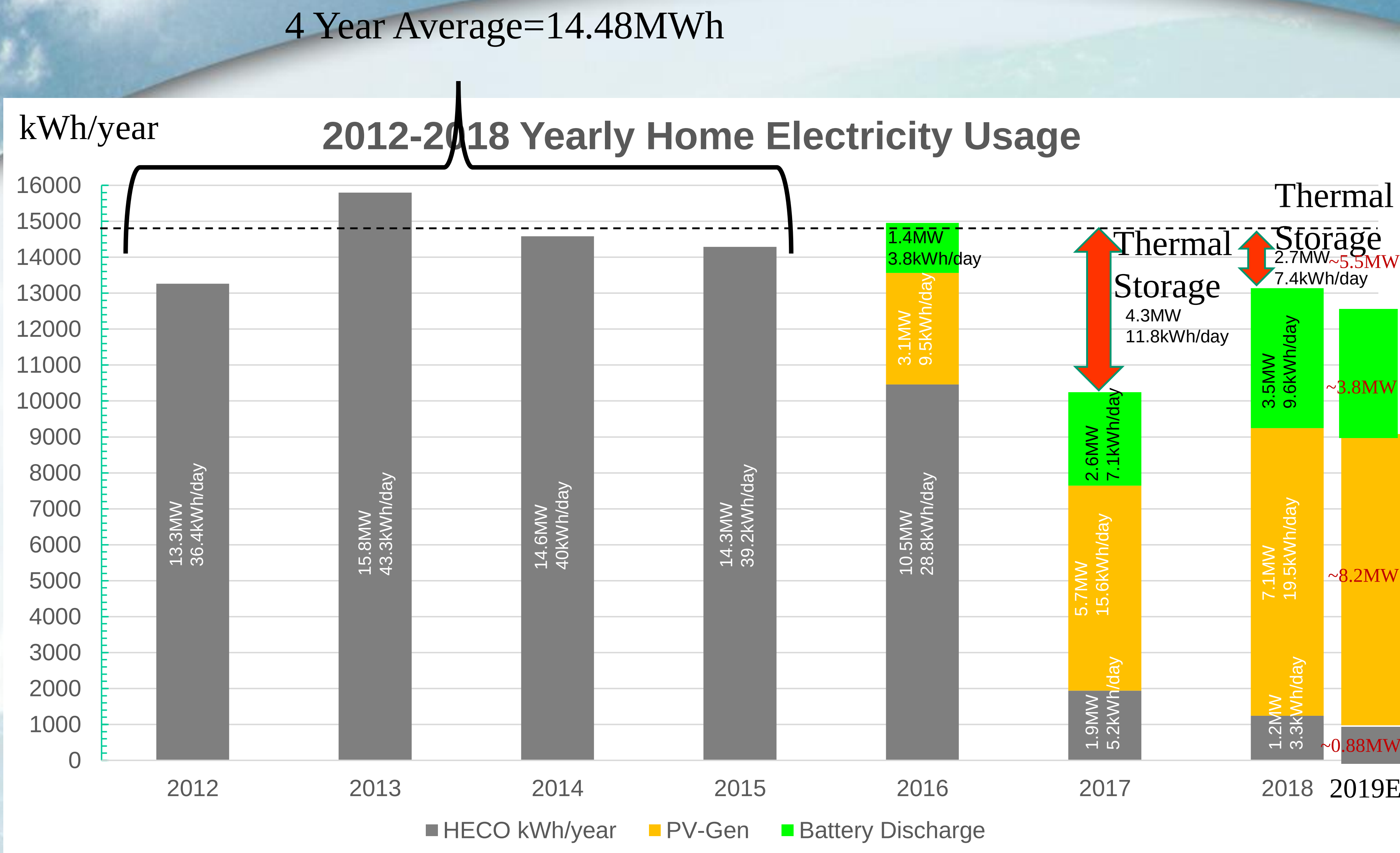
25 years Save $109K!

