Market Based Mechanisms for Mobilizing Electric Demand Flexibility

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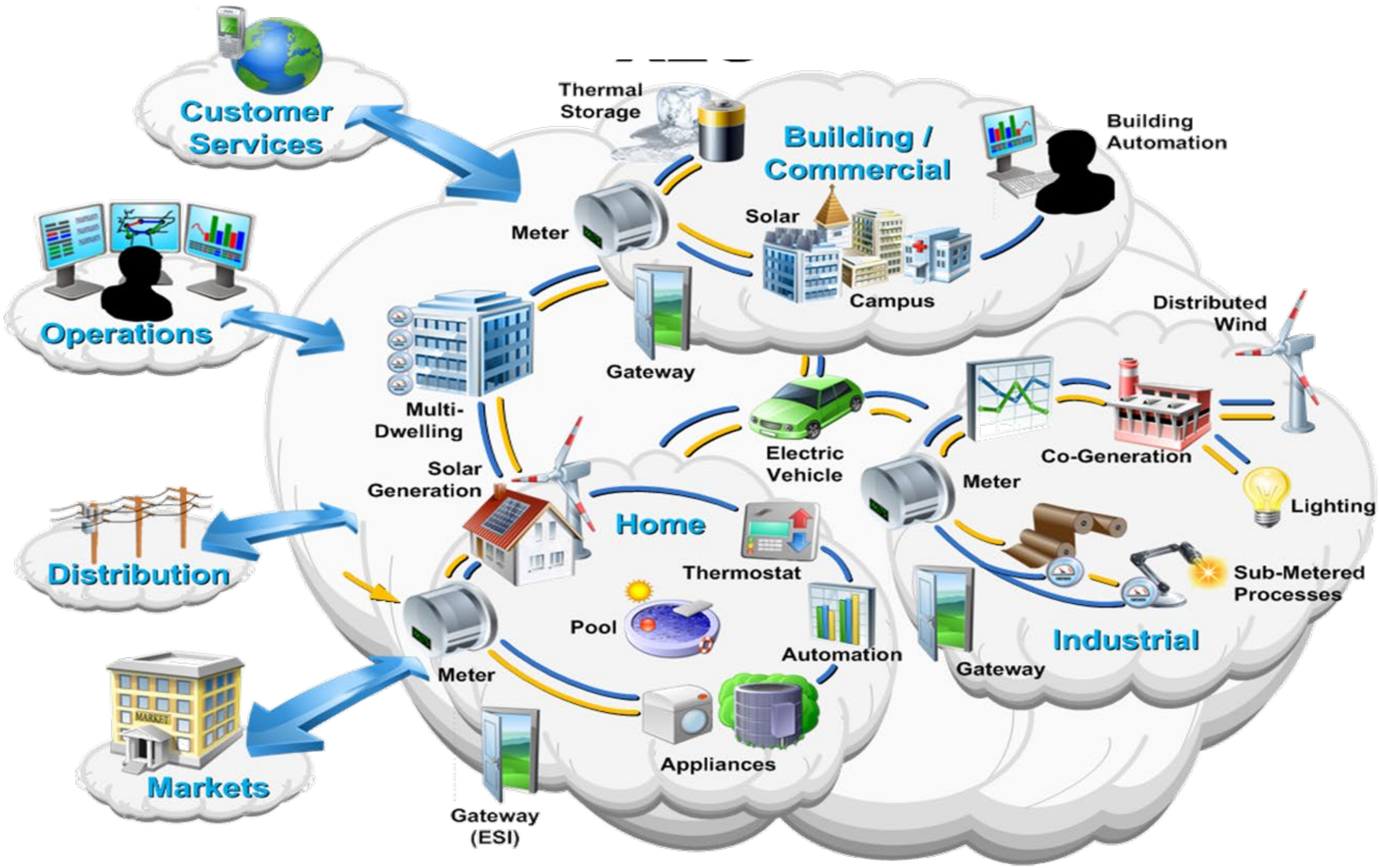
SFB Workshop: Decision-making in Distributed and Volatile Energy Markets
April 21, 2021

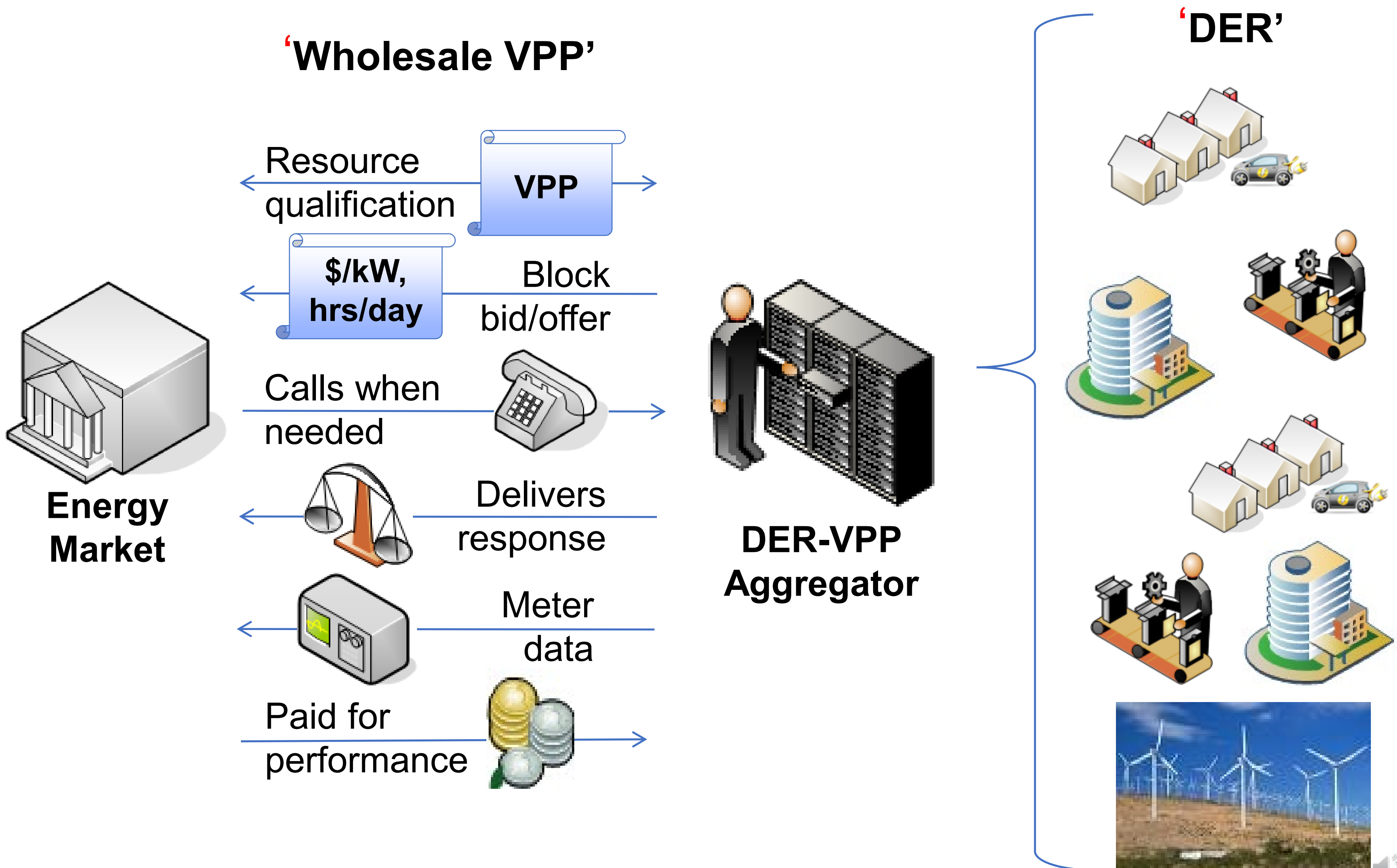
Future Electricity System



Key Challenges and Solutions

- 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.

