Market Based Mechanisms for Mobilizing Electric Demand Flexibility

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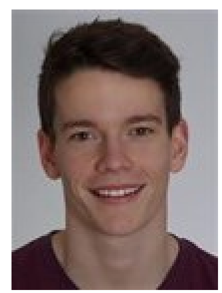
With contribution by Niclas Brok, Ph.D Student DTU



CITIES

CITIES Final Conference
November 9, 2020

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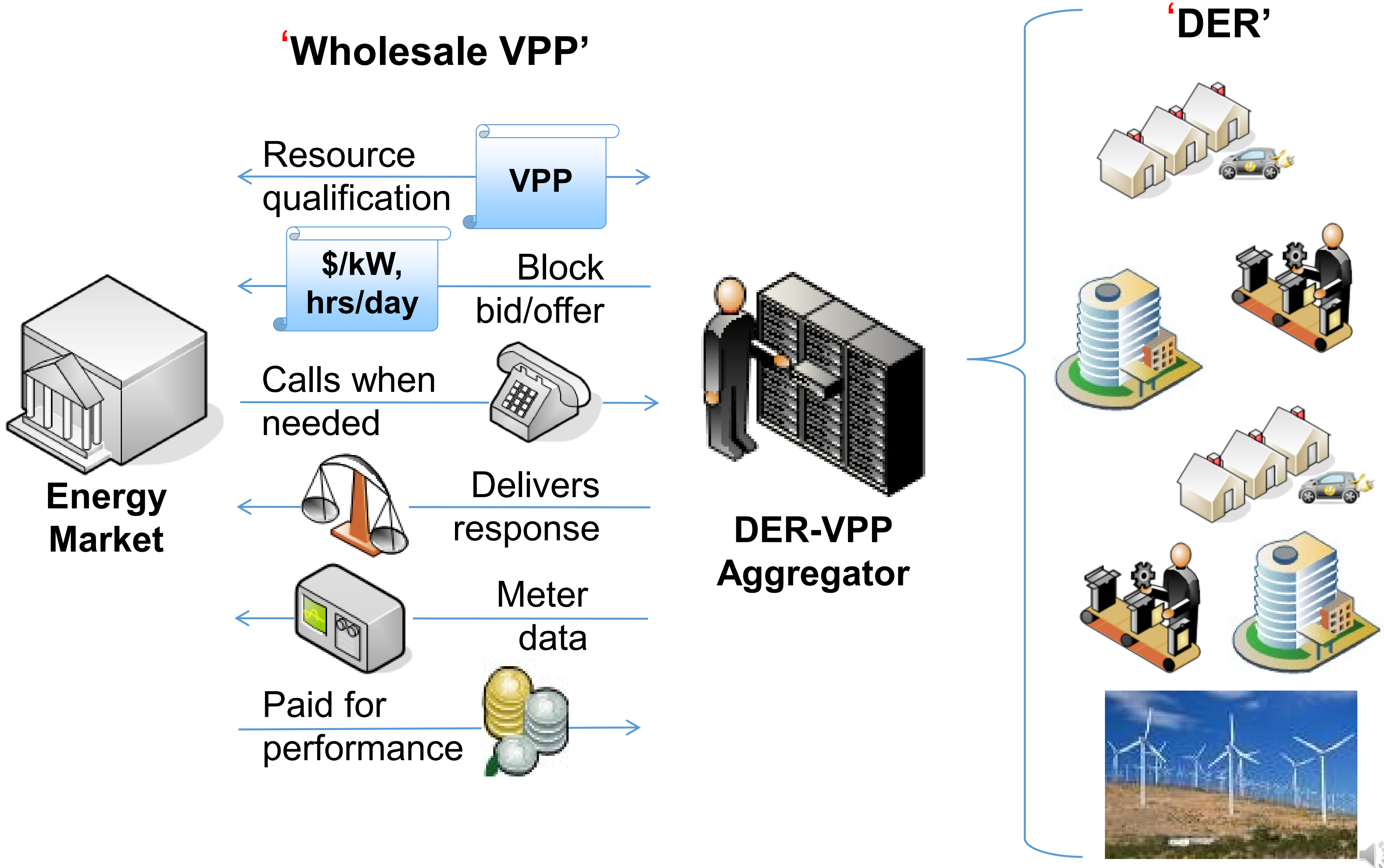
Key Challenges and Solutions

- Challenges:
  - Proliferation of distributed energy resources
  - Uncertainty and variability of renewable resources
  - Proposals for DER integration focus on energy balancing but do not address distribution of risk along the supply chain.
  - Edge technologies enable the privatization of risk through product differentiation and empowering customer choice for cost vs. risk tradeoff by offering flexibility.
  - But we need to develop market mechanisms for demand side participation in risk mitigation
  - Need aggregator end to end business models for mobilizing demand flexibility and real options for risk management in the provision of electricity service.
  - Need wholesale market framework to accommodate such aggregators participation in the market.

DER Aggregation through Virtual Power Plants



155 FERC ¶ 61,229
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

California Independent System Operator Corporation — Docket No. ER16-1085-000

ORDER ACCEPTING PROPOSED TARIFF REVISIONS SUBJECT TO CONDITION

1. On March 4, 2016, pursuant to section 205 of the Federal Power Act (FPA),[1] the California Independent System Operator Corporation (CAISO) filed proposed revisions to its Open Access Transmission Tariff (tariff) to facilitate participation of aggregations of distribution-connected or distributed energy resources in CAISO's energy and ancillary services markets. In this order, we accept the filing subject to condition, as discussed below, to become effective June 3, 2016, as requested.

CAISO's proposed revisions address five topics: (1) provisions that recognize a distributed energy resource provider (DER Provider) as a market participant; (2) provisions that recognize a distributed energy resource aggregation as a market resource; (3) rules governing participation of these resources in the CAISO markets; (4) distinctions between the requirements for scheduling coordinators representing demand response providers and the requirements for scheduling coordinators representing DER Providers; and (5) a new *pro forma* DER Provider Agreement.[3]

FEDERAL ENERGY REGULATORY COMMISSION
Fact Sheet

September 17, 2020

News Media Contact:
Craig Cano, mediadl@ferc.gov
Docket No. RM18-9-000

FERC Order No. 2222: A New Day for Distributed Energy Resources

FERC Order No. 2222 will help usher in the electric grid of the future and promote competition in electric markets by removing the barriers preventing distributed energy resources (DERs) from competing on a level playing field in the organized capacity, energy and ancillary services markets run by regional grid operators.

DERs are small-scale power generation or storage technologies (typically from 1 kW to 10,000 kW) that can provide an alternative to or an enhancement of the traditional electric power system. These can be located on an electric utility's distribution system, a subsystem of the utility's distribution system or behind a customer meter. They may include electric storage, intermittent generation, distributed generation, demand response, energy efficiency, thermal storage or electric vehicles and their charging equipment.

This rule allows several sources of distributed electricity to aggregate in order to satisfy minimum size and performance requirements that each may not be able to meet individually.

"GET CREDIT FOR TAKING TIME OFF."

YES, I'LL TAKE THE CREDIT.

Put the peel-off address label here.

An Edison representative will phone to make arrangements to install the device. Please be sure to include your home or work phone number below:

(____) ______________ home/work

Best time to contact me is: ______ a.m./p.m.

Please complete the following and check appropriate boxes. Tear off and return.

☐ I am an Edison residential customer with electric central air conditioning. Please put me on the new rate schedule D-APS 2 (Air Conditioner Cycling). I have read the brochure information regarding this rate.

Install a device on my air conditioning equipment for the savings option checked below so that I will receive a credit on my bill each month during the 6 summer months.

☐ A—$5.50 credit for each ton of my air conditioner
☐ B—$3.00 credit for each ton of my air conditioner
☐ C—$1.50 credit for each ton of my air conditioner
☐ I am interested but would like additional information about this program.