Solution #3: Zero Grid-Buy Equivalence for $25/month Utility Bill =$300/year =93.7% savings =$4,454.50

ROI Analysis For System Costs =$29,500

Key to Shortest ROI is Zero Grid-Buy Equivalence ($25/month) with Lowest $/W COS





4 Year Average=14.48MWh
kWh/year
2012-2018 Yearly Home Electricity Usage
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
13.3MW
36.4kWh/day
15.8MW
43.3kWh/day
14.6MW
40kWh/day
14.3MW
39.2kWh/day
1.4MW
3.8kWh/day
3.1MW
9.5kWh/day
10.5MW
28.8kWh/day
Thermal
Storage
4.3MW
11.8kWh/day
2.6MW
7.1kWh/day
5.7MW
15.6kWh/day
1.9MW
5.2kWh/day
Thermal
Storage
2.7MW
7.4kWh/day
~5.5MW
3.5MW
9.6kWh/day
7.1MW
19.5kWh/day
1.2MW
3.3kWh/day
~3.8MW
~8.2MW
~0.88MW
2012
2013
2014
2015
2016
2017
2018
2019E
HECO kWh/year
PV-Gen
Battery Discharge

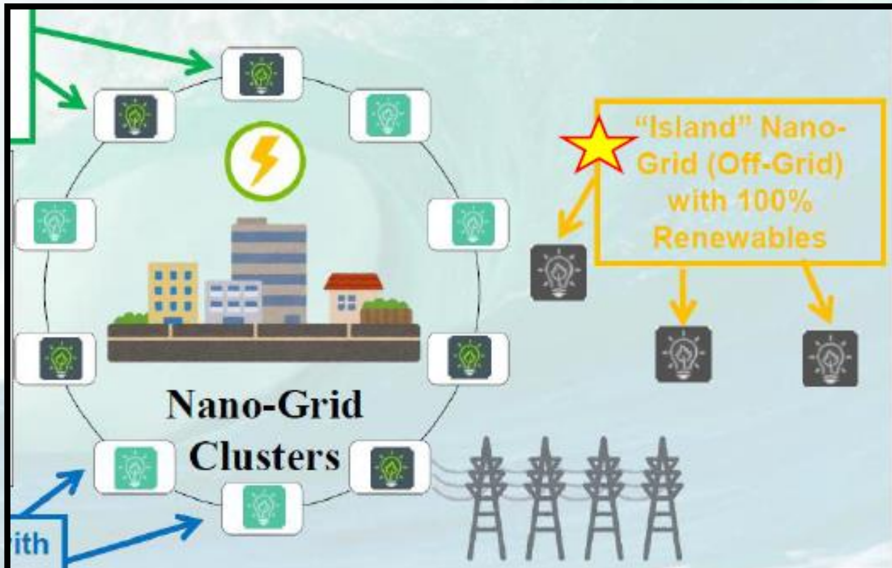
Outline

- Introduction
- Start at Home:
- Summary
  - With Home/Building Island Nano-Grid we achieved 100% Renewable Clean Energy all from the Sun (light & heat), therefore Off-Grid for 336 sunny/partial cloudy days in 2018 reducing home carbon footprint by 92% today!
    - Grid-Buy reduced from 14.5MWh/year (1.21MWh/month, 40.3kWh/day) to 1.2MWh/year (100kWh/month, 3.3kWh/day).
    - Hawaiian Electric yearly bill reduced from $4,754.50/year ($396/month, $13.20/day) to $371/year ($31/month, $1.03/day) a savings of $4,383.50/year ($365/month) and 3 years payback.
    - Average Daily Cost of Electricity (D-COE) = 5.6¢/kWh.
  - Sustainability required use of IoT and Smart devices for data analytics, monitor and control of Energy Ecosystem 24/7 including future weather forecasting capabilities to Balance the Multi-Renewable Energy Sources.

Summary for 2nd Solar Wave

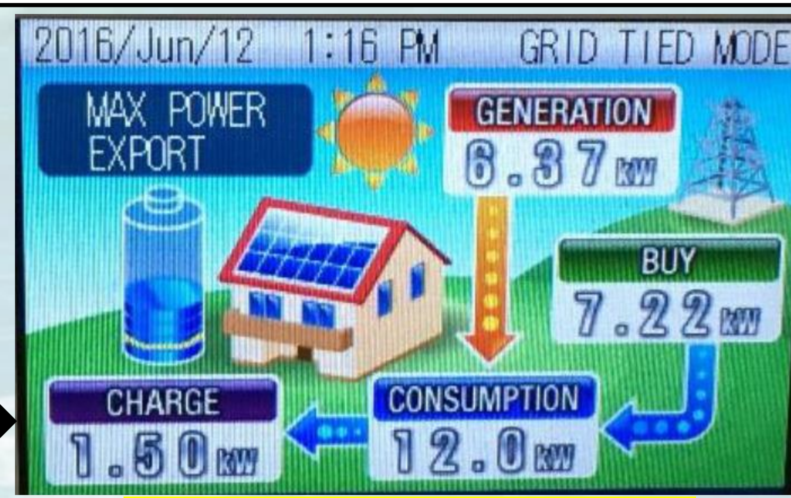
the leap into the mainstream. In the first wave of residential solar, PV systems lived in the background and delivered power with little or no interactivity with the homeowner. That has to change.

