Market Design for Distributed Energy Resources

Shmuel S. Oren

The Earl J. Isaac Chair Professor
University of California at Berkeley

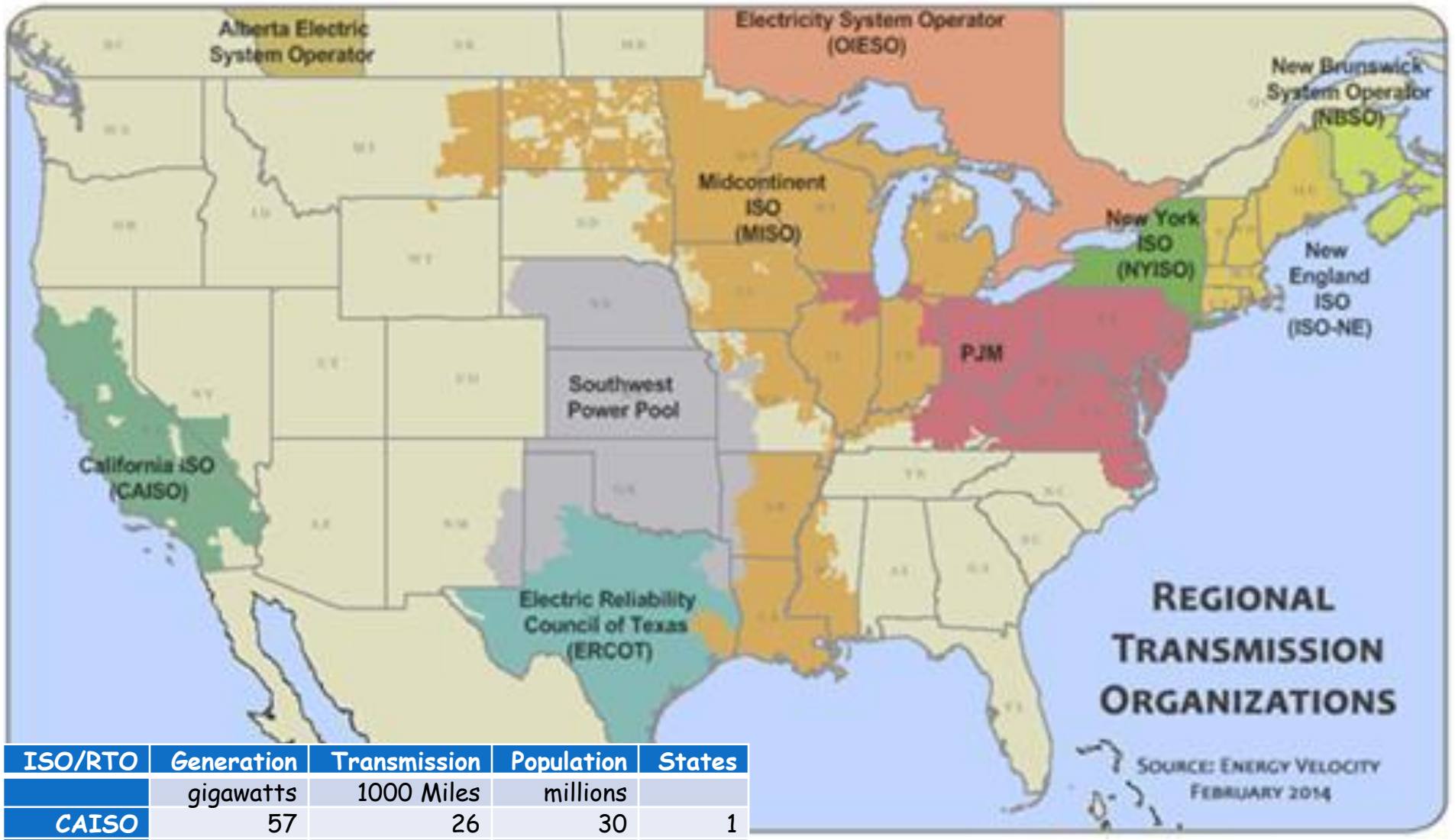
Presented At the CITIES 5th General Consortium Meeting

Fredericia, Denmark

September 20-21, 2018

Three Waves of Electricity Market Reform in the US

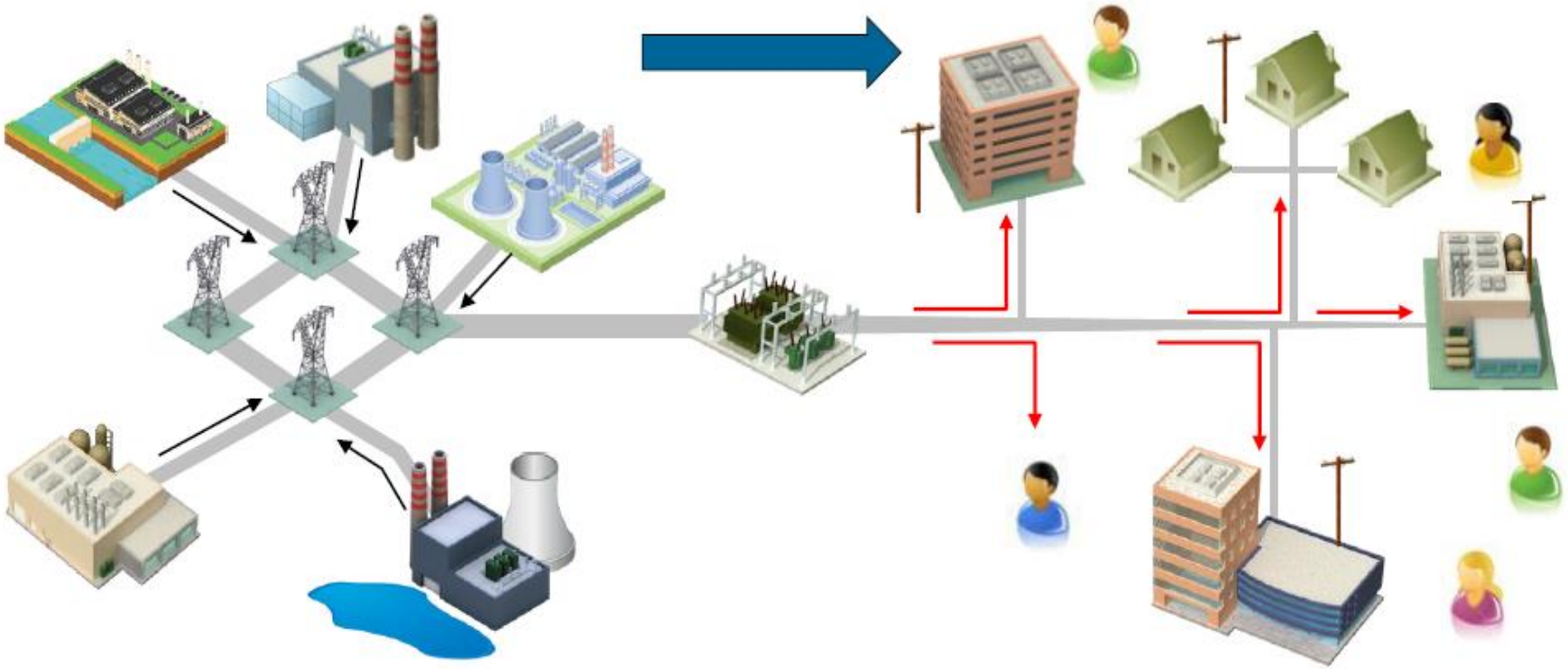
- First Wave:
  - PURPA 1978 (Expanded use of QFs and IPPs)
  - Energy Policy Act 1992 (Open access, wheeling, relax ownership restrictions)
- Second Wave:
  - FERC order 888 (1996) - Open access, OASIS, Divestiture
  - Ferc Order 2000 (1999) - Authority and principle of RTO/ISO, SMD
- Third Wave (in progress):
  - Integration of renewables and smart grid technologies
  - Penetration of DER and storage
  - Expanding role of DSO



ISO/RTO	Generation	Transmission	Population	States
	gigawatts	1000 Miles	millions	
CAISO	57	26	30	1
ISO-NE	34	8	14	6
MISO	201	66	53	15
NYISO	41	11	19	1
PJM	165	56	51	13
SPP	66	51	15	6
ERCOT	70	40	23	1
TOTAL	634	256	205	43

Cover 70% of US load

Today's Power System – Power Flows from Centralized Generation to Distributed Loads