____

Signature of owner/manager, if approval needed.

"Read this. I'd like to see you get up to $165 just by signing up for Air Conditioner Cycling."

—George Burns

If you have central air conditioning, you can save money on your summer electric bills by participating in the Air Conditioner Cycling Program.

This program helps slow the growing demand for new power plants. When business and industry are in full production and residential customers are using electrical appliances and air conditioners, the demand for electricity reaches peak levels. Air Conditioner Cycling helps manage the growth of peaks and reduces the need to build new power plants.

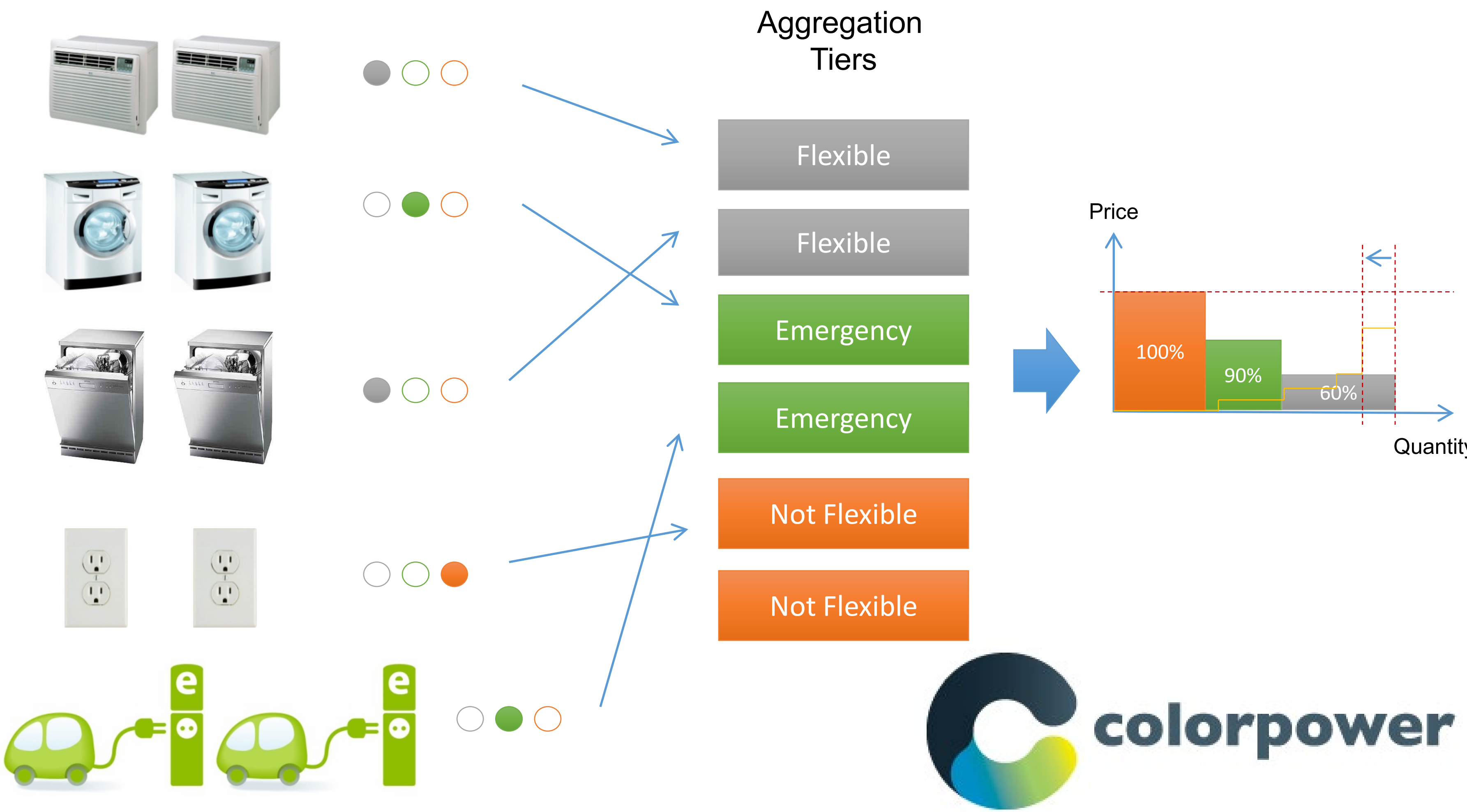
Here's how the program works.

By choosing to participate in the new Air Conditioner Cycling Program, you'll get a credit toward your

THERE ARE THREE SAVINGS OPTIONS.	EXAMPLES*	TOTAL SAVINGS OVER 6 SUMMER MONTHS.					
SAVINGS OPTION	MONTHLY SAVINGS FOR EACH TON OF A/C	2.5-TON UNIT	3-TON UNIT	3.5-TON UNIT	4-TON UNIT	4.5-TON UNIT	5-TON UNIT
A—off full time cycling is in effect	$5.50	$82.50	$99	$115.50	$132	$148.50	$165
B—off 10 min. out of each 15 min. period	$3.00	$45	$54	$63	$72	$81	$90
C—off 7½ min. out of each 15 min. period	$1.50	$22.50	$27	$31.50	$36	$40.50	$45

*Any size electric central air conditioner or heat pump in good working condition qualifies for this program.

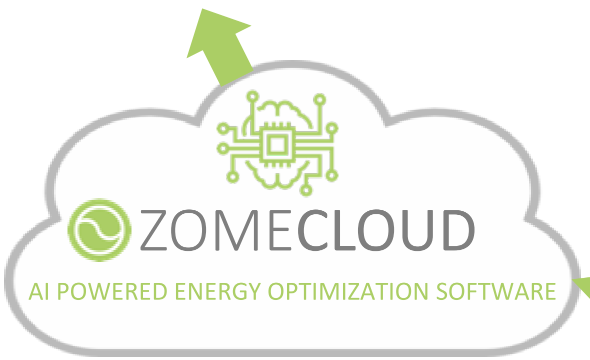
Device Control Paradigm



zome

ZOME TECHNOLOGY

Bidding curtailment into
ISO market energy programs



Multi Family Residences
and Commercial Buildings

1) EASY INSTALL, LOW/NO COST
2) CLIENTS SAVE ENERGY & MONEY
3) AND GET PAID AS A "GRID ASSET"
→ ZOME LINKS BUILDING TO ENERGY MARKETS

