Open Standard Connections to Controlling Flexible Electric Loads with a focus on water heating

CTA-2045 (EcoPort) and OpenADR the time has come

Utility Forum
August 19, 2021

Tristan de Frondeville, SkyCentrics

Agenda

SkyCentrics

- What is the CTA-2045 EcoPort?
- CTA-2045 EcoPort appliances are smart
- Overview of Relevant Policy Proceedings (How to connect?)
- Why Flexible Shiftable Loads? What are they worth?
- The big choice: What time to shift?

  Time of Use = 6 month schedule changes (Connectible)

  vs vs

  Daily or real time schedule changes (Connected)
- Overview of Incentives & Market Transformation
- How Fast Can Humanity Go?

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What is the CTA-2045 EcoPort?

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CTA-2045 Standard – a 'USB port' for appliances

ECOPORT

AC Powered slot and module

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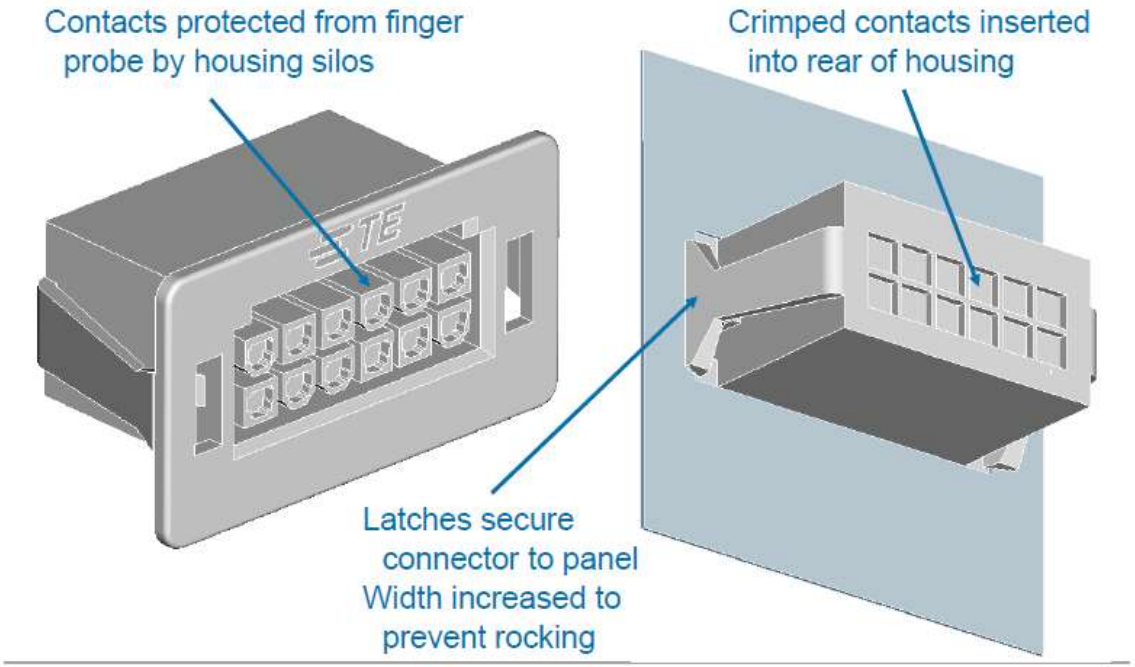

US quarter

AC powered

DC Powered slot and module

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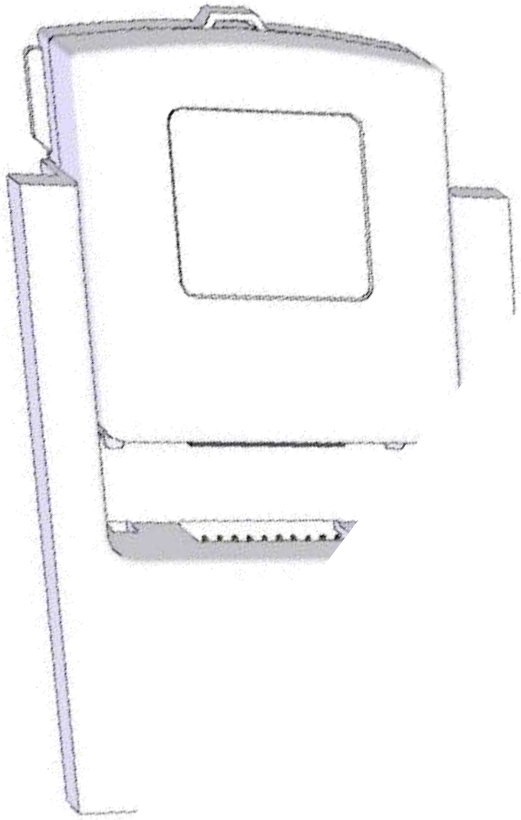

DC powered

Open Standards =

- Competition
- Innovation
- Lower costs
- Interoperability

CTA-2045 ECOPORT Module Innovators

- e-Radio (FM radio, Wi-Fi)
- SkyCentrics (Wi-Fi, Cellular), OpenADR 2.0b cloud VEN
- OTI (Wi-Fi)
- Intwine Connect (Wi-Fi)

Flexible Communication Paths
Multiple Protocol Options (OpenADR)

CTA-2045 ECOPORT appliance family

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Hot Water Heaters

PTACs

Pool Pumps

EV Chargers

Heat Pump HVAC Mini-splits

Commercial Equipment Now Here

Shiftable Water Heater Load = 20,000 watt-hours

Focus on Multi-Family

- Low income Multifamily Retrofit – Seattle Office of Housing
- Existing System: 6 x Rheem Electric Water Heaters
  - 102KW of Electric Resistance Elements
- Number of units: 100
- Estimated number of occupants: 100
- Number of Stories: 13
- HVAC System: Baseboard Electric Heating, no cooling

BAYVIEW TOWER, 2614 4TH AVENUE

SEATTLE, WA 98121

Retrofit kit = both OpenADR & EcoPort

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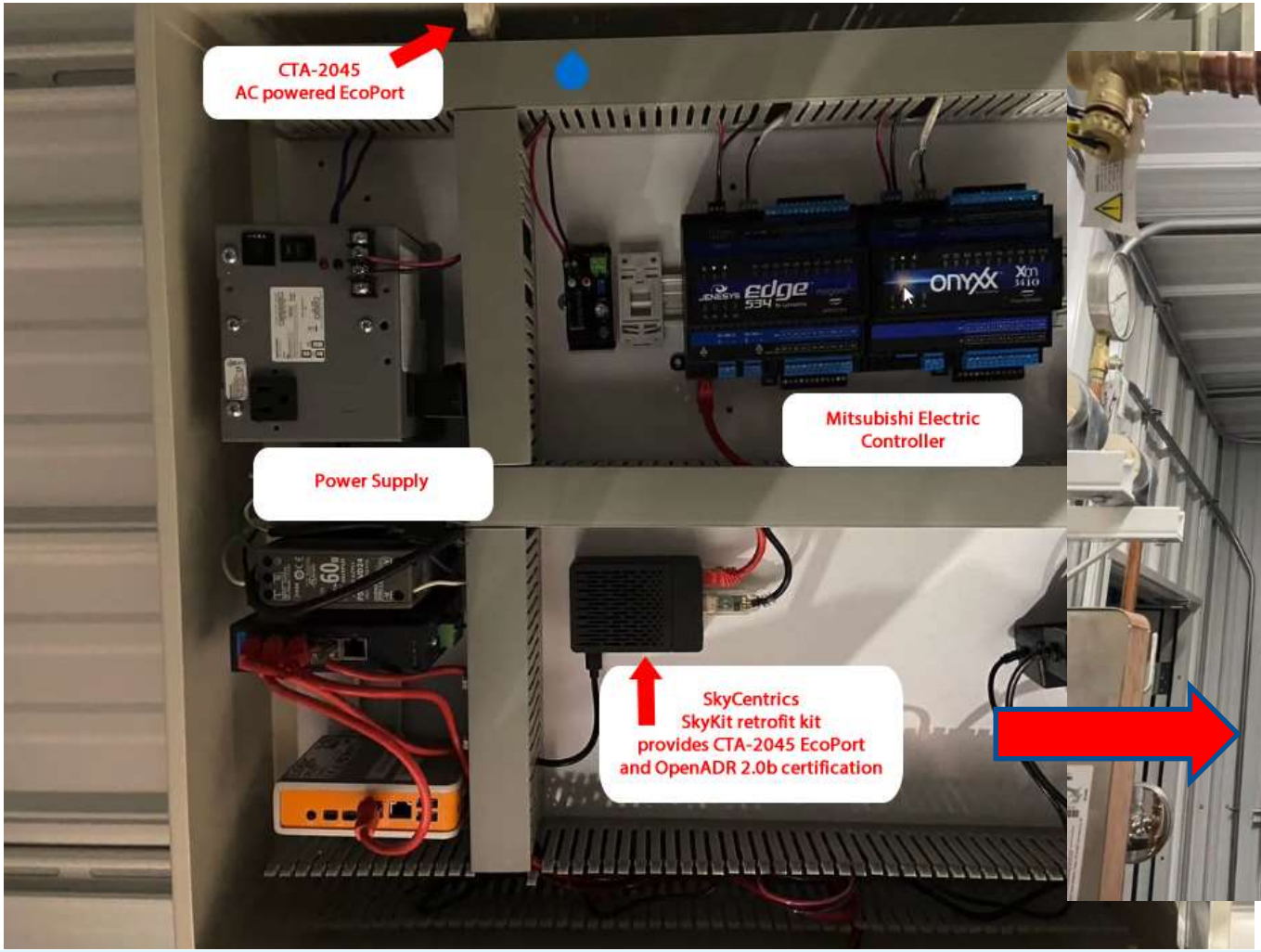
ECOPORT

openADR™ 2.0b CERTIFIED



Control Box

CTA-2045 EcoPort appliance family

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DC Powered	AC Powered
GE Appliances – Heat Pump Water Heater	AO Smith – Electric Resistance Water Heater
Bradford White – Heat Pump Water Heater	AO Smith – Heat Pump Water Heater
Mitsubishi Mini-Splits and Central-Ducted	Rheem – Heat Pump Water Heater
Siemens EVSE Car Charger	Pentair - Variable Speed Pool Pumps
Emerson 30 Amp Water Heater Switch	IslandAire - PTAC HVAC units
Emerson Thermostat	Mitsubishi - Central Water Heater Systems for multi-family

CTA-2045 EcoPort appliances are smart

They protect the customer while supporting the grid

Water Heater Event Behavior

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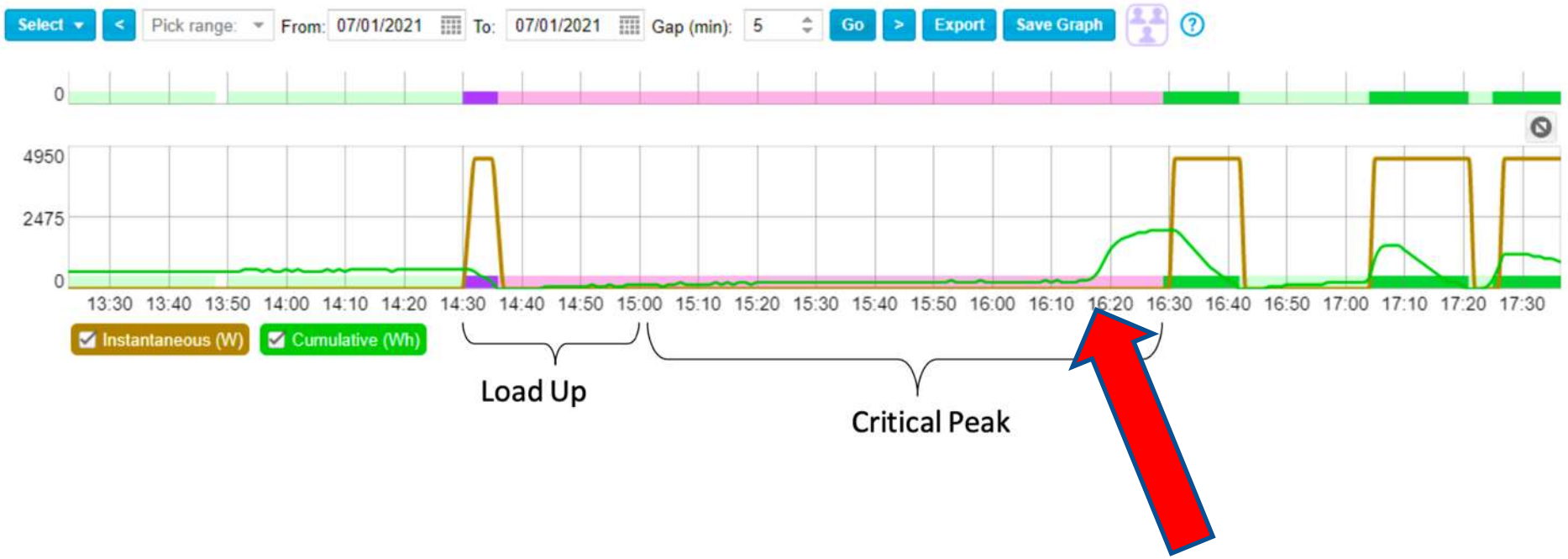
Color should be light purple when power is off during load up