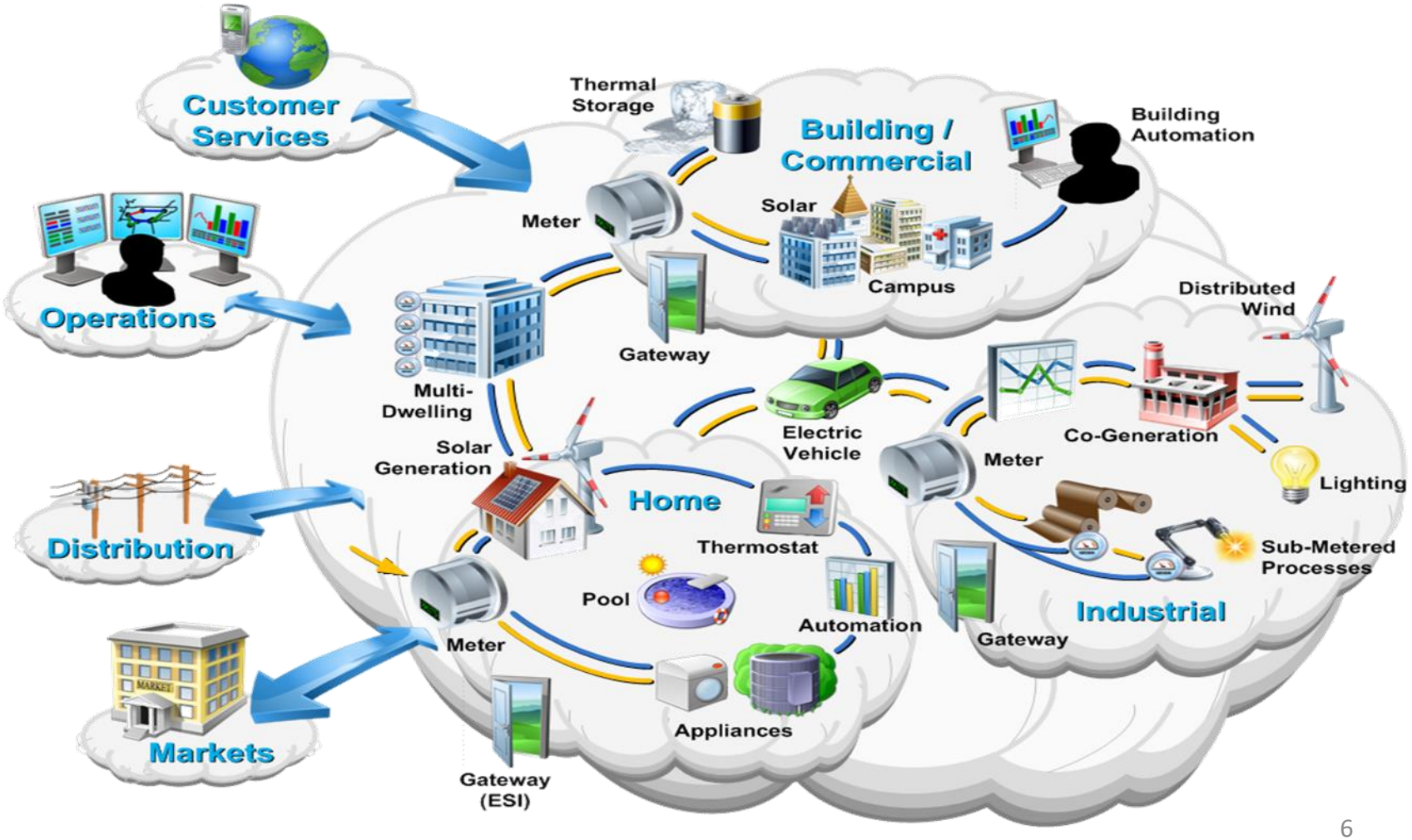
Generation Delivery Customer

Planning and Operations of Generation, Transmission, Distribution, and Customers are Mostly Independent

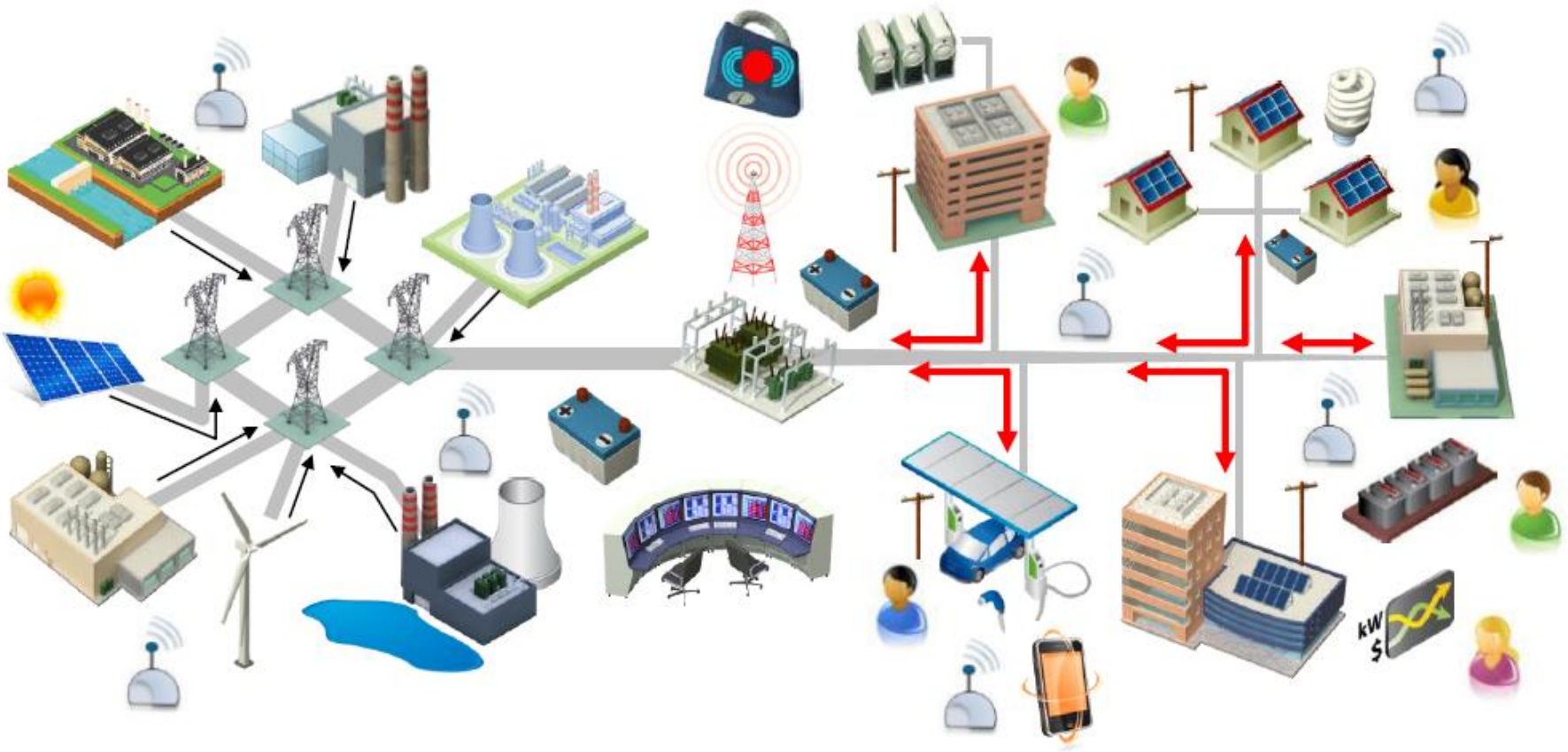
ISO Operating Room

Third Wave of Electrcity Market Reform:

Integration of Renewables and Distributed Energy Resources (DER)



Transformation of the Power System – New Resources, Communication, and Control at all Levels



New Opportunities and Challenges Require Integrated Approaches with New Methods, Tools, and Collaborations