ZOMEKIT
SMART BUILDING GATEWAY

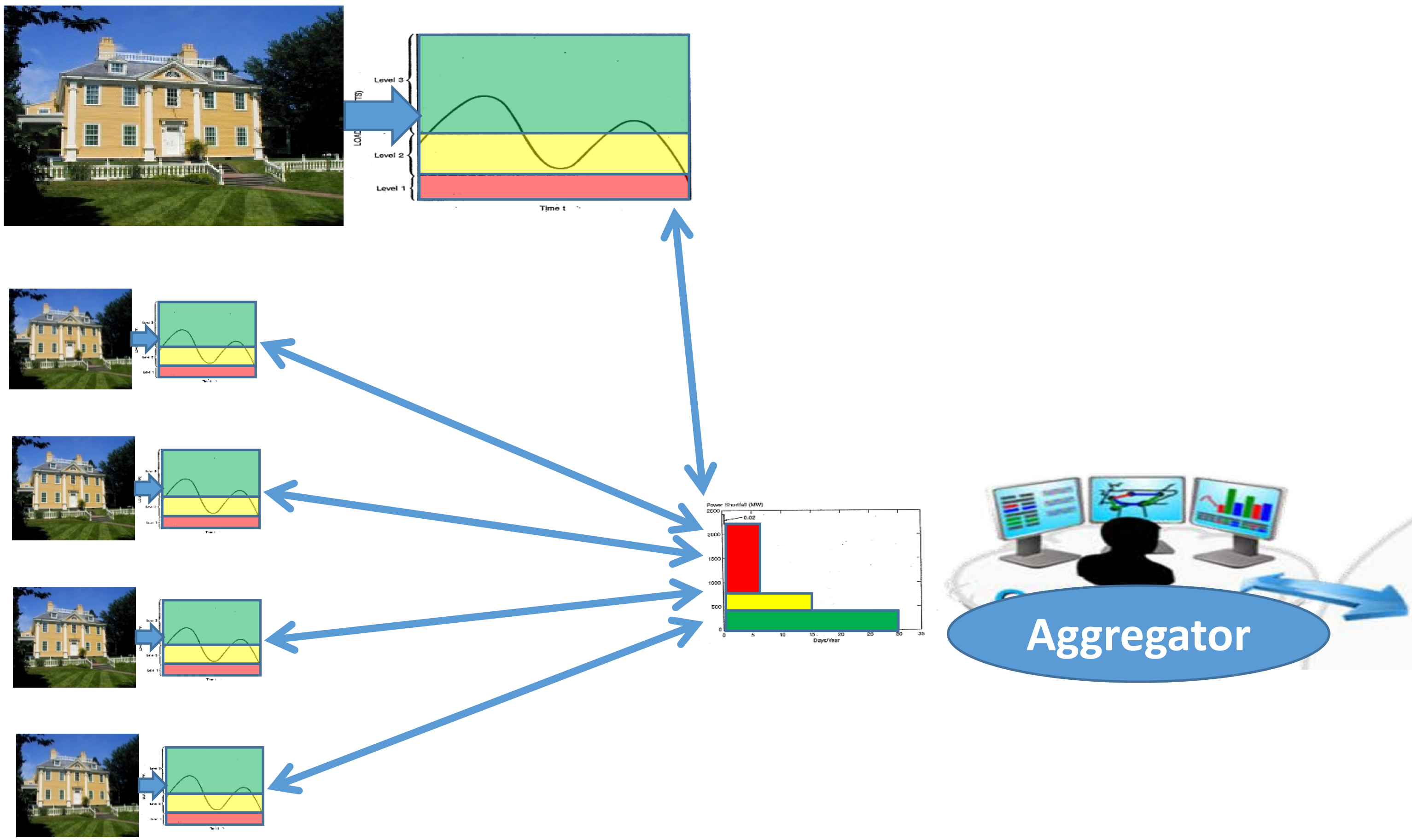
ZOMEKIT Today:

- ***HVAC*** control via kitted networked thermostats
- ***Hot Water Heater*** control via smart on/off adapters

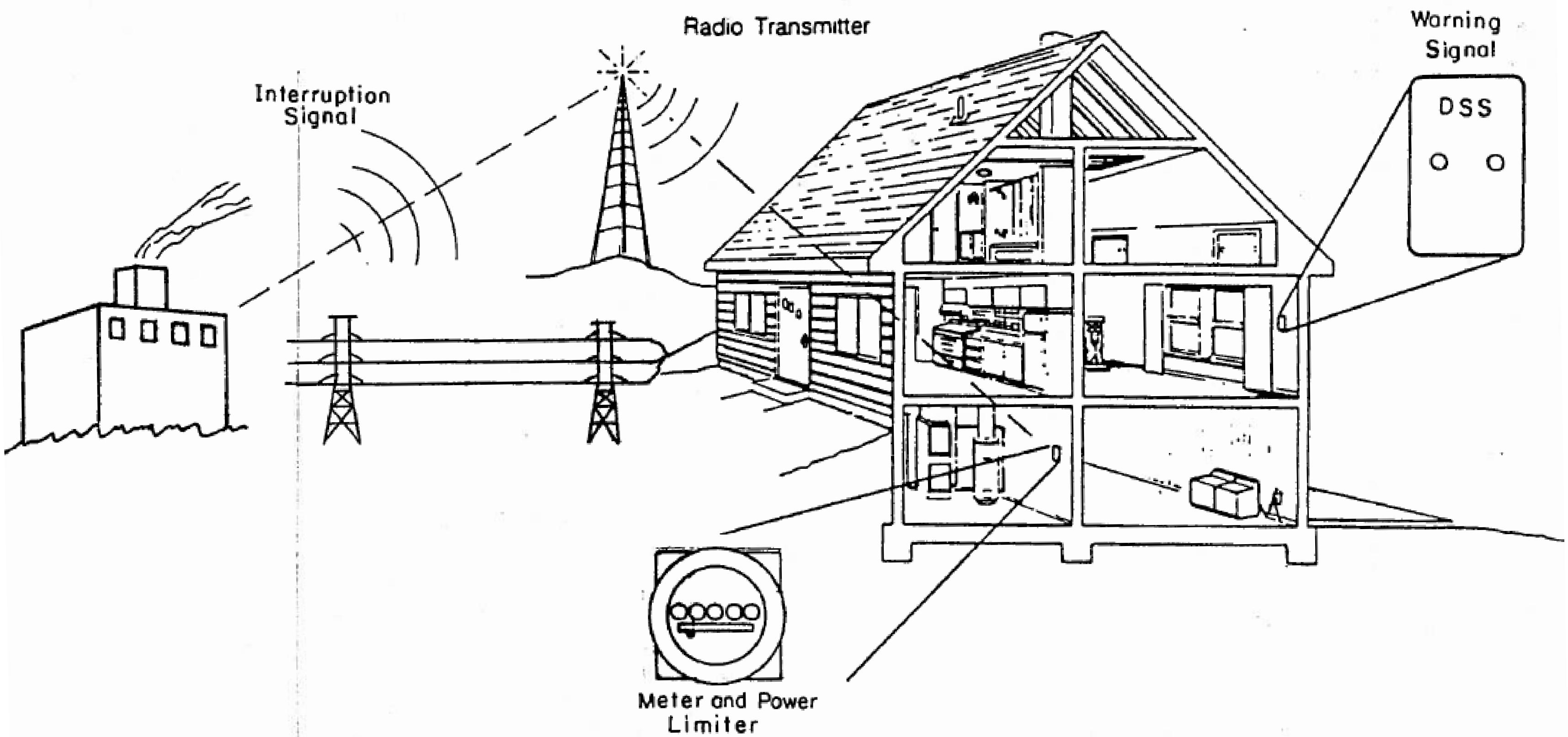
ZOMEKIT Pilots:

- Local ***Solar*** generation, control, optimization
- In-building ***Batteries*** to store/use energy
- Integrated, co-optimizing ***EV Chargers***/charging