Most common response
no power used during event

Water Heater Event Behavior



No power used during event but water was drawn

Water Heater Event Smart Behavior

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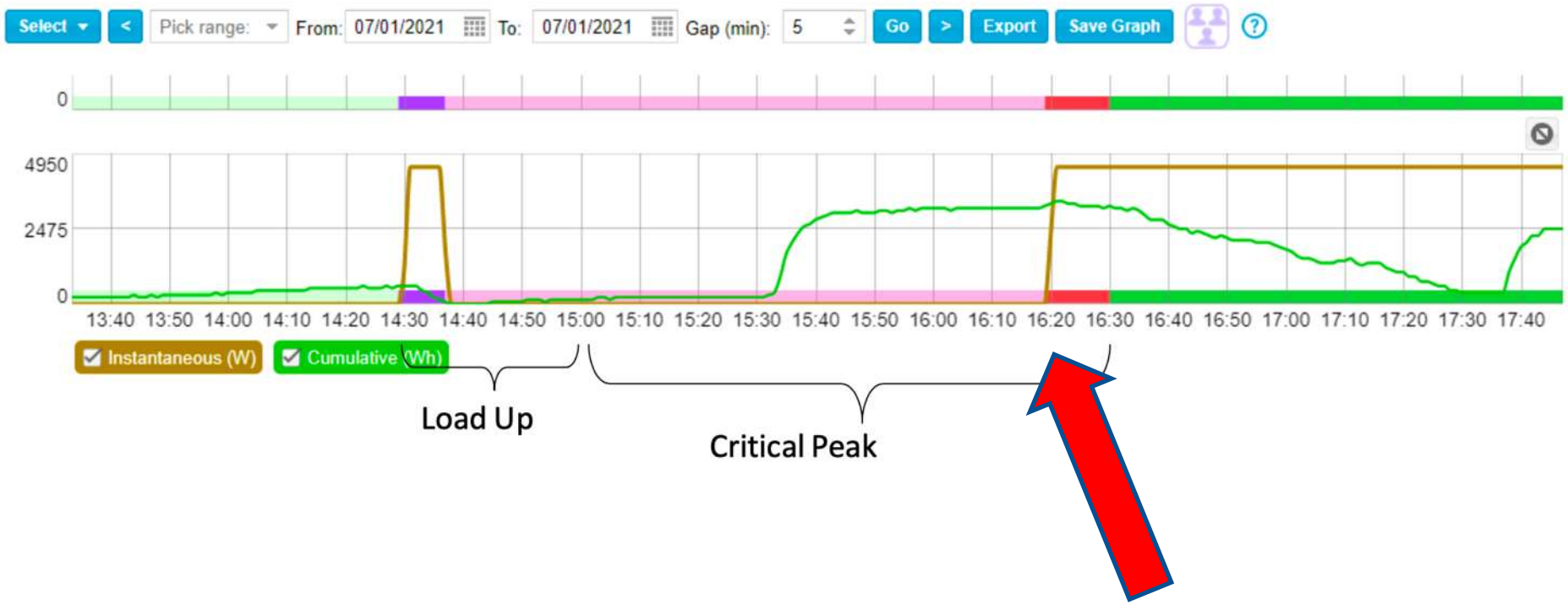
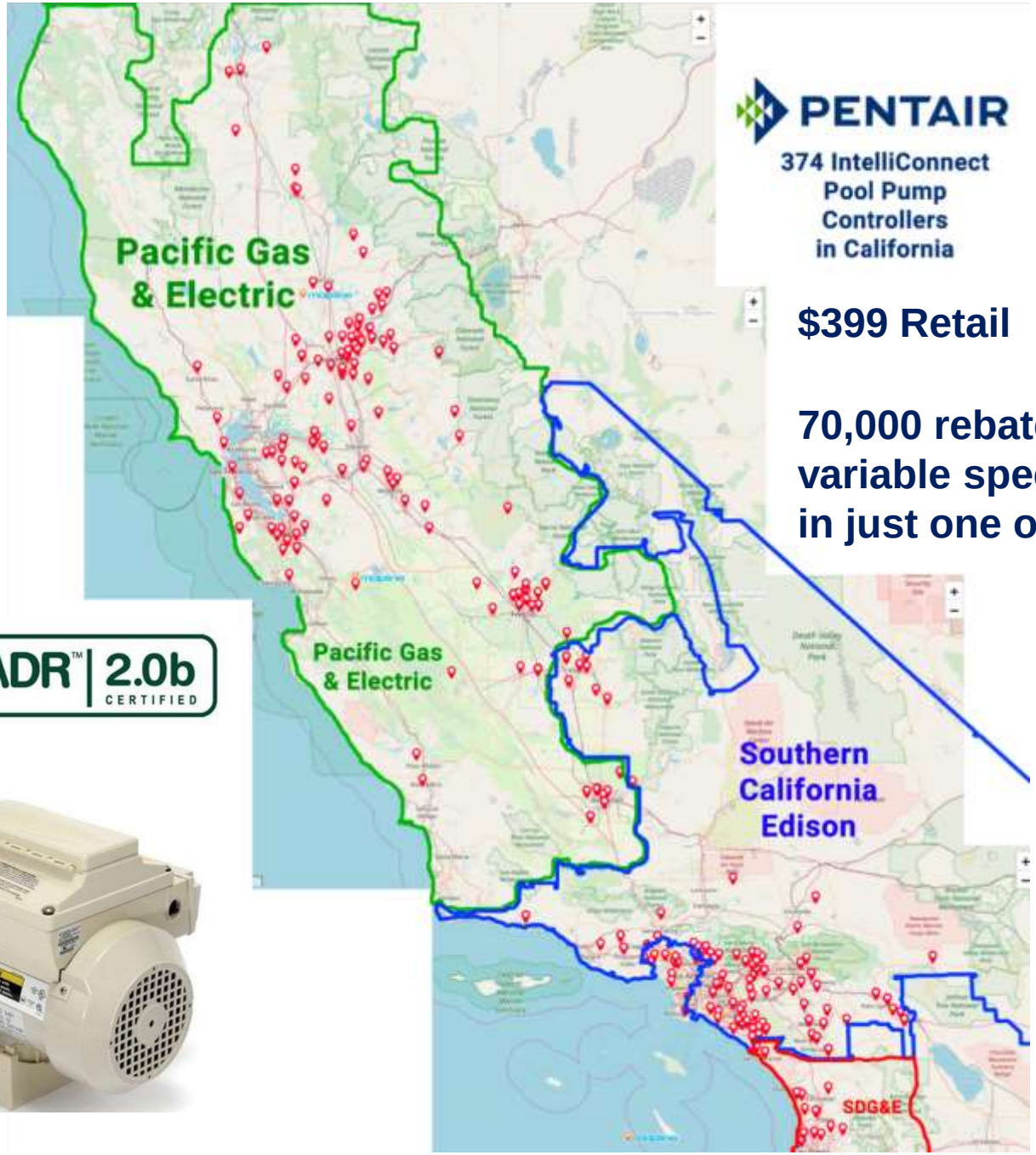


Power used near end of event to prevent cold water event

CTA-2045-B Level 2

1. **Grid signal choices -** 3 levels of shed, 2 levels of Load Up
2. **M&V –** power usage and storage capacity in both load ups
3. **Customer override –** 24-72 hrs with automatic return to grid control
4. **Advanced Load Up –** To comply and match with Title 24 JA13 which defines and Advanced Load Up function to load up more than the normal Load Up.
5. **Efficiency Recommendation –** To be able to change between Heat Pump only, Hybrid, etc.
6. **Prices to Devices –** Can accept 64 time/price pairs for 24 hour ahead smart planning
7. **Time of Use schedule formats** can be supported in the CTA-2045 module to support Title 24 JA13 for the OEMs that do not want to do it themselves, but do want to support CTA-2045.



PENTAIR

374 IntelliConnect Pool Pump Controllers in California

$399 Retail

70,000 rebated variable speed pool pumps in just one of these IOUs

openADR™ | 2.0b CERTIFIED

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Table 2-1
Pentair Power Level Chart

Power Level	Pump Speed [RPM]	Power Consumption [Watts]
80%	2400	1105
50%	1500	329
40%	1230	217
30%	900	134
20%	600	91
10%	600 (reached minimum RPM)	91

Variable Speed Pool Pump Event Behavior

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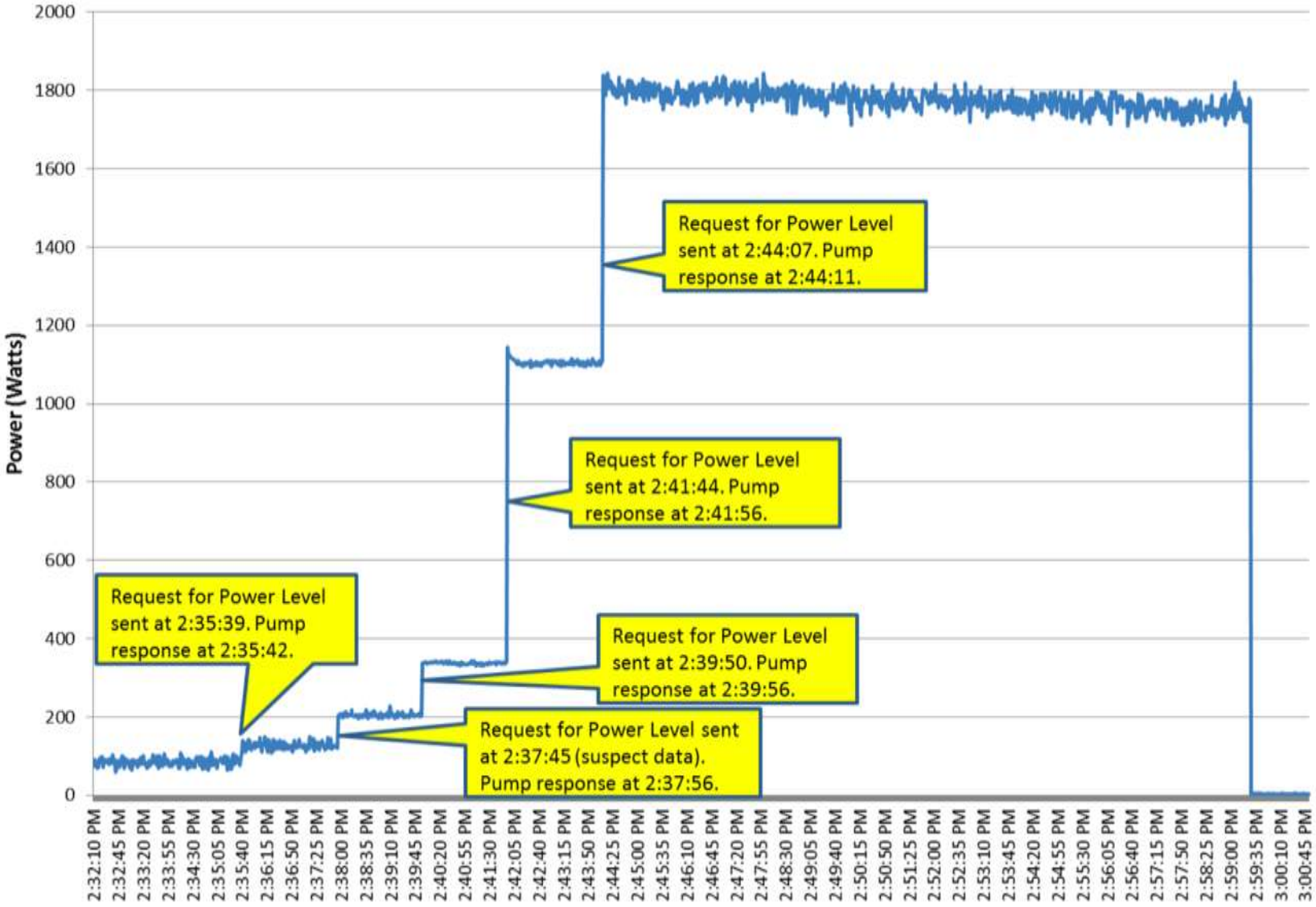
EcoPort Power Level signals sent to increase the speed 0-100%



Variable Speed Pool Pump Event Behavior

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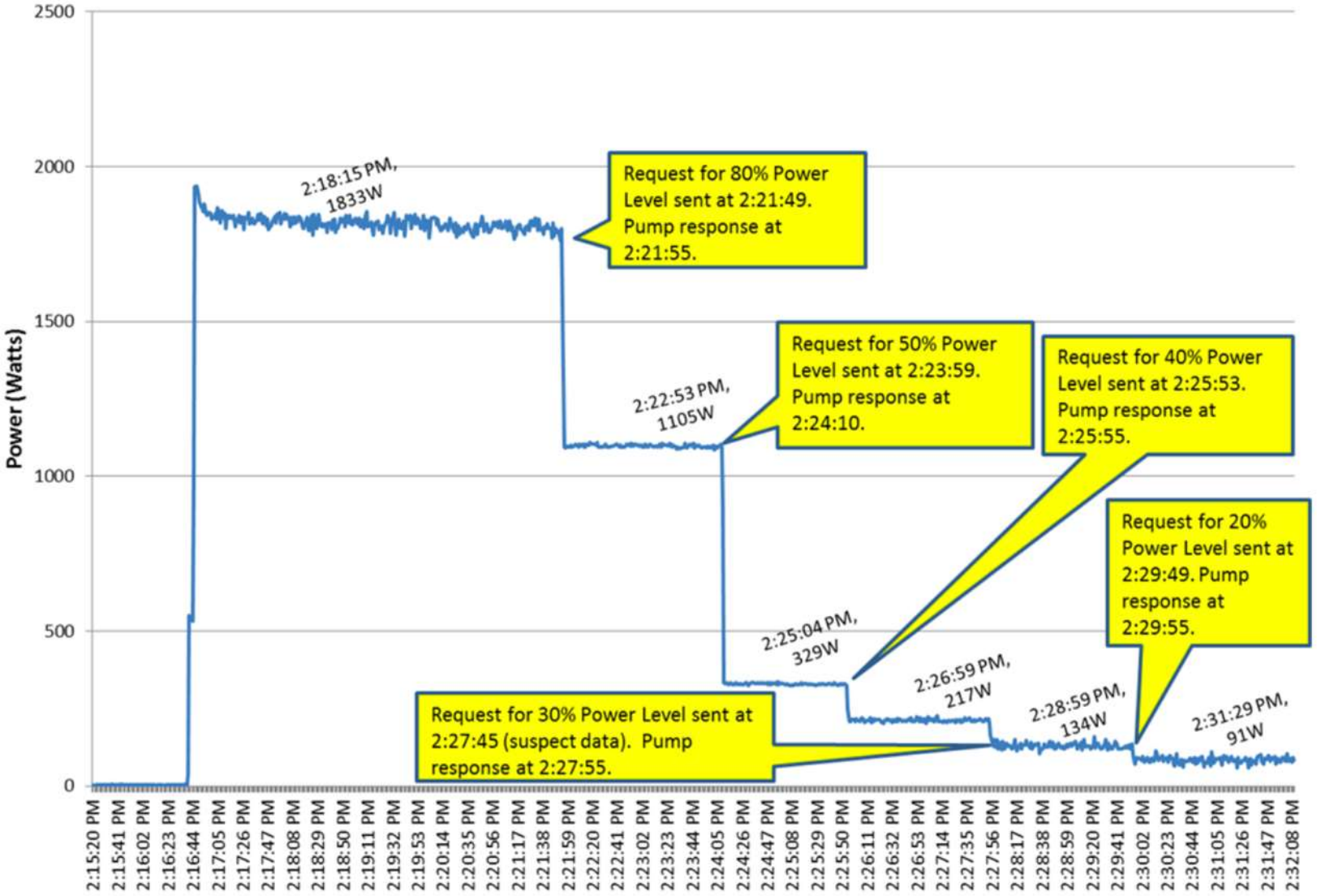
EcoPort Power Level signals sent to decrease the speed 0-100%



Pool Pump SMART Event Behavior

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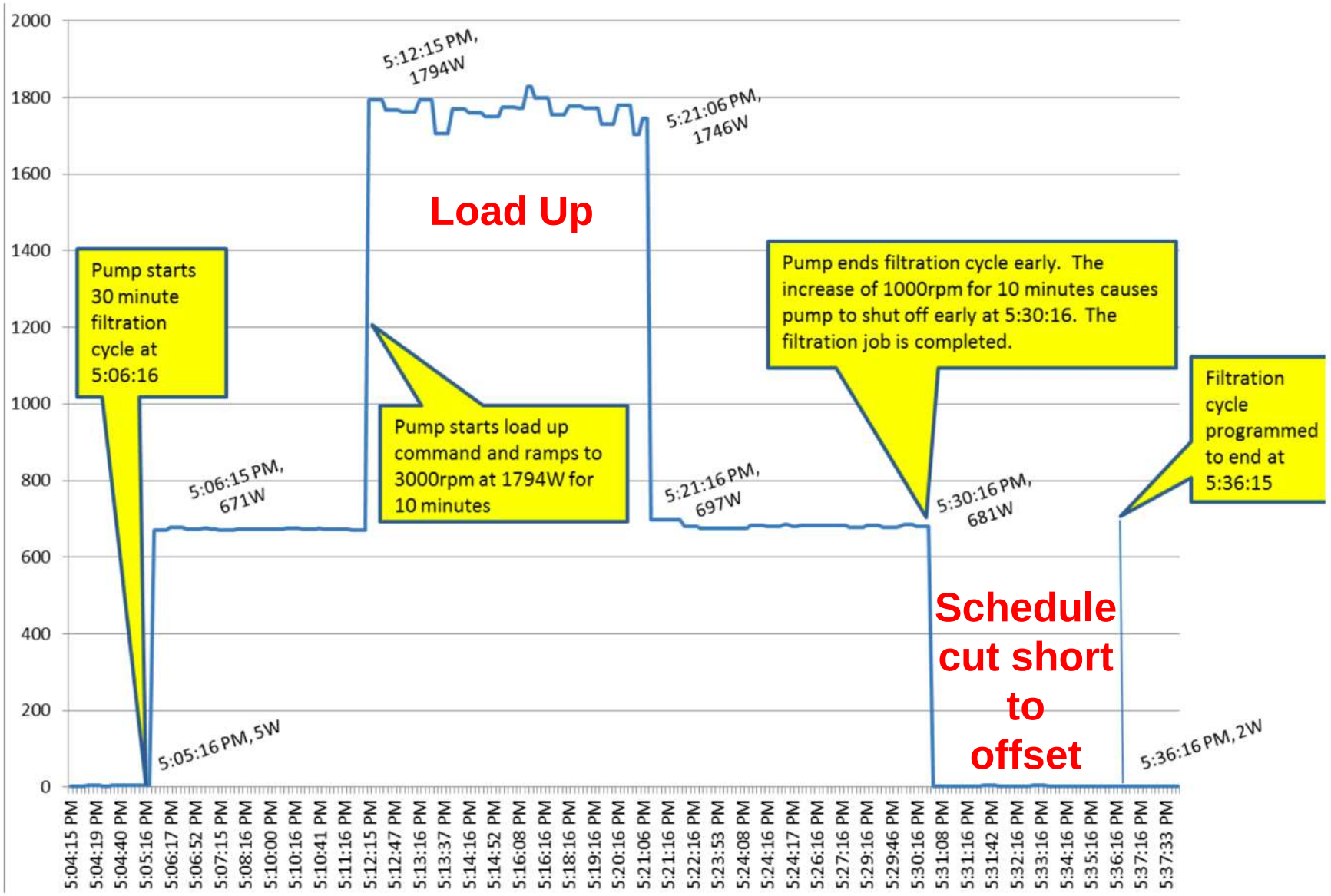