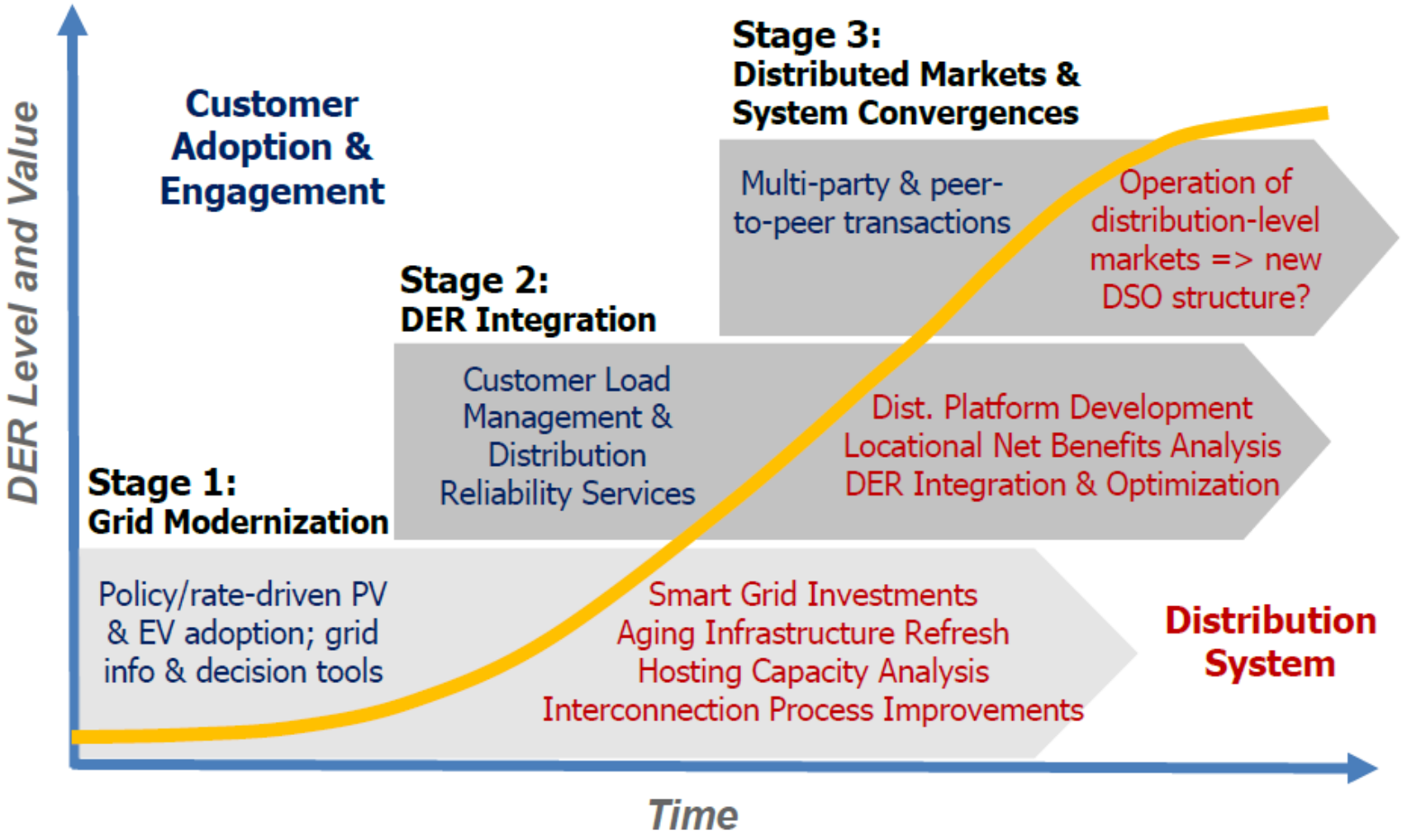
Old vs. New

- First two waves of reforms were driven by:
  - Vertical and horizontal unbundling and privatization of the electricity infrastructure
  - Increased efficiency of investment and operation through competition and wholesale market efficiency
- The third emerging wave of reforms is driven by
  - An environmental agenda for decarbonization of electricity generation to reduce global warming
  - Social movement toward more consumer choice
  - Rapid technological innovation of supply, storage, metering and control in the energy area
  - Social movement toward “democratization” of energy supply through DER growth

DER Drivers

- Penetration of renewables motivated by environmental concerns and declining costs
- Deployment of smart grid technologies, smart metering and and measurement units (PMUs)
- Proliferation of storage
- Changes in consumption pattern due to demand response and electrification of transportation
- Increase in consumer participation in electricity production (prosumage)

Distribution systems will evolve with growth in customer DER adoption and opportunities to realize DER value.



New role of market design

- Efficiency gains, if any, will come from diversification and complementarity of resources and from decentralized utilization of granular information that is not available or computationally prohibitive to account for in a centralized system
- Market design should promote efficiency and resiliency by facilitating coordination and risk sharing.
- Market design should enable the exercise of consumer choice but avoid creation of perverse incentives and loopholes that result in inefficient rent seeking behavior.

Public policy and adverse consequences

- Policies supporting the trend toward the democratization of energy supply and renewable portfolio standards have pushed regulation and tariff structures that often subsidize technological change and consumer choices on ideological grounds rather than social welfare.
- Such tilting of the playing field is counter to fundamental principles of market design.
- Resulting perverse incentives and subsequent rent-seeking behavior on the supply and demand side often result in proposals for increasingly complicated market mechanisms that attempt to mitigate technical challenges and economic distortions resulting from such incentives.

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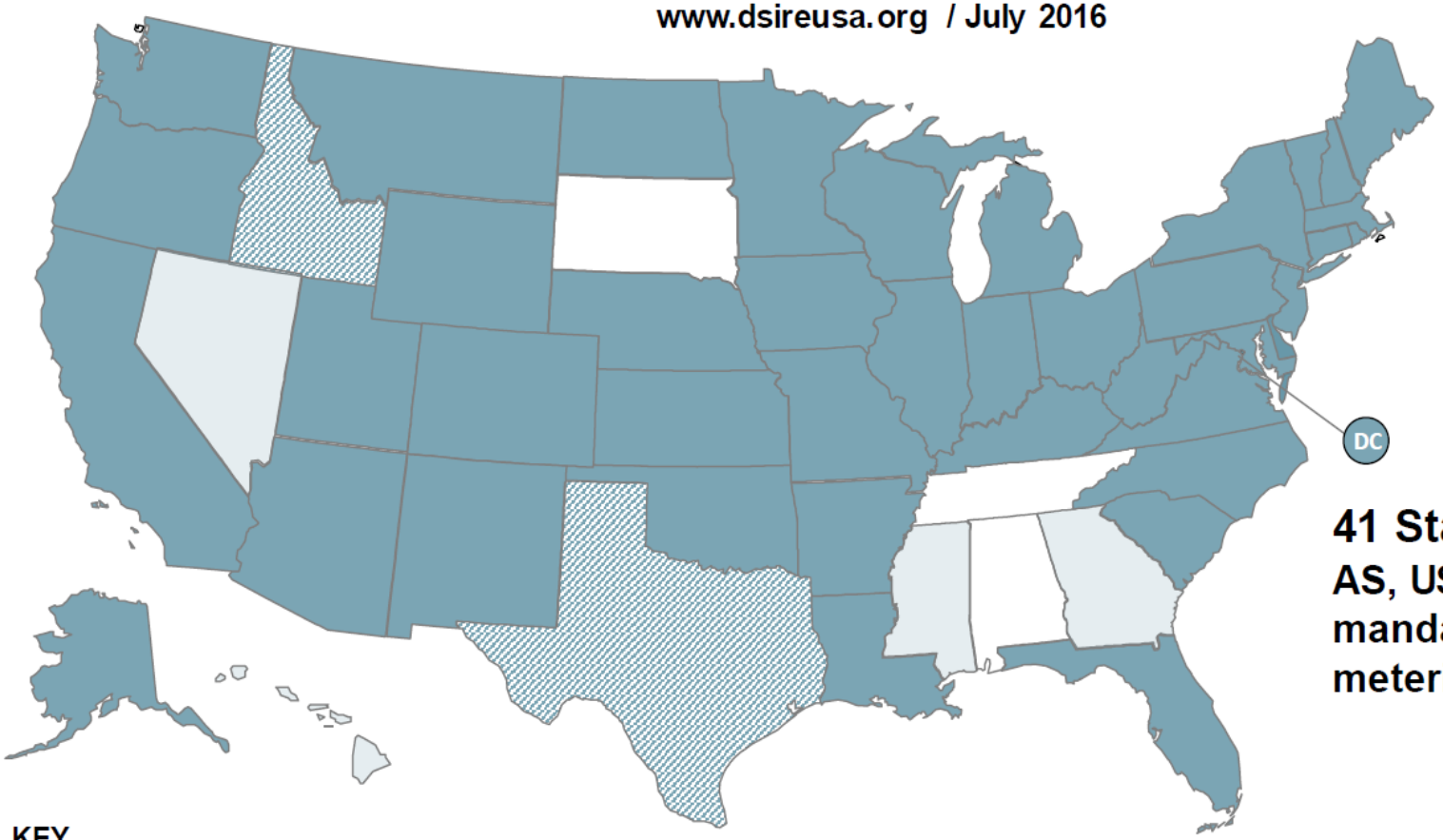
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Net Metering

www.dsireusa.org / July 2016



41 States + DC, AS, USVI, & PR have mandatory net metering rules

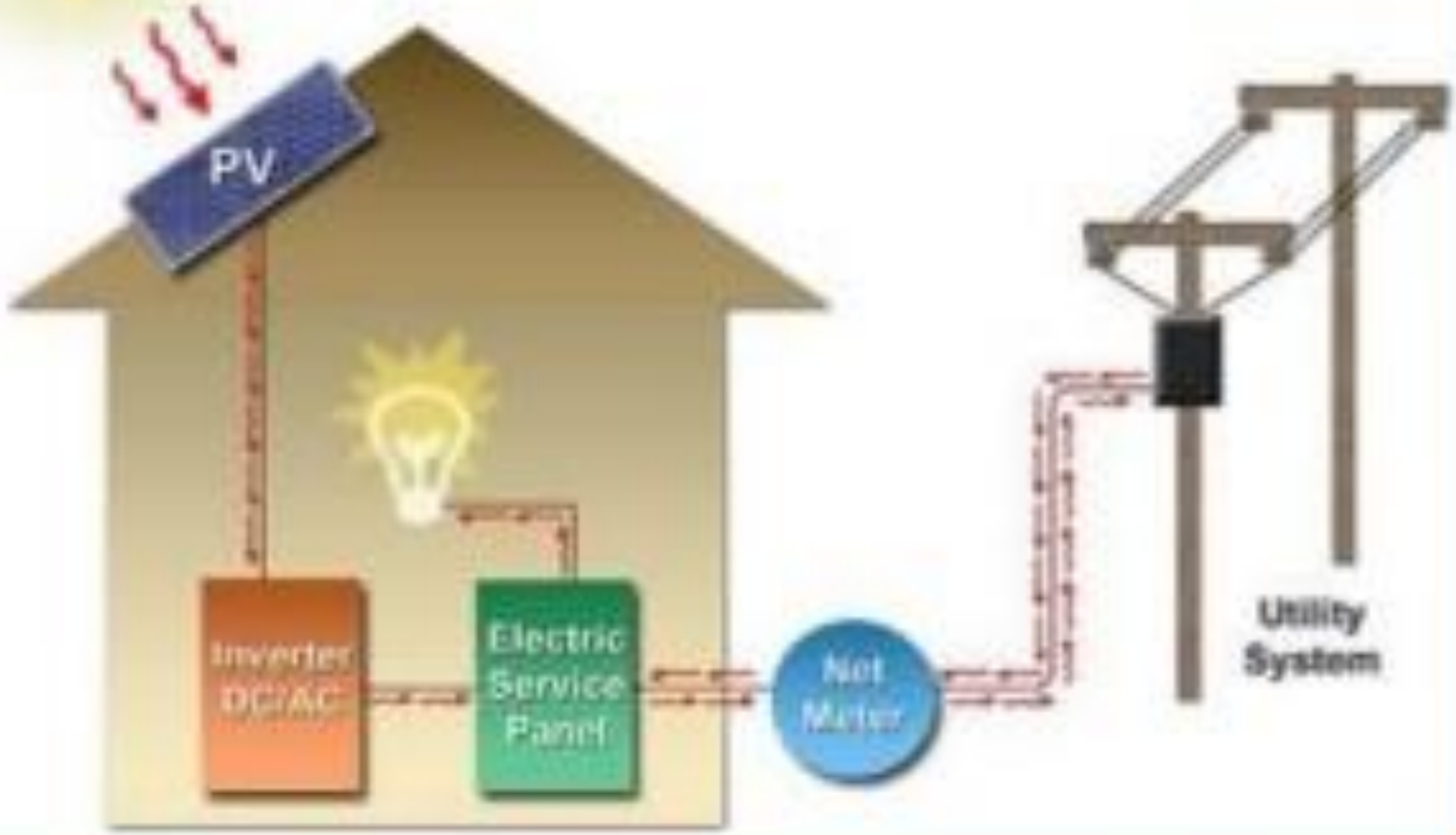
KEY

- State-developed mandatory rules for certain utilities (41 states + DC+ 3 territories)
- No statewide mandatory rules, but some utilities allow net metering (2 states)
- Statewide distributed generation compensation rules other than net metering (4 states + 1 territory)

