

# **Distributed Intelligence and the Future of Dynamic Pricing, Price Responsive Demand, and Demand Response in PJM**

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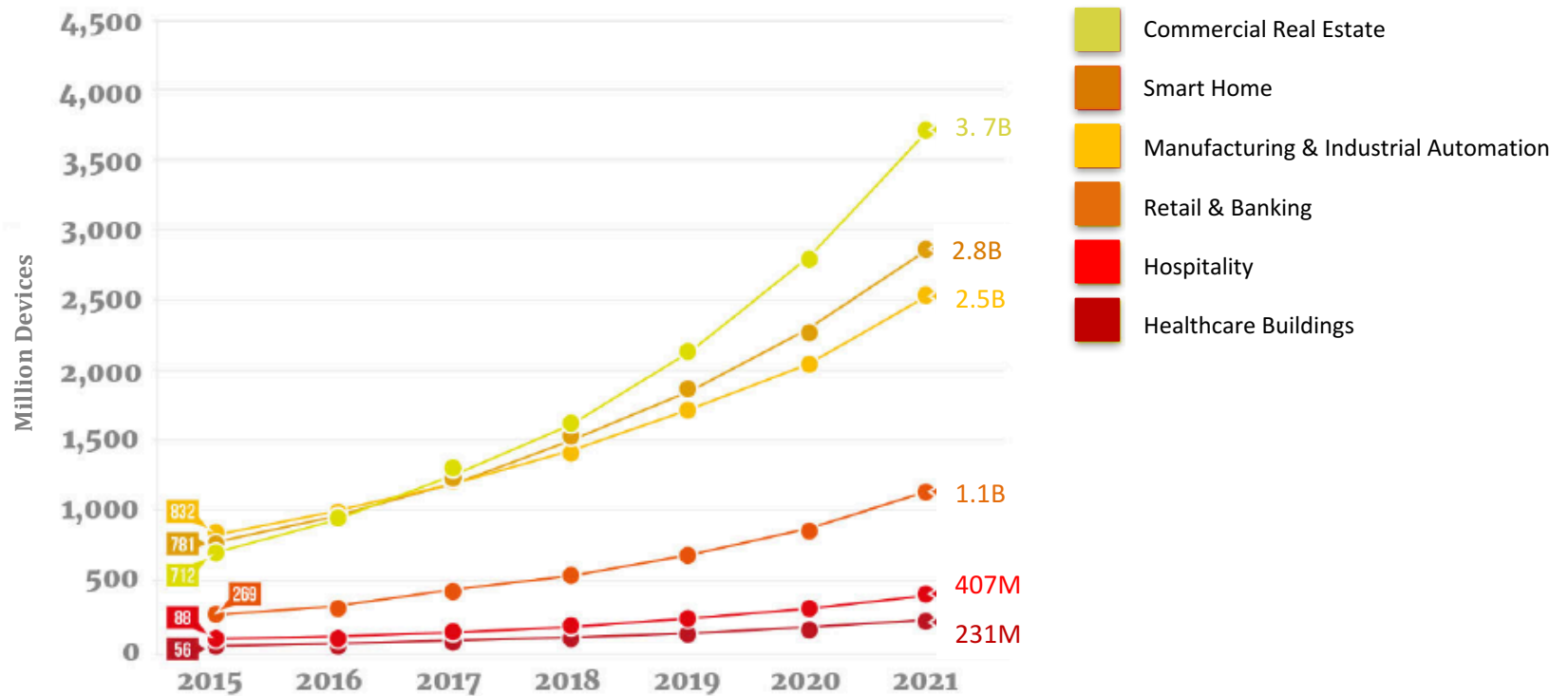
Energy Policy Roundtable in the PJM Footprint  
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# Internet of Things

