Practical Coordination of DERs at Scale using Packetized Energy Management

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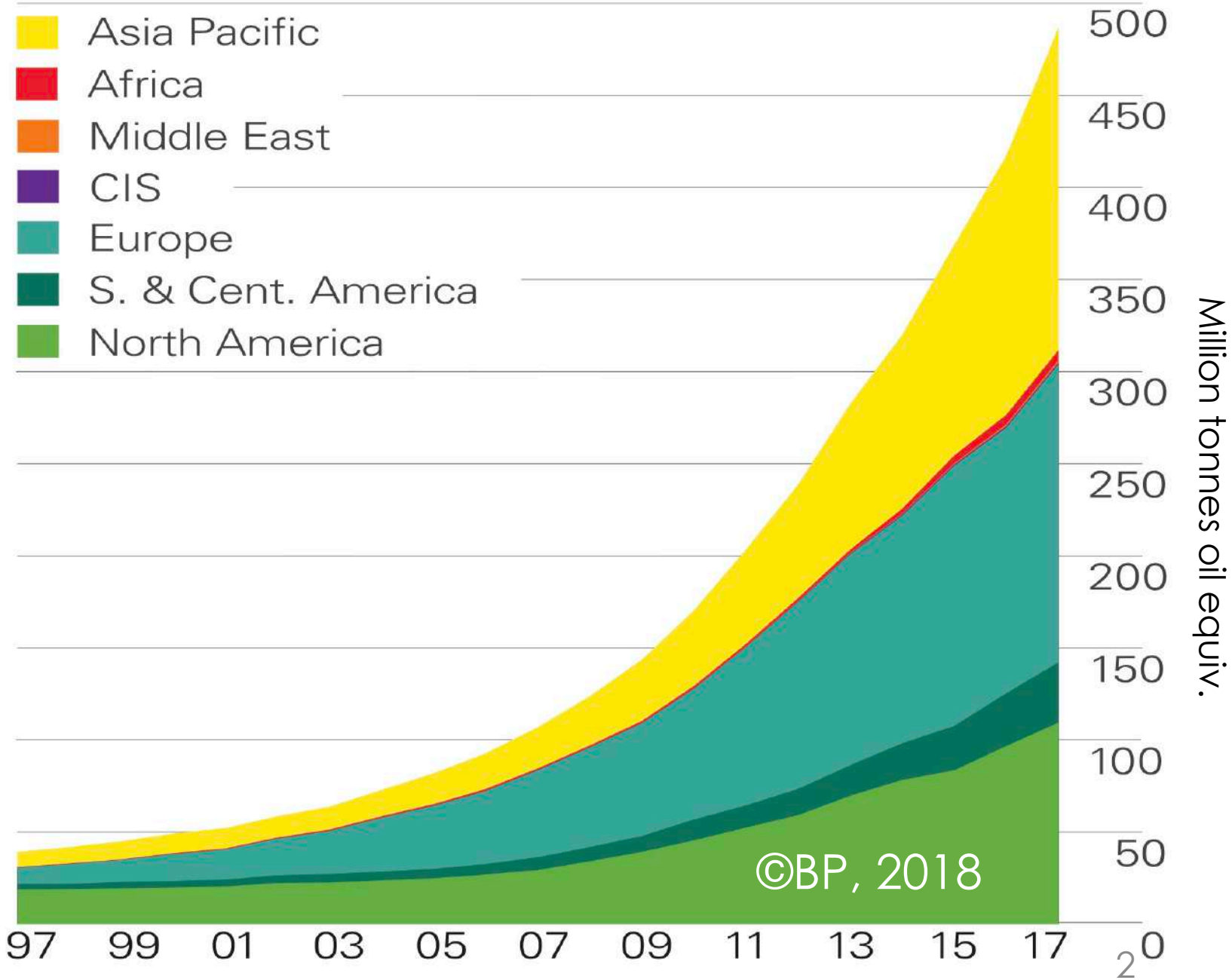
The University of Vermont

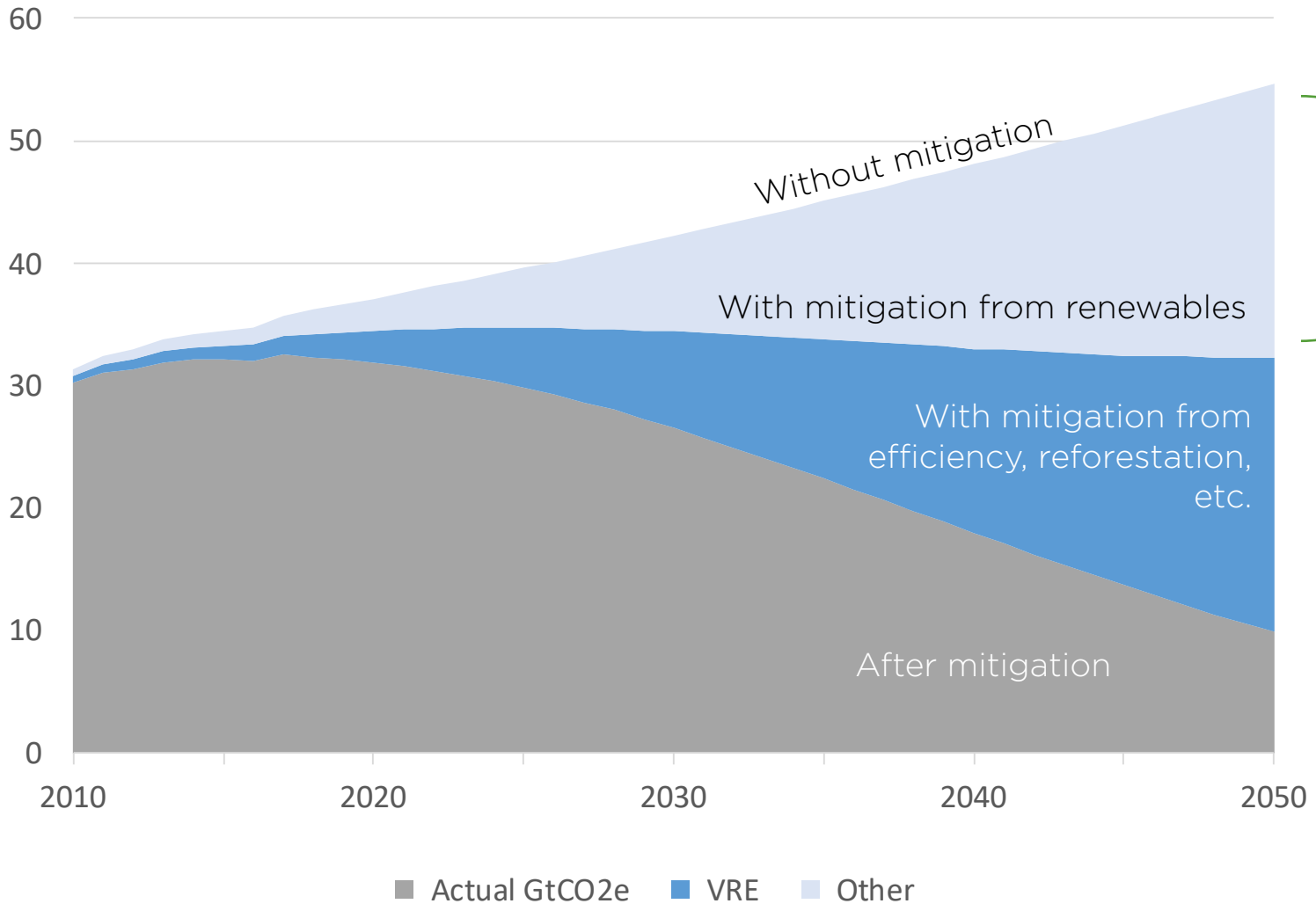
arpa·e awardee

PACKETIZED ENERGY

Non-Hydro (wind/solar) energy consumption



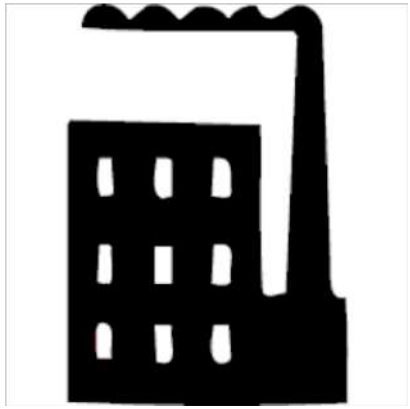
And probably a lot more to come



~10 TW of renewables +
~8-10 TW of flexibility.
Mean load today ~ 3 TW

Perhaps
2 TW of flexible supply
5 TW of storage +
2 TW of flexible demand.