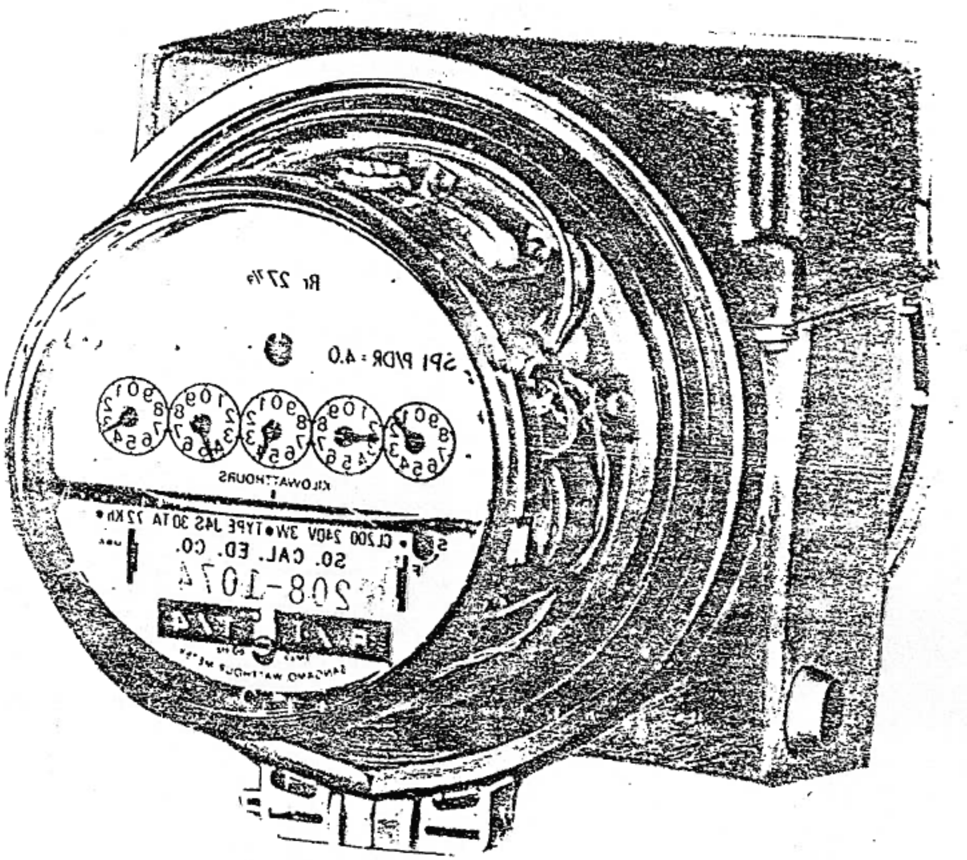
Fuse [capacity] Control Paradigm
(customer controls allocation of curtailed capacity)



Demand Subscription Service
(implemented at SCE in the early 1980’s)

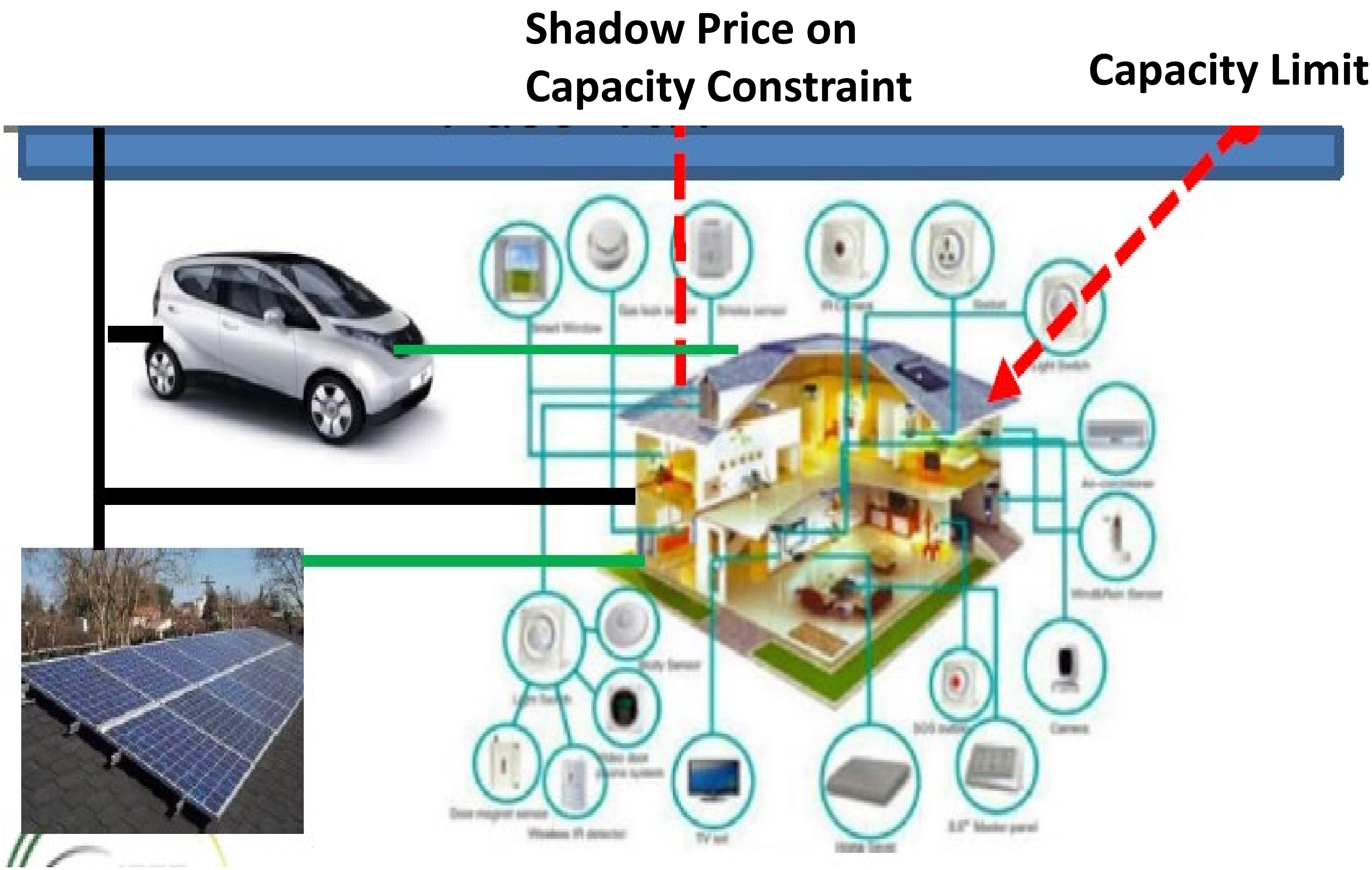


Demand Subscription Service: Radio controlled fuse limits customer's power supply to his subscribed level.