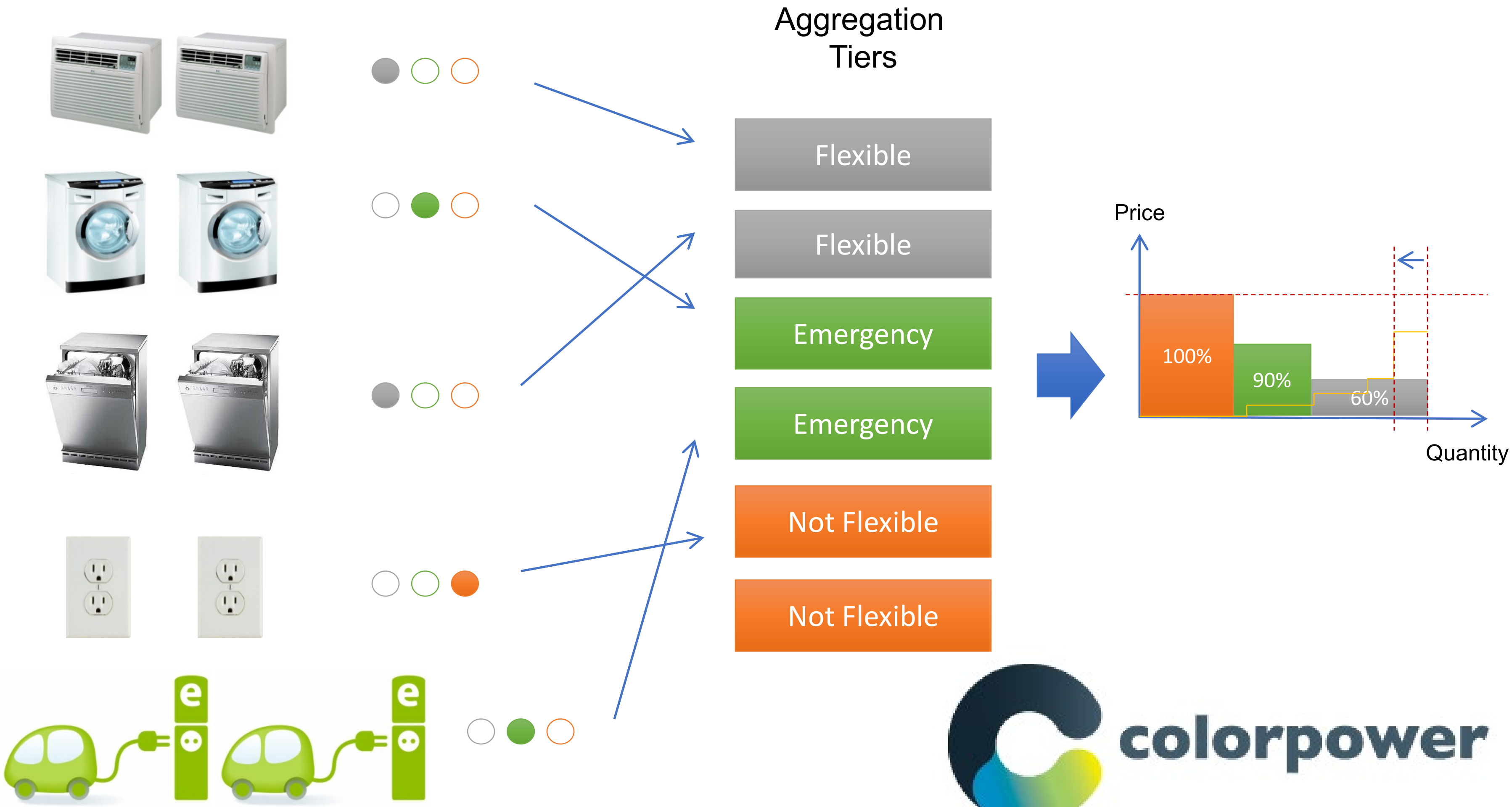
Here's how the program works.

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



colorpower

zome

ZOME TECHNOLOGY

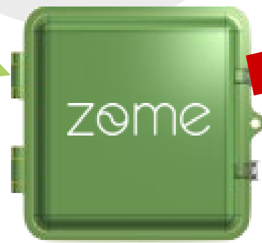
zome

Bidding curtailment into
ISO market energy programs

ZOMECLOUD

AI POWERED ENERGY OPTIMIZATION SOFTWARE

Multi Family Residences
and Commercial Buildings



ZOMEKIT

SMART BUILDING GATEWAY

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

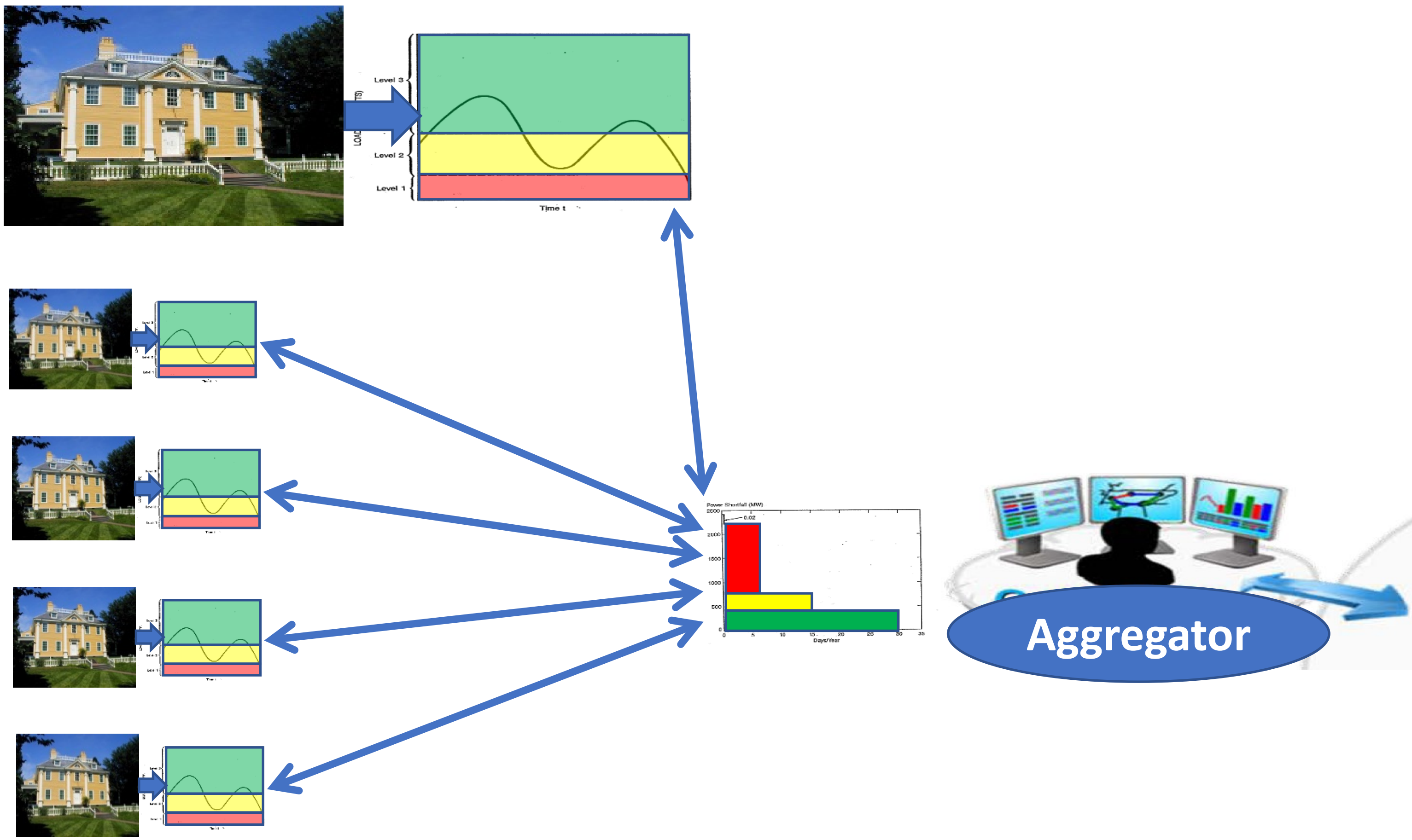
ZOMEKIT Today:

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

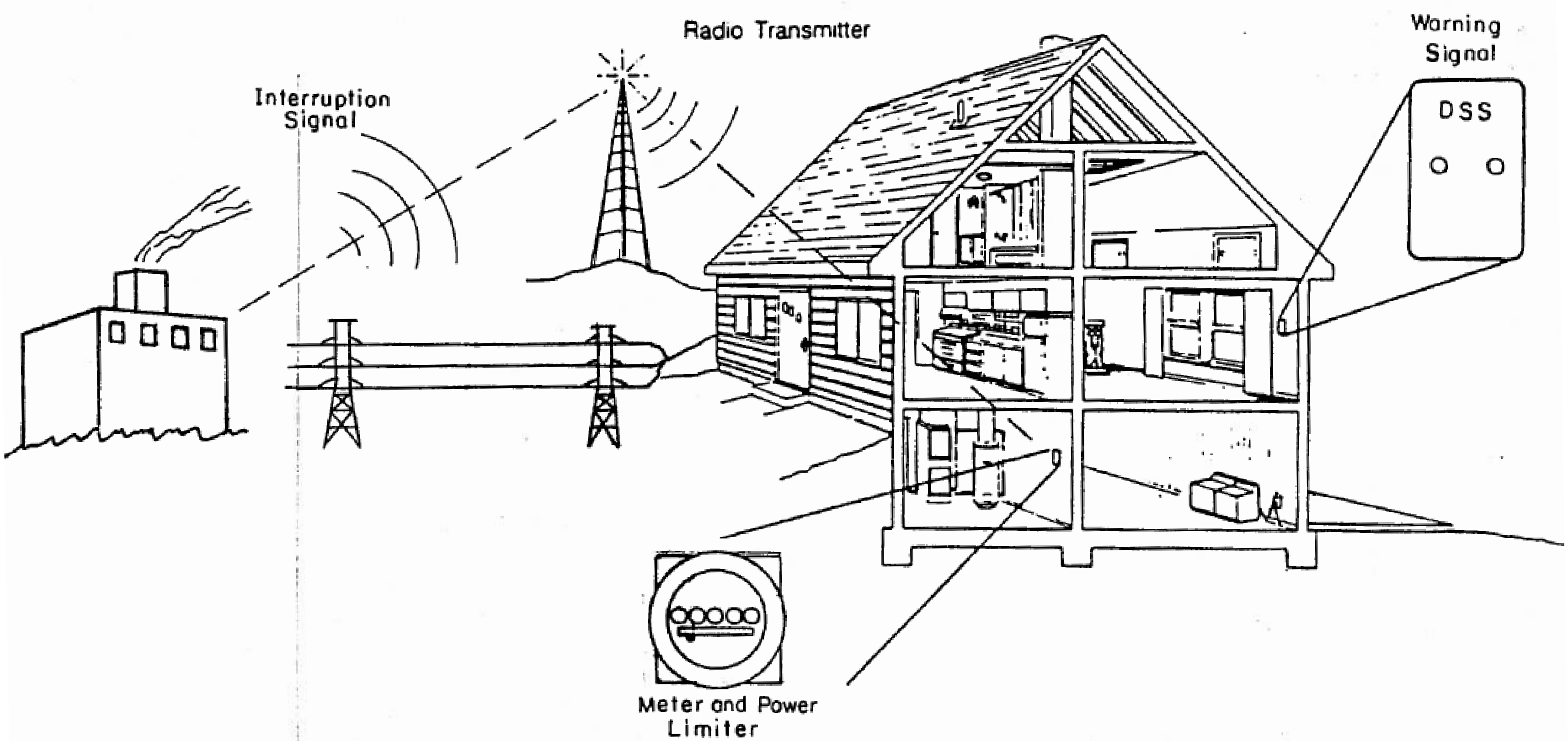
ZOMEKIT Pilots:

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

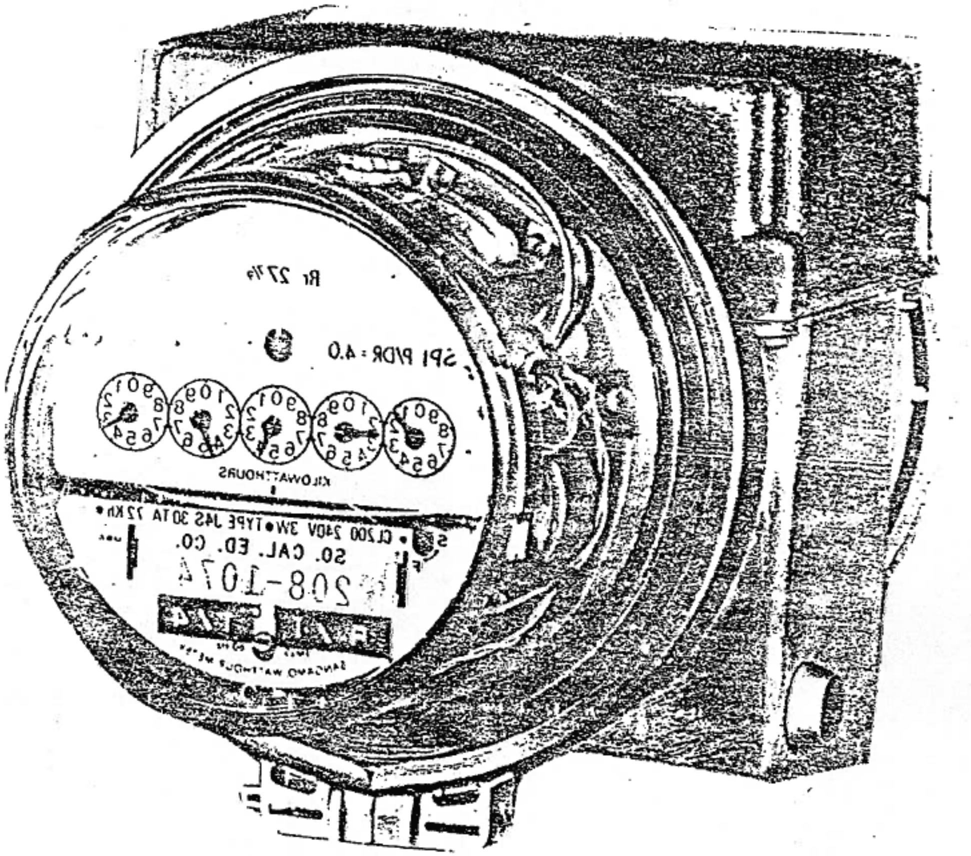
Fuse [capacity] Control Paradigm
(customer controls allocation of curtailed capacity)