Pool Pump SMART Event Behavior

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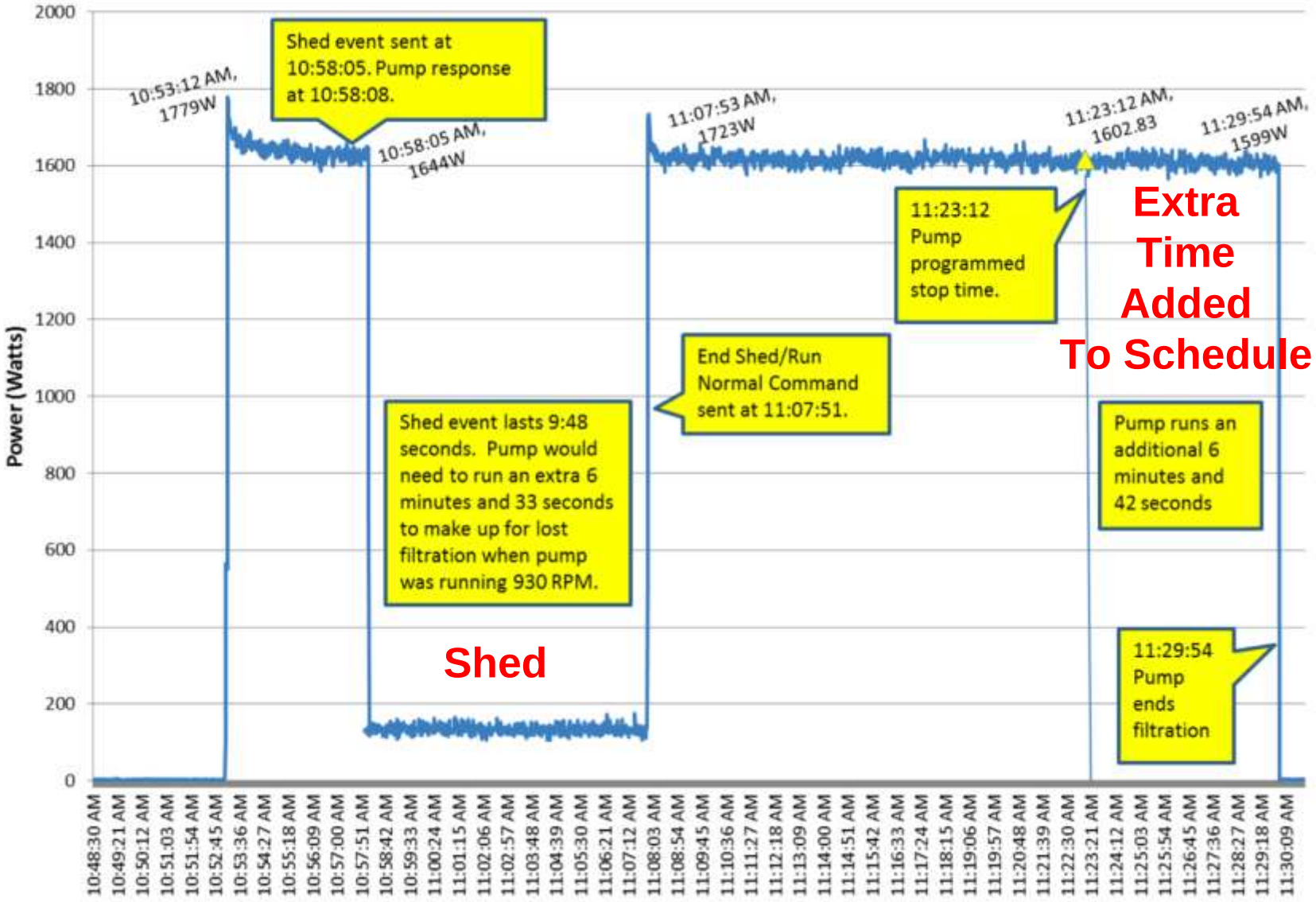

CTA-2045 EcoPort vs OpenADR

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What is the difference?

CTA-2045 EcoPort vs OpenADR

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What is the difference?

- Hardware Agnostic
- Hardware PORT

CTA-2045 EcoPort vs OpenADR

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What is the difference?

- Hardware Agnostic
- Only one comm path risk

- Hardware PORT
- Comm path options

CTA-2045 EcoPort vs OpenADR

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What is the difference?

- Hardware Agnostic
- Only one comm path risk
- Monopoly control risk

- Hardware PORT
- Comm path options
- Competition!

CTA-2045 EcoPort vs OpenADR

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What is the difference?

- Hardware Agnostic
- Only one comm path risk
- Monopoly control risk
- Needs annual SSL certificate

- Hardware PORT
- Comm path options
- Competition!
- OpenADR only when cost justified

CTA-2045 EcoPort vs OpenADR

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What is the difference?

Future Proofing Connectivity

openADR™ 2.0b CERTIFIED

ECOPORT

- Hardware Agnostic
- Only one comm path risk
- Monopoly control risk
- Needs annual SSL certificate

- Hardware PORT
- Comm path options
- Competition!
- OpenADR only when cost justified

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Overview
of
Relevant Policy Proceedings

Can the word ‘or’ be that bad?

ECOPORT

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The West Coast is leading with CTA-2045

- NEEA Advanced Water Heating Specification requires CTA 2045 on tier 3 and above
- Washington State (40-120gallons) under 12kW (SB1444)
  - HPWH January 2021
  - Electric Resistance January 2022
- Oregon (Executive Order 2020-04)
  - HPWH and Electric Resistance 2022
- California
  - Under review for T-24 and T-20 and incorporating
  - JA 13 points to AWHS 7.0 tier 3 or greater

Washington State passed a law:
all new water heaters must have the CTA-2045 EcoPort

RESULT

In 2022, hundreds of thousands of EcoPort water heaters will be made!

All water heater OEMs are putting in the port!

OpenADR can be put on the module, or on the module cloud when cost justified!

Can the water heater law go national?

NOT YET

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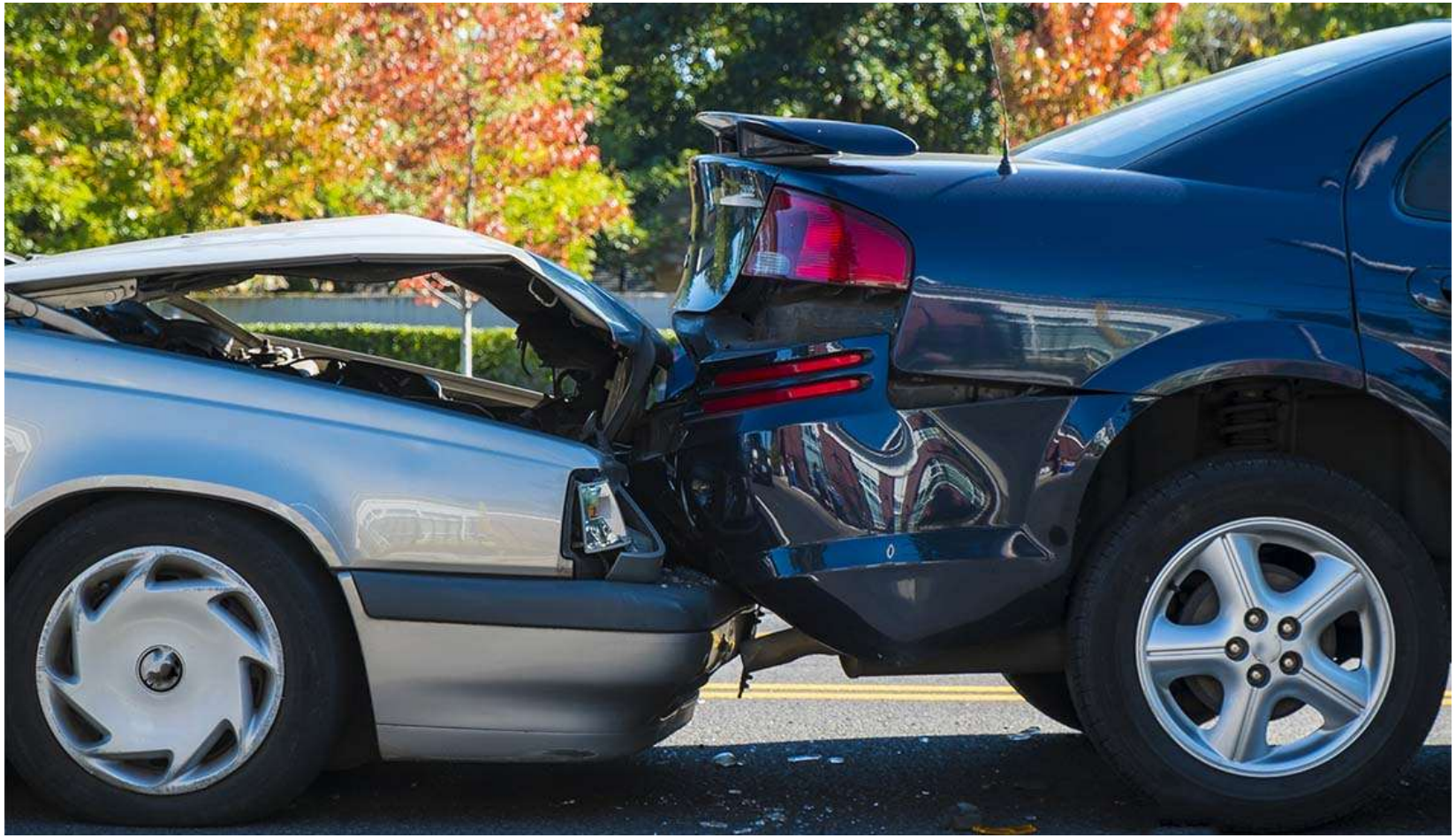

All because of the word ‘or’

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Energy Star Connected Device System Standard

You must have an open standard
at the edge of your ‘system’,
which can be:
the appliance,
the module on the appliance,
or the cloud.

ENERGY STAR

AHRI
AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

we make life better®

We will follow Energy Star

That effectively translates to:

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You can have openADR 2.0b CERTIFIED OR ECOPORT

AND

You can have it on the appliance OR in the cloud.

Any manufacturer given those options will choose:

- To make no hardware change (those are costly)

  Which means no EcoPort

- To have OpenADR in the cloud (to have monopoly access)

  Which means no competition

National Regulation Details

State	Regulation	Date of Implementation	Details
Energy Star	Connected Appliances	Pool Pumps Pentair IntelliConnect $399	OpenADR certified (through SkyCentrics), Energy Star Connected Device certified, CTA-2045 version Q4 2021
Energy Star	Connected Appliances	Water Heaters	Connected device specification in progress
AHRI	AHRI 1380	2021	DR-ready Variable Capacity HVAC systems rated to 65,000 Btu/hr or less shall have CTA-2045-A or OpenADR 2.0b or both.
AHRI	AHRI 1430	2021	Water Heater specification in line with Energy Star

Help Energy Star & AHRI get behind EcoPort

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	Regulation	Flexible Comm. Path	Fosters Competition	OEM Toll Booth is the only option
NEEA & T24 JA13	CTA-2045 EcoPort Required	YES	Yes guaranteed CTA-2045 EcoPort Option	NO
CEE	EcoPort required Local OpenADR ok	YES	Yes guaranteed CTA-2045 EcoPort Option	NO
Energy Star	EcoPort or OpenADR in cloud	NO	NO May not have a port	YES
AHRI	EcoPort or OpenADR in cloud	NO	NO May not have a port	YES

Every water heater OEM is putting in the PORT.
Energy Star and AHRI can help push the cart.

CTA-2045 EcoPort joins OpenADR

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No more confusion!

- OpenADR hosting CTA-2405 Qualified Product List on their website
- OpenADR hosting the CTA-2045 certification process

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Why Flexible Shiftable Loads?

What are they worth?

13M CA water heaters = $1B/yr or $10B/yr ?

$76 or $760 per year per water heater

A different grid is coming

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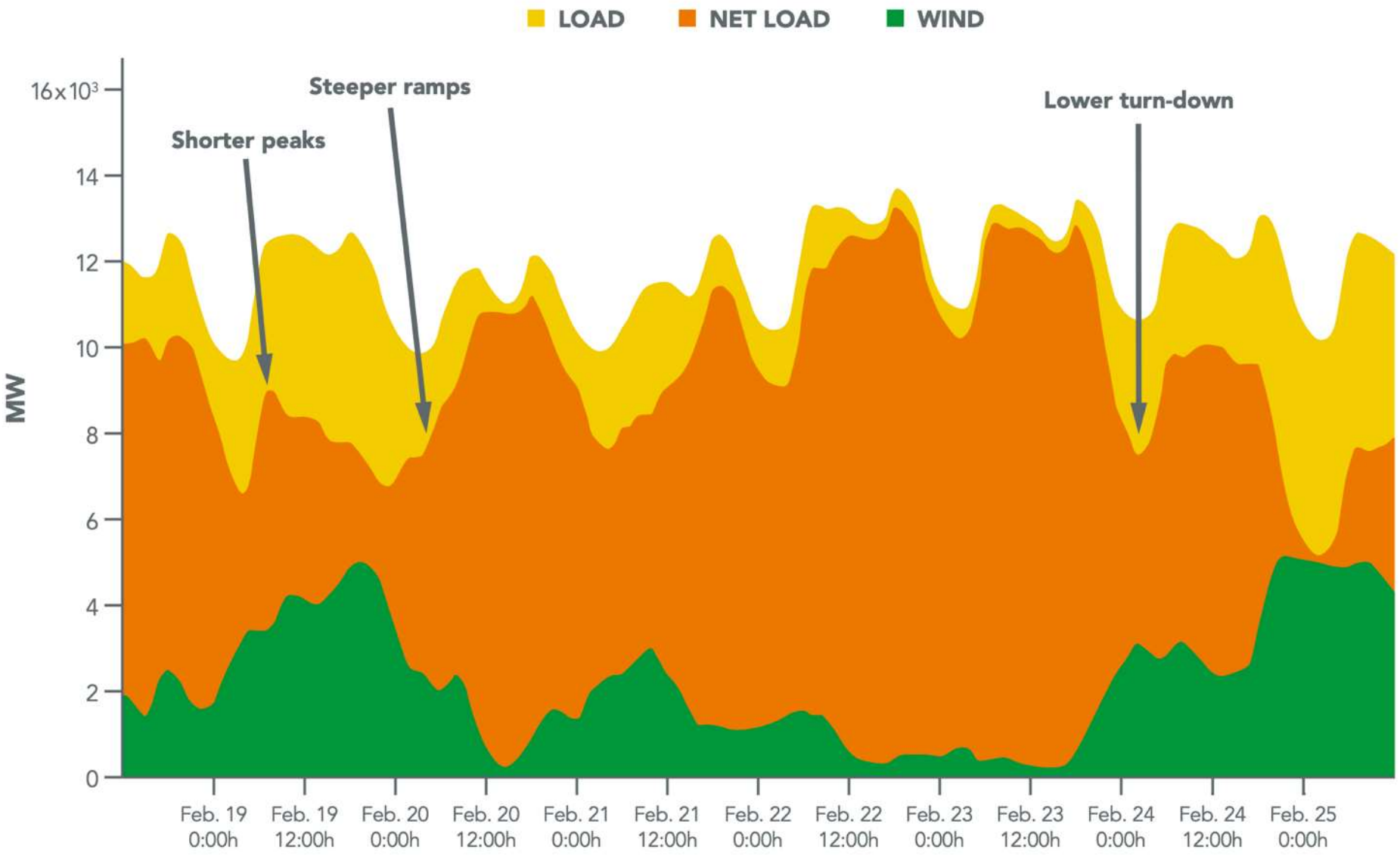

Source = Flexibility in 21st Century Power Systems, NREL - May 2014

Grid-Interactive Efficient Buildings (GEBs) could save up to $18 billion per year in power system costs by 2030, or roughly **$100 to $200 billion** between 2020 and 2040

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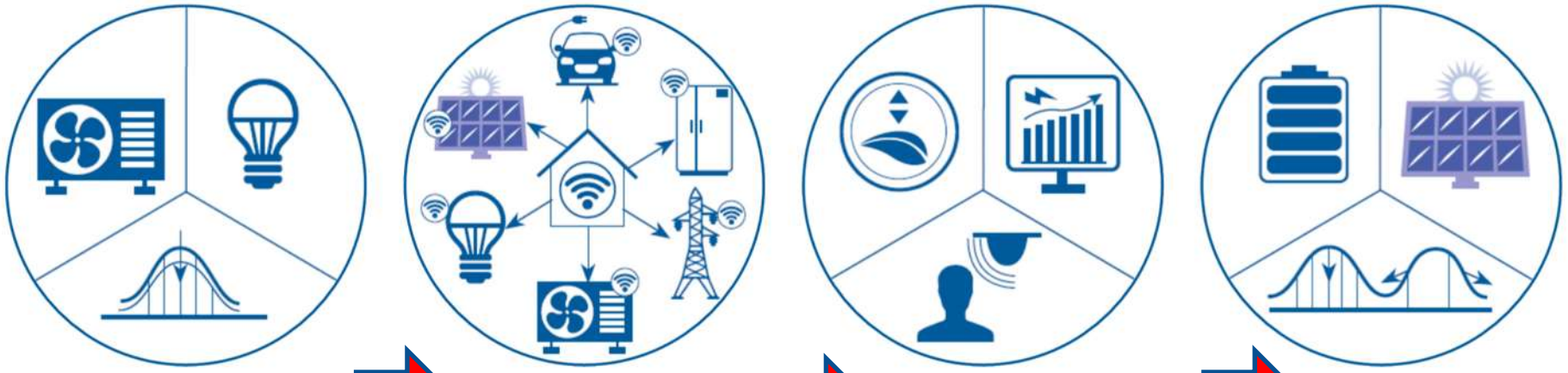
…but less than 2% of commercial buildings are connected!