2 TW of flexible demand



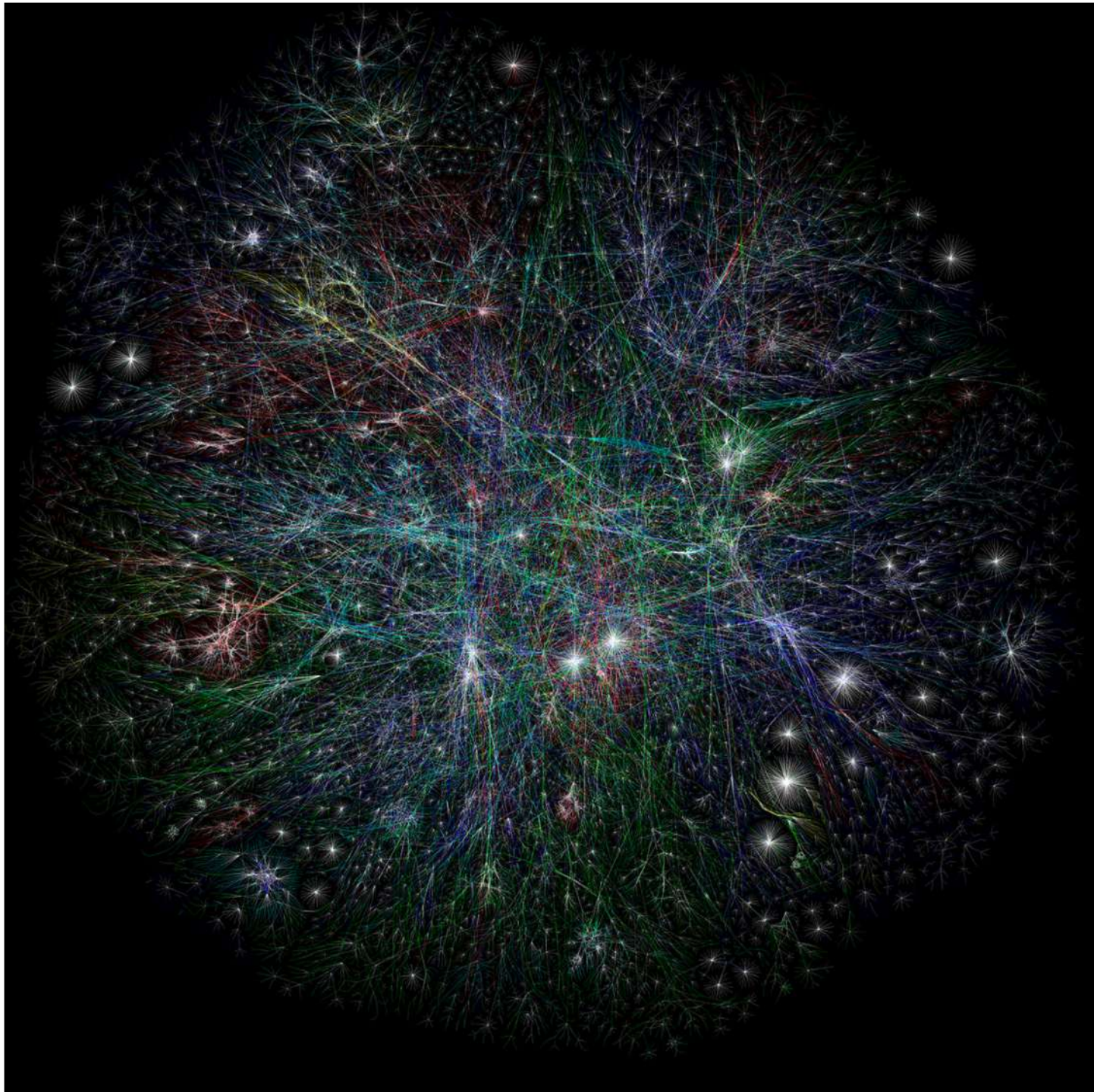
1 TW of flexible
large C&I load

1 TW of flexible
small c&R load
~2 billion devices

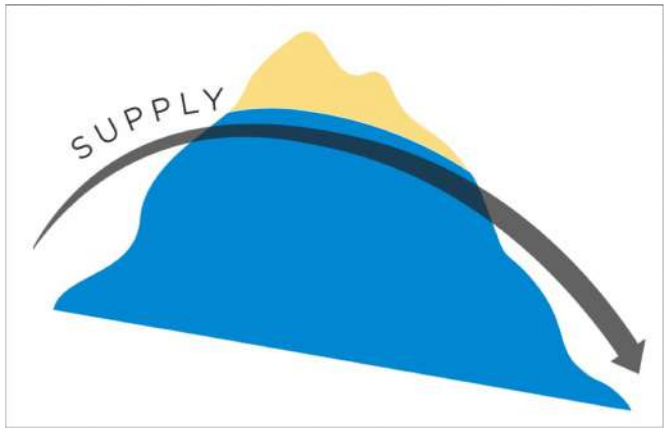
So:

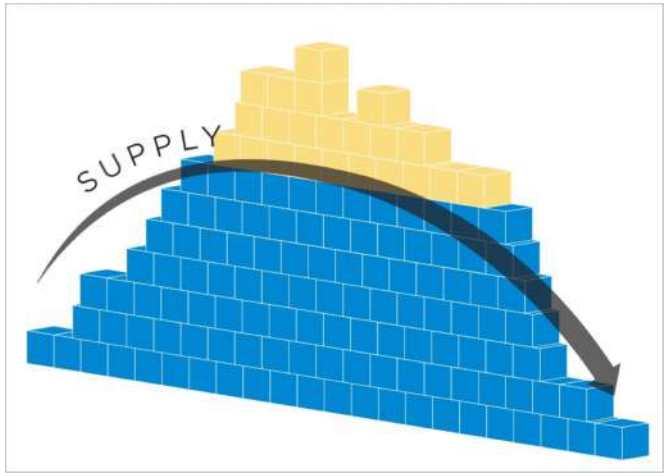
How do we coordinate billions of connected devices to solve grid problems?