Over 10 Billion Smart Building Connected Devices Forecast by 2021

5X Increase since 2015 <sup>1</sup>



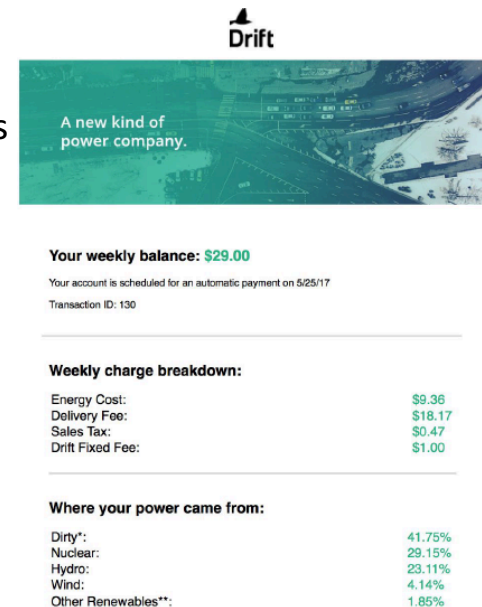
# Platform Markets: Services

- Marketplaces: First Step towards a Service Platforms
  - Platforms connect customers to valued services
  - 6 of World's 10 Most Valuable Companies are Platforms
- Utilities are creating online marketplaces for their customers, including at least:
  - 25 US Investor Owned EDUs
  - 4 of the largest EDUs in Europe
  - 49 Cooperative and Publicly Owned US EDUs
- Vast Majority of Marketplaces offer Smart Thermostats &/or Connected Home Devices
- Some offer 1000s of Products with Energy Efficiency & Consumer Product Ratings



# Smart Contracts: 30+ Energy Initiatives

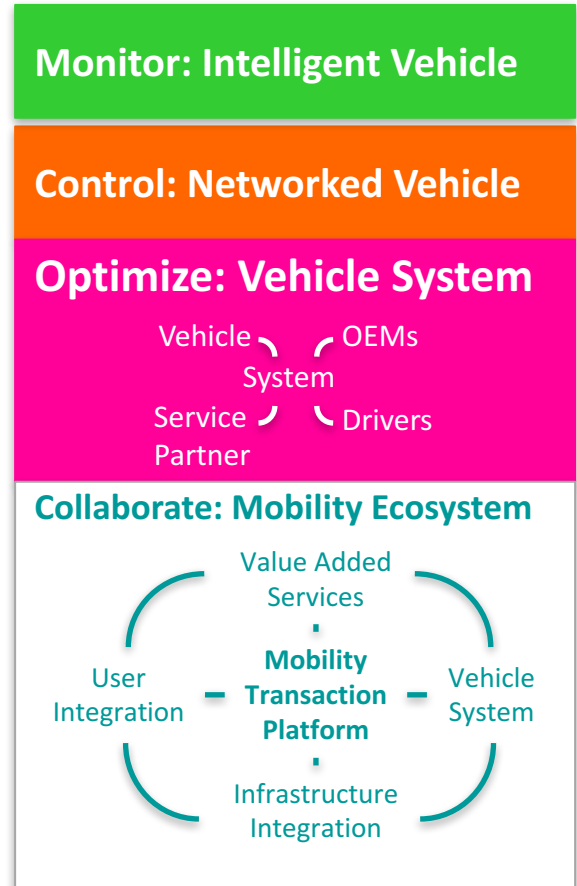
- **Drift:** Approximates peer-to-peer trading as NY retailer supplier for Residential & Small Commercial customers
  - Matches customer preferences for clean or low cost energy with residential PV, small hydro, & demand response, making up shortfalls in wholesale market
  - Provides data on their transactions in weekly bill
  - Charges consumers \$1/week with no contract & claims to cut customer costs 10%-20%
- **Alliander:** Dutch utility developing blockchain for integrating DER into operation of an island grid, plans to:
  - Use variable pricing, flexible transport tariffs, and smart contracts to integrate renewable generation, micro-CHP, EV charging, and active demand management
  - Allows consumers to use smart contracts to buy energy from one another or the wholesale market
  - Provide data visualization to the utility and transaction based bills to customers