"The grid of the future is the solar inverter enabled with storage that is part of the home ecosystem," said Marshall. "It's an interactive asset that can be controlled in part by the homeowner but also in part by the grid operator or an energy aggregator.



Data analytics and intelligence to maximize PV self-consumption when a battery is installed

1) No Export of excess rooftop solar-PV back to Grid so no further Duck Curve degradation and Grid instability.
2) No need for special 2-way metering and for utility to control home inverter PV-generation.
4) Switch to TOU rates and save more $$ with Grid-Tie for back-up power on cloudy/rainy days (92% yearly savings).
5) DER for residential rooftop solar with multi-storage will not work especially wintertime, to be economical homes must be ZGB-Equivalence, keep 100% of self-generated power except on very sunny days for!
6) DER requires 2x oversizing battery increasing Battery COS from $10K→**>$20K!** This can increase ROI payback from 3.1years →**>5 years** unless lease or rent as virtual grid!



Wall Remote Monitor for Data Analytics

Backup Slides

Daily-Cost Of Electricity (D-COE)

D-COE for Grid-Buy from HECO is 30¢/kWh (2018).

D-COE for a $3.20/W solar-PV system is 7.8¢/kWh/20 years or 3.6¢/kWh/20 years for full tax credit (solar radiation 5.6hours/day X 7.0kW PV generation X 365 days/year X 20 years product life cycle =286.168MWh÷ 1/system cost [$22.4K or $13.5K full tax credit]) =7.8¢/kWh or 3.6¢/kWh.

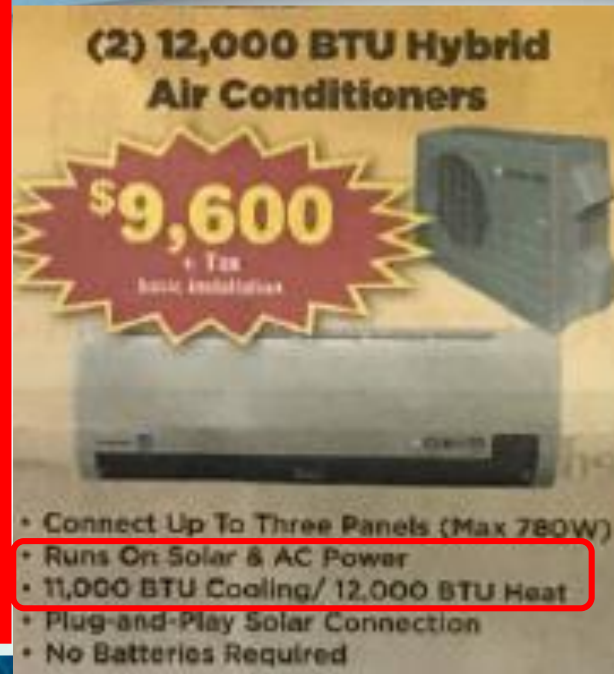
D-COE for a $0.70/W battery discharge is 32.4¢/kWh or 14.9¢/kWh full tax credit (6.0kWh/day [60%] X 365 days/year X 10 year product life cycle=21.9MWh ÷ 1/$7.1K) =32.4¢/kWh or 14.9¢/kWh.

D-COE for hot thermal storage is 13.7¢/kWh or 6.3¢/kWh full tax credit (16kWh/day X 365 days/year X 10 year product life cycle=58.4MWh ÷ 1/$8K)=13.7¢/kWh or 6.3¢/kWh.