Let’s borrow ideas from something that already connects billions of devices

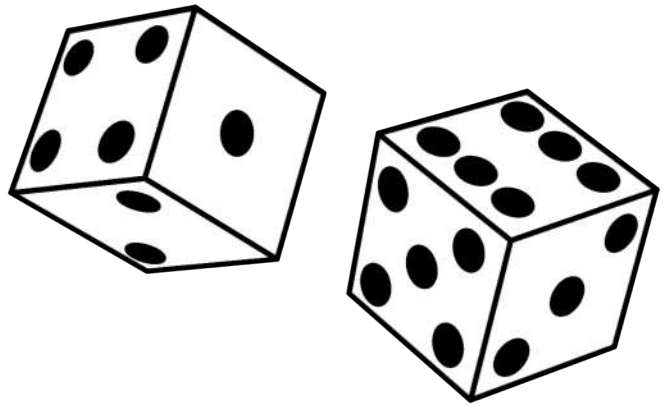


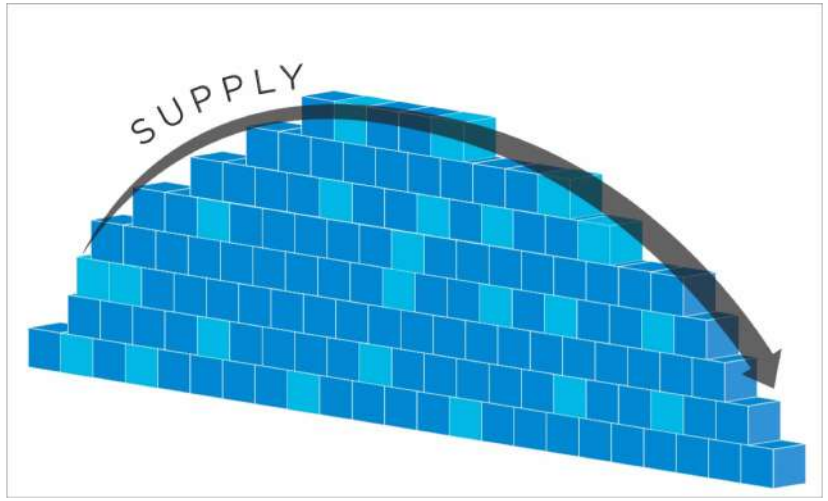
Packetization





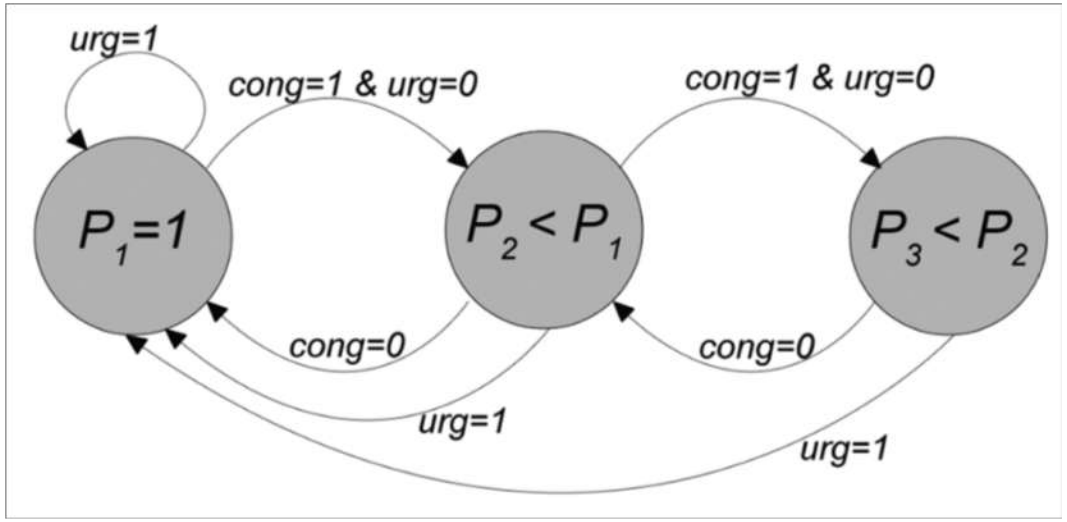
Randomization

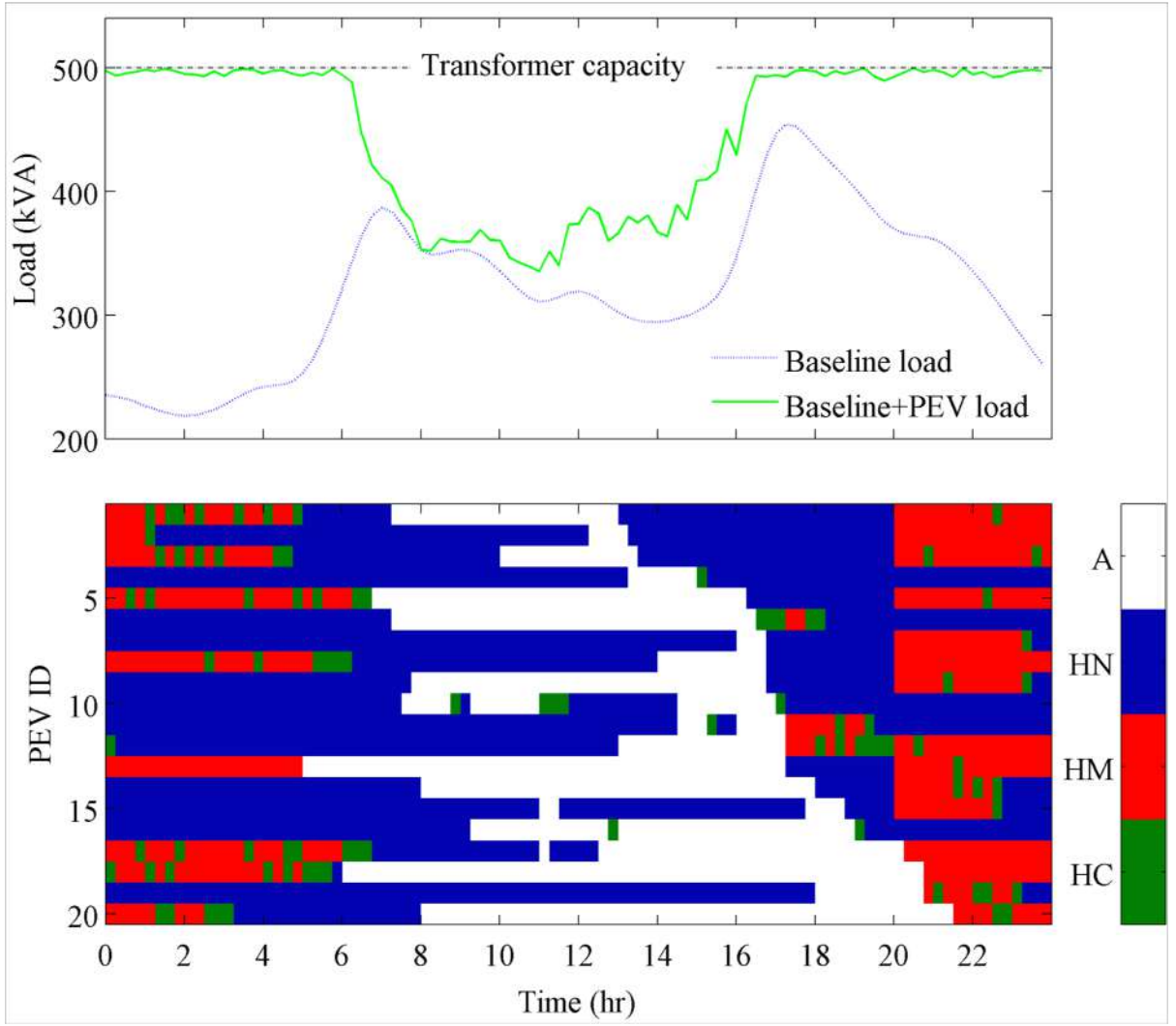




Simple state machines for EV charging

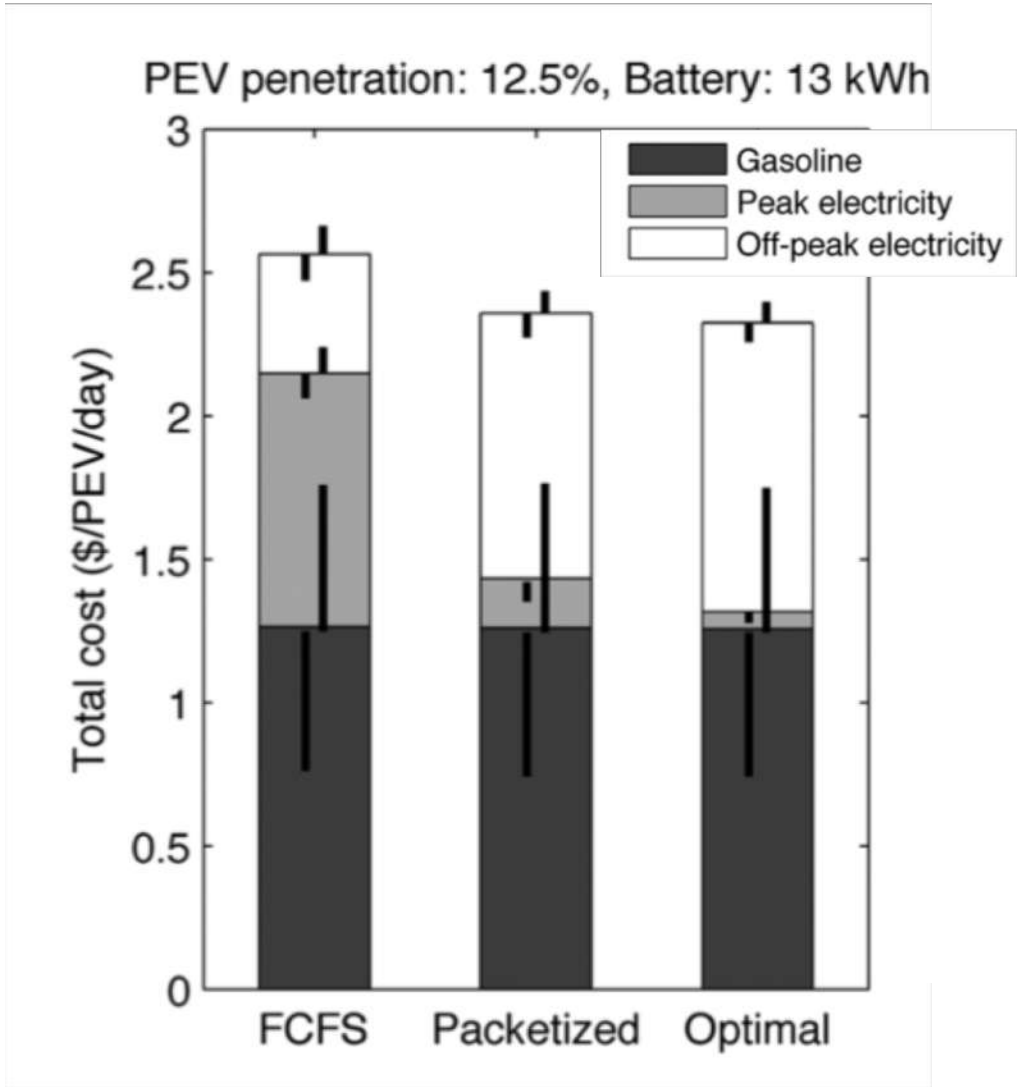