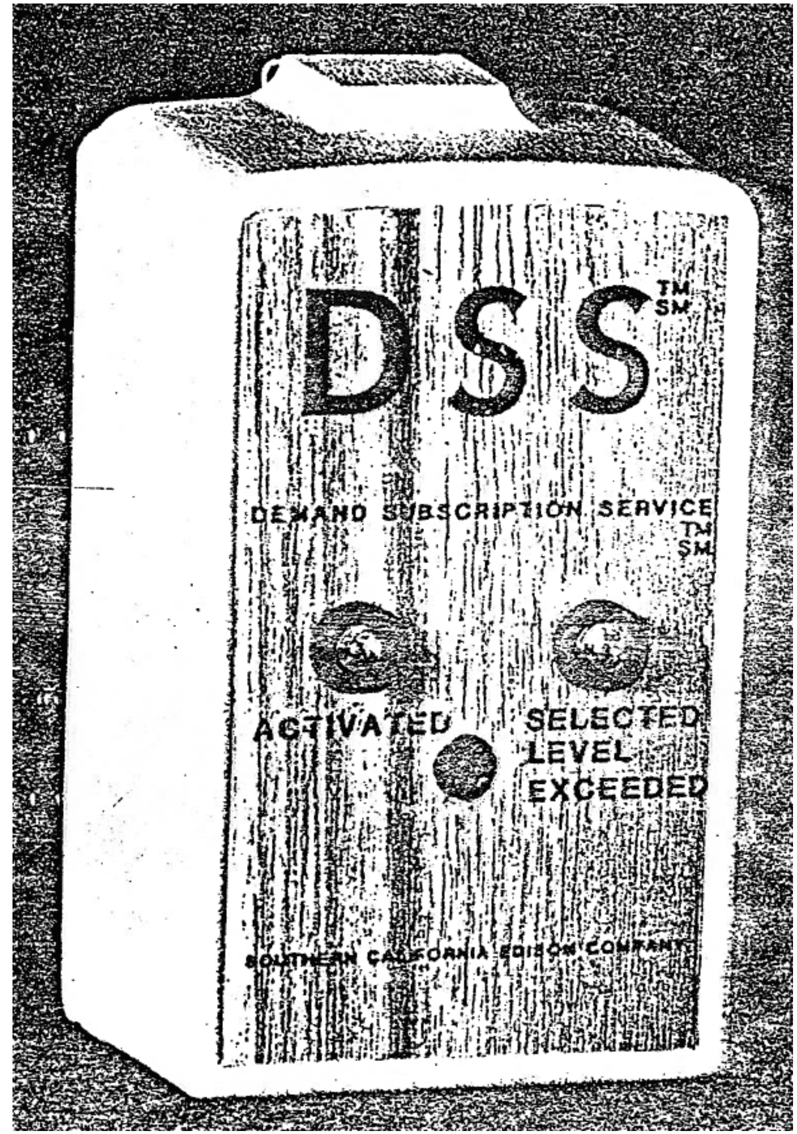


Demand Subscription Service
(implemented at SCE in the early 1980's)

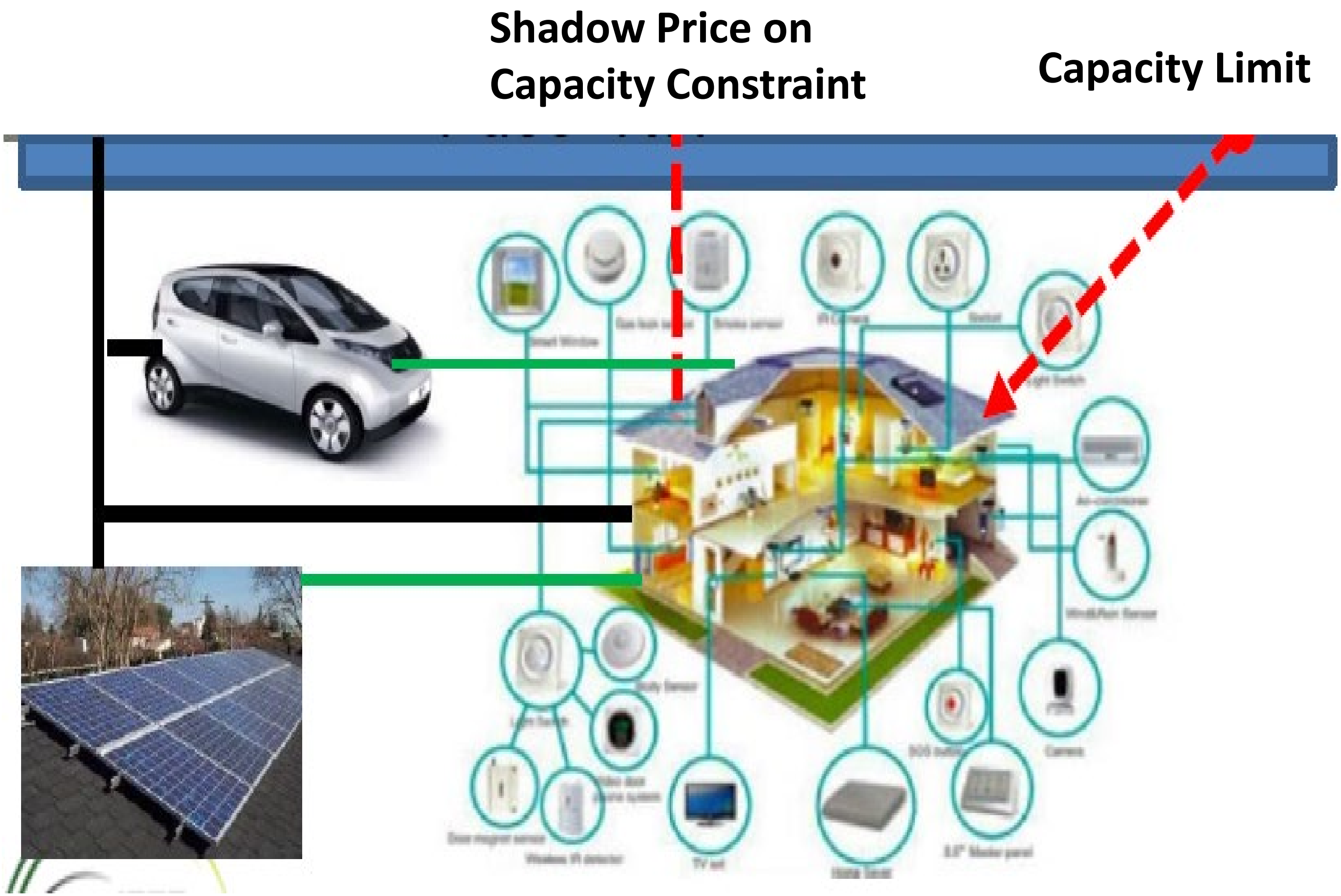


Demand Subscription Service: Radio controlled fuse limits customer's power supply to his subscribed level.