GEBs are characterized by active, continuous, and integrated energy use



EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

Two-way communication with flexible technologies, the grid, and occupants

SMART

Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

FLEXIBLE

Flexible loads and distributed generation/ storage can be sued to reduce, shift, or modulate energy use

Figure source: Neukomm et al. (2019). Grid-interactive Efficient Buildings: Overview. US DOE Report.

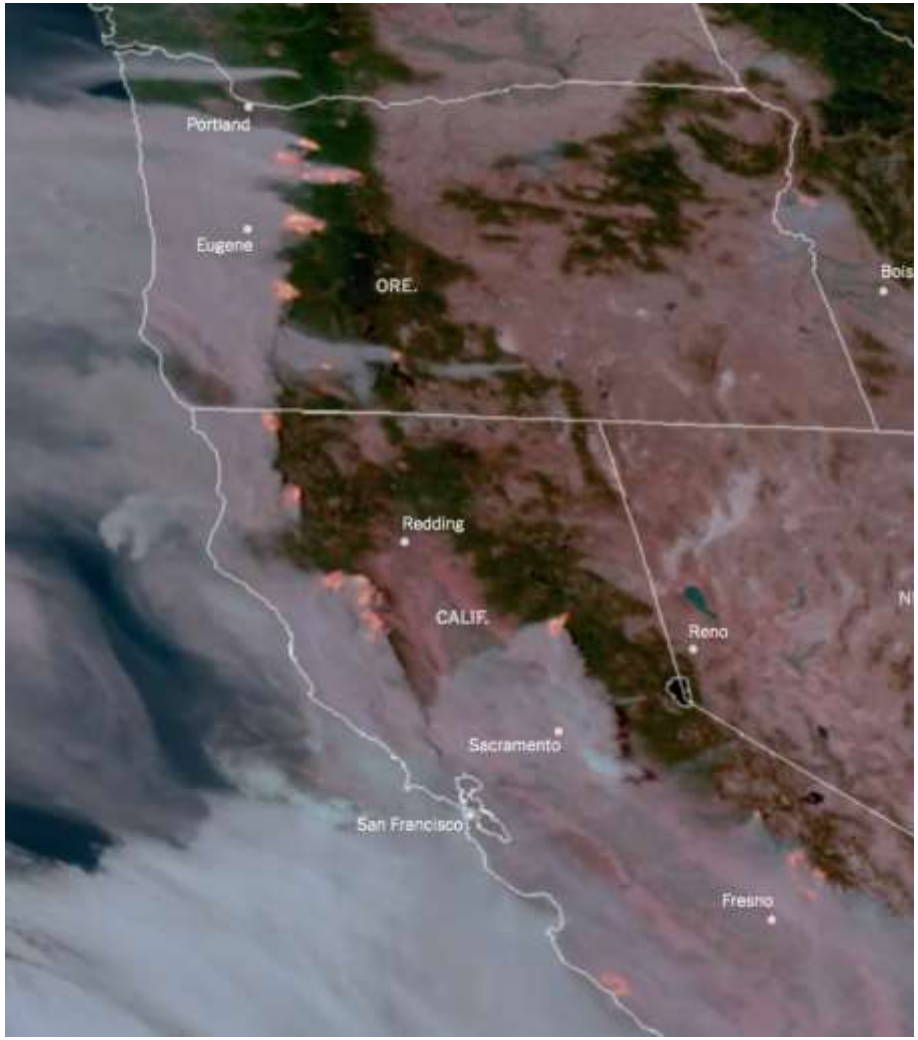
A National Roadmap for Grid-Interactive Efficient Buildings 3

Source = A National Roadmap for Grid-Interactive Efficient Buildings - gebroadmap.lbl.gov

Grid problems are multiplying

We need a grid that just works better

- More reliable
- More resilient
- With more renewables
- Emitting less carbon



Source = Flexibility in 21st Century Power Systems, NREL - May 2014

Aug' 19 CO2 mapped onto CA ISO Net Demand

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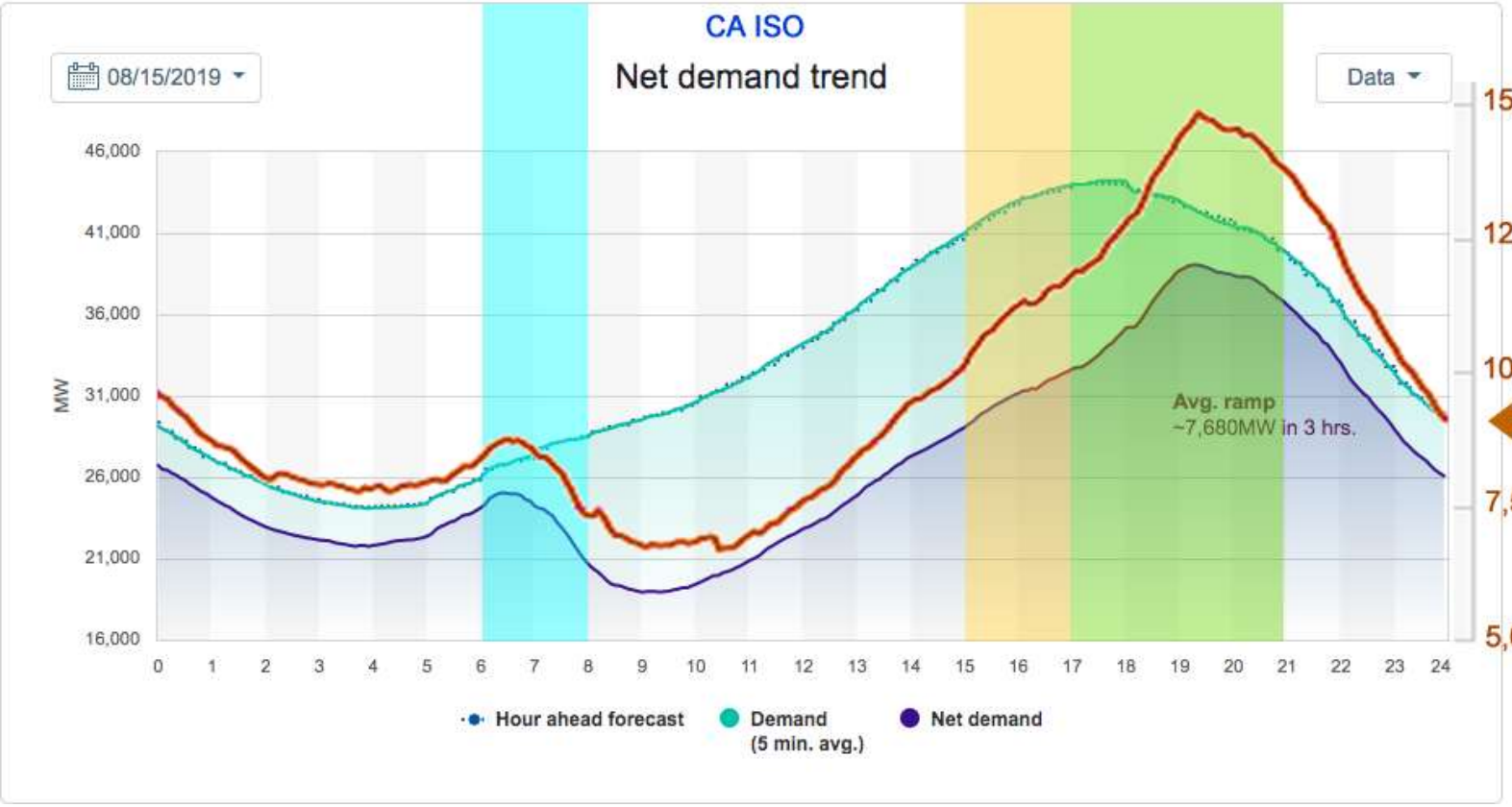
Net demand (demand minus solar and wind) AS OF 15:20

This graph illustrates how the ISO meets demand while managing the quickly changing ramp rates of variable energy resources, such as solar and wind. Learn how the ISO maintains reliability while maximizing clean energy sources.



15,000
12,500
mTCO2/h
10,000
Aug 15, 2019
7,500
5,000

6-8 am
5-9 pm
3-5 pm

Note how the CO2 curve matches the Net Demand Curve

Business case for connected heat pumps

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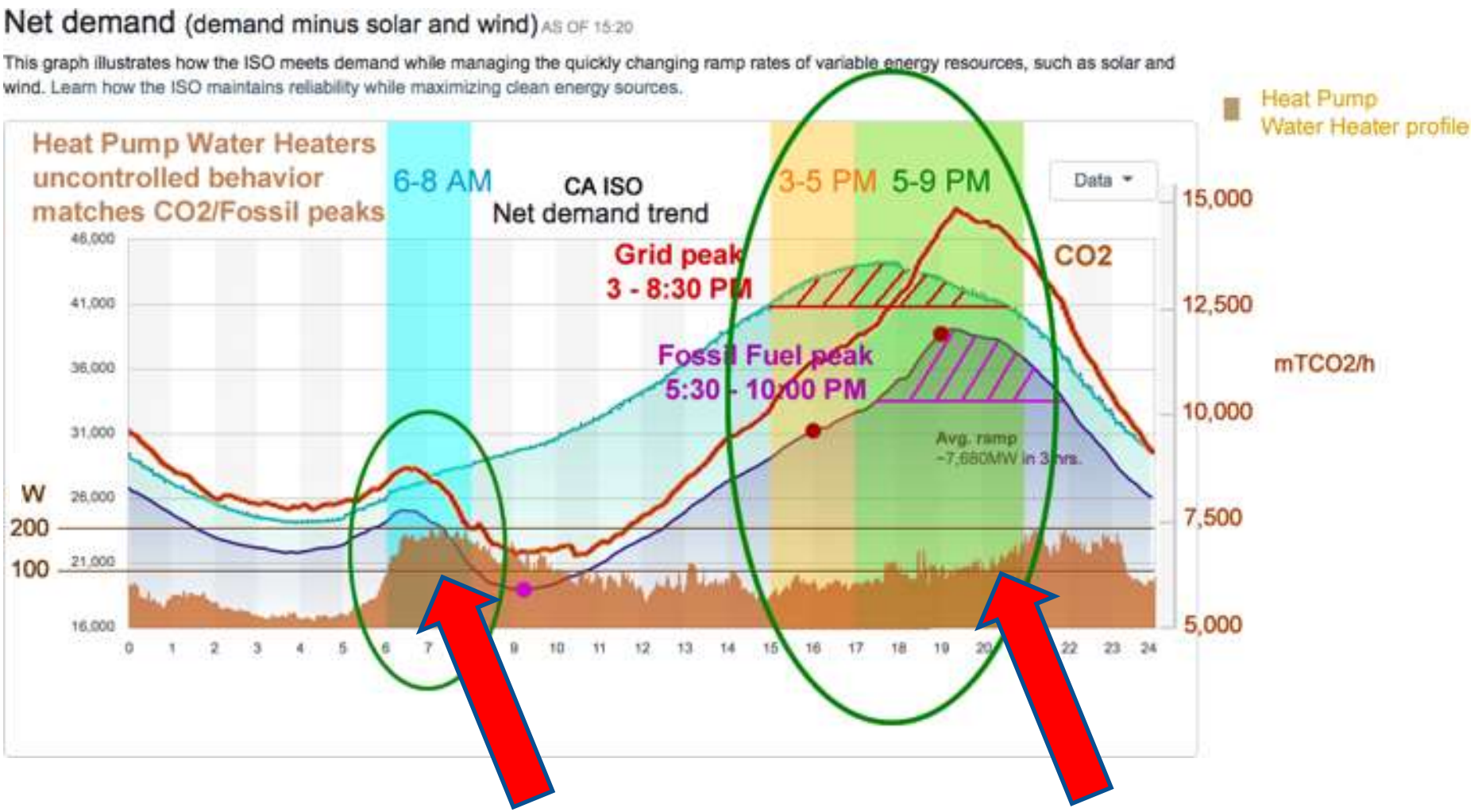

Note how the water heater peaks match the grid peaks.

Shed, Shift, Shape, and Shimmy

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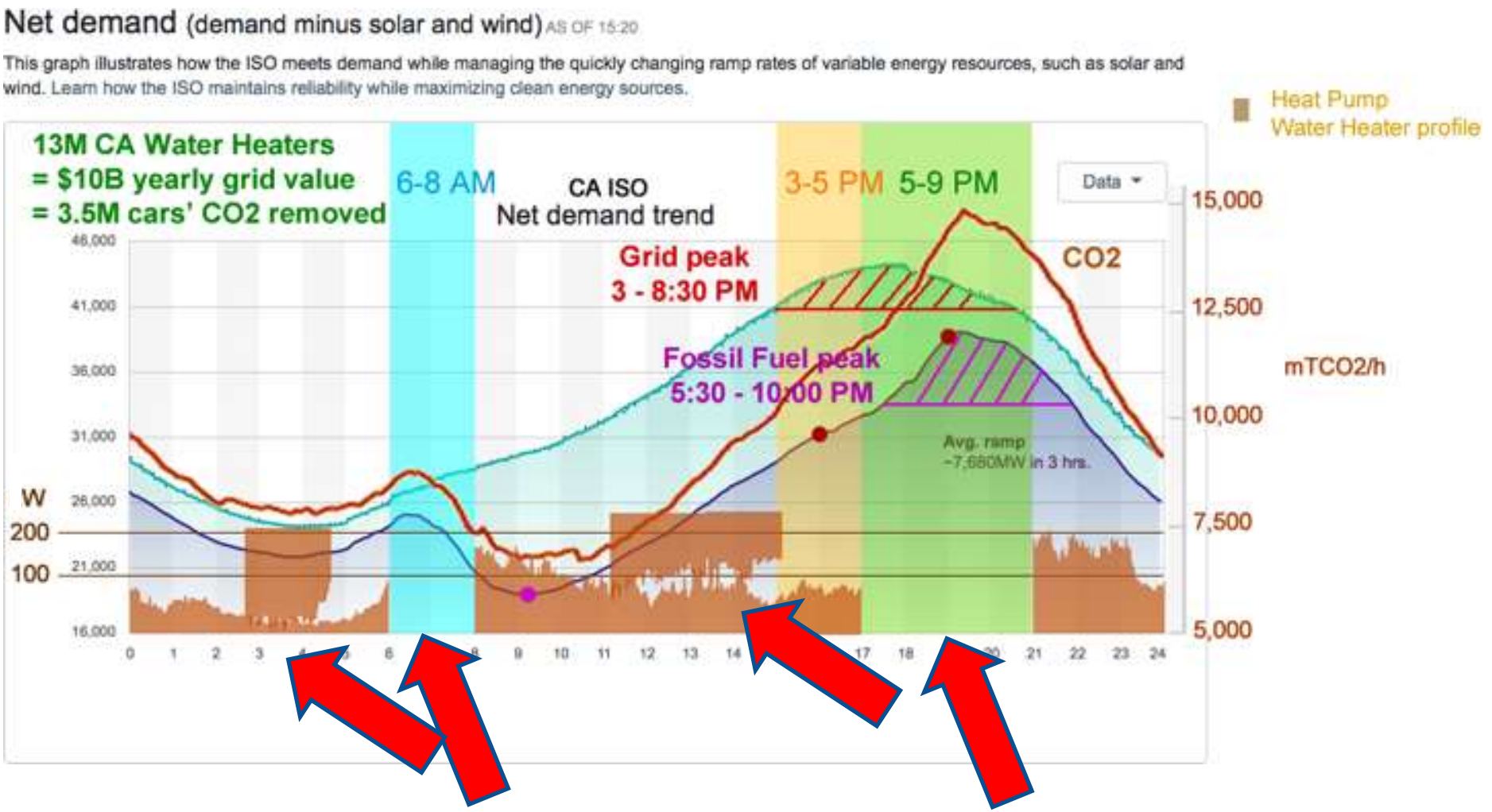

You can get almost 100% of the load shifted to a better time.