Totally D-COE = Grid-Buy COE (8%) + PV-gen COE (49%) + Battery Discharge COE (24%) + Thermal COE (19%) = 5.6¢/kWh

Various Options For Spacing Cooling or Heating $/kWh

We Can Store "Cool" as Ice (in fact, most of us already do)



Ice Bear 20 for the Home

- Replaces home AC unit
- Hybrid air conditioning and energy storage solution
- 14.56 SEER Air Conditioning
- 150 EER Ice Cooling

Thermal Energy Storage
+ Air Conditioning

Storage capacity	20 T-hours / 19.2 kW-h
Discharge duration	4 hours @ 5T
Charge Power / time @ 75°F	24 kW-hr / 7.5 hours
Peak capacity	4.80 kW
Modes of Operation	Air Conditioning, TES & Ice Cooling

IceEnergy

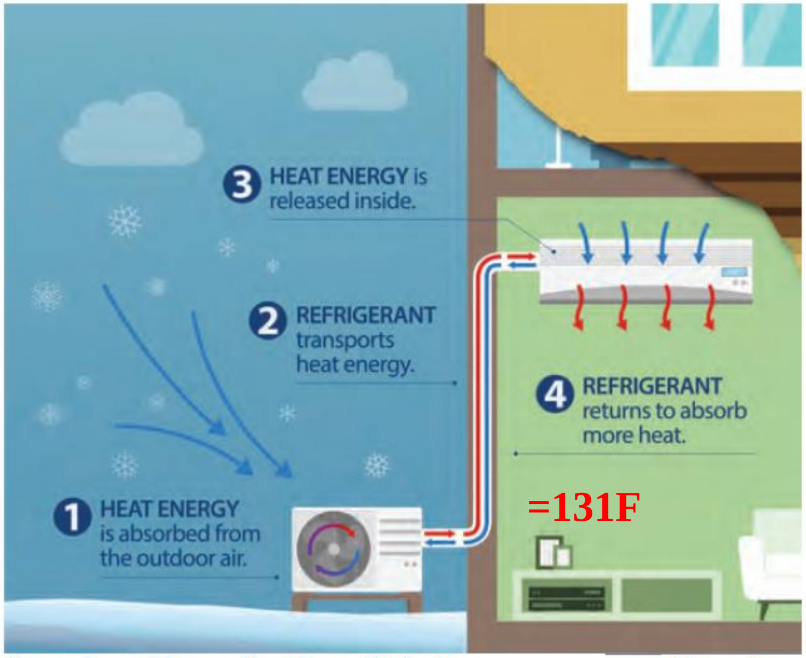
Ice Bear 20
Price Comparison vs Li-Ion batteries

Ice Bear 20	Equivalent 5T AC	Ice Bear 20 TES	Equivalent Battery*
Equipment Cost: $12,900	Equipment Cost: $6,500	Ice Bear 20 Installed Cost: $14,900	Equipment Cost: $15,500
Installation Cost: $2,000	Installation Cost: $2,000	Less 5T AC Installed Cost of $8,500	Installation Cost: $1,500
Total Cost: $14,900	Total Cost: $8,500	Net Cost of Ice Bear TES: $6,400	Total Cost: $17,000
		$1,333/kW (4.8kW)	$2,300/kW (7 kW)
		$333/kW-h (19.2 kW-h)	$1,063/kW-h (16 kW-h)