EV requests charge based on the state of the vehicle. Urgent/non-urgent, response to prior charges





Rezaei, Frolik, Hines, "Packetized Plug-in Electric Vehicle Charge Management", IEEE TSG, 2014

How much does it cost to avoid fancy optimization?



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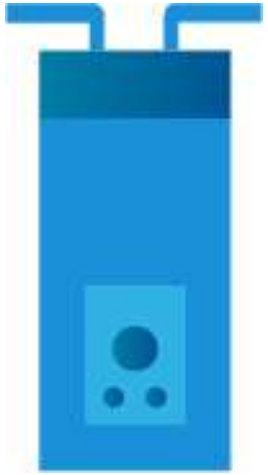
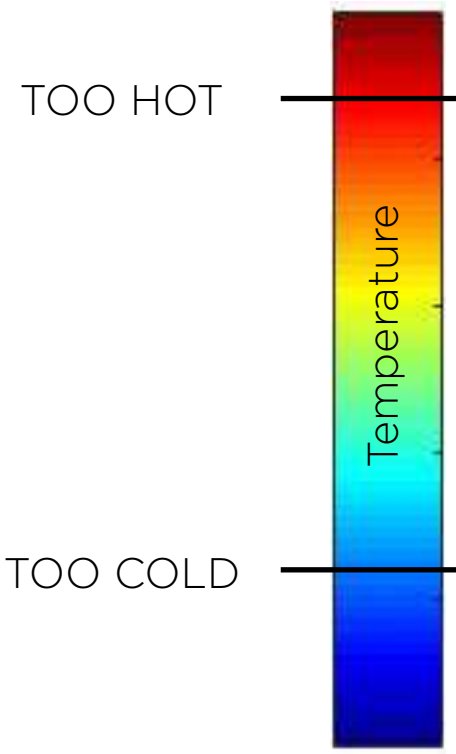
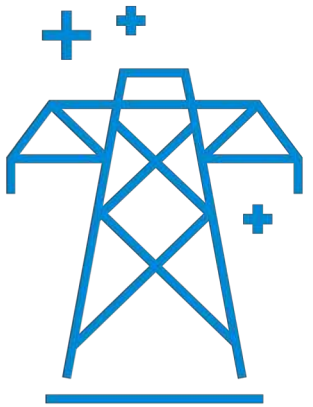
What about a water heater?