Josh Butzbaugh, PNNL – Load Reduction*

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Table 10. Forecasted Peak Load Reduction (Megawatts) by Hour for Winter Mornings for DEF

	Average Megawatts				
	6–7 a.m.	**7–8 a.m.**	**8–9 a.m.**	**9–10 a.m.**	**Hourly Average**
Connected ERWH	172	184	196	172	181
HPWH	142	151	186	243	180
Connected HPWH	206	262	289	319	269

Table 11. Forecasted Peak Load Reduction (Megawatts) by Hour for Summer Evenings fo[illegible]F

	Average Megawatts					
	5–6 p.m.	**6–7 p.m.**	**7–8 p.m.**	**8–9 p.m.**	**9–10 p.m.**	**Hourly Average**
Connected ERWH	149	159	136	143	110	140
HPWH	138	160	153	152	156	152
Connected HPWH	163	190	187	182	191	183

* We Just Want to Pump... You Up! Forecasting Grid-Connected Heat Pump Water Heater Energy Savings
and Load Shifting Potential for the Southeast U.S.
- Joshua Butzbaugh and David Winiarski, Pacific Northwest National Laboratory

Interpreting the value of water heaters to grid

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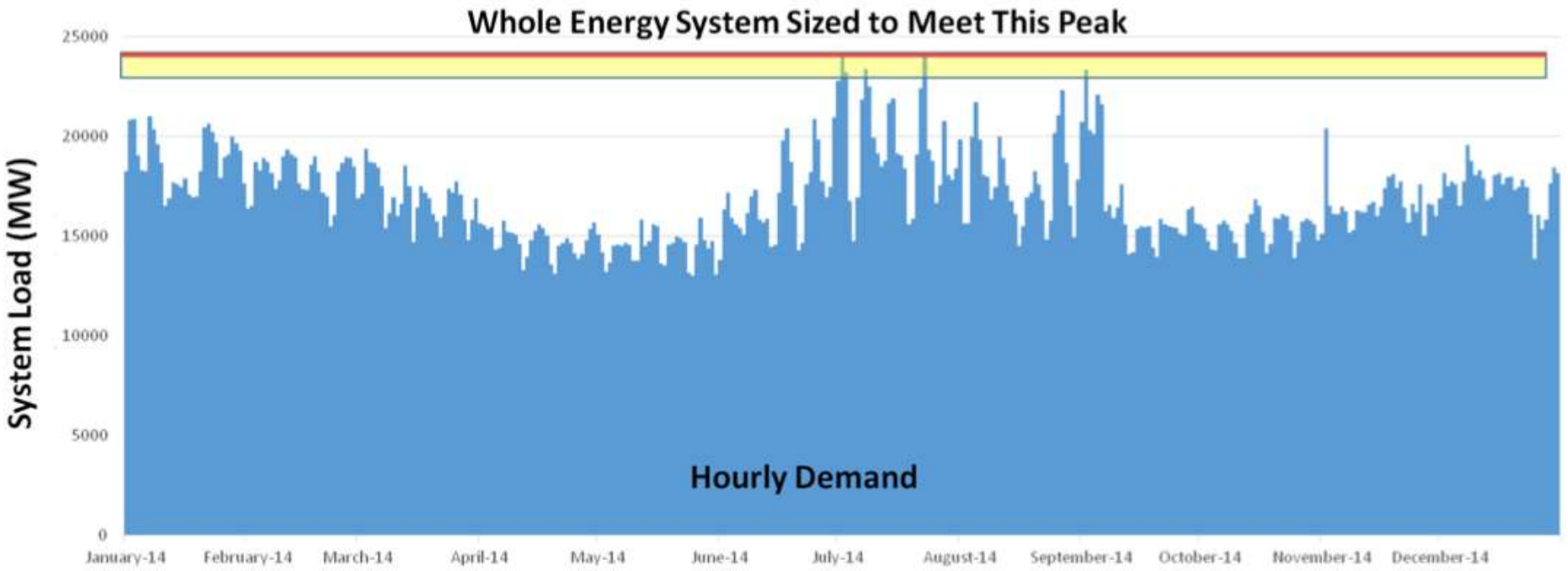

Figure 2: The whole electricity system is sized to meet peak demand

"Over the last three years from 2013 – 2015 on average, the top 1% most expensive hours accounted for 8% ($680 million) of Massachusetts ratepayers' annual spend on electricity. The top 10% of hours during these years, on average, accounted for 40% of annual electricity spend, over $3B [per year]."

- State of Charge - Massachusetts Energy Storage Initiative Study

Detailed Value of Water Heaters to grid

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CA annual spend is about 5x MA

If the numbers are similar, then:

The top 1% most expensive hours would account for 5 x $680M = $3.4B

The top 10% of hours would account for 5 x $3B = $15B

13M managed heat pump water heaters could shave 3.3% off of the peak every day.

Using the 1% number, we get a value of 3.3 x $3.4B = $11B annually

Using the 10% number, we get a value of 6 x ($15B/10) = $5B annually

The only problem is CA's water heaters are gas.
Let's get busy making them electric!

The value of grid connected water heaters

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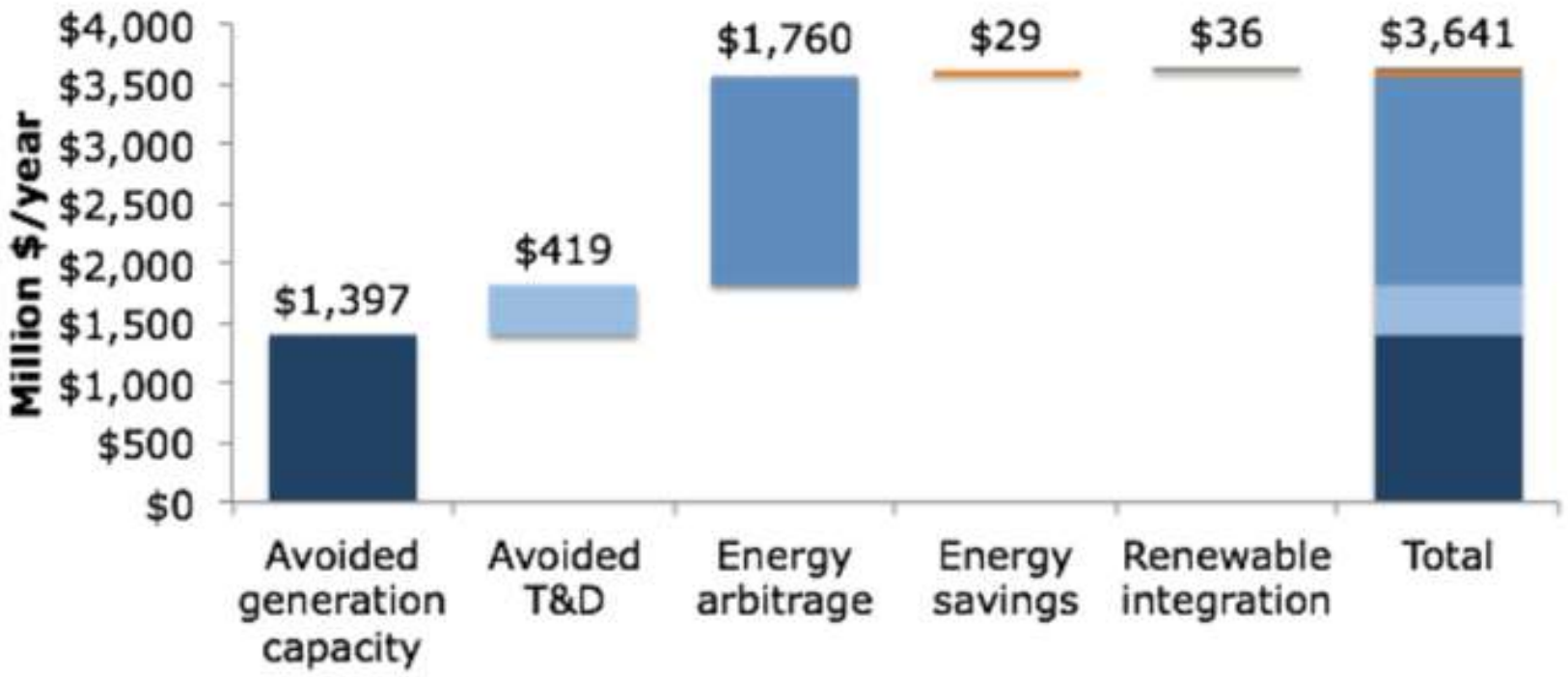

$3.6 billion/year in value from a grid-interactive fleet of water heaters. Source: RMI.

Based on 50M US water heaters = $72/year/water heater, but up to $200

CA 13M water heaters = $936 million/year in value (minimum)

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In Summary

13M CA water heaters = $1B/yr and maybe $10B/yr

$76 or up to $760 per year per water heater

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The next big choice

Time of Use 6 month schedule changes (Connectible)

vs

Daily or real time schedule changes (Connected)

Four choices of water heater scheduling

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	Schedule Type	Pro-Con	Cost
	Unscheduled	Energy Efficiency Only	-
	TOU – changes every 6 months	Misses daily, weekly, and monthly variability	JA13 – built in to water heater
	Daily changes	Can match daily variability	Low cost cellular add on
	Real Time changes	Needed for the 3 months of DR or Fire season	Low cost cellular add on x 2

JA13 solution uses a battery that is rated for 3 months without power for the lull between construction and sale of the home. What if that battery dies at some later time?

The water heater will instantly and randomly have the wrong time, and may come on at the worst time!

12 months of CA ISO CO2 emissions variations

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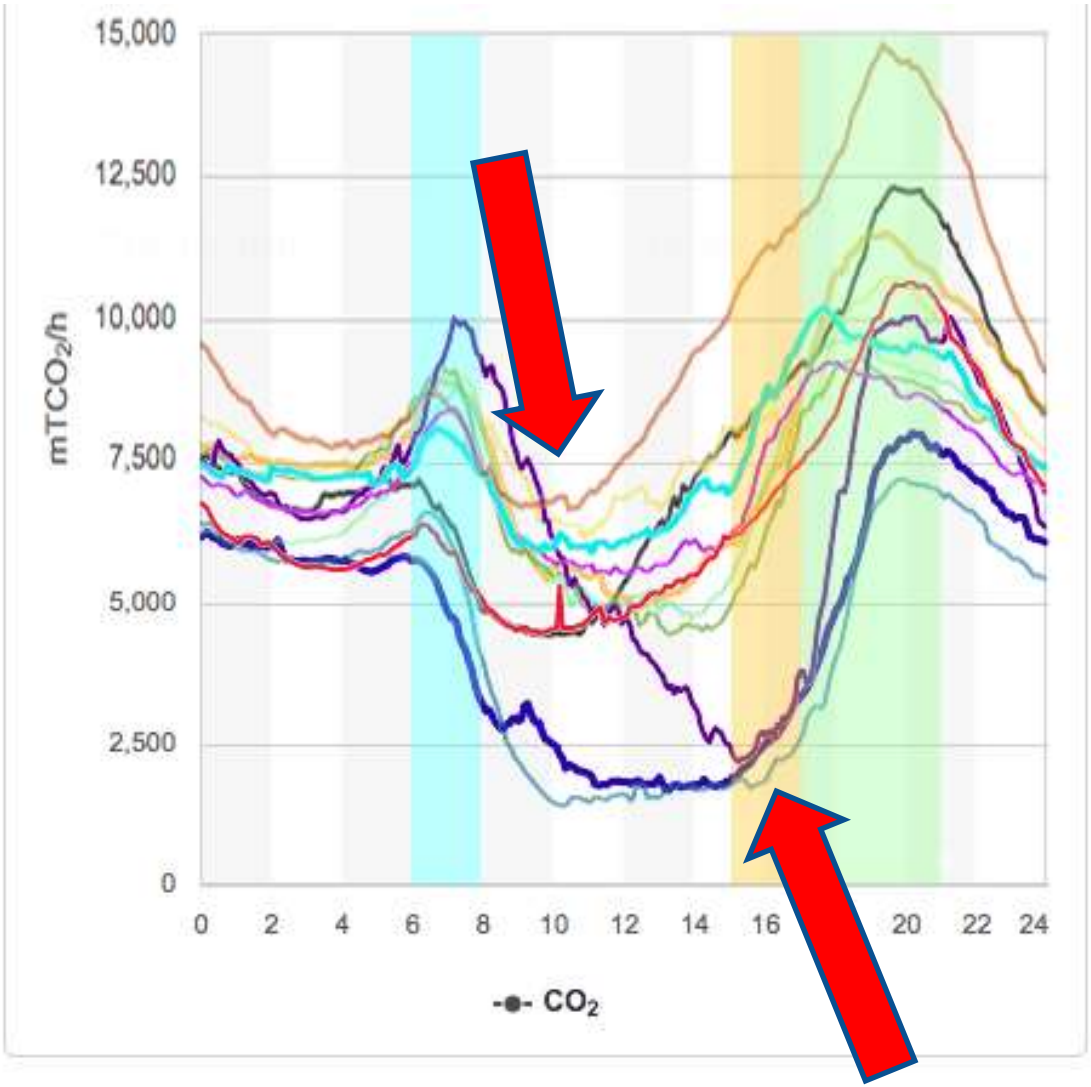

Jun 10, 2020
May 15, 2020
Apr 15, 2020
Mar 13, 2020
Feb 14, 2020
Jan 15, 2020
Dec 13, 2019
Nov 15, 2019
Oct 15, 2019
Sep 16, 2019
Aug 15, 2019
Jul 15, 2019