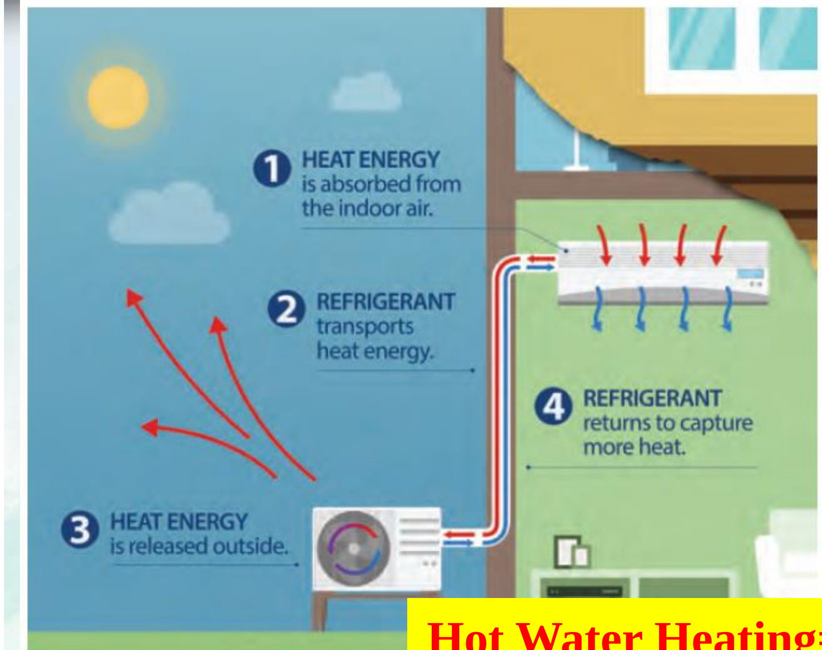
$$$

*Li-Ion batteries cannot be operated to store solar over-gen like Ice Bear TES system w/o significant degradation and shortening of life: practical as backup only

How an Air Source Heat Pump Works in the **Winter**

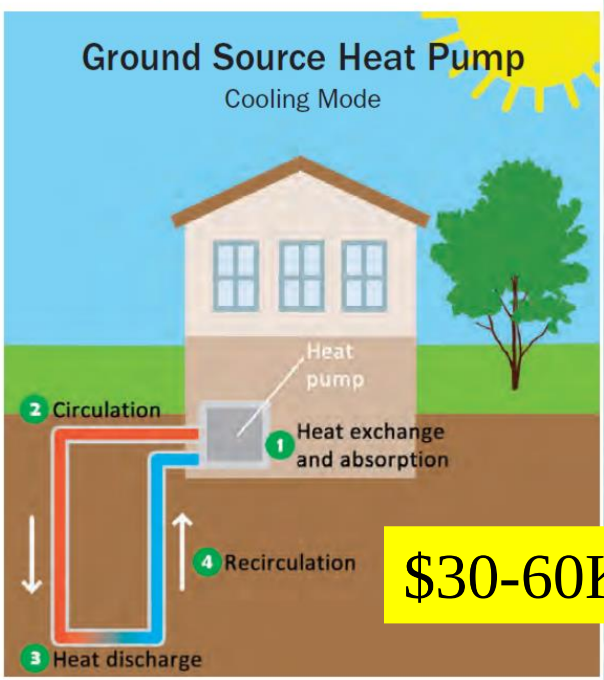


How an Air Source Heat Pump Works in the **Summer**



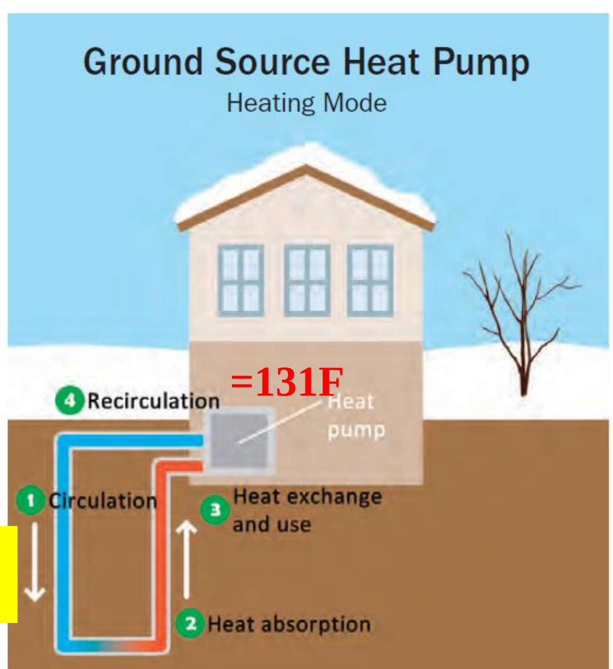
Hot Water Heating=16kWh/day

How a Ground Source Heat Pump Works to Cool a Building



$30-60K?