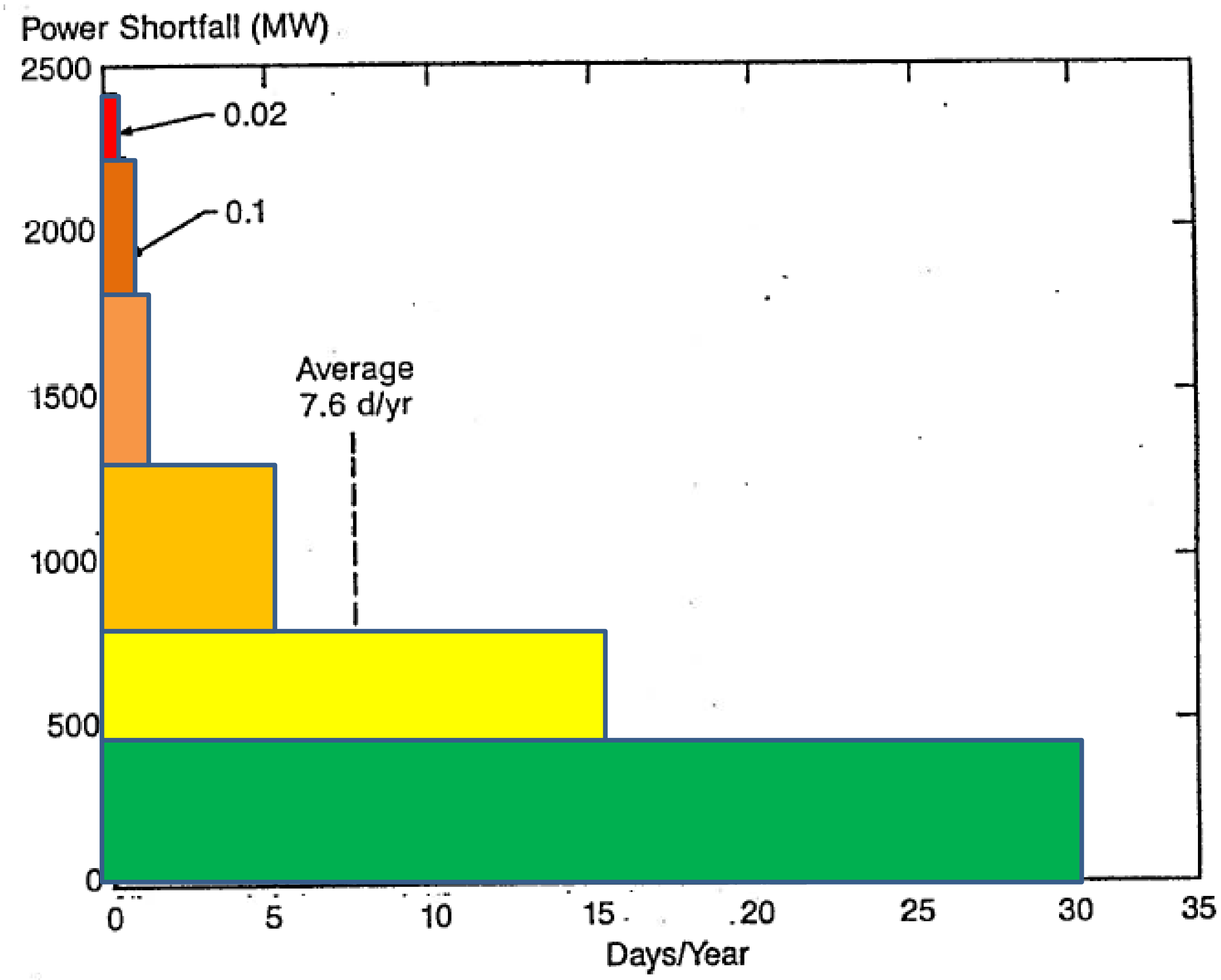


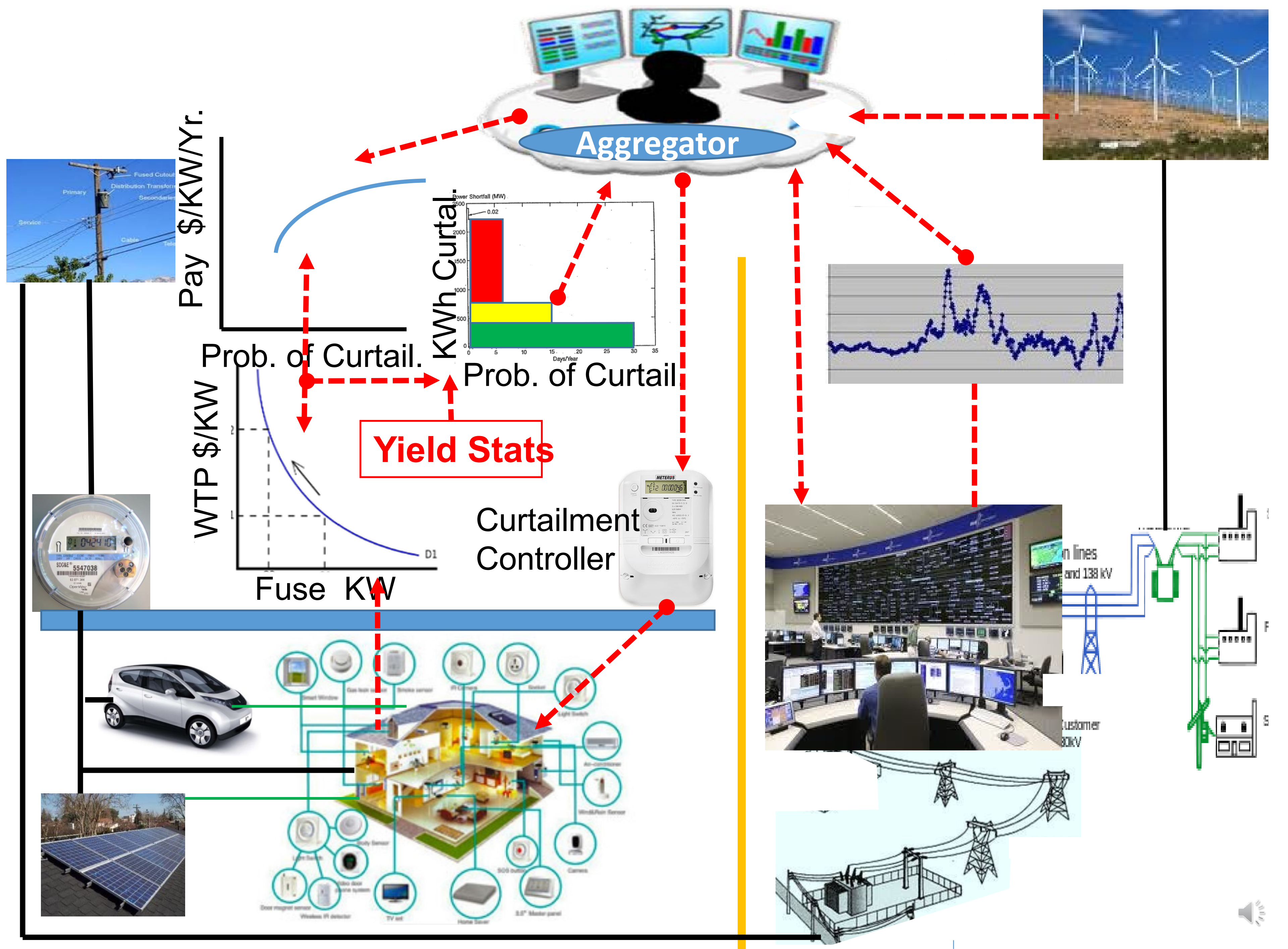

DSS TM SM
DEMAND SUBSCRIPTION SERVICE TM SM
ACTIVATED
SELECTED LEVEL EXCEEDED
SOUTHERN CALIFORNIA EDISON COMPANY

Autonomous Capacity Constrained Energy Management



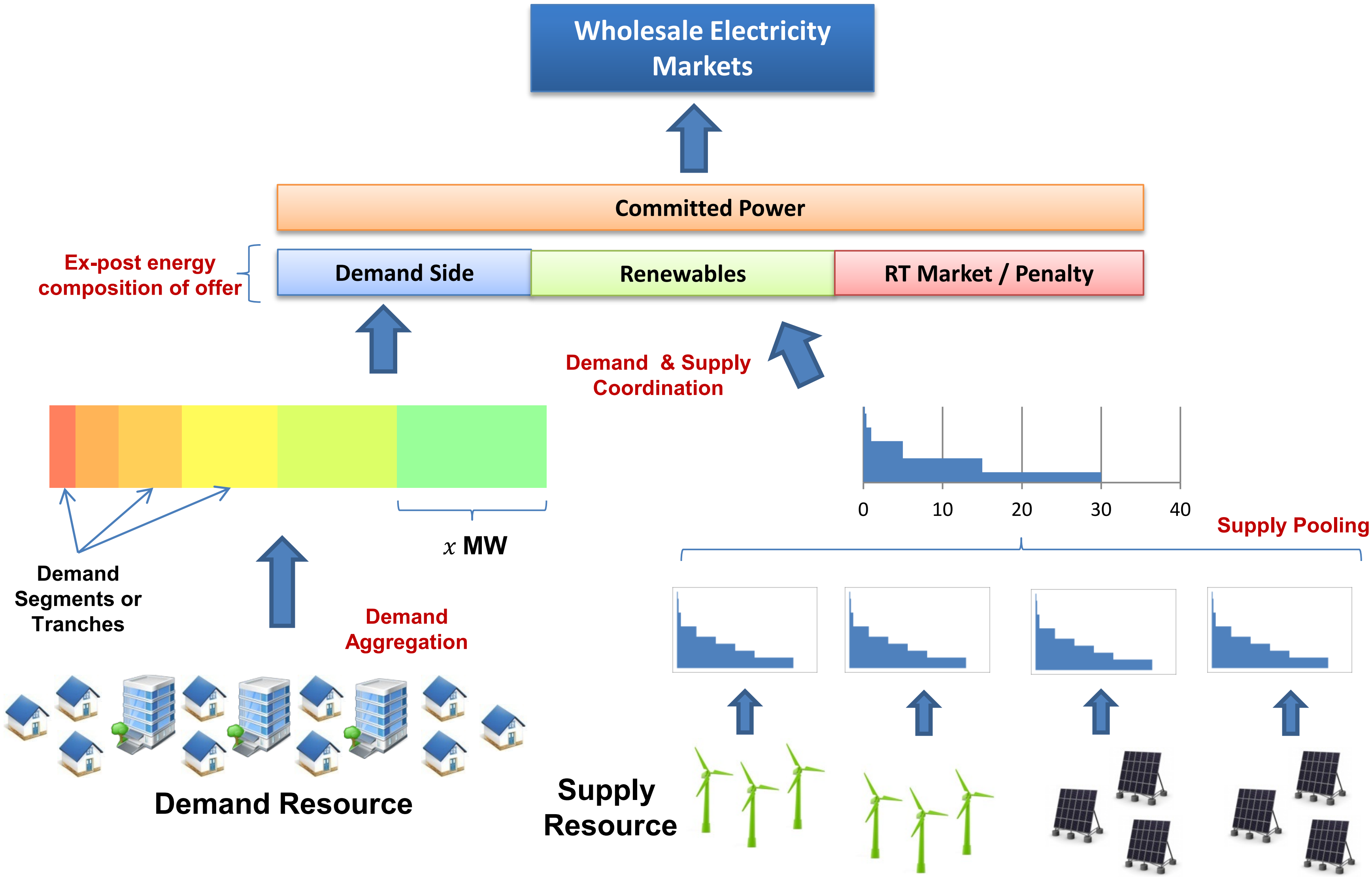
Avaiable Load Curtailment Profile





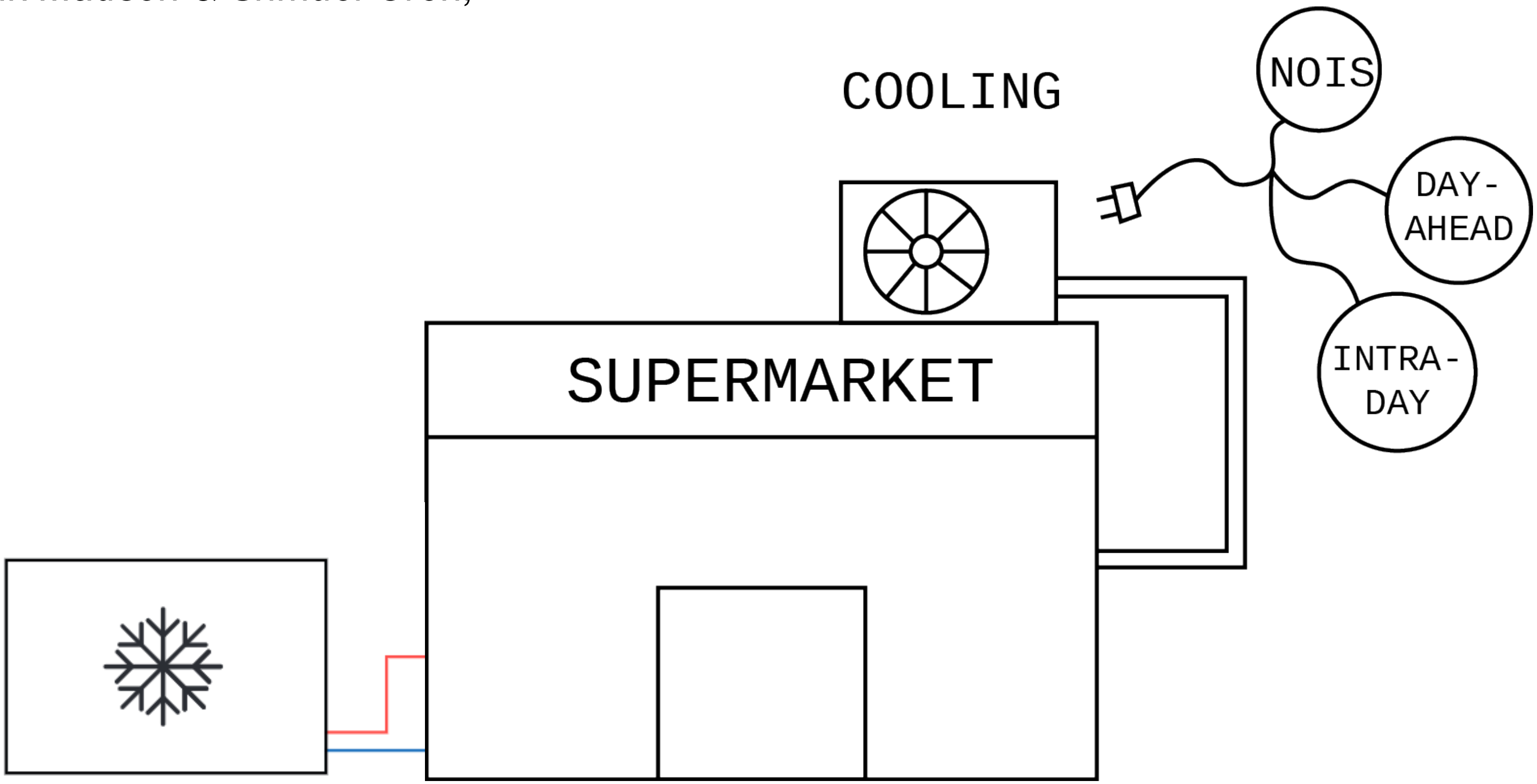