6-8 am
5-9 pm
3-5 pm

http://www.caiso.com/TodaysOutlook/Pages/Emissions.aspx

CA ISO daily variations – Time of Use is blunt

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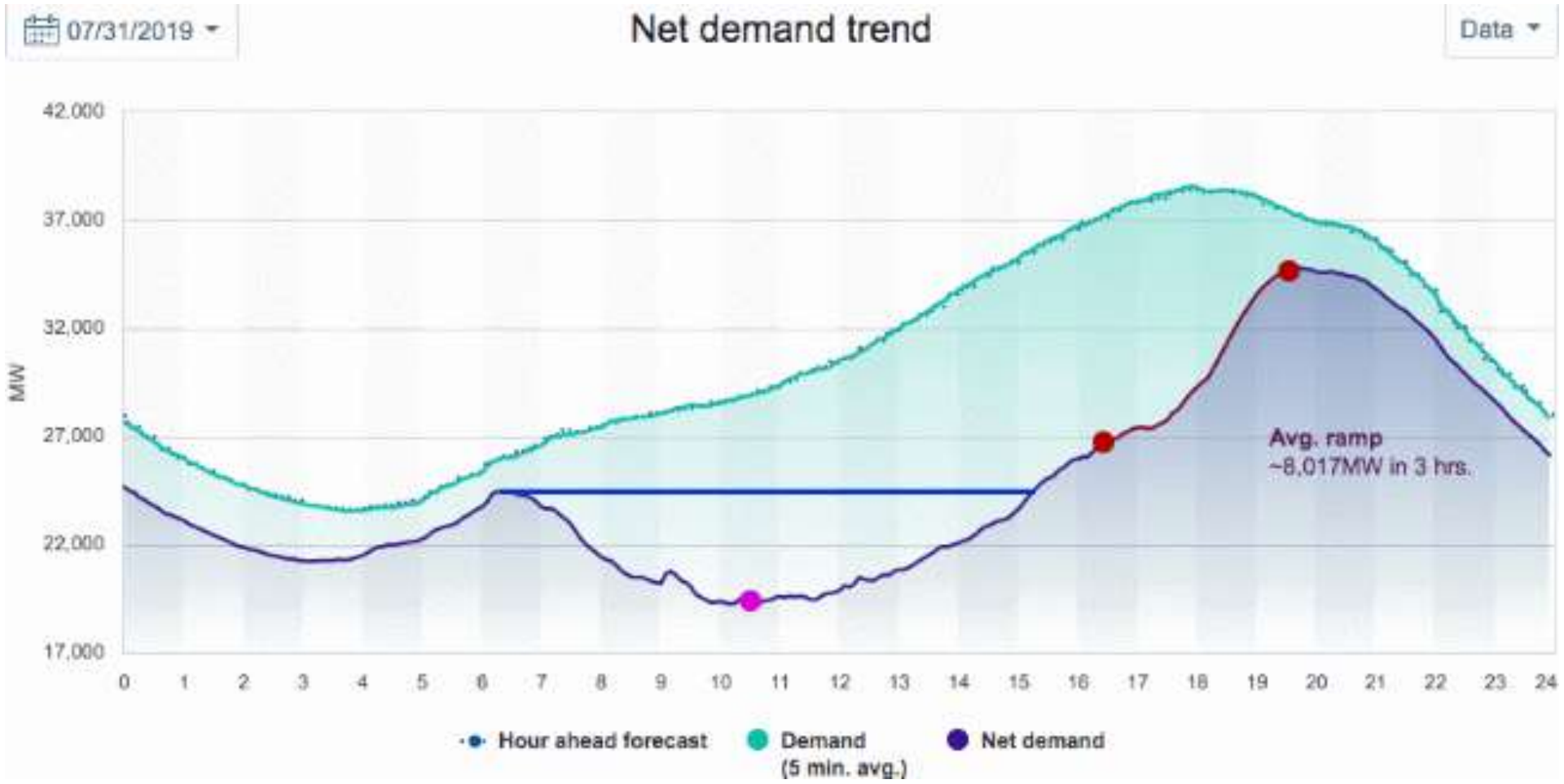
Daily schedule adjustments 2-5x more valuable than TOU
- Pierre Delforge (NRDC), Owen Howlett (SMUD)



SDG&E feeder mis-alignment

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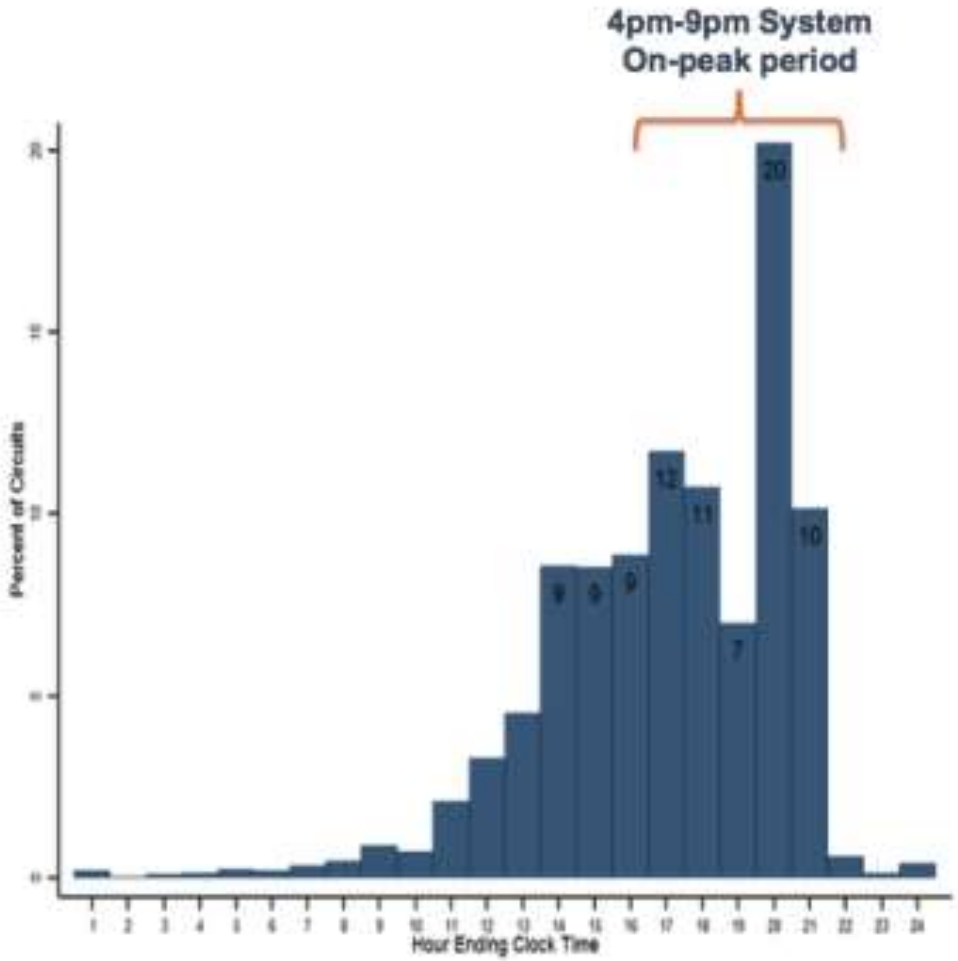
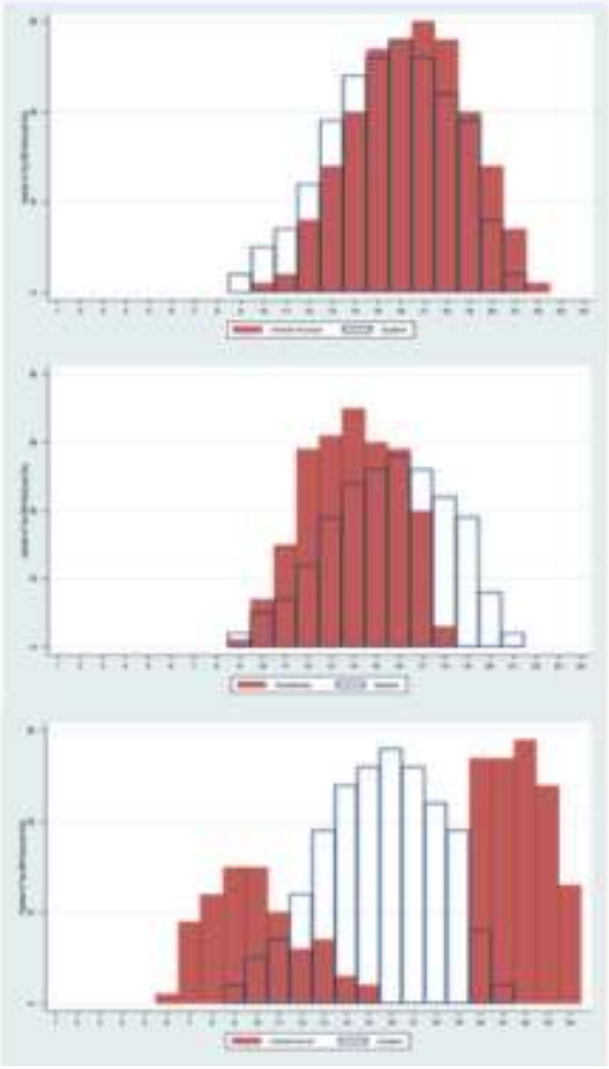
The timing of circuit peaks may not align with system peak





Do you believe that CONNECTED is more valuable than CONNECTIBLE?

- What about variations introduced by fire season?
- Biden Administration releases "A National Roadmap for Grid Interactive Buildings (GEBs) – a $200B value"

You have two choices on time of install

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	When to Install	Pro-con	Cost
CONNECTED	At Purchase	Get every water heater	Hardware cost
CONNECTIBLE	Later through the mail with a marketing campaign	Get only 10%?	Hardware cost + Marketing campaign

What if we don't install the connectivity at time of purchase

and the difference in value of connected is $1B/yr?
Or $5B/yr?
Will it be a big mistake?

Overview of Incentives & Market Transformation

13.5M CA water heaters are gas

The CEC wants them to be Heat Pump Electric

California Incentives

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Cost	Incentive Layer	Program	Incentives For:	Potential Incentive Amount	Benefit Claim (% of Share)
Smart Controls $400	4	ESP&IP	Smart Controls Only	$300?	• Peak Demand Reduction • GHG Reduction
Labor $700-$1,000	3	SGIP	Equipment and Labor	$1,700?	• Peak Demand Reduction • GHG Reduction
Wiring $300-$1,000	2	TECH Pilot	Equipment, Labor, and Panel Upgrade	$2,500?	• GHG Reduction
Panel Upgrade $3,000-$4,000					
50G HPWH $1,500	1	Energy Efficiency	Equipment	$500?	• Energy Efficiency Savings • GHG Reduction

$6,000 Total Installed Cost

Potential Incentives <= $5,000

Customer Installed Cost after Incentives >= $1,000

California Incentives

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Cost	Incentive Layer	Program	Incentives For:	Potential Incentive Amount	Benefit Claim (% of Share)
Smart Controls $400	4	ESP&IP	Smart Controls Only	$300?	• Peak Demand Reduction • GHG Reduction
Labor $700-$1,000	3	SGIP	Equipment and Labor	$1,700?	• Peak Demand Reduction • GHG Reduction
Wiring $300-$1,000	2	TECH Pilot	Equipment, Labor, and Panel Upgrade	$2,500?	• GHG Reduction
Panel Upgrade $3,000-$4,000					
50G HPWH $1,500	1	Energy Efficiency	Equipment	$500?	• Energy Efficiency Savings • GHG Reduction

$6,000 Total Installed Cost

Potential Incentives <= $5,000

Customer Installed Cost after Incentives >= $1,000

Cellular + 10 years of connectivity is less than $400 !

Status of CA incentives – Multi-Family

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Cost	Incentive Layer	Program	Incentives For:	Potential Incentive Amount	Benefit Claim (% of Share)
Battery $8,000	3	ESP&IP (New Homes Energy Storage Pilot)	Battery Storage	$7,650?	• Peak Demand Reduction • GHG Reduction
Smart Controls $400		ESP&IP	HPWH Smart Controls Only	$300?	
HPWH $1,120 HPSH $620 Dryer $820 Cooking $1,800	2	BUILD Pilot	Above EE Emissions Reductions	$1,000?	• GHG Reduction
	1	Energy Efficiency	Above Code Equipment Efficiency	$1,000?	• Energy Efficiency Savings
Development Costs $1,595	0	SCE Clean Energy Homes	To Code	$1,595?	• Bill Savings • GHG Reduction

$14,355 Total Installed Cost

Potential Incentives <= $11,545

Customer Installed Cost After Incentives >= $2,810

Hawaii is providing $2,000 per water heater in Multi-Family developments…

SkyCentrics

…if the water heater can be

shown to be controllable

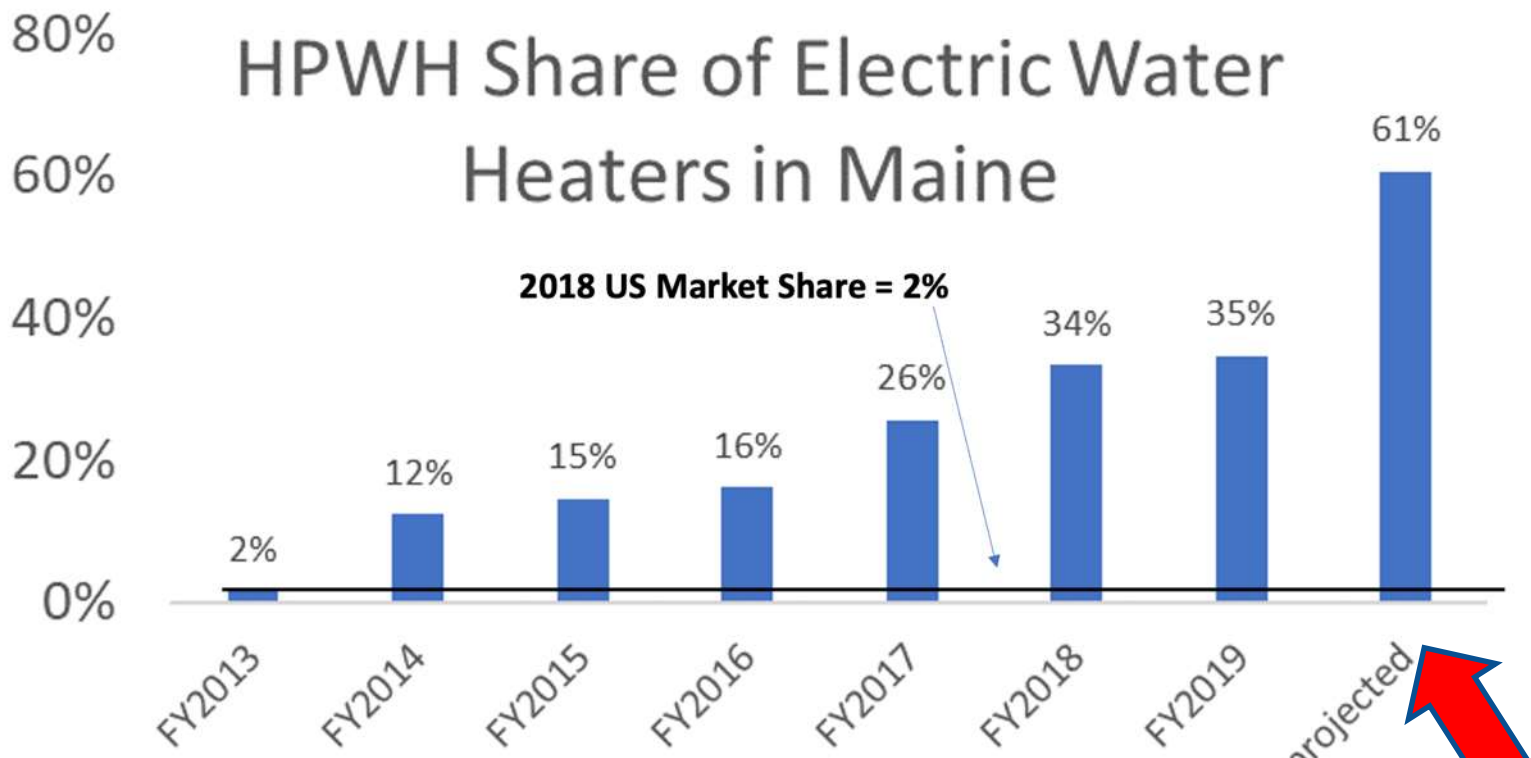
by a solar array.

That carport has a direct link to controlling 140 water heaters.

MAINE has cracked the code

SkyCentrics

Maine Retail/Distributor Results



efficiency MAINE

- 2018 Energy Star® Market Penetration Report was 2%
- 25,000 HPWHs rebated in Maine

60% of new water heaters in Maine are Heat Pump

Distributor Program

- Per MOU with distributors, for installation data Efficiency Maine pays:
  - $750 per unit sold (any price)
  - $50 administrative fee
  - $100 additional if sell <=$250
- Eligibility = ENERGY STAR®, residential/commercial
- Efficiency Maine reps visit weekly

FW Webb Oakland, ME

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Retail Program

- $750 mail-in rebate
- ENERGY STAR®
- Residential or commercial
- In-store or on-line purchases
- Any installer including self-install
- Field reps visit big box stores weekly

efficiency MAINE

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Messaging

Right to compete

- Tens of thousands installed in Maine
- Produce lots of hot water

Right to win

- Lowest price

Bonus features

- Can save more than $3,000 over 10-year life
- Help to dehumidify

NOT: new, exciting, different, unproven (cold showers)

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All that success…..AND….

They are not connected,

or even connectible :(

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How Fast Can Humanity Go?

Will we ever be able to move beyond ‘First Costs’ to lifetime Total Cost of Operation?

Rapid Change Can Happen

SkyCentrics

ONLY BY MAKING THESE MACHINES THE MOST AFFORDABLE CAN WE SUCCEED.

1900. 100's of horses, 1 car.

1913. 100's of cars, 1 horse.