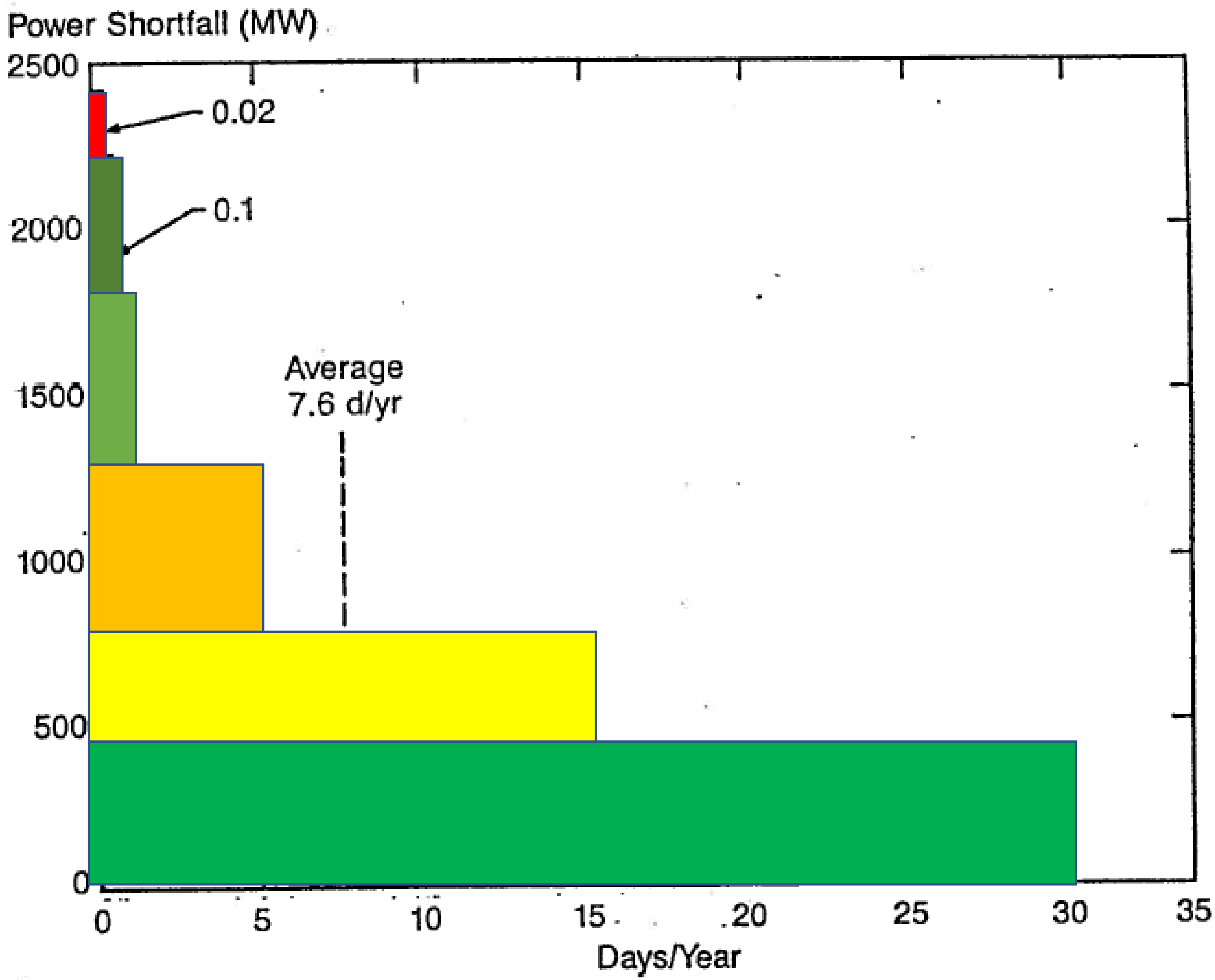


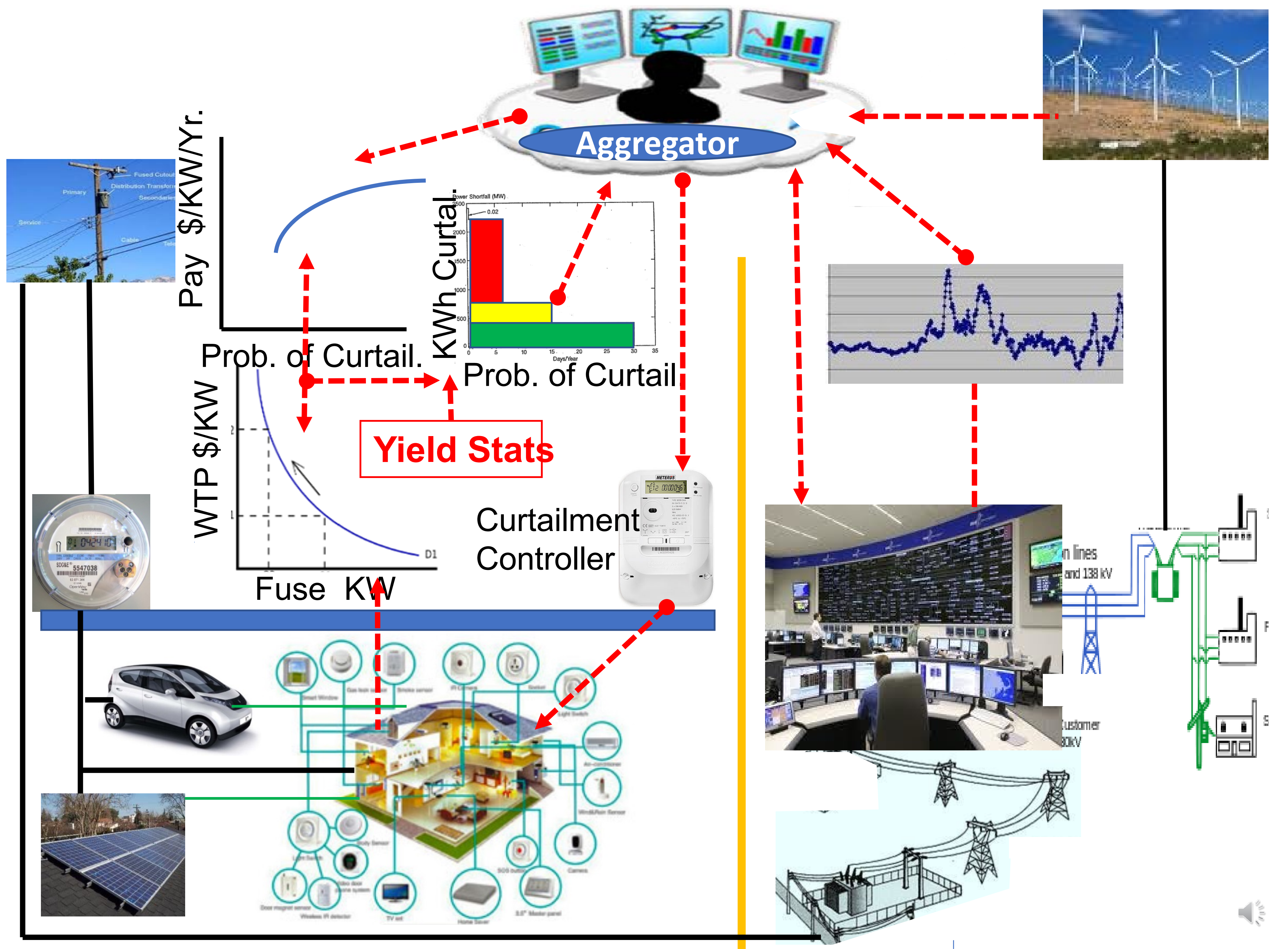

DSS TM SM
DEMAND SUBSCRIPTION SERVICE TM SM
ACTIVATED
SELECTED LEVEL EXCEEDED
SOUTHERN CALIFORNIA EDISON COMPANY

Autonomous Capacity Constrained Energy Management



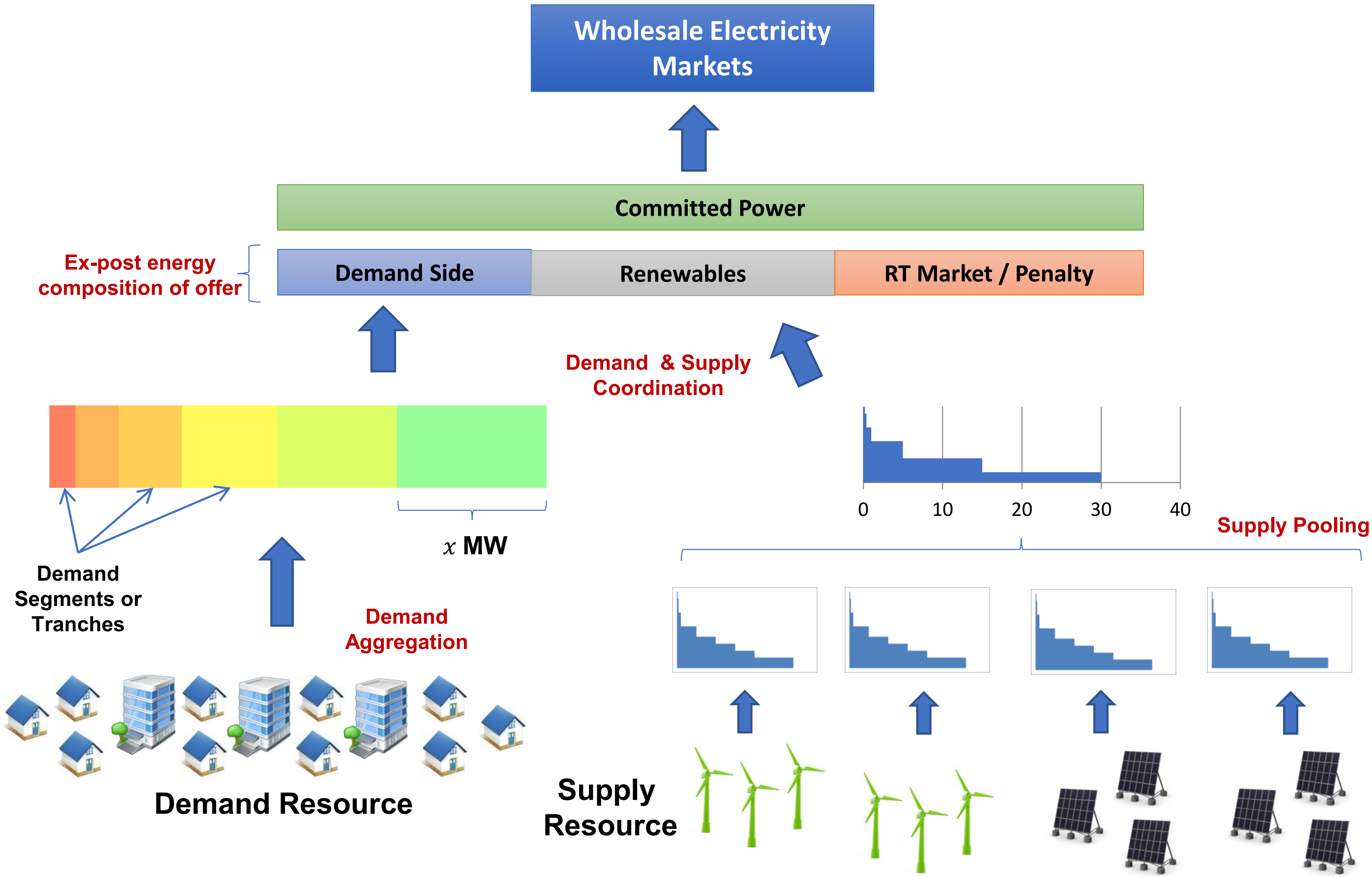
Avaiable Load Curtailment Profile



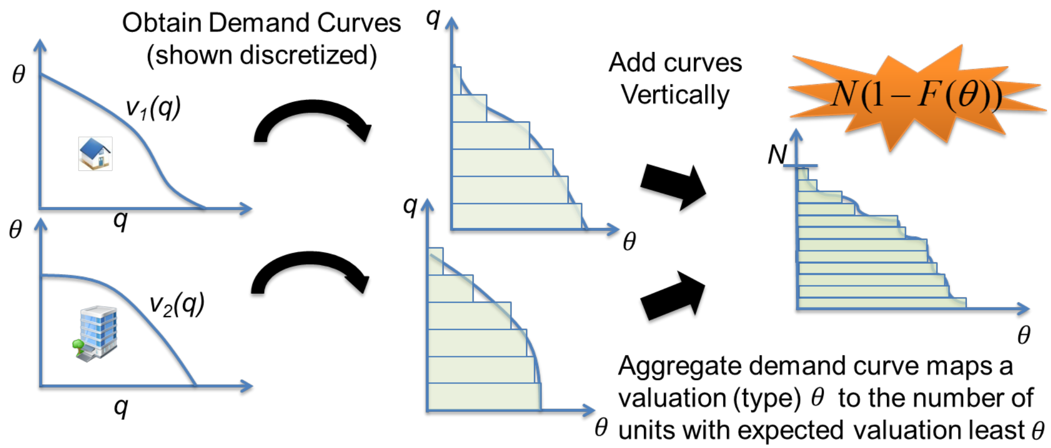


Aggregator
Pay $/KW/Yr.
Prob. of Curtail.
KWh Curtal.
Power Shortfall (MW)
Days/Year
Prob. of Curtail
WTP $/KW
Fuse KW
D1
Yield Stats
Curtailment
Controller
METERUS
Primary
Service
Cable
5547038

The Wholesale Product Offered by the Aggregator



Contract design Framework



When presented with a menu of contracts options consisting of compensation and curtailment probability $(t_i, r_i) \in M$ each load segment with valuation θ and retail cost R, will self-select a contract that satisfies Incentive Compatibility (IC) and Individual Rationality (IR) conditions as follows:

(IC) $(t(\theta), r(\theta)) = Arg \underset{(r,t)\in M}{Max} \{r \cdot [\theta - R]^+ + t\}$ (IR) $\{r(\theta) \cdot [\theta - R]^+ + t(\theta)\} \geq [\theta - R]^+$

ILLUSTRATIVE EXAMPLE OF BENEFITS OF RELIABILITY BASED PRICING

Profile of Demands (MW) and Interruption Costs

	Customer Type 1	2	3	4	5	6	7	8	Total MW	Interruption Cost ($/kW)
MW of Demand	100	—	—	100	—	—	—	—	200	200
	—	—	100	100	100	100	—	—	400	50
	100	100	100	—	—	100	100	100	600	10
	—	100	—	100	100	—	100	100	500	3
	—	100	100	—	—	100	—	100	400	1
	100	—	—	—	100	—	100	—	300	0.5

Only the last two columns characterizing the shortage cost histogram in the population are needed for price menu design