U.S. Territories:

AS | PR | VI | GU

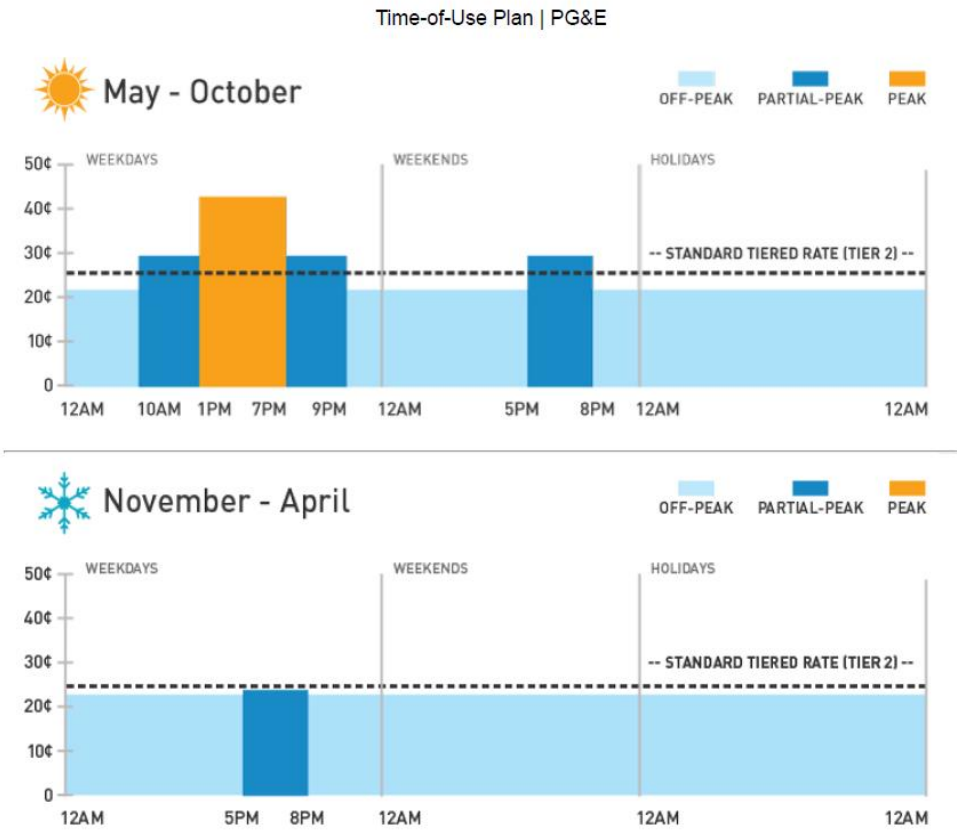
Net Energy Metering 101



Net Energy Metering (NEM)

- Customers who install small solar, wind, biogas, and fuel cell generation facilities (1 MW or less) to serve all or a portion of onsite electricity needs are eligible for the state's net metering program.
- NEM allows a customer-generator to receive a financial credit for power generated by their onsite system and fed back to the utility. The credit is used to offset the customer's electricity bill.
- NEM allows customers to receive the fully bundled retail rate for generation that offsets load (coincident or non-coincident), and may be expanded to cover net excess generation.

PG&E Time-of-Use Rate (E6)



Price Cent/Kwh

Time-of-Use	Tier 1	Tier 2	Tier 3
MAY - OCTOBER			
Peak	34.2	40.0	55.9
Partial-Peak	22.6	28.5	44.3
Off-Peak	15.0	20.8	36.7
NOVEMBER - APRIL			
Partial-Peak	17.1	23.0	38.8
Off-Peak	15.4	21.3	37.1
Tiered Rate Plan			
YEAR ROUND	18.2	24.1	40.0

Time-of-Use and Tiers

Like the Tiered rate plan, as you use the electricity allotments in each tier, you move to the next tier and higher prices.

SmartRate™ Add-on

Available with the Tiered and Time-of-Use Base Plan, the SmartRate™ Add-on discounts your summer rate in exchange for a higher rate, 2-7 p.m., on up to 15 SmartDays, May through October.

HOUSE OF REPRESENTATIVES
TWENTY-SEVENTH LEGISLATURE, 2014
STATE OF HAWAII

HB1943 CD1 HMS 2014-3486-1

- Enable a diverse portfolio of renewable energy resources;
- Expand options for customers to manage their energy use;
- Maximize interconnection of distributed generation to the State's electric grids on a cost-effective basis at non-discriminatory terms and at just and reasonable rates
- Determine fair compensation for electric grid services and other benefits provided to customers by distributed generation customers and other non- utility service providers; and
- Maintaining or enhancing grid reliability and safety through modernization of the State's electric grids.

Too Much of a Good Thing

- Net Metering systems have increased by over 60 times the cap established by the initial 1996 legislation that set up the metering program. Program capacity now runs from 30% to 53% of system peak load, depending on the utility. Nearly 20% of all customers of the Oahu (HECO) and Maui (MECO) utilities have net metered DG.
- The Hawaii Public Utility Commission concluded that simple retail rate net metering credit is driving uncontrolled, undirected growth, and raising questions about cost shifting to non-solar customers.

Hawaii Regulators Discontinue NEM for Rooftop Solar

(October 12, 2015) .

- The Hawaii Public Utility Commission closed retail rate net energy metering (NEM) reimbursement programs from the Hawaiian Electric utilities to owners of solar and other distributed generation (DG).
- Electric programs capped at existing levels as of the release of the Oct. 12 decision
  - **lower remuneration rates put into place for new rooftop solar systems**
  - **Systems with existing retail rate net metering deals will be able to keep them for the life of their contracts.**
- The commission will consider further modifications (Phase 2) of DER policies to ensure Hawaii continues to benefit from the safe and reliable integration of these resources.

Nevada Ends Net Metering

- The Nevada PUC order of December 22, 2015, tripled the fixed charges solar customers will pay over the next four years, and reduced the credit solar customers receive for net excess generation by three-quarters.
- Under the new rates, Southern Nevada solar customers, who make up the vast majority of solar customers in the state, will see their monthly fixed charge increase incrementally from $12.75 to $38.51 by 2020. Over the same period, the net-metering credit will drop from 11 cents per kilowatt-hour to 2.6 cents per kilowatt-hour.
- Regulators said the order was designed to make solar customers pay their fair share for use of NV Energy's grid and it implements Nevada Senate Bill 374.

Final Decision Released On California's NEM 2.0 Program

- On January 28, 2016, the California Public Utilities Commission (CPUC) narrowly voted 3-to-2 to enact its net energy metering (NEM)
- For the past decade, the original California NEM program provided investor owned utility (IOU) customers that went solar with a full retail-rate credit for the surplus solar power they send back to the grid.
- As of September 30, 2015, over 410,000 customers had connected over 3,200 Megawatts of net-metered generation systems, making California the leading state for U.S. solar adoption.