Rapid Change Can Happen

SkyCentrics

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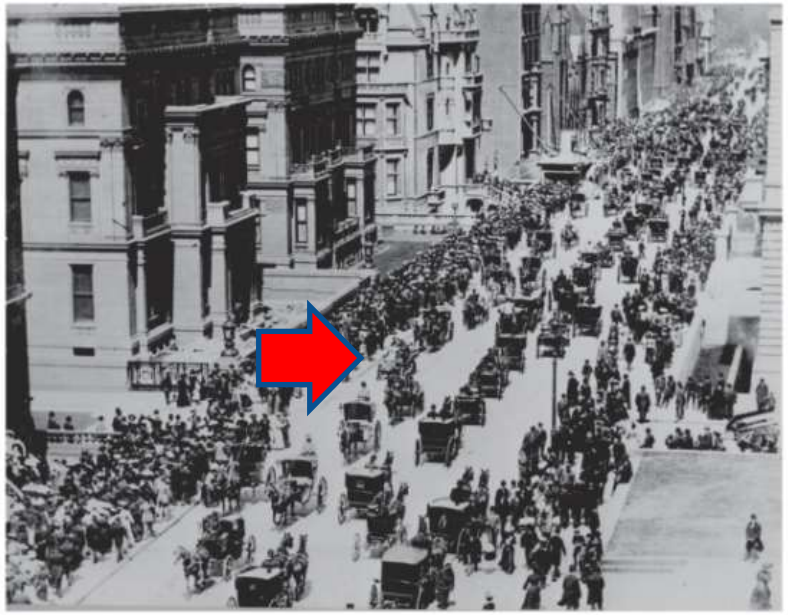

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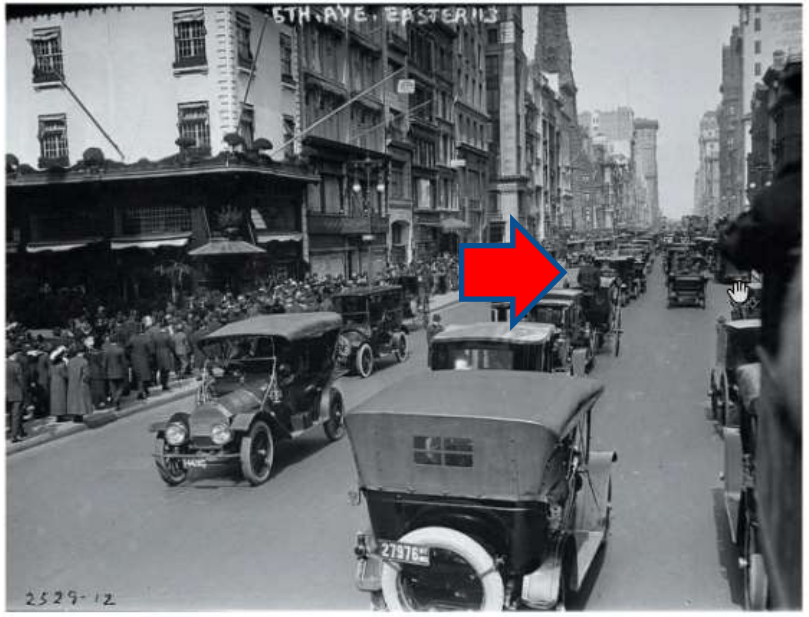

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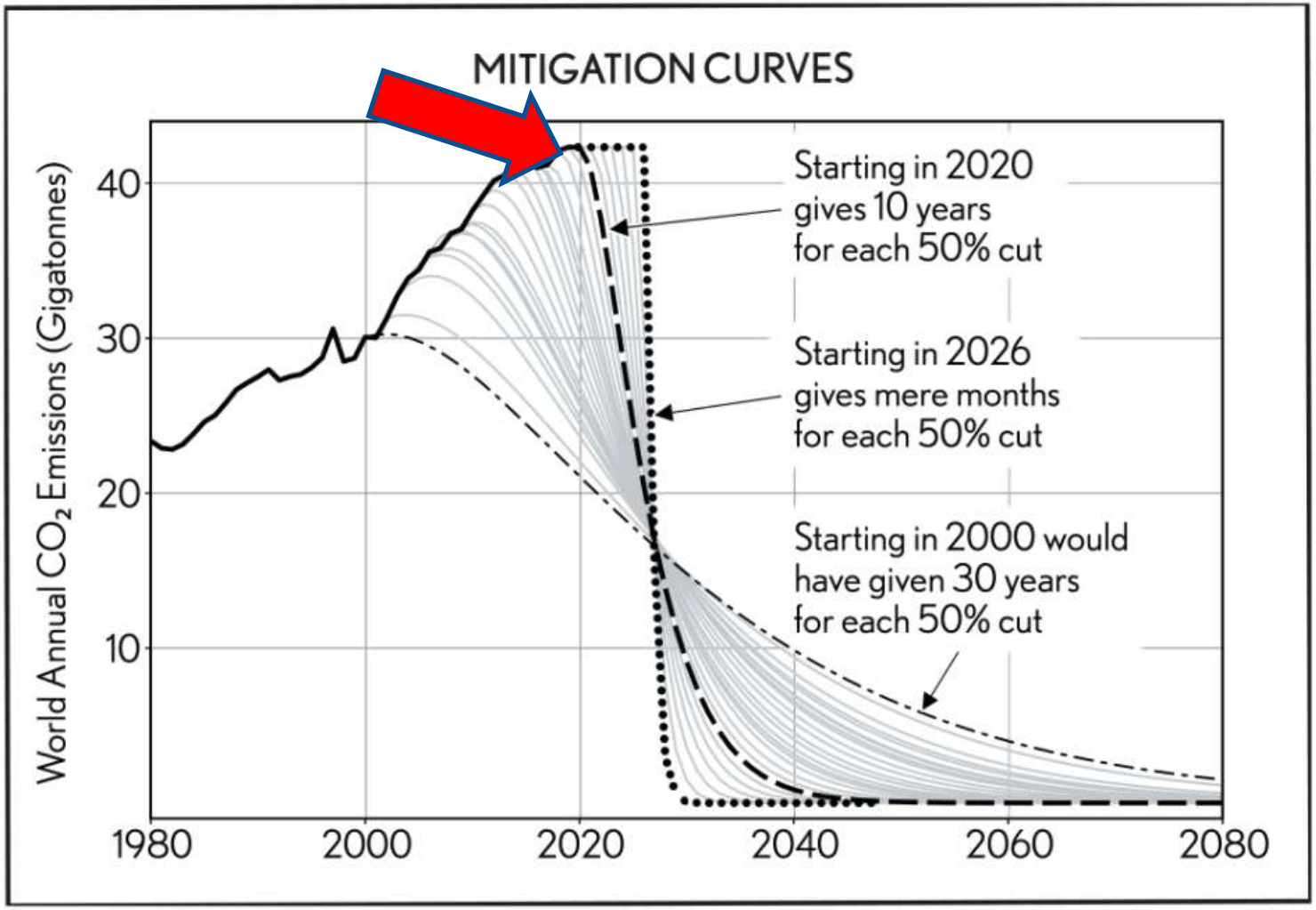
Rapid Change MUST Happen

SkyCentrics



THERE IS NO TIME OTHER THAN NOW.

Rapid Change MUST Happen

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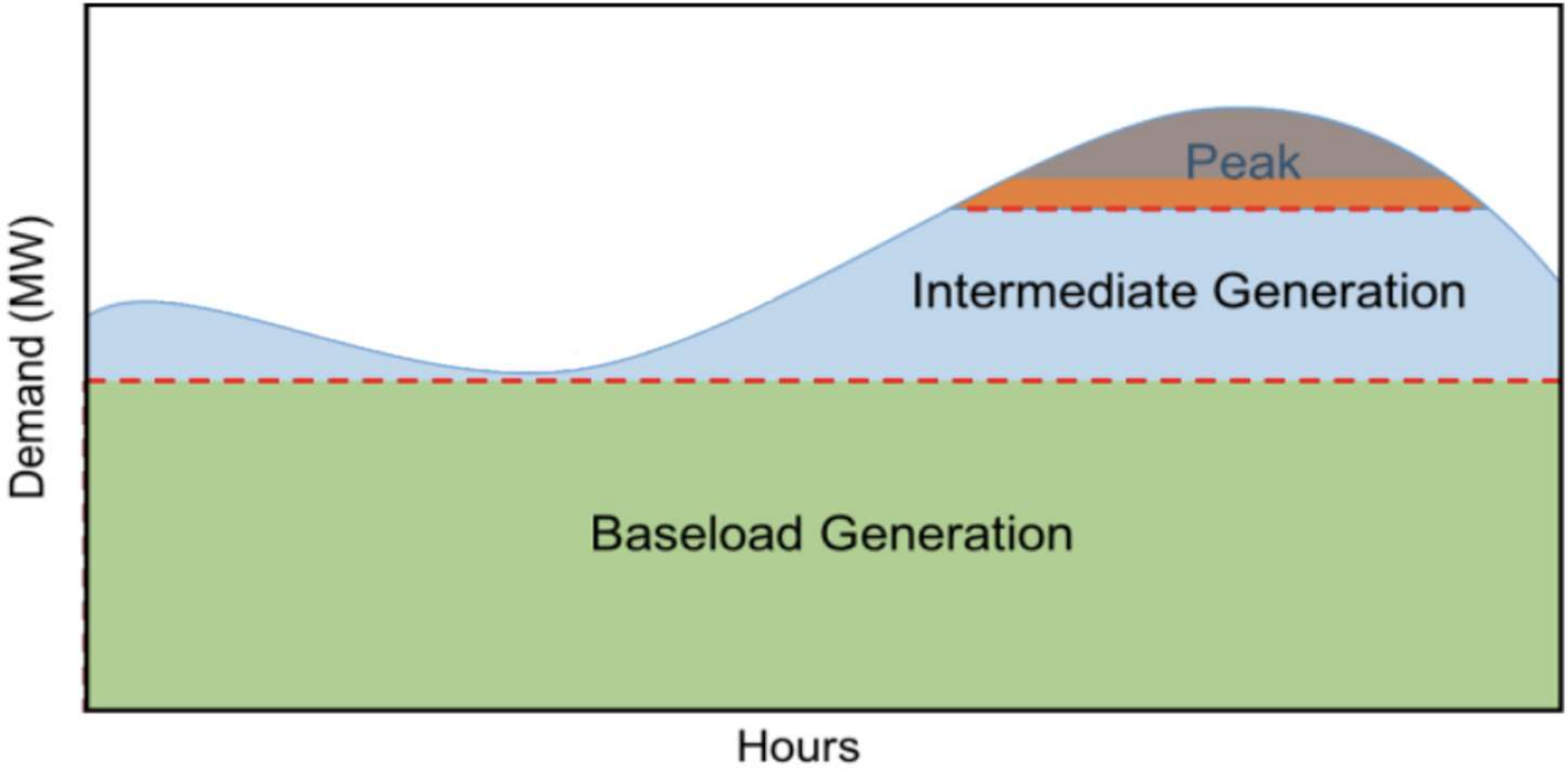
The grid likes FLAT, not the duck curve



Rapid Change MUST Happen

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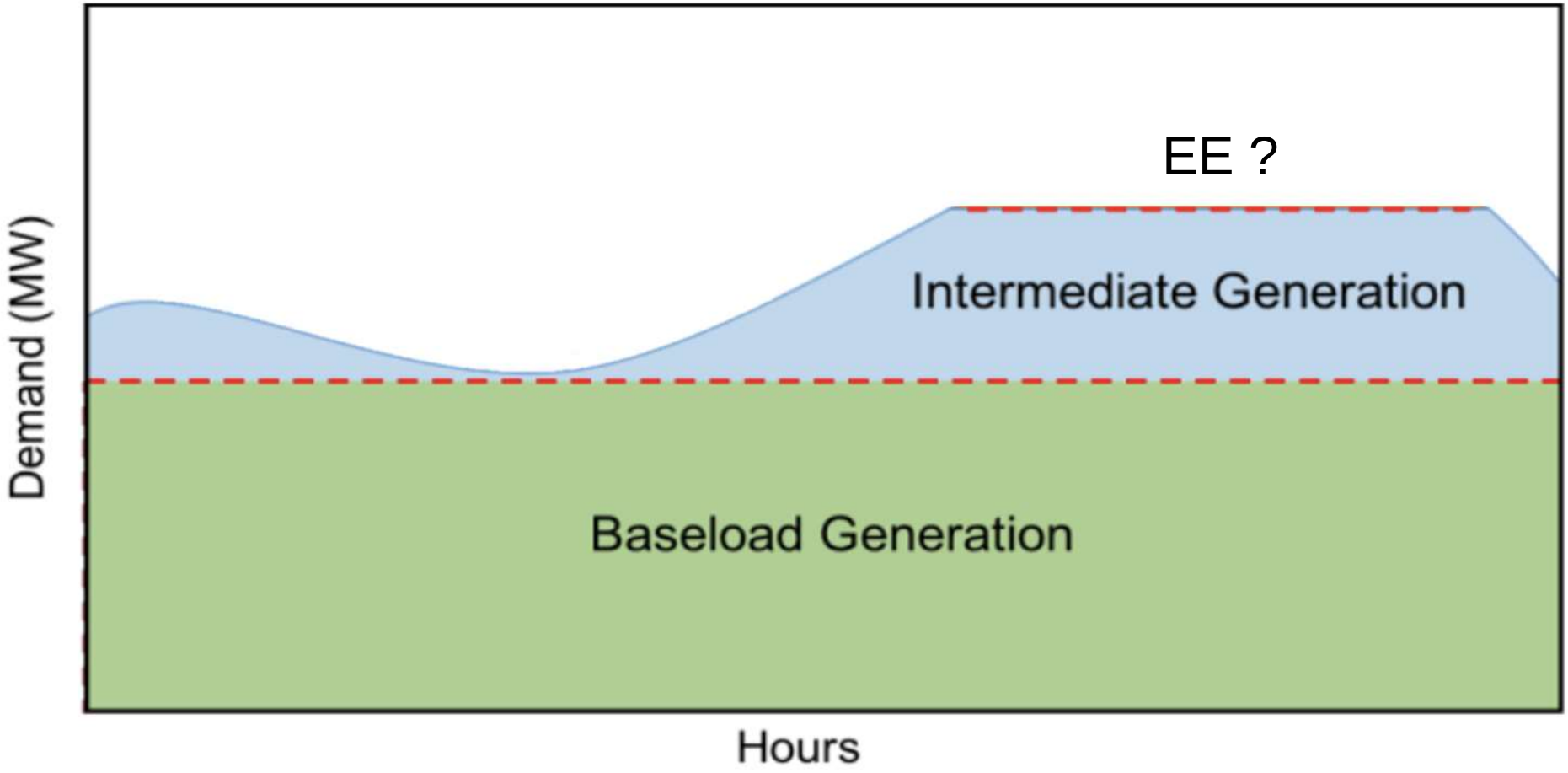
Energy Efficiency has been the focus for 30 years