THE AVAILABLE SERVICE RELIABILITY OPTIONS

Menu of Service Options

	Average Number of Days/Year Interrupted					
	0.02	*0.1*	*1*	*5*	*15*	*30*
Demand charge ($/kW/yr)	84	72	48	30	12	0

- Each customer type minimizes service charge + expected interruption cost
- Menu prices are designed to induce appropriate customer selections

BASIS FOR SELECTING PREFERRED SERVICE OPTION
Minimize (service charge + expected interruption cost)/kW

	Expected No. of Interruptions per Year					
	0.02	*0.1*	*1*	*5*	*15*	*30*
$ Cost/kW interrupted						
200	88	92	248	1030	3012	6000
50	85	77	98	280	762	1500
10	84.2	73	58	98	162	300
3	84.1	72.3	51	45	57	90
1	84.0	72.1	49	35	27	30
0.50	84.0	72.05	48.5	32.5	19.5	15

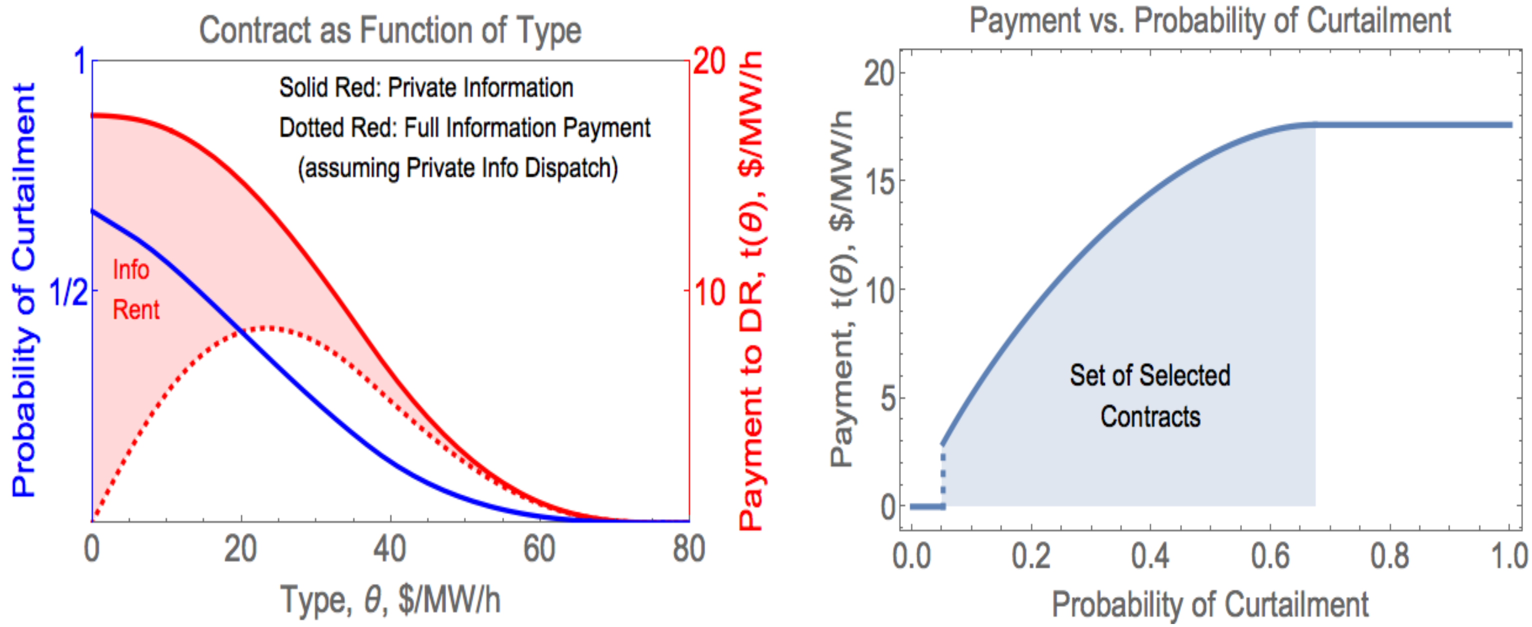
Customers' selections ◯

THE DISTRIBUTION OF CUSTOMERS' RELIABILITY SELECTIONS
(matches deliverable service reliability)

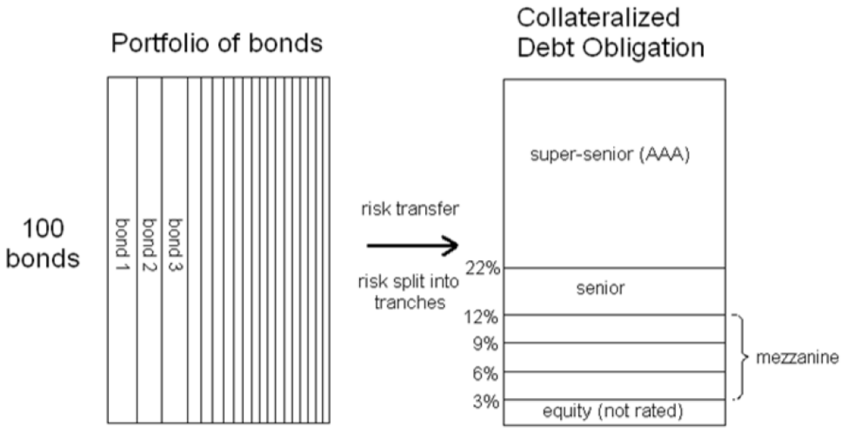
Interruption cost $/kW interrupted	200	50	10	3	1	0.5
Interruptions per year selected	0.02	0.1	1	5	15	30
Total MW selecting that level	200	400	600	500	400	300
Interruptible MW at that frequency	2400	2200	1800	1200	700	300