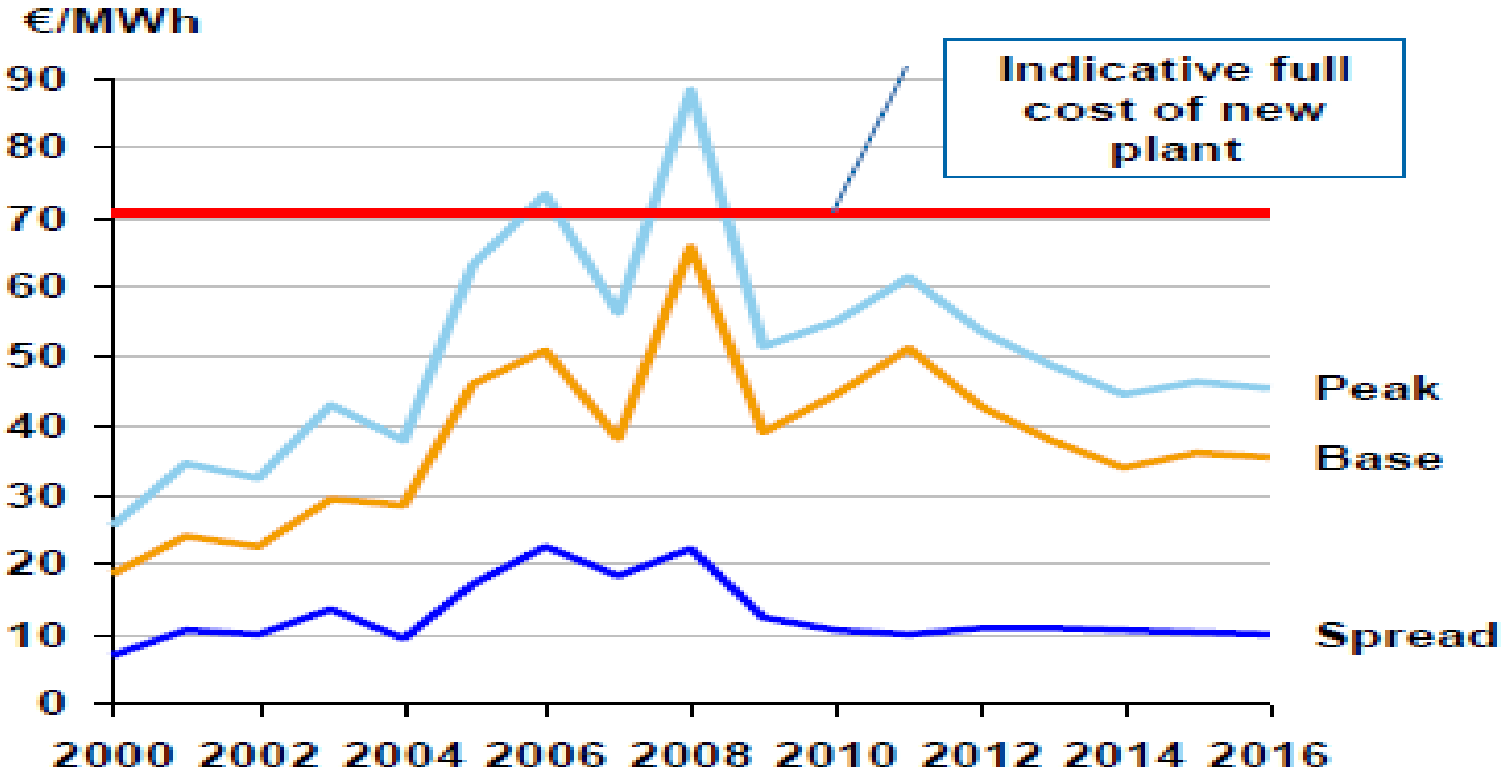
So what is wrong with Net Metering

- Prevailing volumetric retail rates were designed to recover infrastructure cost through increasing block energy markups so that users of more energy pay a disproportional bigger share of the distribution network cost.
- Under net metering large users can reduce or zero out their energy usage so the network cost ends up being paid by small user, and apartment dweller who do not install rooftop solar.
- Under net metering the system serves as storage for access production eliminating incentives for local storage installation.
- Retail tariffs should reduce volumetric charges to be more in line with wholesale prices and impose connection charges to recover infrastructure costs.
- Social value of inflated incentives for rooftop solar questionable given that system scale solar cost half of roof top and is becoming competitive at 3-6 c/kWh (e.g. DOE, Israel, Atacama dessrt).

Must take and feed in tariffs for wind

- Prevailing approach in many countries is based on the false premise that wind is free so all wind energy is scheduled and if curtailed still gets full payment at regulated feed-in rates (sometimes supplemented by production based subsidies).
- Added costs due to must take policy:
  - Higher commitment cost for thermal units
  - Cost of flexible resources and reserves needed to mitigate uncertainty and variability of wind
- Distorted incentives due to feed in payment
  - No incentives to control wind output or firm up wind through bundling with demand response or collocated storage
  - Incentives for over investment in wind

German Wholesale prices Down 50%



Consequences

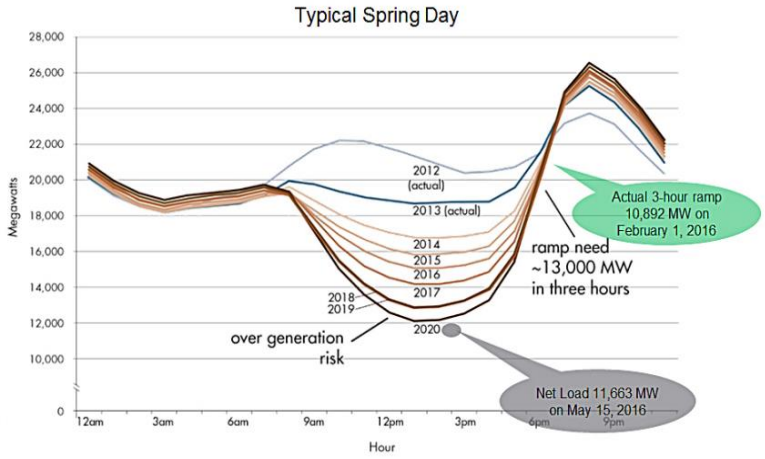
- “Missing money leading to Capacity (“strategic reserves) payment
- Closure of nuclear plants
- Drop in price of carbon permits leading to increased use of lignite

Alternative visions for DER integration

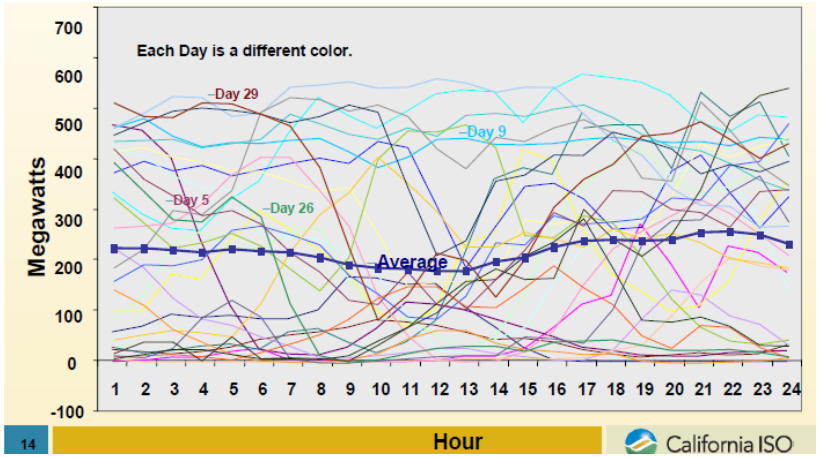
- Expanded ISO/RTO down to the distribution level (DLMP based)
  - Not enough visibility and model granularity
  - Computationally infeasible
- Hierarchical ISO-centric system (e.g., CAISO, PJM)
  - DER and load response aggregation through DSO and third party aggregators
  - Virtual power plants representing resource portfolios
- DSO dominated system (e.g. NY REV)
  - Load balancing, retail settlements and reliability function handled at DSO level or microgrid level
  - Limited high level coordination role for ISO operating market for centralized system wide generation facilities
  - Risk sharing arrangements down the supply chain with local utilities or third party offering service backup, trading platforms for peer to peer transactions and other quality differentiated energy services

Challenges for an ISO/RTO

The “Duck Curve”