# Smart Mobility: Oxygen EV Initiative

- **Oxygen EV/Power System Integration Initiative:**
  - At SCE & SDG&E, Marketed to other Utilities
  - Utility sponsor (Innogy) has developed apps to support:
    - Demand Clearinghouse for price responsive charging and vehicle-to-grid power
    - Uniform payment system for charging, tolls, & parking
    - Car Sharing including identity verification, keyless access, usage authorization, and receipt of funds
    - Keyless trunk access for parcel drop off
  - Goal is to support Fleets of Autonomous Vehicles that are Electric and Shared (FAVES)
    - Optimize by swarming to low prices for charging
- **Mobility Transaction Platform for:**
  - Value added services: Power system and fleet optimization
  - Vehicle Systems: Manages vehicle registration, insurance, and service; Supports OEMs and FAVES
  - Infrastructure Integration: Enables use of public and private infrastructure
  - User Integration: Manages user / vehicle identities and personalized services

## Oxygen's Intelligent Mobility Landscape



# Distributed Smart Devices & DR Programs

- Smart Demand Response: Distributed smart devices will continuously seek to optimize based on anticipated, real-time, location-specific prices
- Existing DR programs not designed to support adoption of smart devices:
  - **Dispatch:** Centralized RTO &/or aggregator dispatch of millions of smart devices will be computationally intractable – intelligence will be distributed in smart devices
  - **Transaction Costs:** Registration, tracking, & verification requirements as well as any penalty provisions will reduce participation of small commercial & residential customers
  - **Baselines:** Smart devices shift demand in response to relative price differentials, which will tend to reduce load in baseline periods, such that event-based demand response may provide little or no net incentive to invest in smart technology
- A level playing field for distributed smart devices will require efficient market structures and pricing

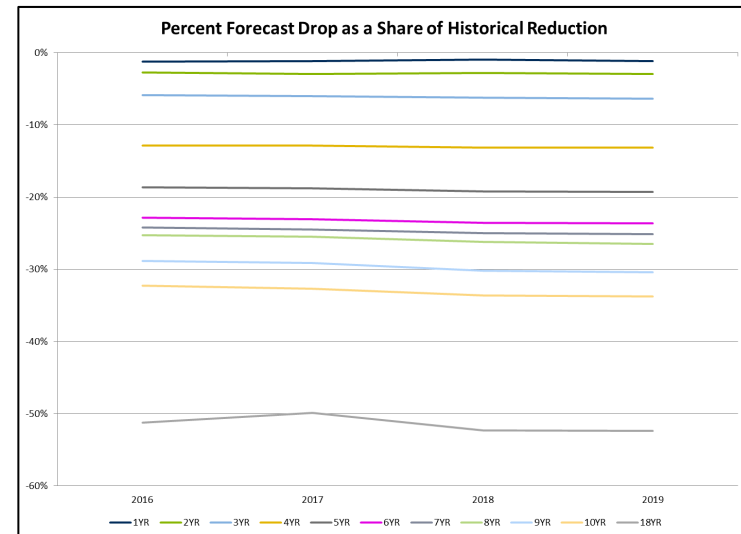
# Price Responsive Demand: Centolella & Ott 2009<sup>2</sup>

- **Problem statement:** “Current demand forecast methods ... produce resource and planning reserve requirements which would force LSEs with Price Responsive Demand to carry resources and reserves for demand that would not be present at higher spot prices. The requirement to hold this additional capacity both eliminates the opportunity to avoid capacity costs and dampens prices. With the additional capacity in place, ... prices rarely will reach a level that evokes a significant demand response.”
- **Simple Proposal:**
  - “Use in system planning and operations, ... forecast demand response curves that *reflect a statistically predictable relationship between prices and demand*;
  - Reforming scarcity pricing by implementing an *Operating Reserve Demand Curve with an appropriately high price*, potentially reflecting the Value of Lost Load (VOLL) at minimum reserve levels...;
  - Requiring price responsive loads to have capacity and planning reserves for forecasted firm demand, *after accounting for expected Price Responsive Demand*, while providing the option ... to carry additional capacity;
  - Applying non-discriminatory procedures ... in a capacity emergency based upon the extent to which ... price responsive and non-price responsive loads are capacity deficient.”
- **Stakeholder Process Altered this Simple Proposal:** Imposed requirements on PRD comparable to supply, despite the lack of any wholesale market payment to PRD