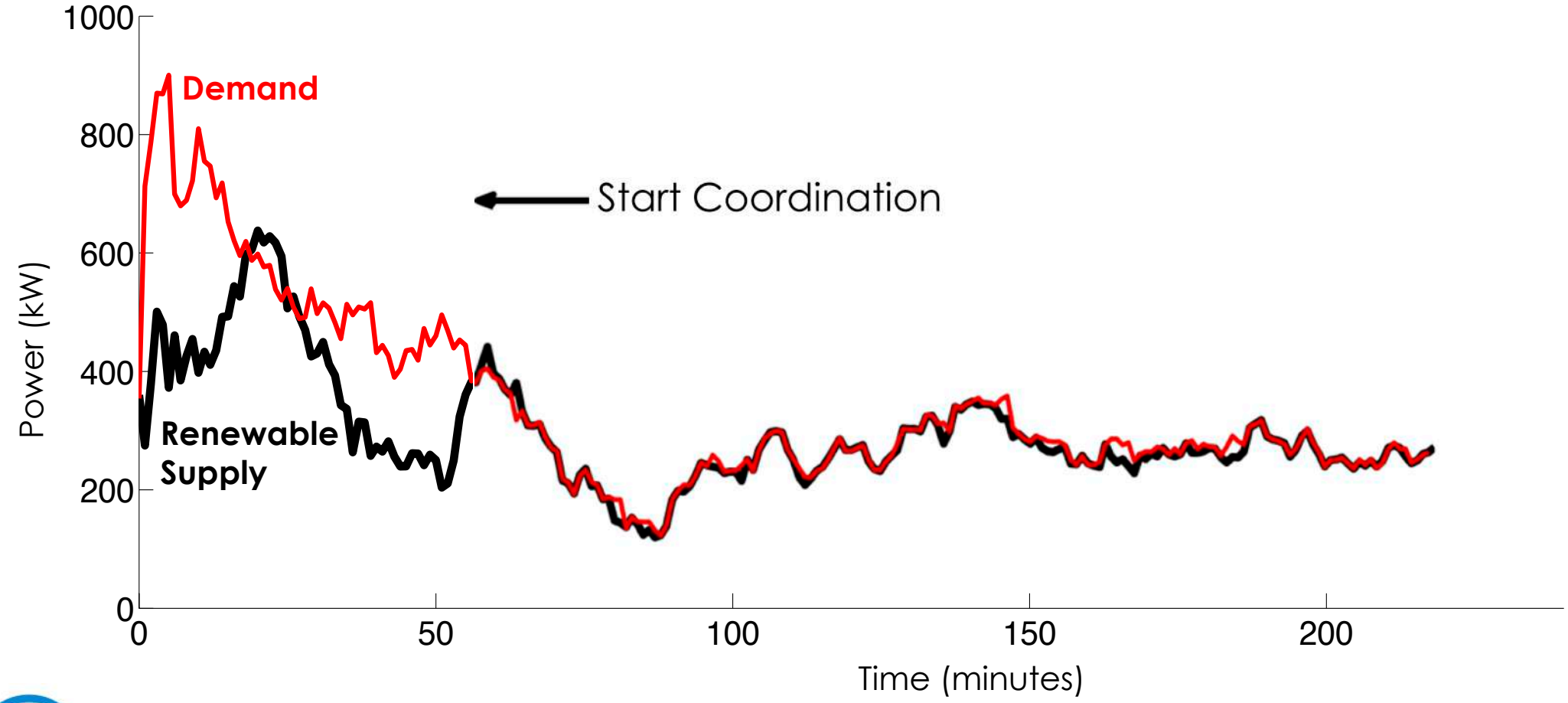


Virtual Battery server replies to requests based on grid conditions



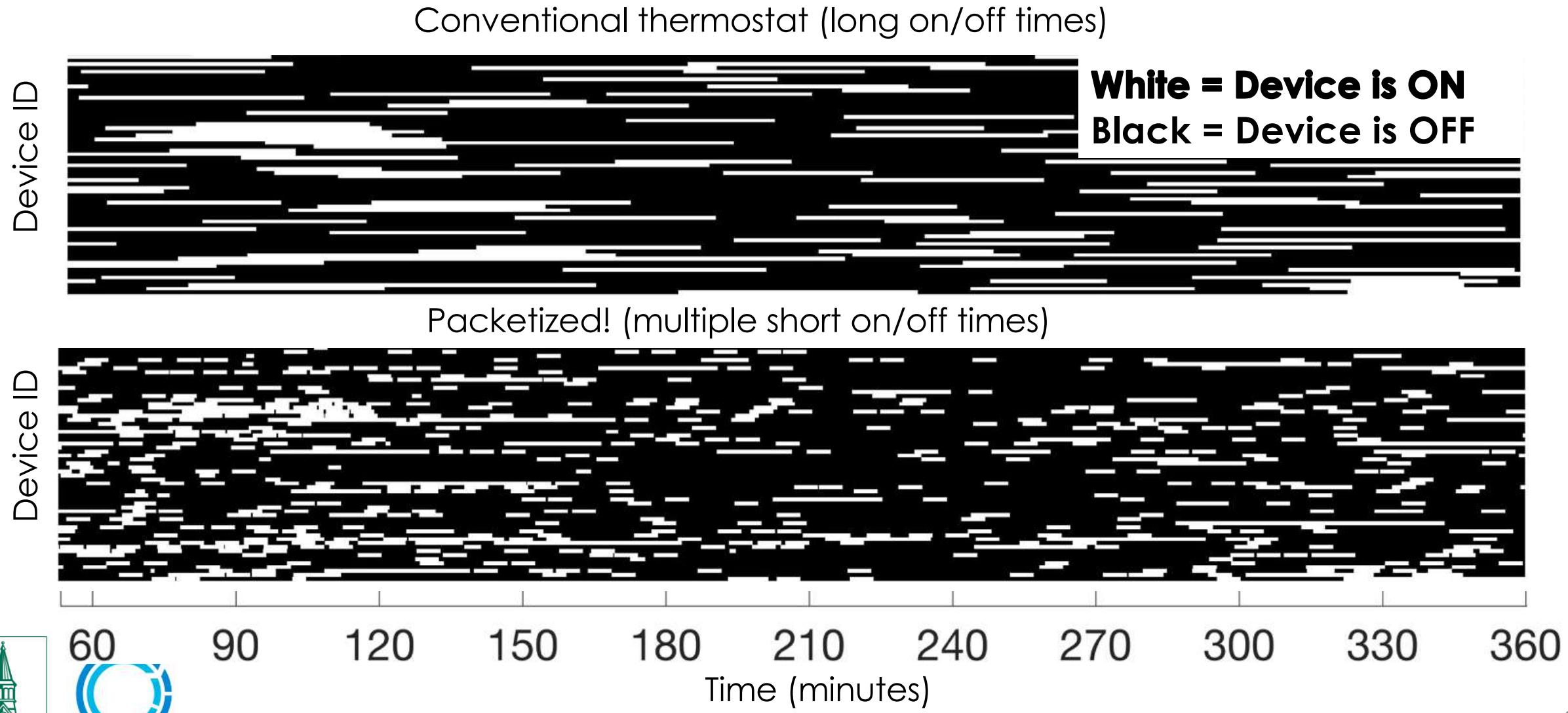
Virtual Battery solves grid problems

300 electric hot water heaters

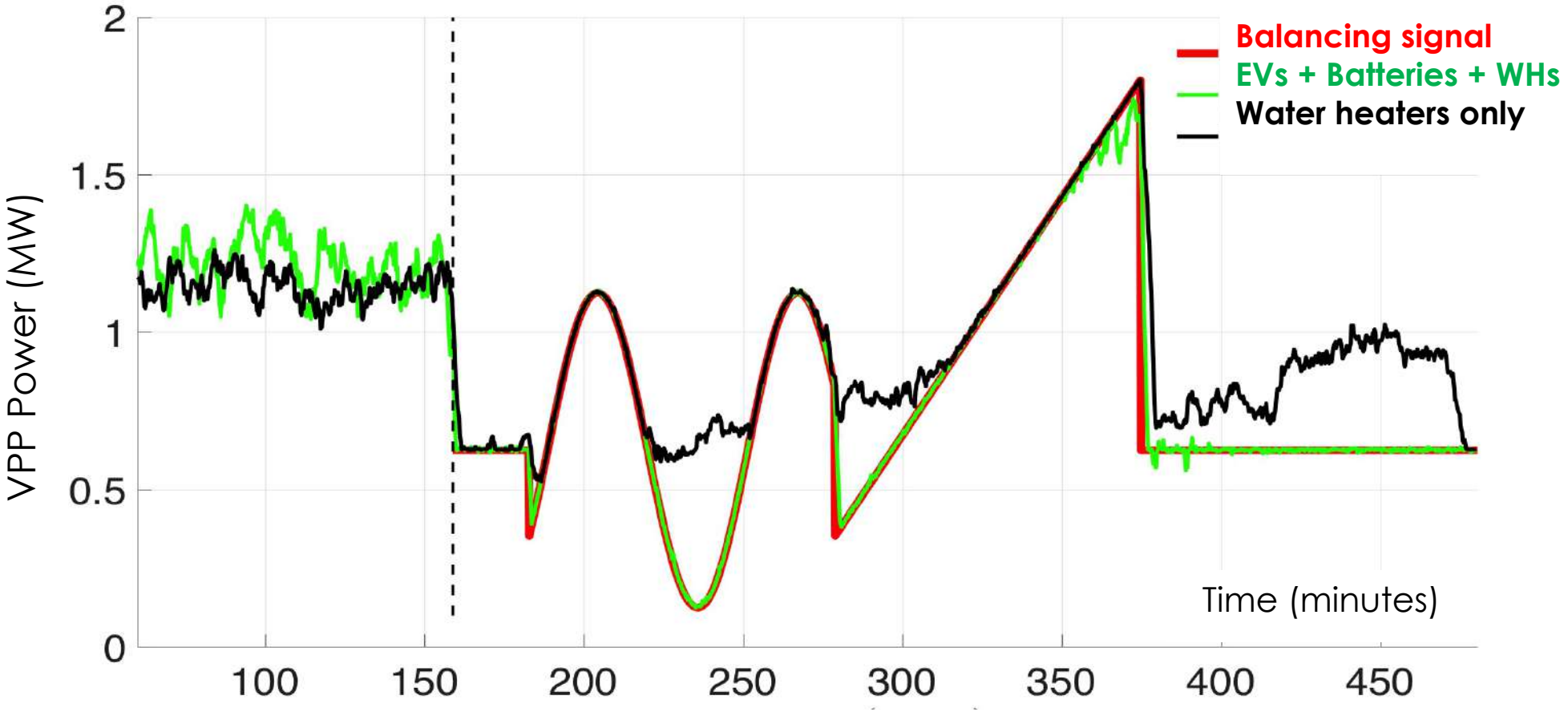


Almassalkhi, Frolik, Hines, "Packetized energy management...," ACC, 2017

Conventional vs. Packetized