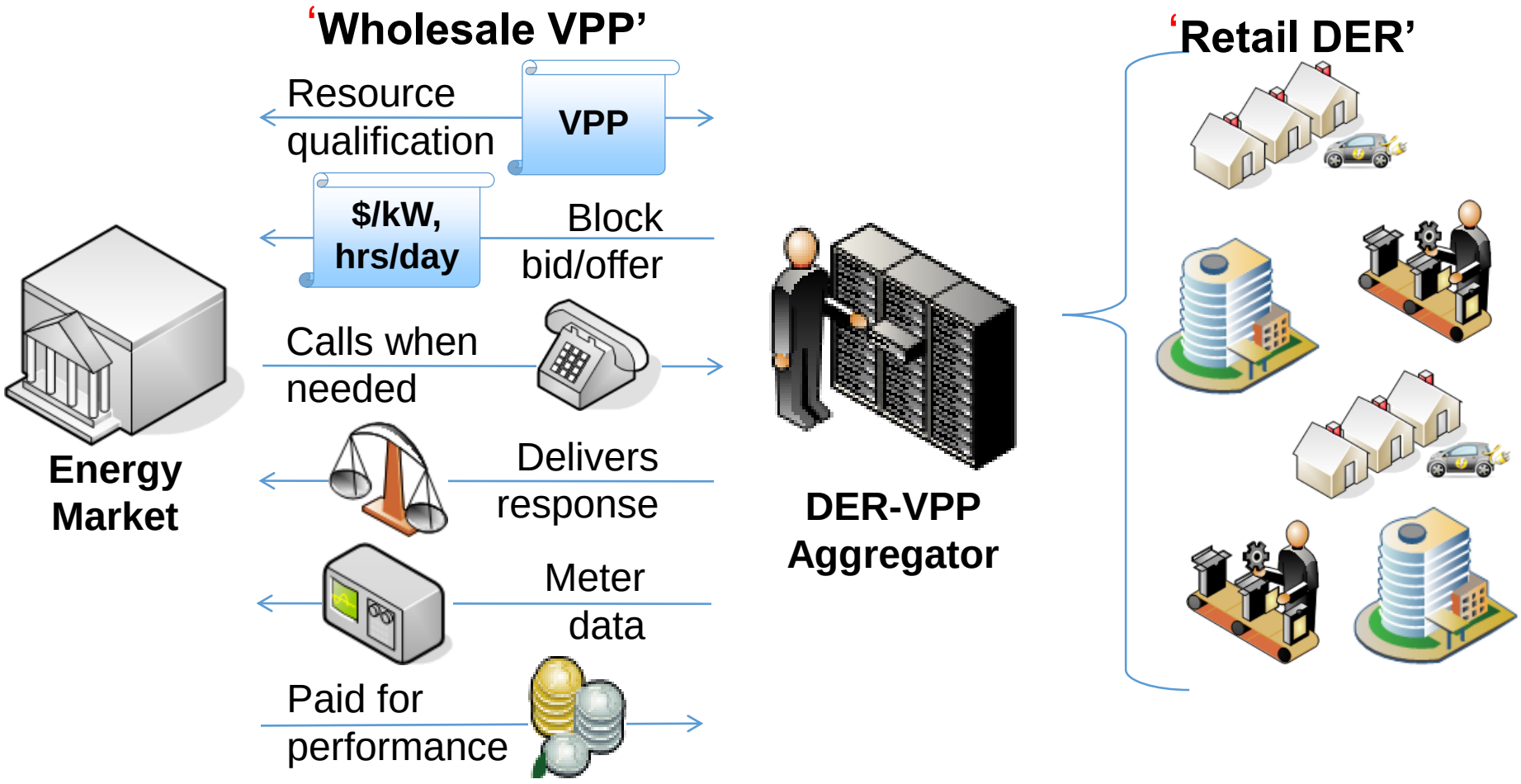


Wind Uncertainty



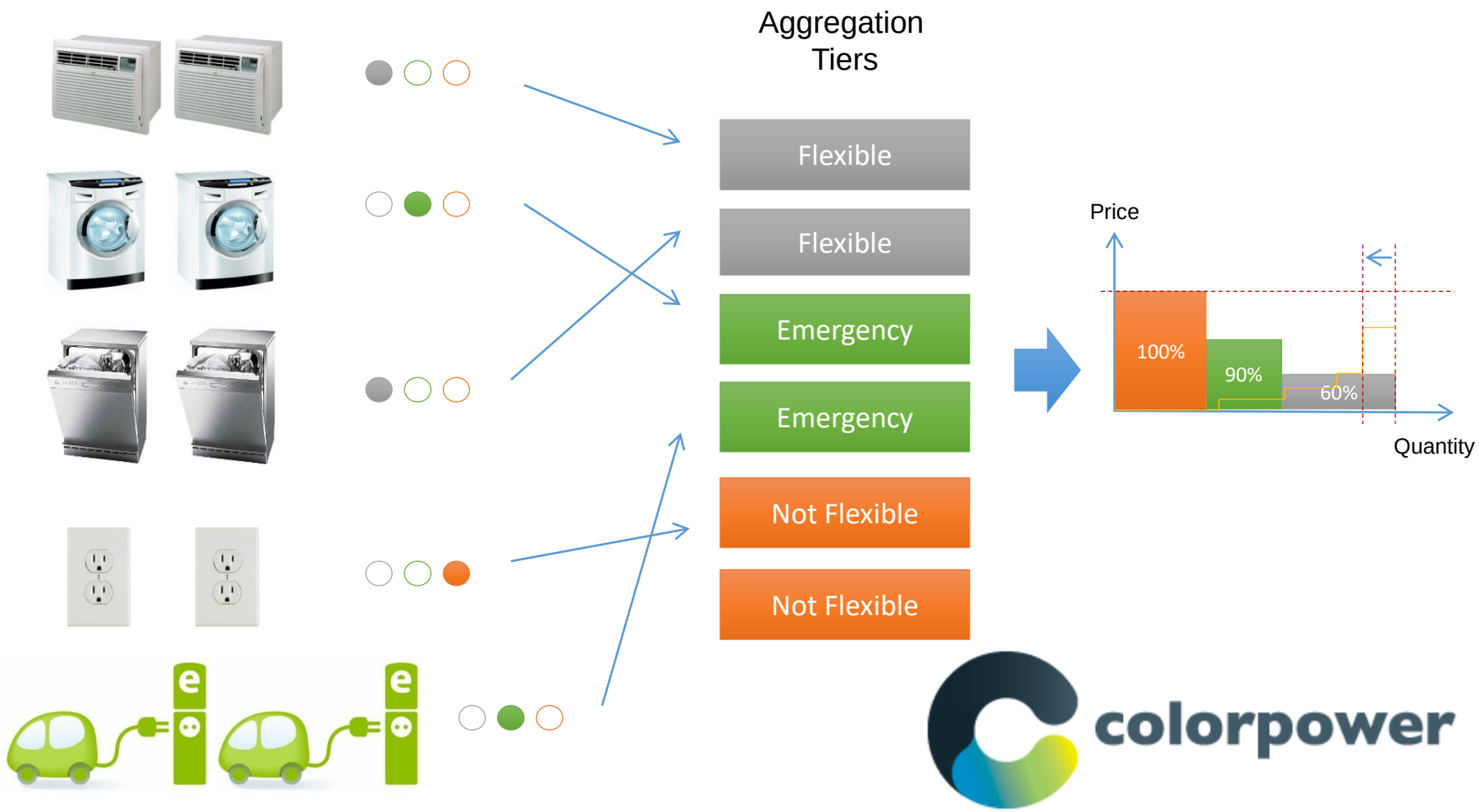
Needs dispatchable flexible resources for ramping and short term risk mitigation

DER Aggregators and Virtual Power Plants

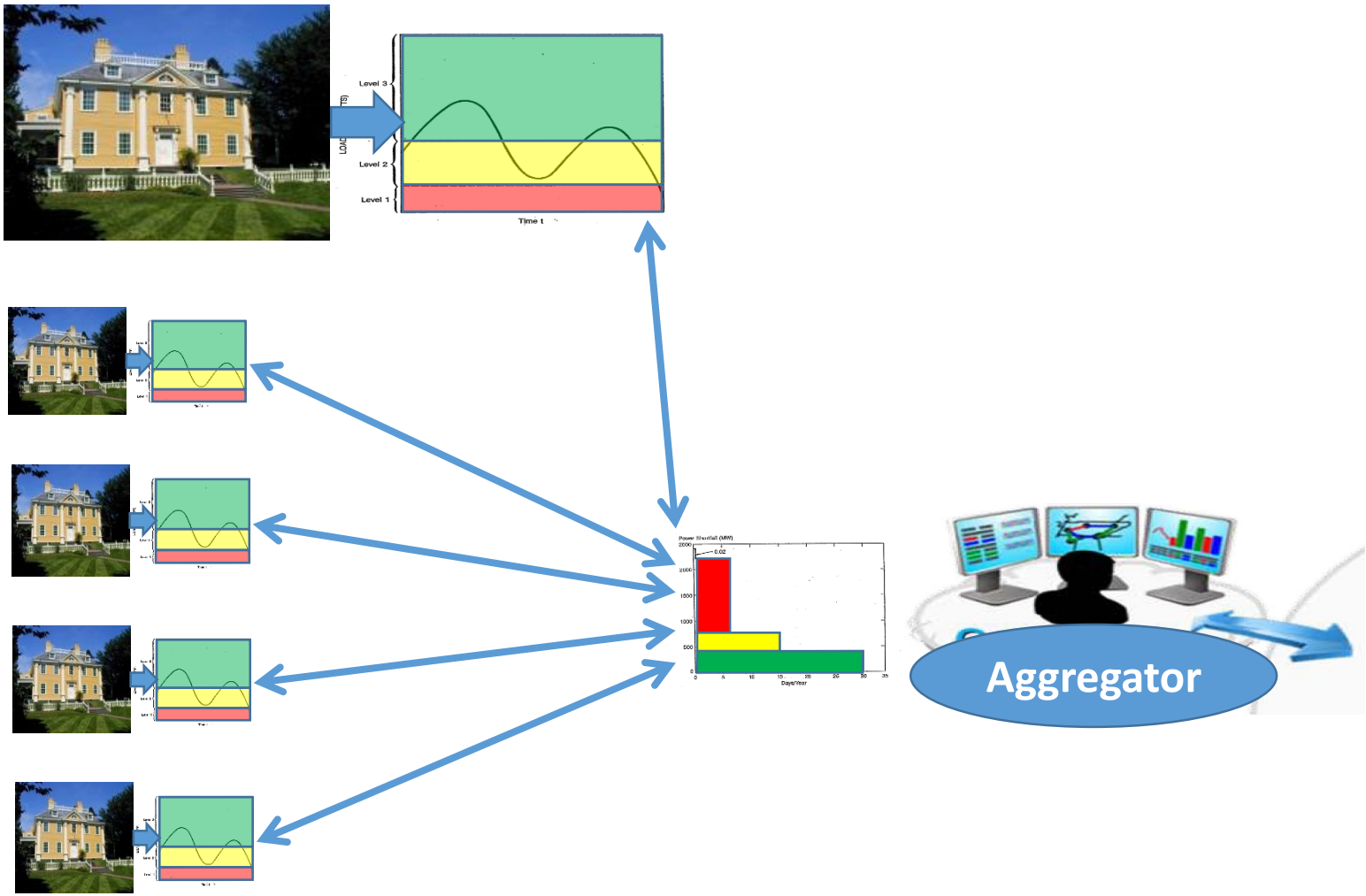


Source: Alex Papalexopoulos, ECCO International CO.