# RPM Forecasts Remain a Barrier to Price Response

- **Simple Proposal:** Recognize predictable price response in forecast capacity requirements – create accurate, non-discriminatory forecasts
- **Current State:** PJM Capacity Mechanism creates a barrier to responsive demand by failing to acknowledge statistically predictable relationships between variable prices and demand
- Under current forecast process actual reductions in peak demand have limited impacts on capacity requirements
  - Reductions on 10 Coincident Peak days for 18 years to produce only 50% reduction in forecast capacity requirements <sup>3</sup>
- Customer peak shaving can shift capacity cost to other customers

**Reduction in PJM Zonal Load Forecast As a Percent of Peak Reductions <sup>3</sup>**

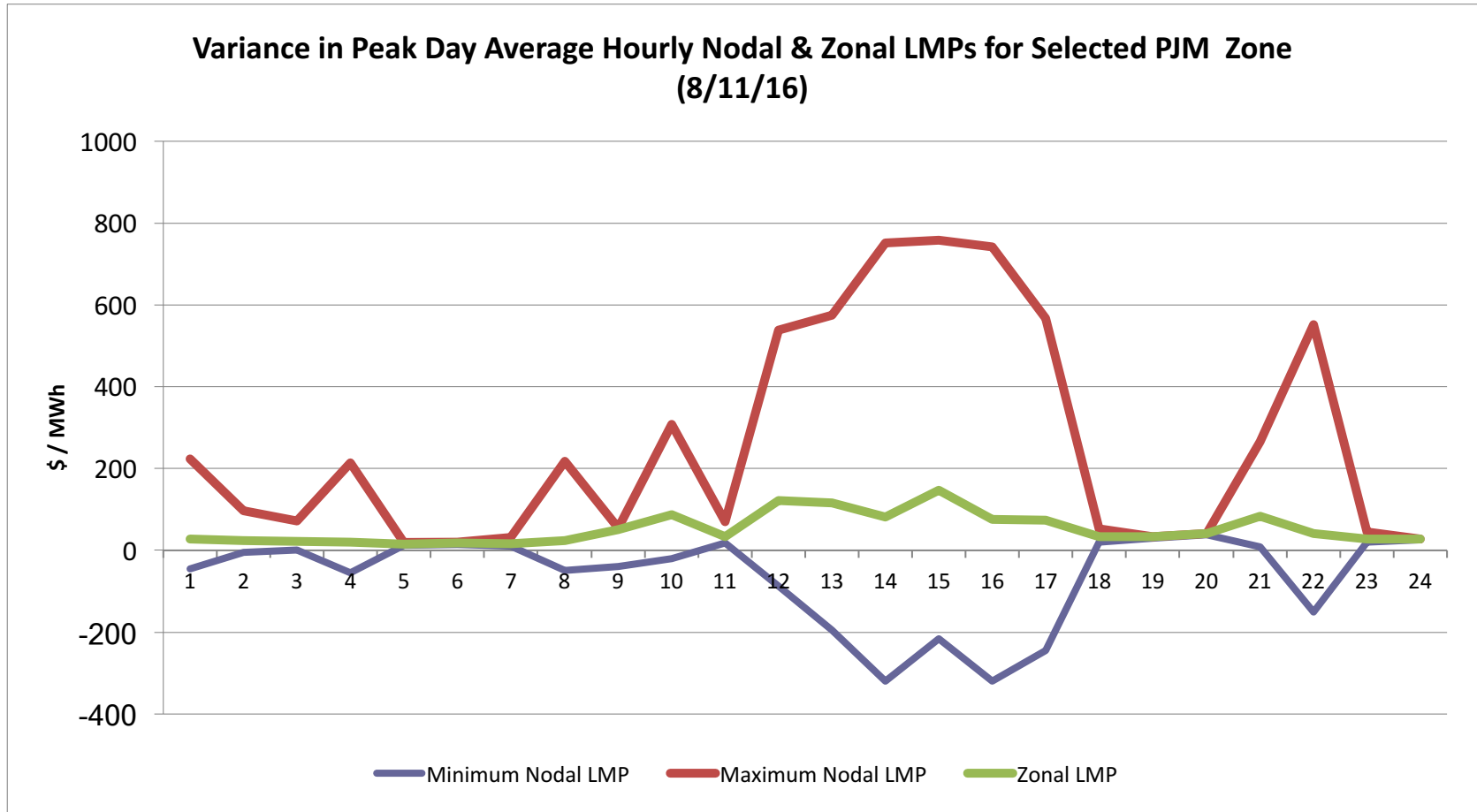




# Energy Market Settlements are a Barrier

- For most consumers in PJM and other organized markets:
  - Load is settled at an **Average Zonal Price**: Fails to recognize nodal price differences
  - Load is settled at an **Average Hourly Price**: Fails to recognize opportunities to shift demand between intervals to minimize costs
  - Load is often settled on **Historical Average Customer Class Load Profiles**: Unrelated to actual demand by the customers of load serving entities
- The socialization of energy prices reflects the formation of markets before AMI and the growth of the digital economy
- Retail electric suppliers have limited or no incentives to compete based on helping customers manage demand

# Peak Day Intrazone LMP Variance in Selected Zone



- Large price variances between load nodes within PJM Zone
- Price swings suggest interval to interval variances are likely to be significant