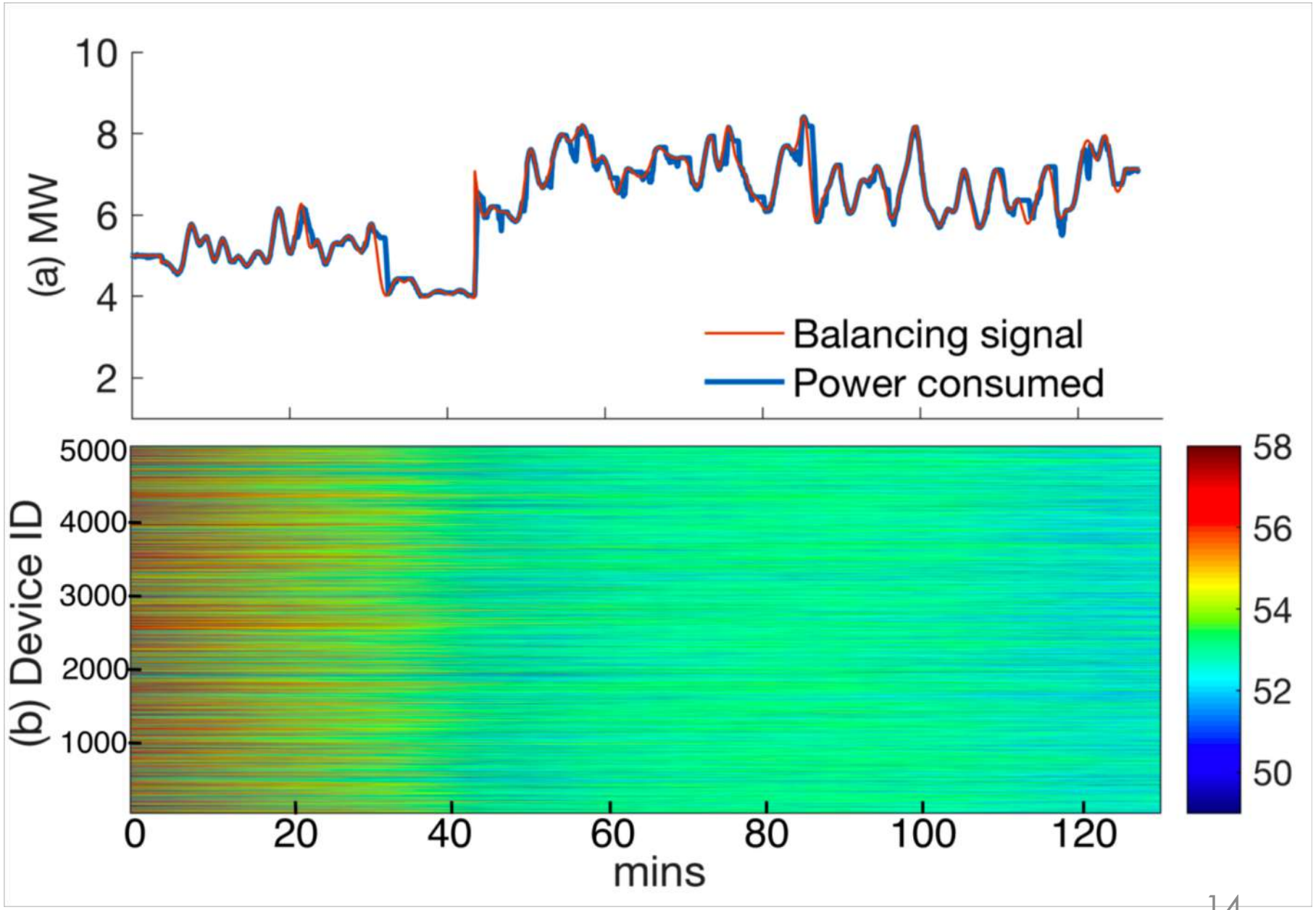
Diversity makes stuff work better

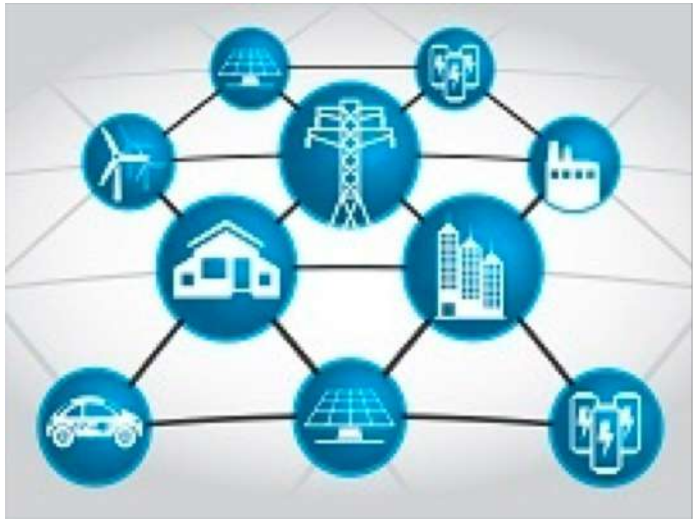


Almassalkhi, Duffaut-Espinosa, Hines, JFrolik, Paudyal, Amini, "Asynchronous coordination of DERs...," in Energy Markets and Responsive Grids, Springer, 2018

At scale?

5000 water heaters





How do we make it work in the real world?