Rapid Change MUST Happen

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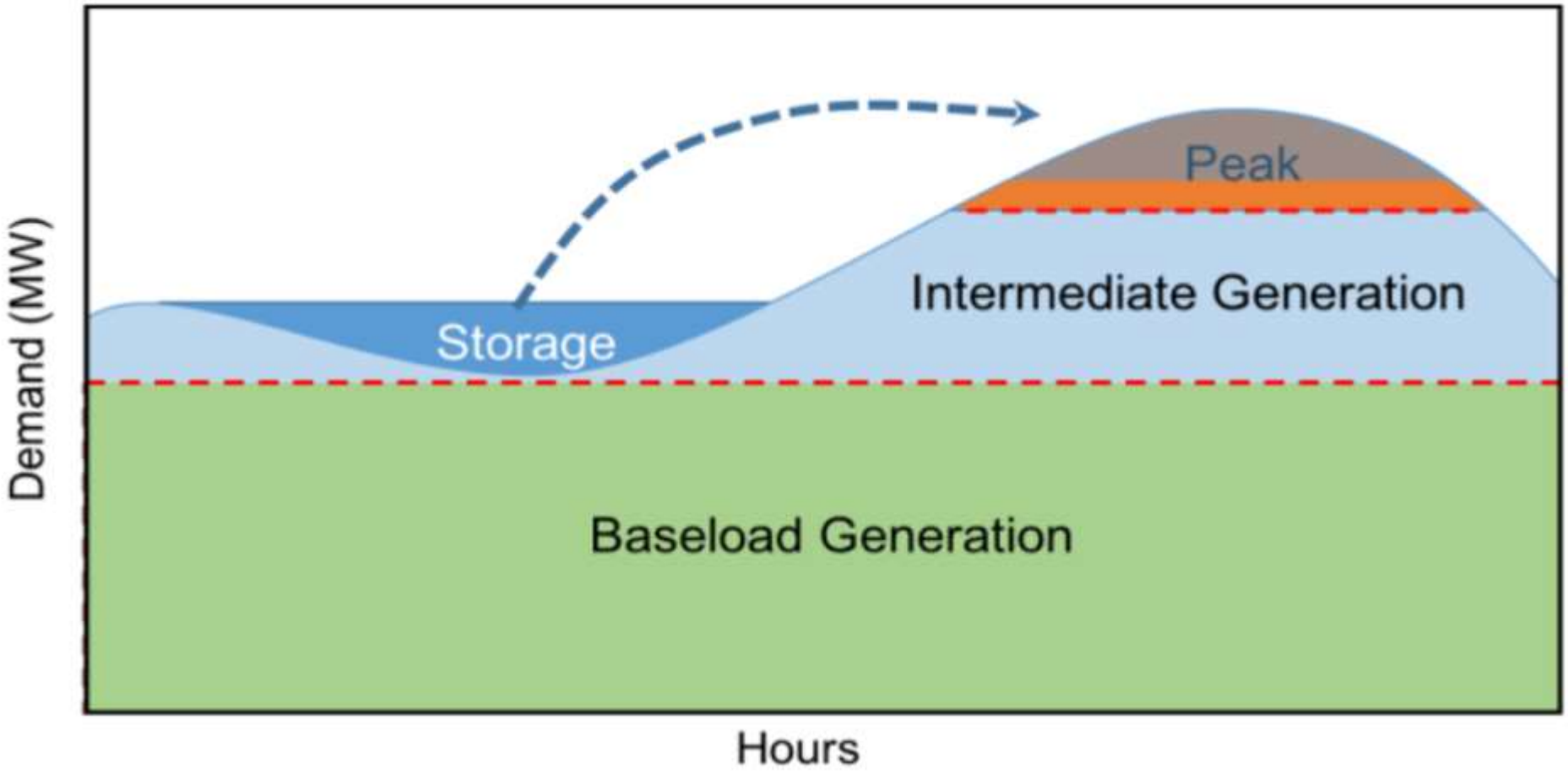
Storage (batteries?) is expensive



Rapid Change MUST Happen

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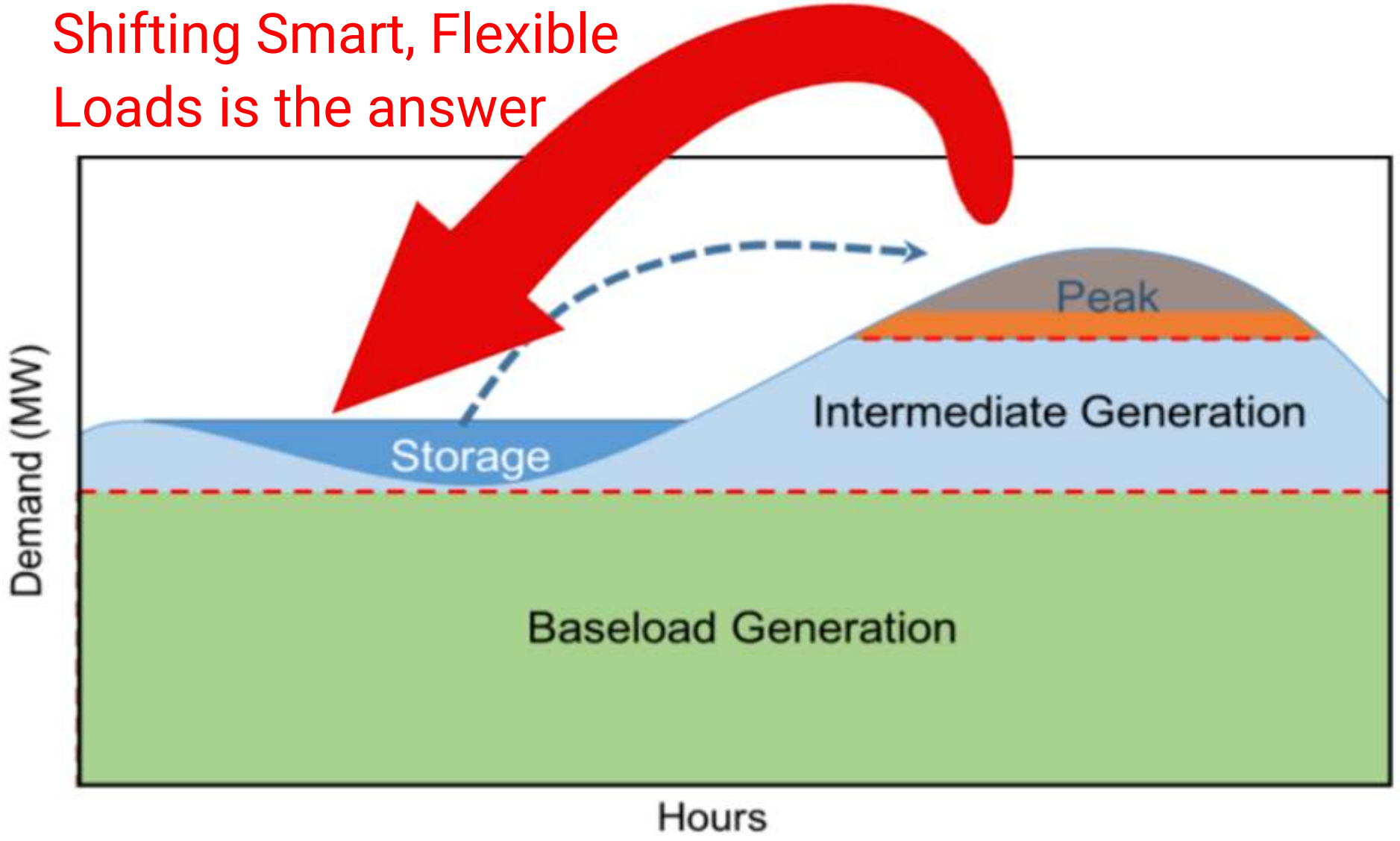
Shifting Smart, Flexible
Loads is the answer



Rapid Change MUST Happen

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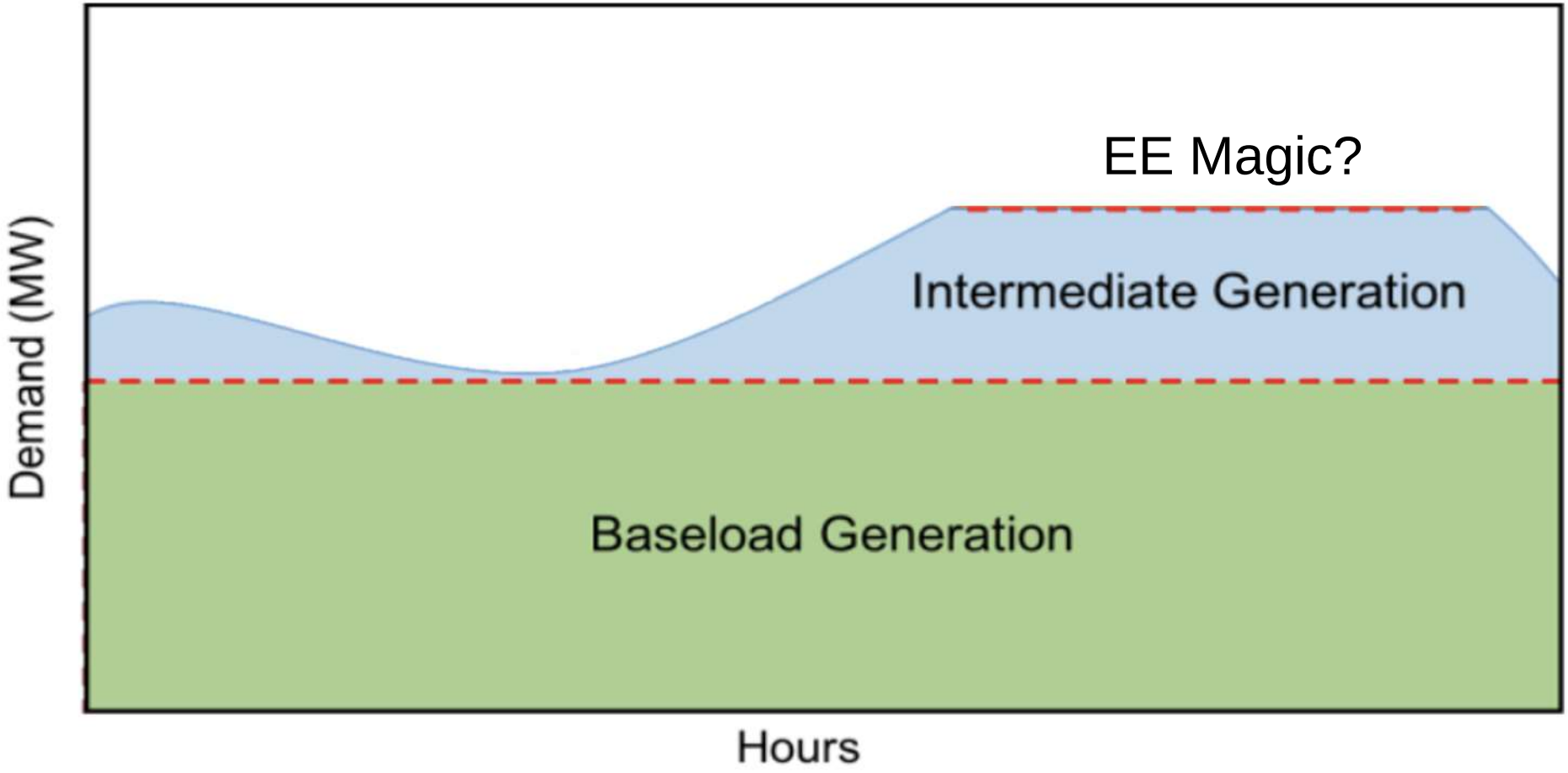
But Energy Efficiency still seems to rule



Can we get here?

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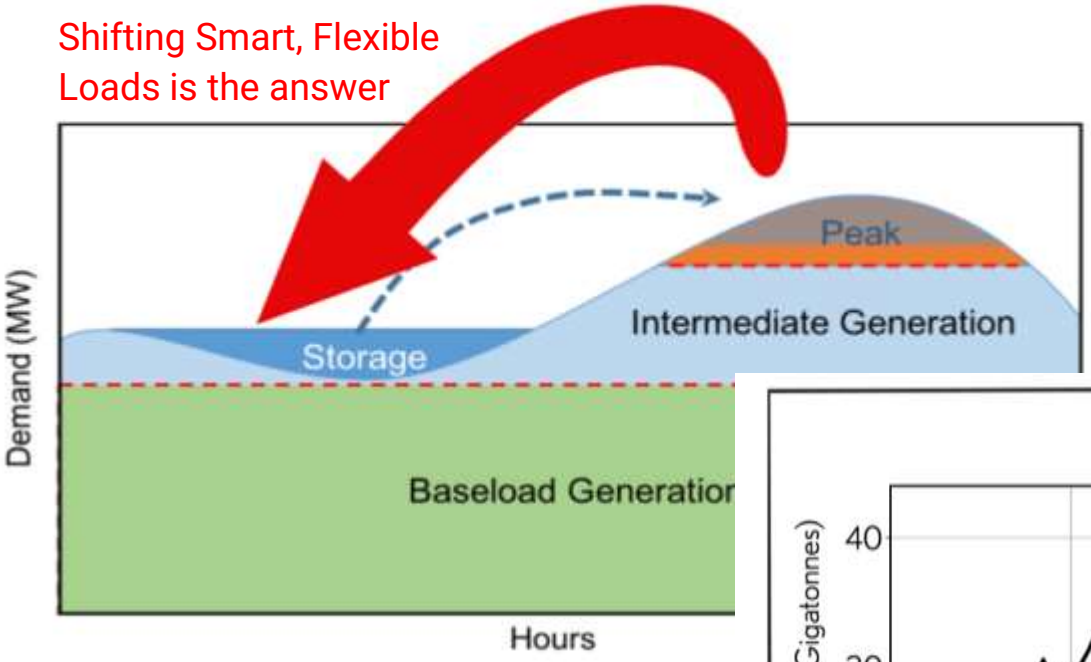
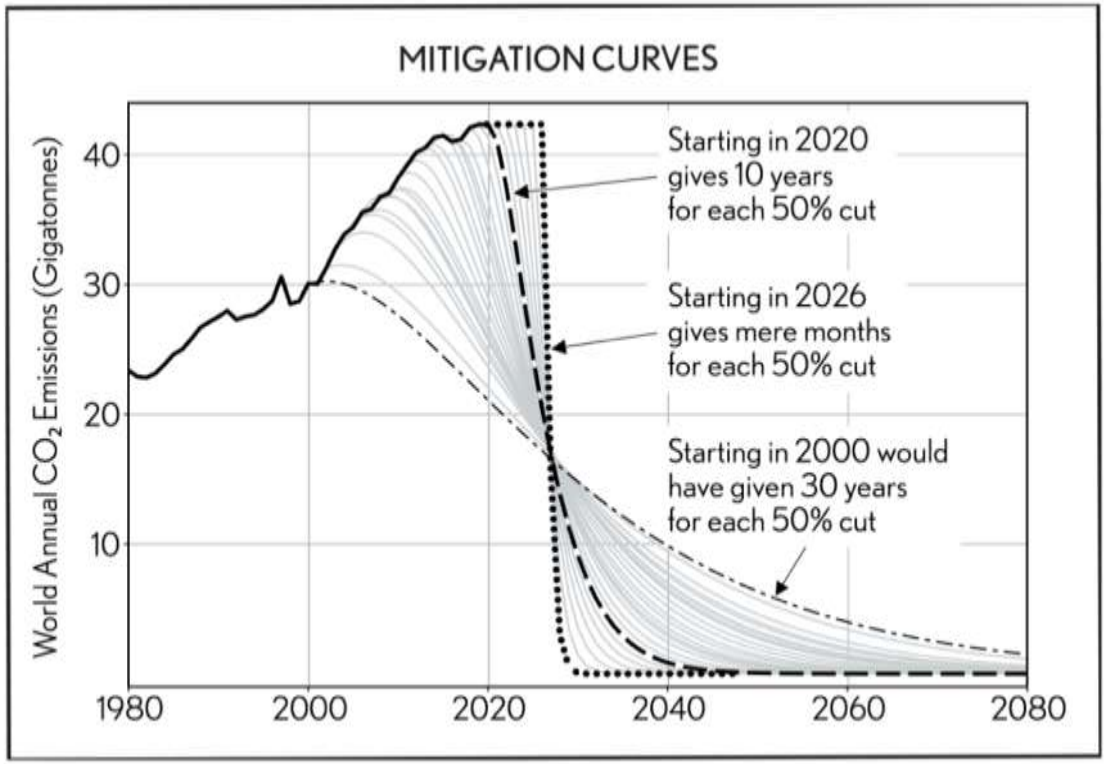
Shifting Smart, Flexible Loads is the answer



In Time?



THERE IS NO TIME OTHER THAN NOW.

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Connect devices on installation.

It costs so much more later to market the connection to customers!

More About Open Standards

Email us at info@skycentrics.com

for the white paper on OpenADR and CTA-2045

or the MAINE heat pump presentation

- CTA-2045, OpenADR and Heat Pump Water Heater studies https://skycentrics.com/studies/
- CTA-2045 Water Heater Demand Response (SkyCentrics) https://www.youtube.com/watch?v=baPmqPgQhDE
- AO Smith SkyCentrics CTA-2045 hardware install - https://www.youtube.com/watch?v=-oLVHxGaZAM
- AO Smith SkyCentrics CTA-2045 connect Wi-Fi - https://www.youtube.com/watch?v=B_Yy_zLR17w
- EPRI CEA-2045 Field Demonstration Project (EPRI) https://www.youtube.com/watch?v=BHMssq6_R94
- Water heaters, as sexy as a Tesla? (Rocky Mountain Institute) https://www.rmi.org/news/water-heaters-sexy-tesla/
- Economic Sizing of Batteries for the Smart Home (NREL) https://www.nrel.gov/docs/fy18osti/70684.pdf

Questions

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