Aggregator
Pay $/KW/Yr.
Prob. of Curtail.
KWh Curtal.
Prob. of Curtail
Power Shortfall (MW)
Days/Year
WTP $/KW
Fuse KW
D1
Yield Stats
Curtailment
Controller

The Wholesale Product Offered by the Aggregator



OPTIMAL OPERATION OF A COMBINED ICE-STORAGE AND REFRIGERATON SYSTEM

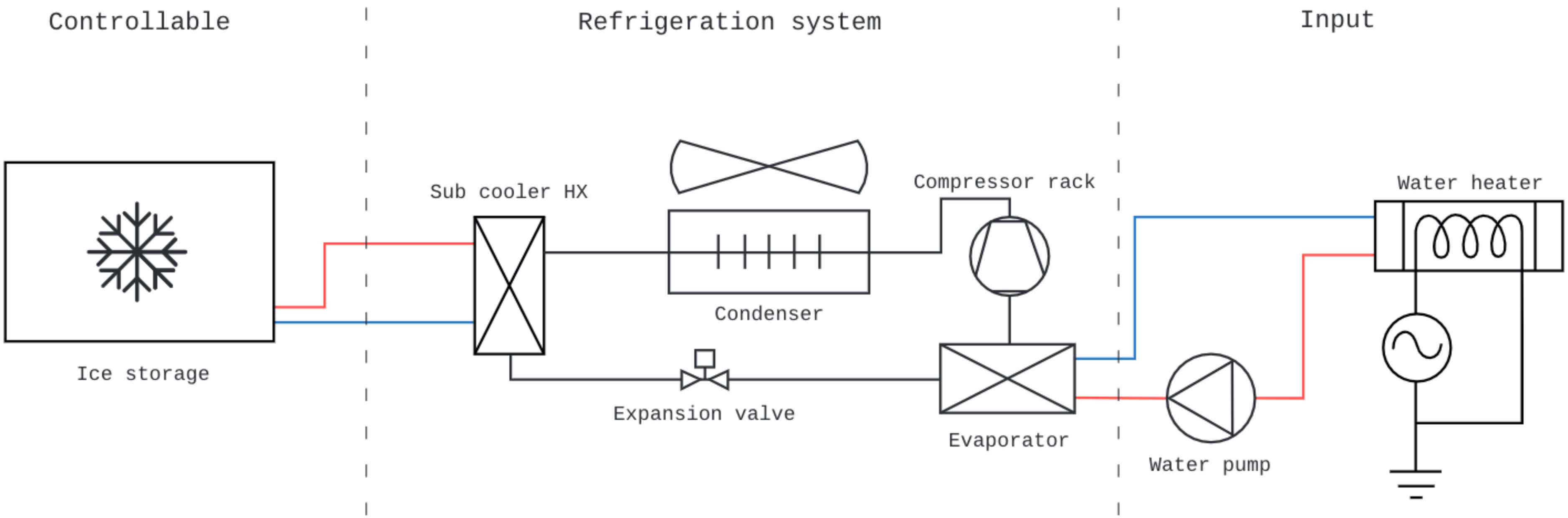
Niclas Brok Henrik Madsen & Shmuel Oren,