Step 1: Start a company

PACKETIZED ENERGY

Step n: Build a device and a lot of software

aws

Step q: Partner with utilities

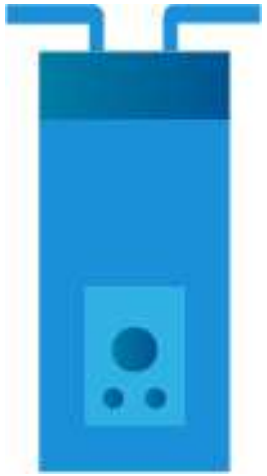
BURLINGTON Electric DEPARTMENT

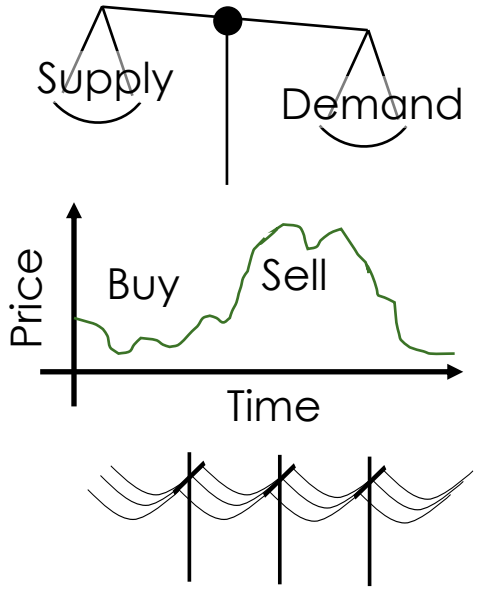
VERMONT ELECTRIC CO OP INC

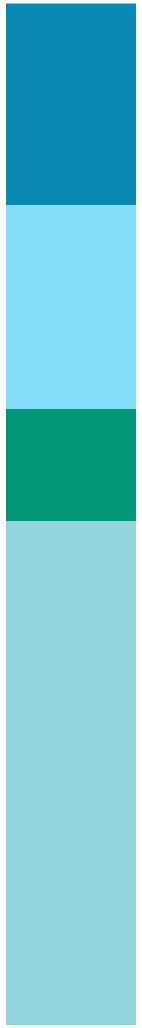
GREEN MOUNTAIN POWER

PG&E

Step π: build a business case







Frequency regulation
~$30/device/year

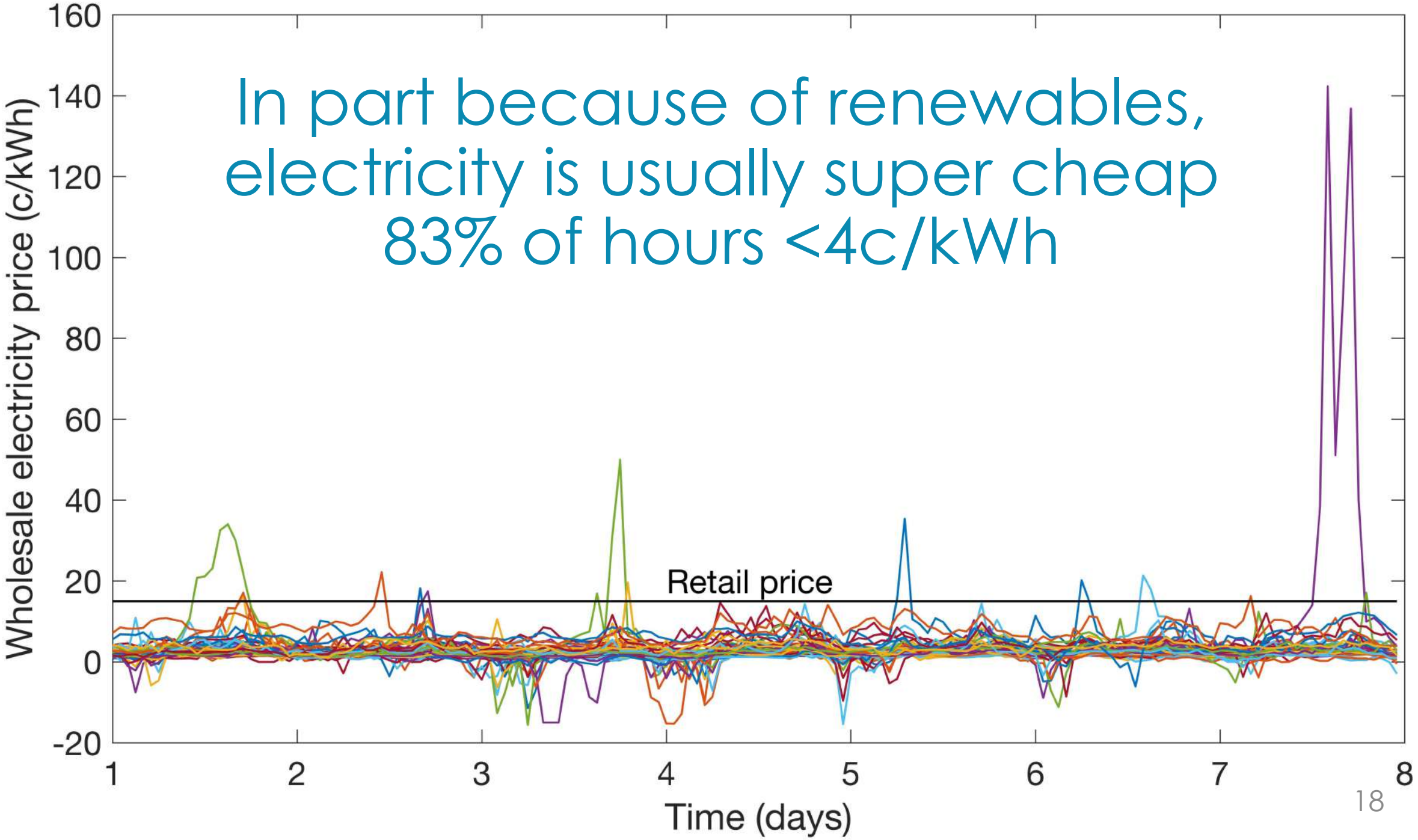
Wholesale energy arbitrage
~$30/device/year

Avoided T&D CapEx
~$20/device/year

Avoided generation capacity (ICAP)
~$100/device/year

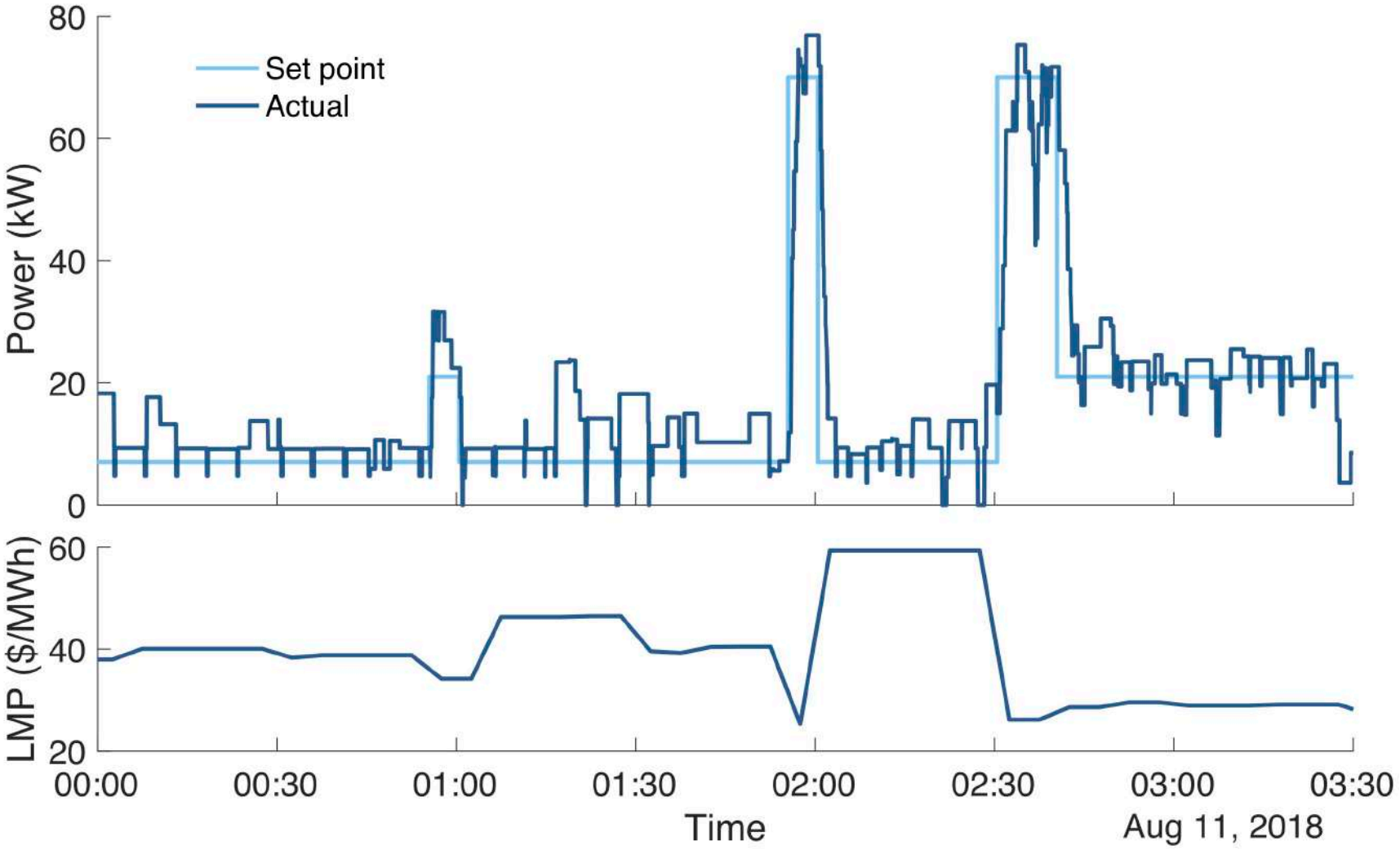
Total = $200/device/year

In part because of renewables, electricity is usually super cheap 83% of hours <4c/kWh