Device Control Paradigm

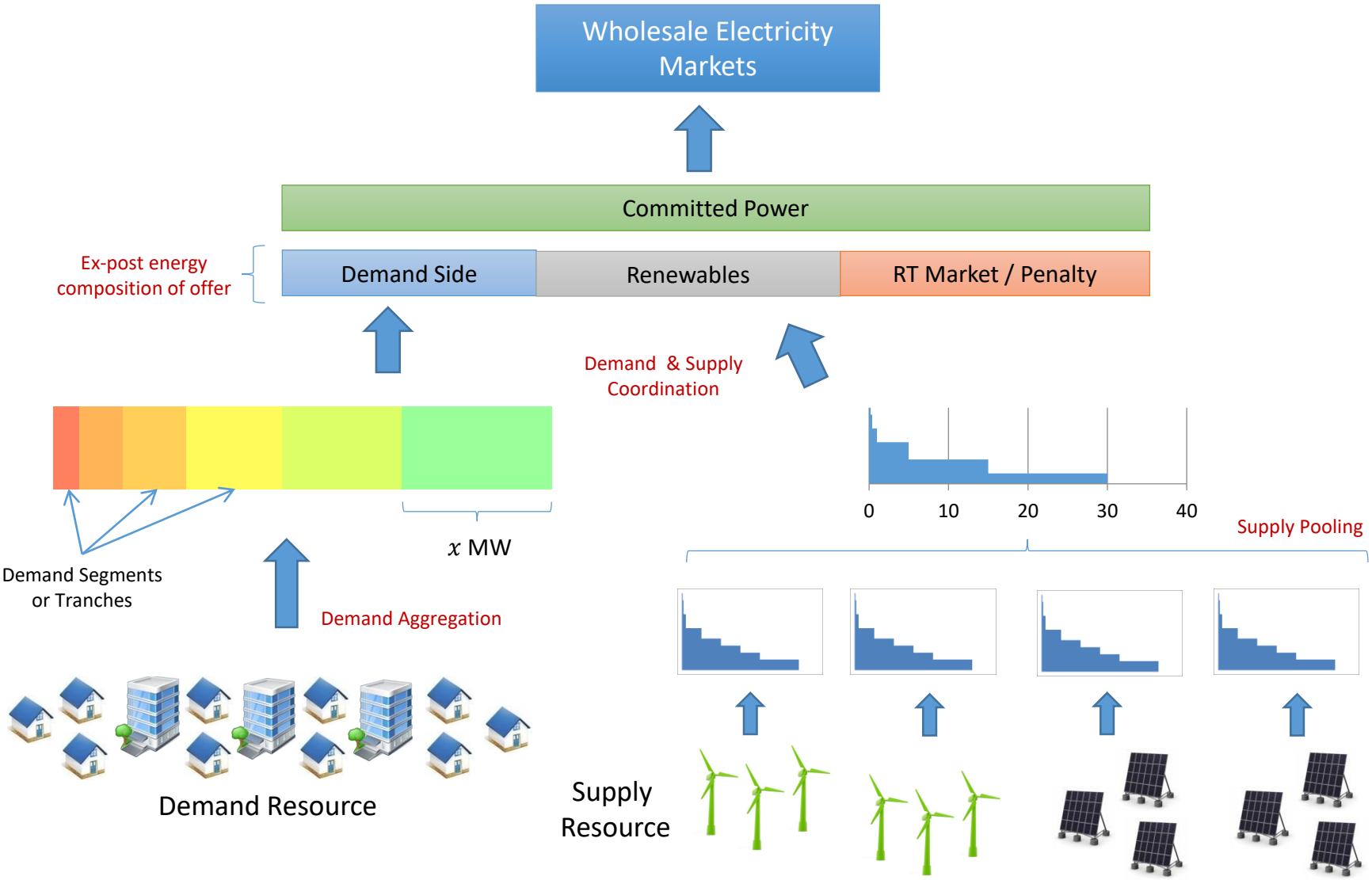


Fuse [capacity] Control Paradigm
(customer controls allocation of curtailed capacity)



Campaign Clay and Shmuel Oren, "Firming Renewable Power with Demand Response: An End to End Aggregator Business Model", *Journal of Regulatory Economics*, Vol 50, No. 1, (2016), pp. 1-37.

Aggregated Firmed up Renewables Product



What is Being Done

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]

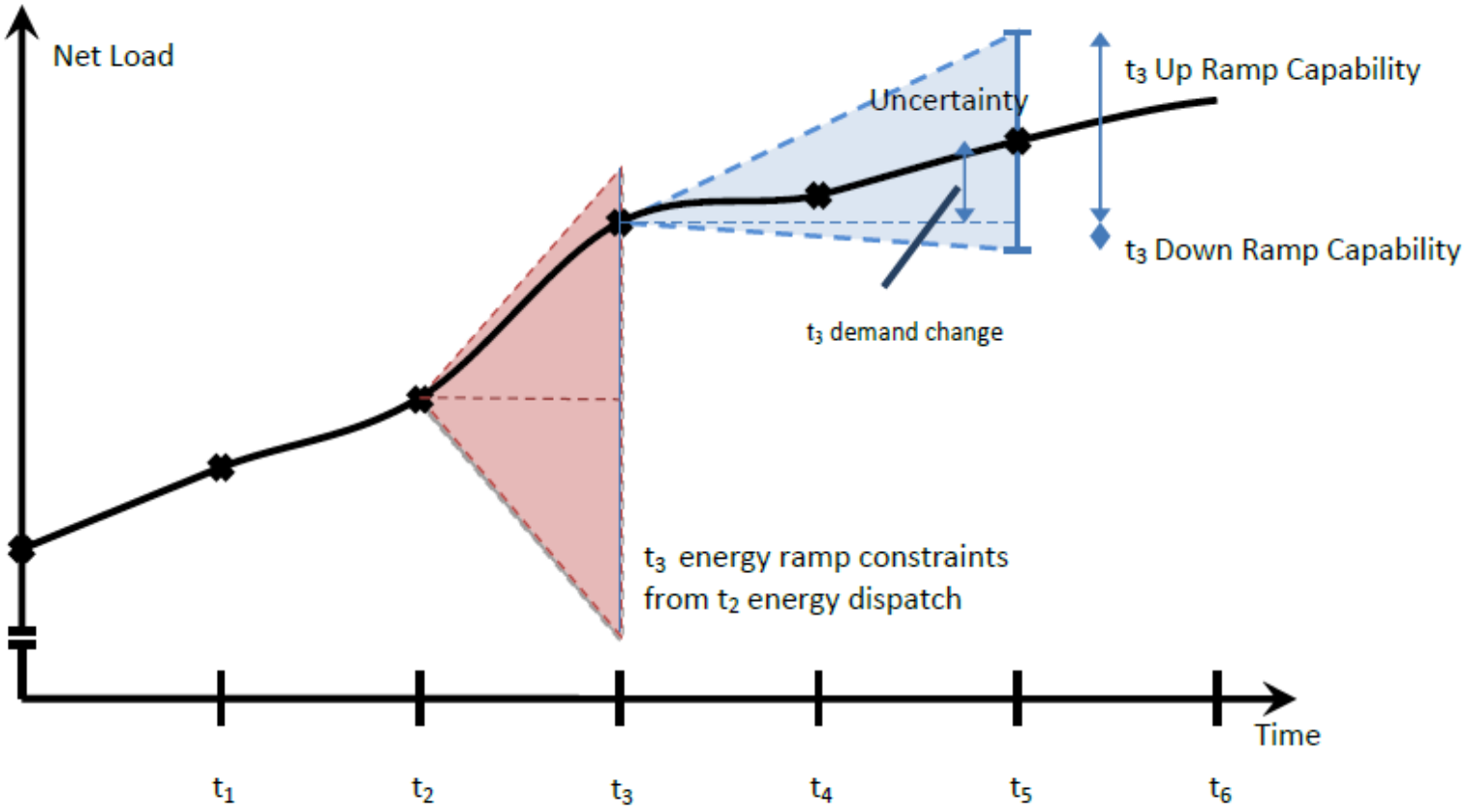
CAISO Proposed Tariff Revision

- CAISO tariff to support the participation of distributed energy resources in the CAISO markets. The proposed tariff revisions establish an initial framework to enable resources connected to distribution systems within CAISO's balancing authority area to form aggregations of 0.5 MW or more and participate in its energy and ancillary services markets.
- 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 and requirements for scheduling coordinators representing DER providers
  5. A new *pro forma* DER Provider Agreement