PHYSICAL SETUP

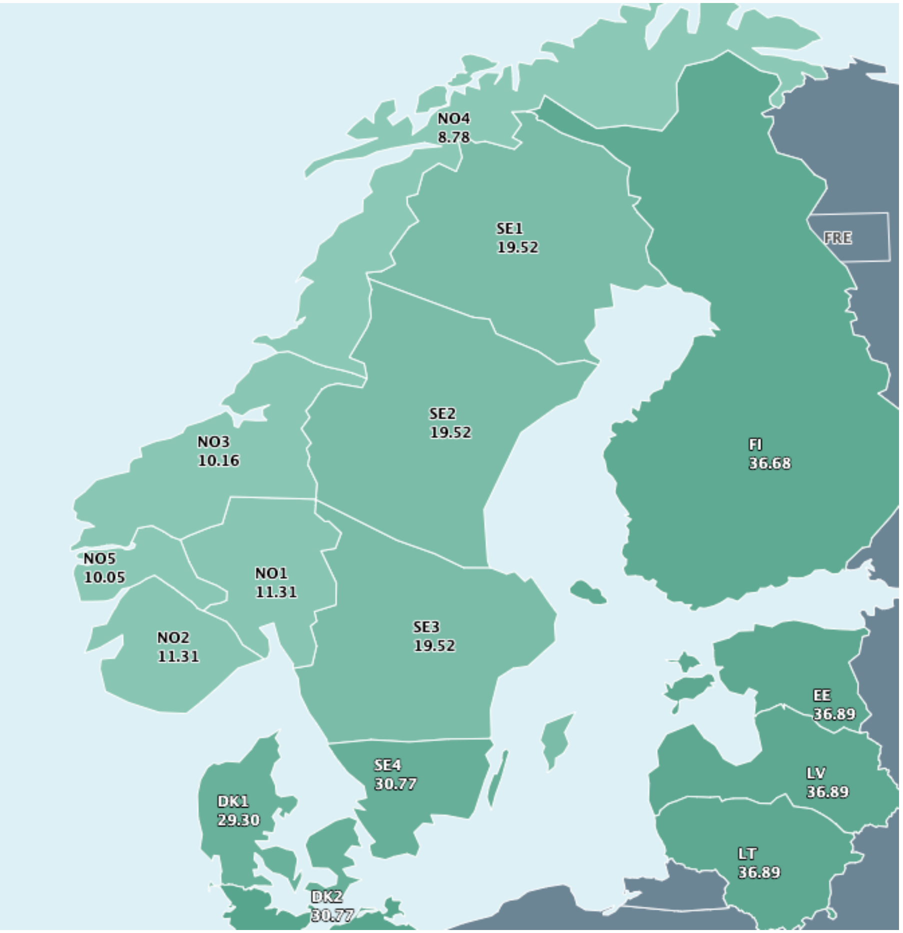
- We can use the ice storage to curtail the refrigeration system
  the refrigeration system is a small supermarket at Danfoss

- We use heated water to simulate an outdoor temperature



OPTIMIZATION GOAL

- We want to *minimize electricity costs*
- We assume that we are price-taker of the day-ahead prices
- The day-ahead market prices are the result of a market clearing between 15 inter-connected price zones
- The day-ahead market defines 24 hourly prices each day of operation
  the day-ahead market closes at 12:00 on the day prior to operation



OPTIMAL CONTROL PROBLEM

- c is the instantaneous power consumption of the combined refrigeration system

- τ is the curtailment vector
when to initiate and stop a curtail cycle

- x models the compressor capacity of the refrigeration system
this is proportional to the power consumption

- f is the dynamical model

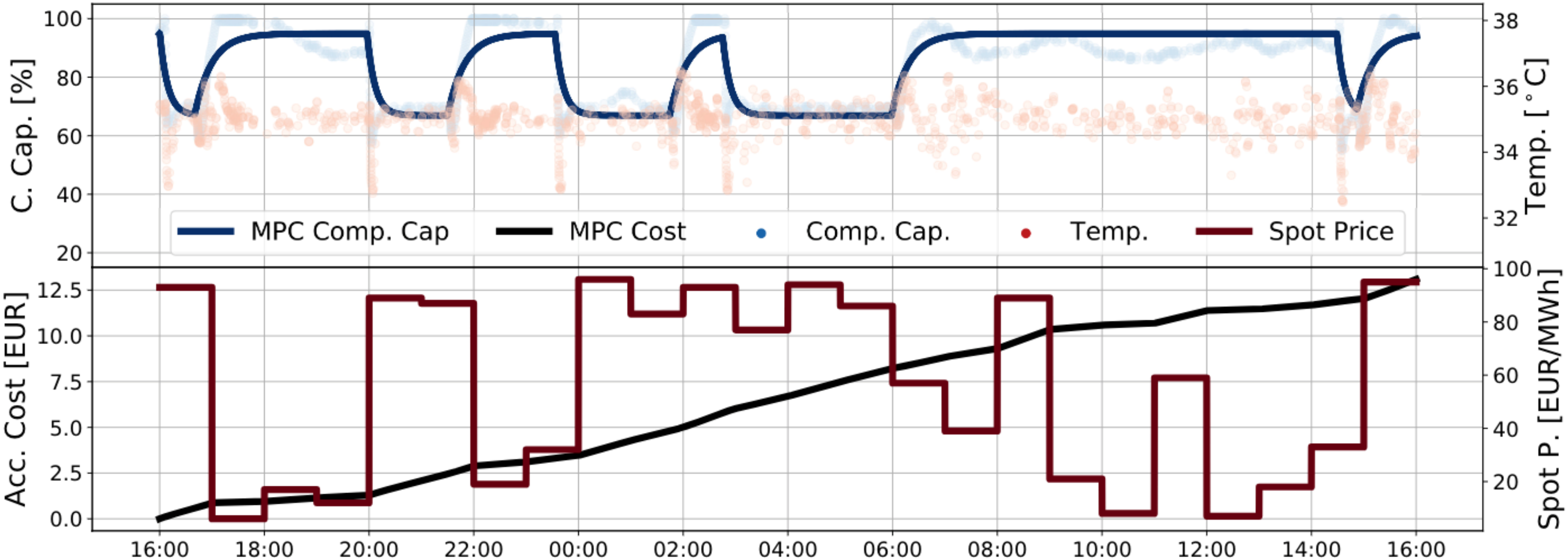
$$\min_{x,\tau} \left\{ J(x,\tau) = \int_0^T c(x(t), t; \tau)\, \mathrm{d}t \right\},$$

s.t.

$$\begin{aligned} \tau &\in \mathcal{T}, \\ \dot{x} &= f\,(x; p, \tau), \quad \text{in } [0,T], \\ x(0) &= x_0, \end{aligned}$$