Example of Contract Menu

N=100MW, R=$30/MW. Uniform distribution of $\theta \in [0, 80]$ $/MWh



Resource Portfolio Risk Allocated to Priority Tranches



Renewable resources **Curtailable demand priorities**

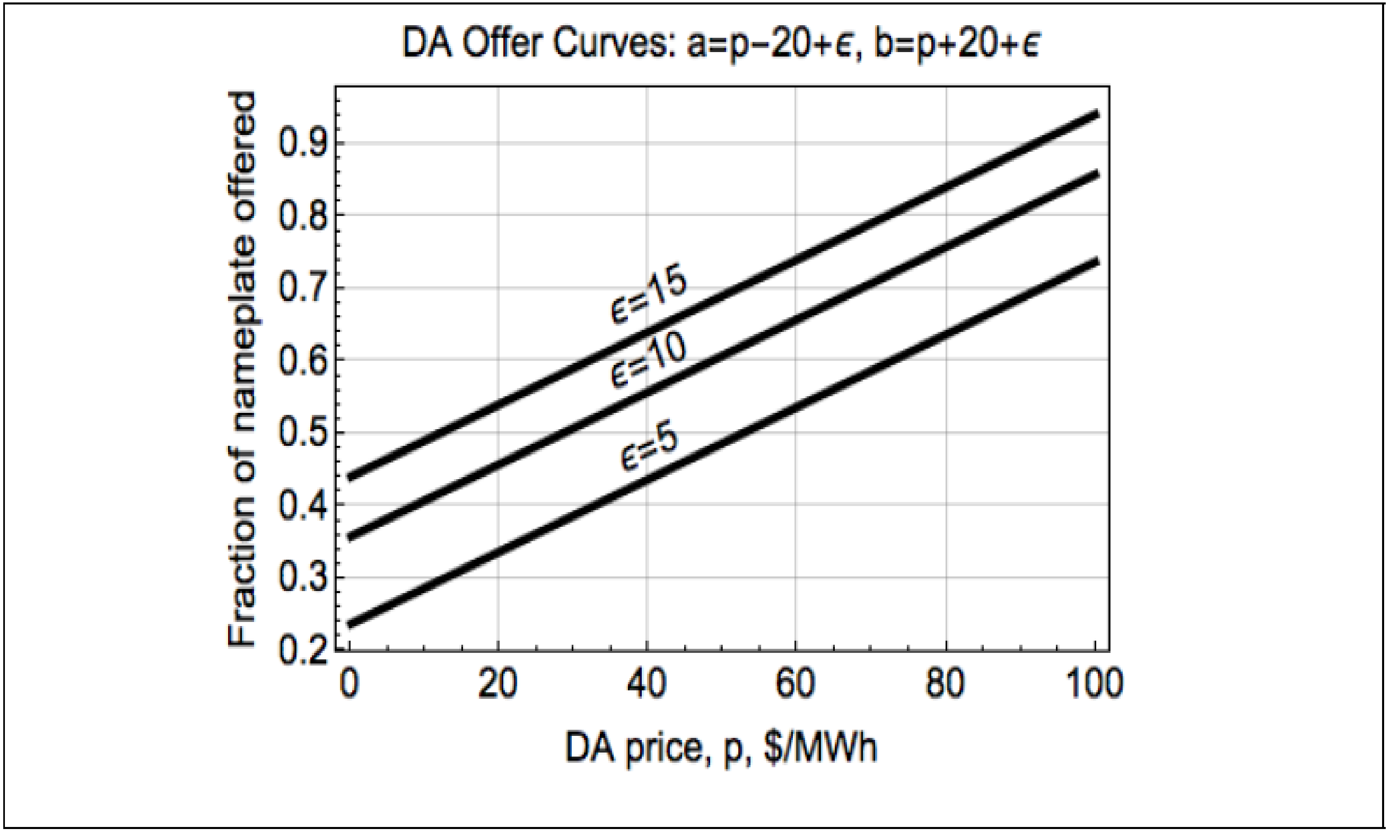
Unlike mortgages, energy resources risks are independent

The Aggregator's Operations

- Aggregator owned DER, produce power s with pdf $g(s)$
- Offers a menu of contracts to capacity increments with ex-ante payments that vary with customer self-selected probability of curtailment for each increment
- Commits to supply power quantity *q* in the forward wholesale market contingent on the whole sale price *p*
- After observing variable energy realization, dispatches a scenario-dependent quantity of contracted DR
- Collects a net settlement

$$\max\{pq + a[DR + s - q]^{+} + b[DR + s - q]^{-}\}$$

Supply Functions



CHANGING WHAT'S POSSIBLE

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

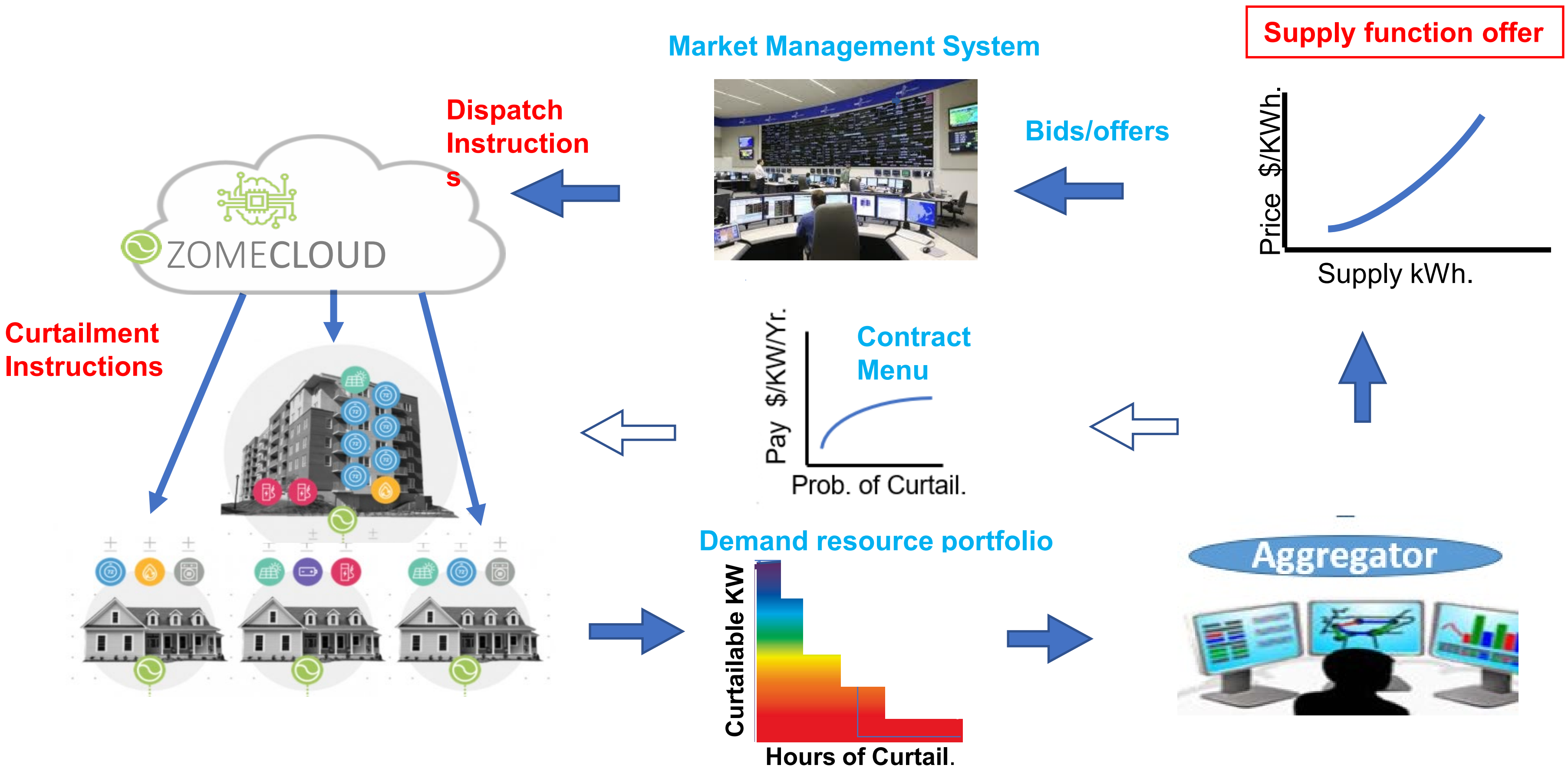
PROJECT DESCRIPTIONS

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.

Demand Resource Risk Management Framework (ZOME)



ZOMEKIT for Buildings

12 issued patents relate to this solution

Convert your apartment tower/complex or commercial building into an energy grid aware smart building providing meaningful energy savings and revenue-generation

- The ZOME Gateway itself is a piece of hardware that is made to be physically secured somewhere on the property. A central location is usually best, closets that don’t overheat are good candidate locations, and a standard 110V power outlet nearby is a requirement. Most often a cable modem or DSL modem will be mounted in the same spot as the ZOMEKit, to thus feed broadband access.

CES INNOVATION AWARDS 2019 BEST OF INNOVATION

SMART CITIES CATAGORY

WINNER

BLOCKCHAIN enabled

GREEN BUTTON enabled

Z-WAVE Mesh network