Flexible Resource Adequacy in CA

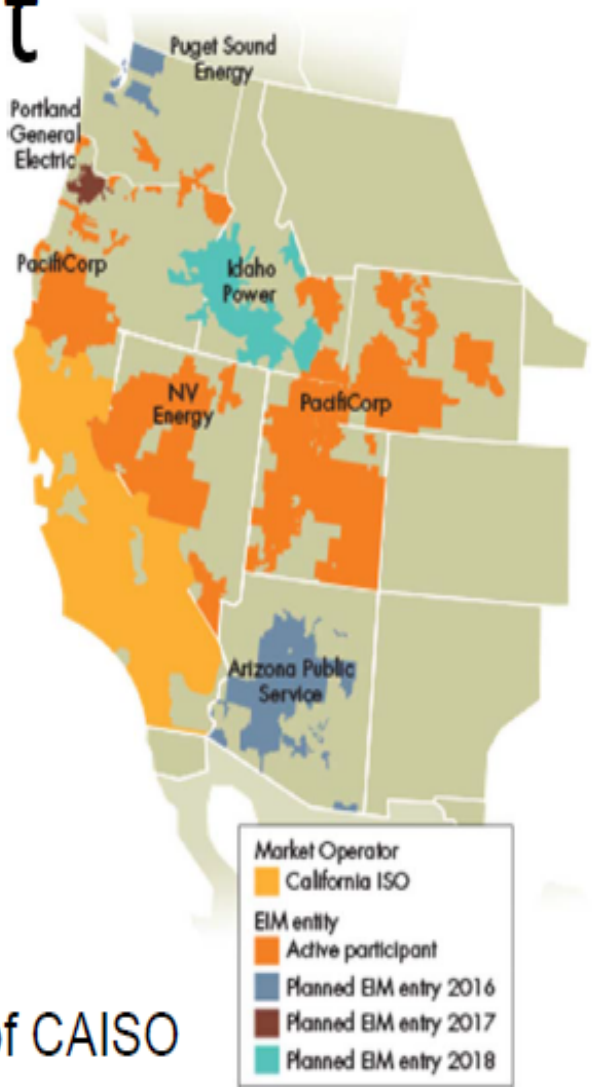
- On June 27, 2013 the California Public Utility Commission issued a ruling revising the Resource Adequacy Mechanism to include a fraction of Flexible Capacity:
  - Rule recognizes reliability needs due to 33% RPS target by 2020 and reduction in available flexible generation due to pending shut down of “once through cooling plants”.
  - Flexible capacity is defined as capacity able to sustain a 3 hour continuous ramp.
  - Procurement amount will be based on forecasted highest annual 3 hour continuous coincident ramp.
  - RA Mechanism requires each load serving entity to show three year forward contracting with sufficient capacity (with an appropriate fraction of flexible capacity) to serve it load (90% of need year ahead and 100% of need month ahead)

Flexiramp Product at CAISO Covers Potential Future Interval Variation in Current Dispatch. Opportunity Cost Based Remuneration



Energy Imbalance Market

- Benefits of EIM (Energy Imbalance Market)
  - Efficiency Automated dispatch to balance load and generation is more efficient than manual dispatch.
- Reduced costs
  - A wider portfolio of resources to maintain system balance could reduce the costs of energy and capacity.
- Operating flexibility
  - Improved situational awareness and real-time visibility of transmission constraints, and dispatches resources to reduce and avoid congestion issues. Captures the benefits of geographical diversity of load and resources.



Courtesy of CAISO

PJM Curtailment Service Providers

A Curtailment Service Provider (CSP) is the PJM member that nominates the end use customer location(s) as a capacity resource and is fully responsible for the performance of the resource. Load Management products are required to respond to PJM Pre-Emergency or Emergency Load Management events, based on the availability period for each product (see Table 2: DR product availability), or receive a penalty. PJM may declare Emergency Load Management events outside the required availability window but does not measure capacity compliance in such cases (resources are eligible for emergency energy revenue if they reduce load). Load Management that is not dispatched during its availability period must perform a mandatory test to demonstrate it can meet its capacity commitment or receive a penalty.

NEW YORK STATE OF OPPORTUNITY. | Reforming the Energy Vision

Reforming the Energy Vision (REV) is New York's comprehensive strategy to develop a cleaner and more reliable, resilient and affordable energy system for all New Yorkers

STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

CASE 14-M-0101 - Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision.

First, our targets will be clear and ambitious. The 2015 New York State Energy Plan includes a target to meet 50% of the State's electric consumption with renewable resources in 2030, as well as targets of a 40% reduction in greenhouse gas emissions from 1990 levels and a 600 trillion Btu increase in statewide energy efficiency.

New York's Reforming the Energy Vision End-State Vision

- Objective: A transactional, distributed electric grid that
  - Improves system efficiency, resilience, and air emissions,
  - Encompasses both sides of the utility meter
  - Relies increasingly on distributed resources and dynamic load management

- Defined "distribution system platform" (DSP) functions to include:
  - Planning, operations and enabling of markets
  - Improved temporal and spatial granularity of information
  - Improved information accessibility to consumers and participants
  - Greater transparency to grid needs to encourage innovation and investment

- Requires utilities to file Distributed System Implementation Plans (DSIP) –individual and joint. Address distribution system planning and operations for high DER penetration.

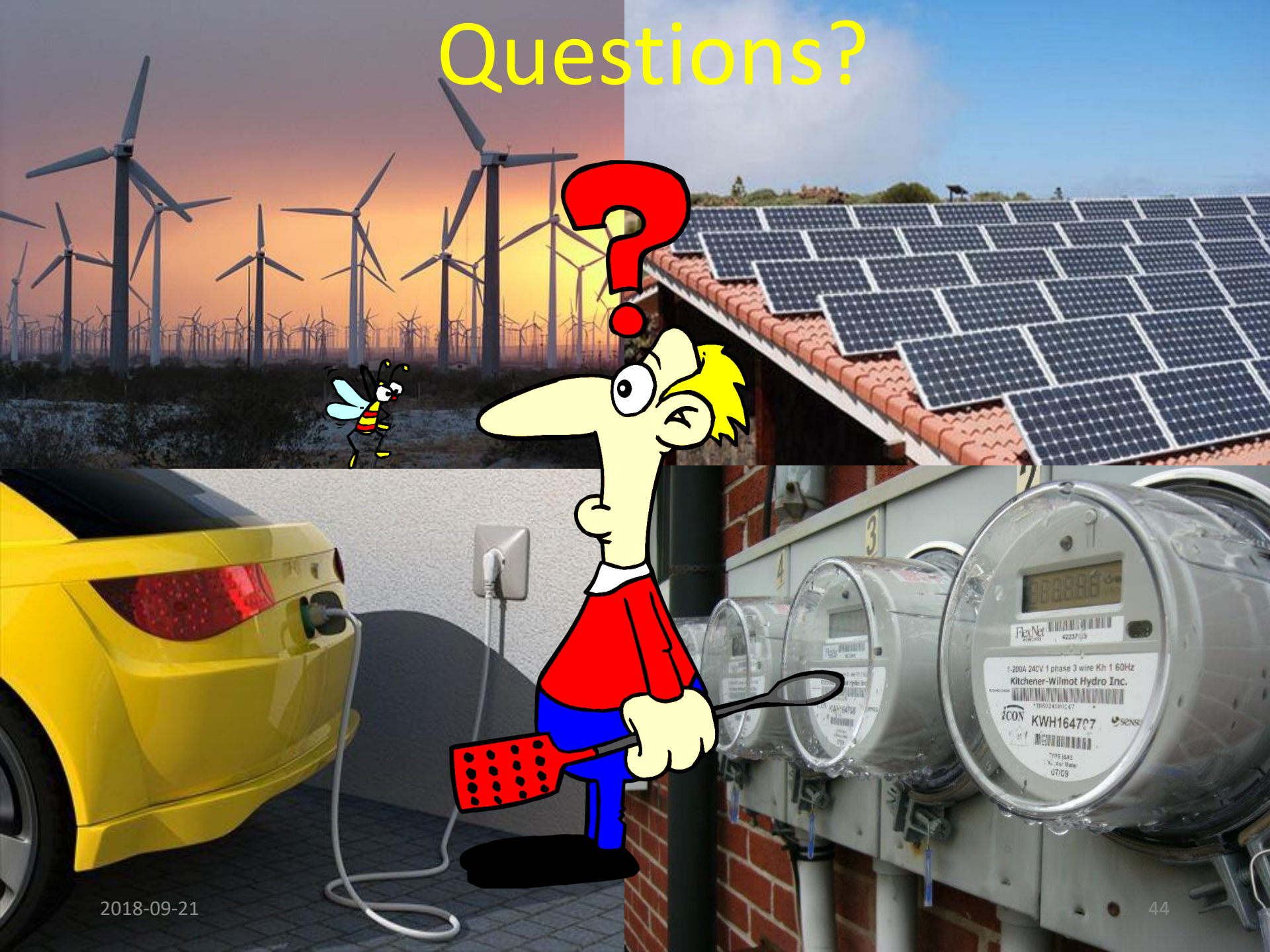
Summary and Conclusions

- Penetration of DER into the supply chain of electricity is a reality which is driven by the global movement toward clean affordable and sustainable energy and the growth in electric transportation.
- Unlike the first two waves of market reform, DER penetration is not motivated by efficiency but rather by customer choice and a socio economic movement toward democratization of the grid.
- Integration of DER will require massive investment in the distribution system to allow multidirectional flows and eventually, peer to peer transactions among consumers, turning consumers into prosumers and storage operators.
- New market design paradigms that accommodate aggregators of DER and virtual power plants will evolve. And at the retail level the commodity supply view will give way to a quality differentiated service provision.
- Need clear definition of risk sharing responsibility along the supply chain with customers employing smart grid technologies and storage to opt for risk sharing alternatives offered at different service prices

Summary and Conclusions (cont'd)

- The volumetric revenue base of the traditional utility will shrink with the increase of self supply and the the utility business model will change to be a provider of backup supply service, a platform for peer to peer energy trading and of network interconnection
- Many of the policies incentivizing renewables and other forms of DER involve economic distortions and are not sustainable and will need to be revised (like in Hawaii and Nevada)
- Retail rates will eventually migrate to a two part approach with substantial fixed connection charge differentiated according to service quality attributes and net metering policies will be discontinued in favor of energy rates that track closer real time wholesale prices
- **The DER train is out of the station** so the key question that should be addressed by policy maker and system operator is not **why** move to a DER based system but rather **how** to do it in a way that will continue to provide reliable service at affordable prices.

Questions?


1-200A 240V 1 phase 3 wire Kh 1 60Hz
Kitchener-Wilmot Hydro Inc.
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