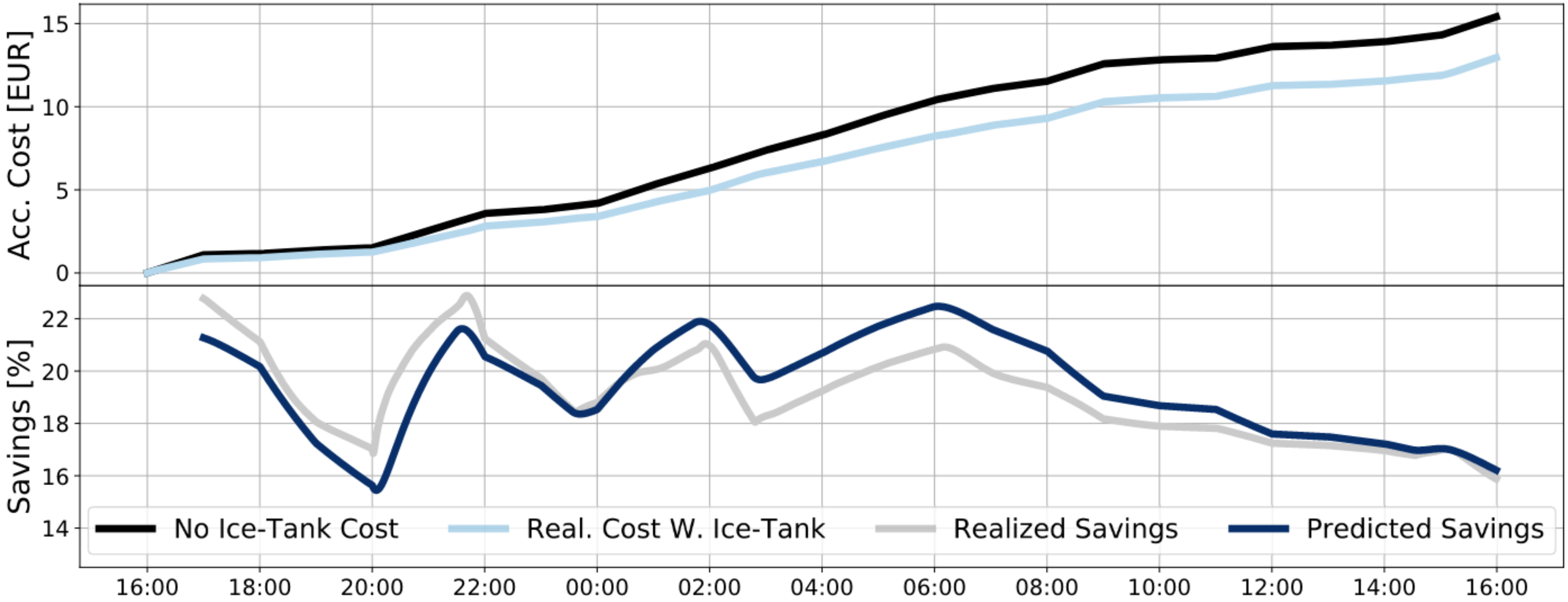
1 DAY OF OPERATION

- These results show 1 day of operation by implementing 5 optimal curtailment cycles
- The optimal control problem has been solved only once in the beginning at 4pm

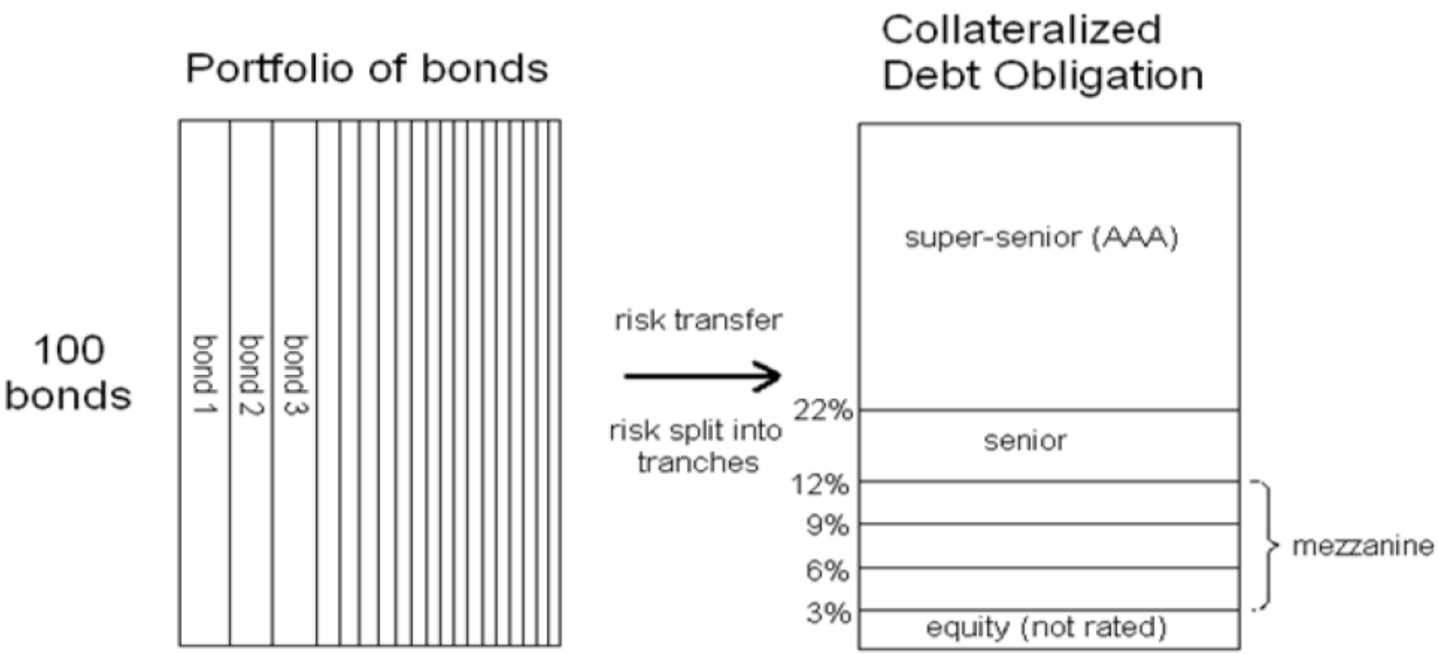


1 DAY OF OPERATION - SAVINGS

- Realized savings of 15-20 % using the control strategy *compared to not having ice-storage available*



Resource Portfolio Risk Allocated to Priority Tranches



Renewable resources **Curtailable demand priorities**

Unlike mortgages, energy resources risks are independent

CHANGING WHAT'S POSSIBLE

PERFORM—Performance-based Energy Resource Feedback, Optimization, and Risk Management

PROJECT DESCRIPTIONS

Energy Trading Analytics, LLC – Phoenixville, PA

Stochastic Market Auction Redesigned Trading System (SMARTS) - $3,360,000

The proposed effort is to develop a novel, state-of-the-art stochastic redesign for wholesale real-time energy and reserve markets coupled with intelligent energy-portfolio risk management tools that enable consumers to prioritize their flexible demand assets (such as air conditioners, water heaters, energy storage) to offer their flexibility into markets as demand reserves. This project will evaluate the risk and performance of the proposed market trading system and conduct simulation and pre-pilot tests to demonstrate the approach in the world's largest wholesale electricity market, PJM Interconnection. The redesigned market trading system will advance price-responsive risk management, foster robust decentralized decision making for real-time operations and operational planning under uncertainty, and attract innovation and investment opportunities.

2020 Nobel Prize Co-Winner in Economics – Robert WilsoN

Robert Wilson

Shmuel Oren

Hung Po Chao