How a Ground Source Heat Pump Works to Heat a Building



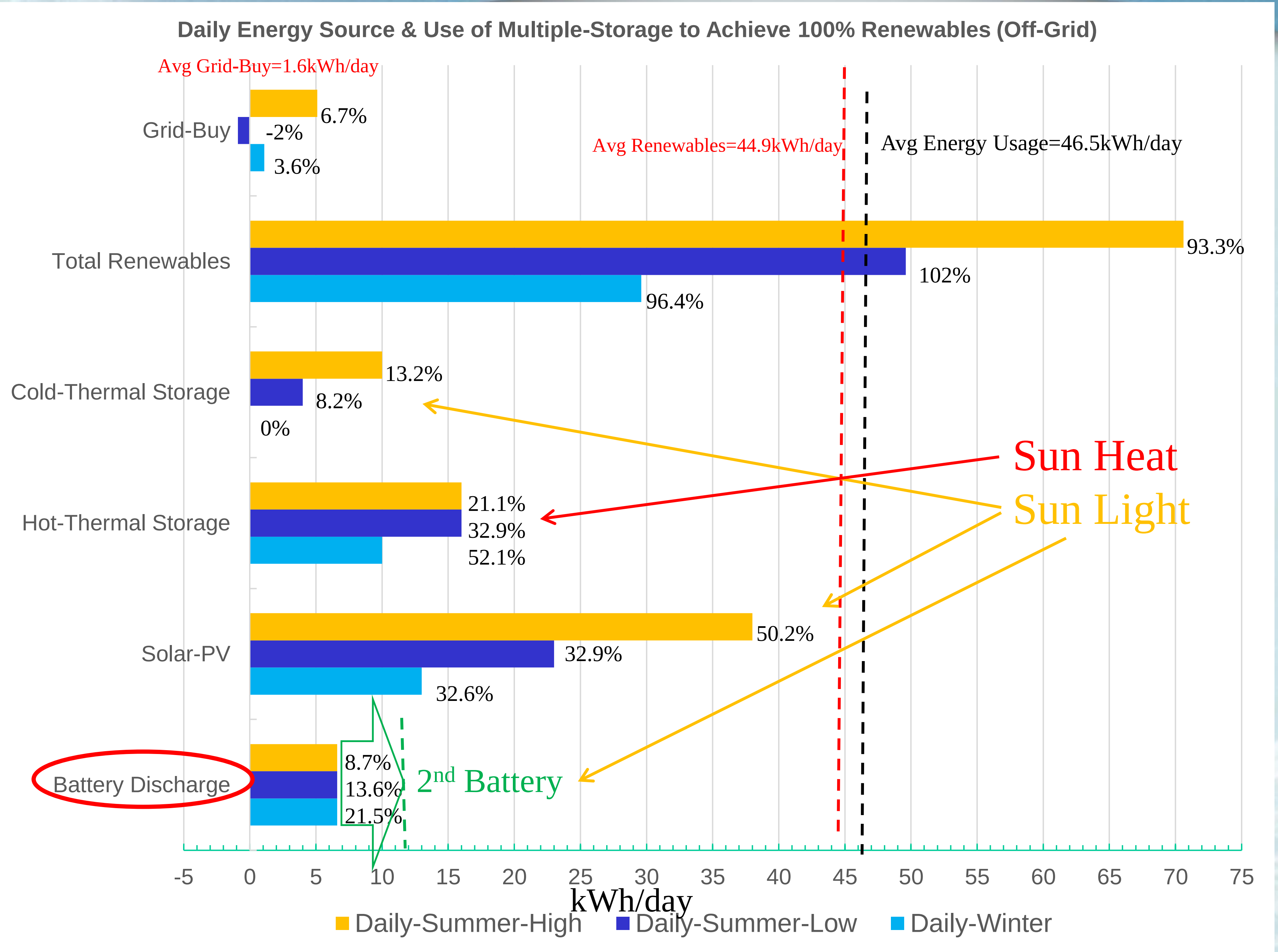
Community Campaigns for Renewable Heating and Cooling Technologies

FOUR CASE STUDIES

Clean Energy States Alliance

Georgena Terry and Val Stori

June 2019


Daily Energy Source & Use of Multiple-Storage to Achieve 100% Renewables (Off-Grid)
Avg Grid-Buy=1.6kWh/day
Avg Renewables=44.9kWh/day
Avg Energy Usage=46.5kWh/day
Grid-Buy
6.7%
-2%
3.6%
Total Renewables
93.3%
102%
96.4%
Cold-Thermal Storage
13.2%
8.2%
0%
Hot-Thermal Storage
21.1%
32.9%
52.1%
Solar-PV
50.2%
32.9%
32.6%
Battery Discharge
8.7%
13.6%
21.5%
2nd Battery
Sun Heat
Sun Light
-5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
kWh/day
Daily-Summer-High
Daily-Summer-Low
Daily-Winter