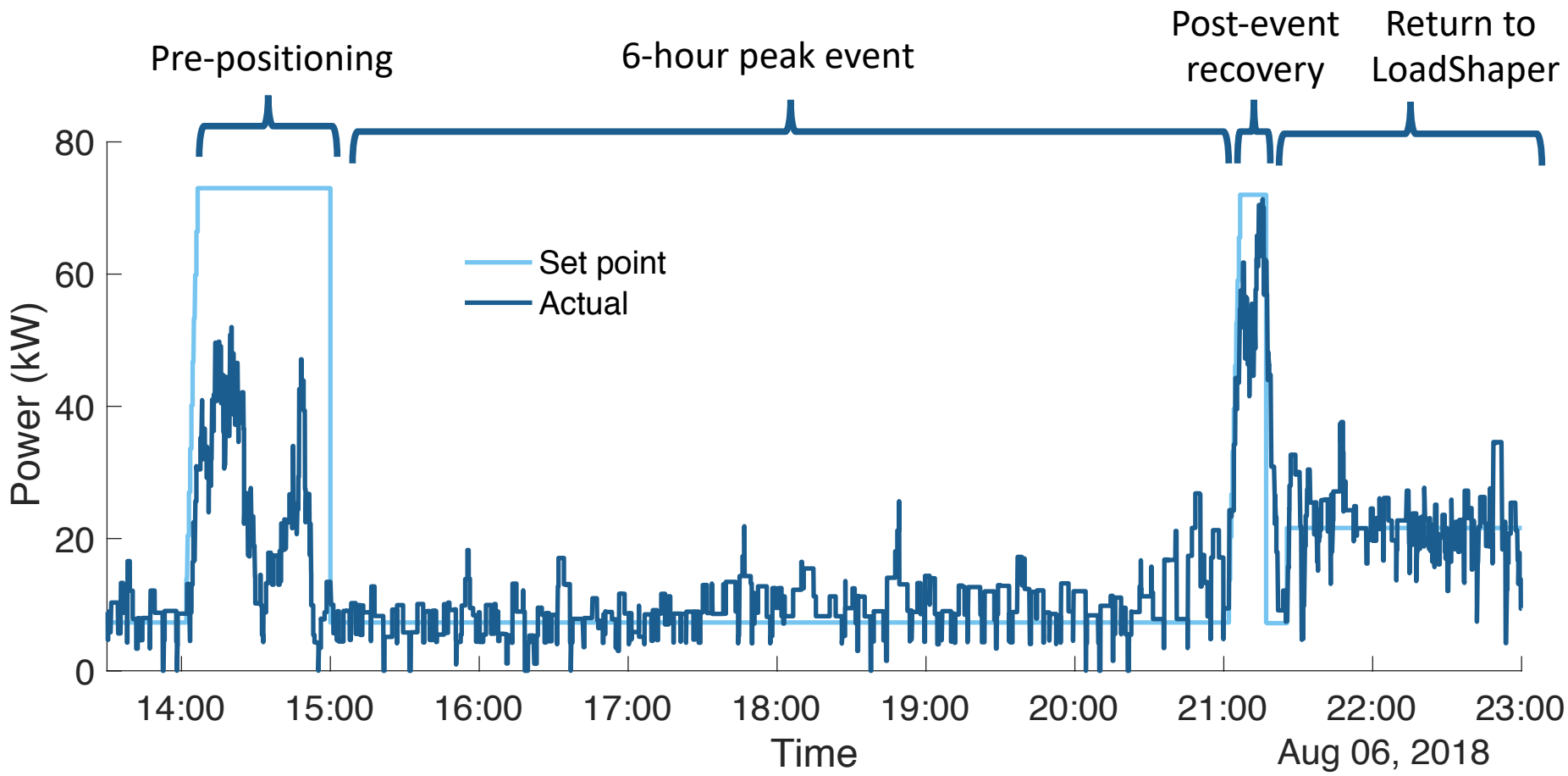


Which means that utilities should do this

LoadShaper: Automated Energy Arbitrage



PeakCrusher: Automated Peak Management



The most important step: build a great team

SCOTT JOHNSTONE
CEO
Energy leader
Former CEO of $100M Vermont Energy Investment Corp. (VEIC)

MADS ALMASSALKHI
CO-FOUNDER
Serial entrepreneur
SaaS, real-time controls
Michigan PhD

JEFF FROLIK
CO-FOUNDER
Communication systems, patents
Michigan PhD

PAUL HINES
CO-FOUNDER
Electricity systems/software, electricity policy/markets
Carnegie Mellon PhD

ANDREW GIROUX
IoT/Hardware
Formerly: UTC, GM
Builds Evs for fun

KATE DESROCHERS
Initiative Lead, MBA
Formerly: energy consultant

JOHN SLINKMAN
SaaS/AWS
Formerly: Director at POLCO

FORREST WALLACE
Embedded Systems
Formerly: DEKA

- Advisors

BOB ZULKOSKI
Vermont Works
Co-founder Greenlots

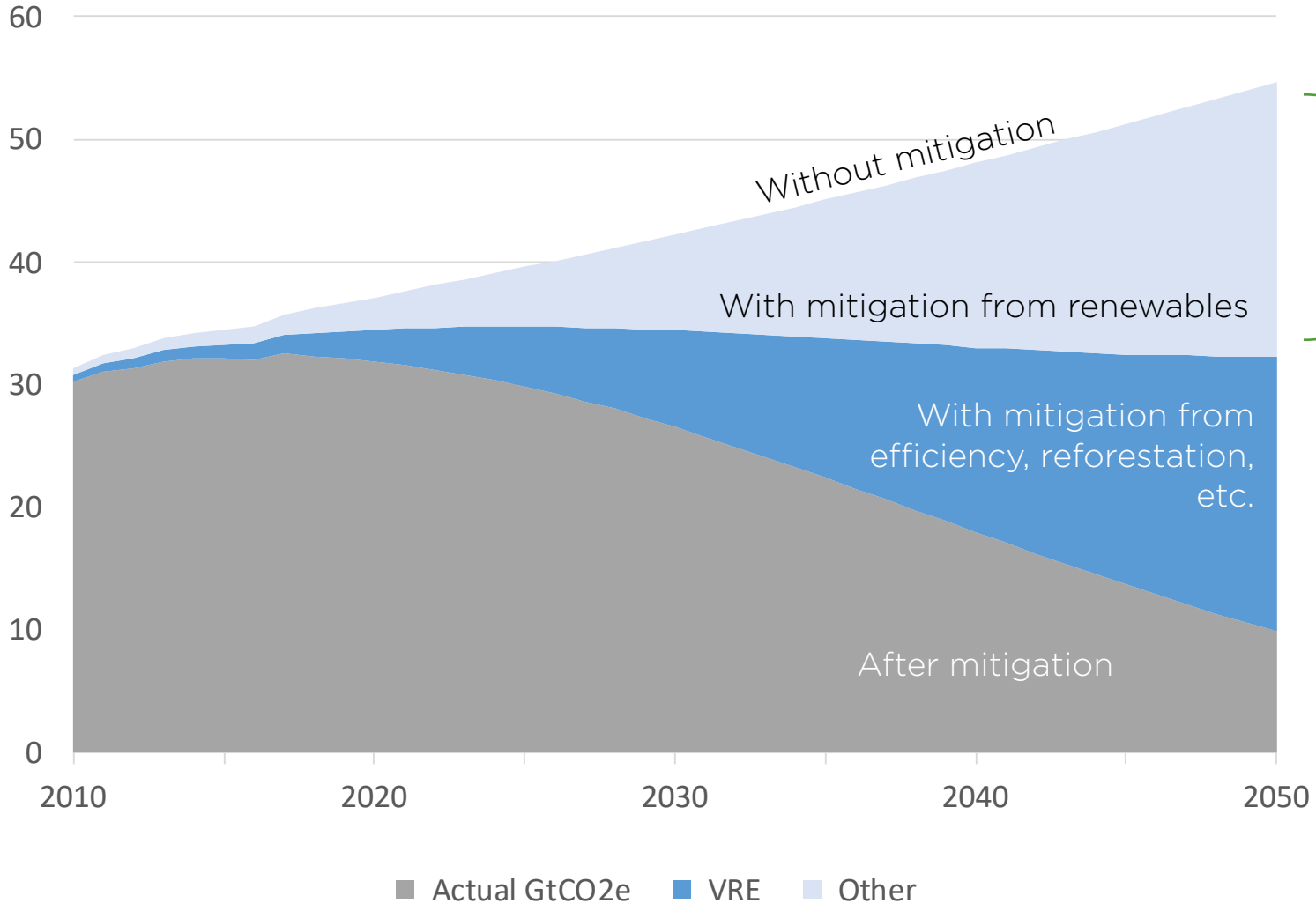
LAURY SALIGMAN
Vernal Ventures
Environmental leader

MICHAEL BEER
Marketing expert

HEMAL SHAH
Facebook/Instagram
Focus: UI/UX

BJOERN SIMON
Altair Engineering
Focus: Back-end/ Architecure

But then again, if we can do this, it's worth it.



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