- ***Accurate nodal and interval pricing of demand is foundational for the valuation of DER & flexible demand***<sup>4</sup>

# Findings and Recommendations

- New technologies and business models are rapidly expanding opportunities to benefit from distributed intelligence
- Retaining wholesale market rules designed for a different time will impede innovation and contribute to poor asset utilization and high costs

## Recommendations:

- *Implement a procedure that recognizes predictable price response and the impact of smart devices in forecasts of capacity requirements*
- *Settle both demand and supply in wholesale markets based on nodal and interval LMPs*
- *Focus on creating efficient wholesale markets and pricing*
  - The PRD requirement of a dynamic retail price is outdated – smart devices allow utilities and retail suppliers to integrate automated demand management and flat pricing
  - Wholesale pricing can animate retail service markets by creating an incentive for utilities and retail suppliers to compete to help customer manage their energy bills

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# **ADDITIONAL SLIDES & REFERENCES**

# Asset Utilization Challenge

## Existing Power System Asset Utilization

- PJM 2016 Generation Capacity Factor<sup>5</sup> = 51%
- U.S. 2016 Generation Capacity Factor<sup>6</sup> = 43%
- Average Transmission and Distribution Asset Utilization – Typically below Generation
- Asset Utilization in Other Capital Intensive Industries = 70% to 90%+

**Key: Demand Side of Market**

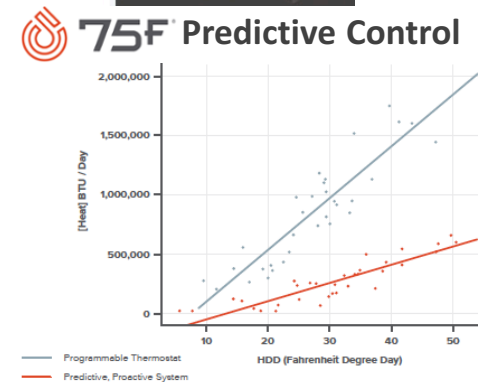
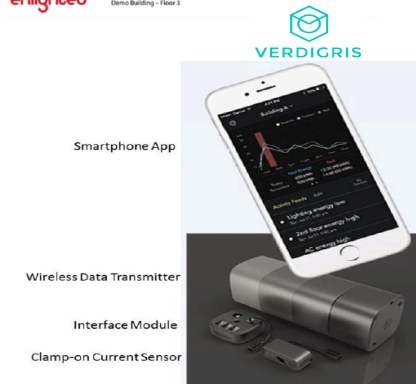
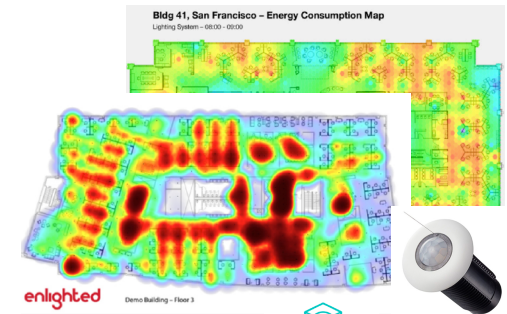
Additional Capacity  
Needed based on Not  
Achieving 70% Utilization

**@51% = Need 37% More  
Capacity**

**@43% = Need 63% More  
Capacity**

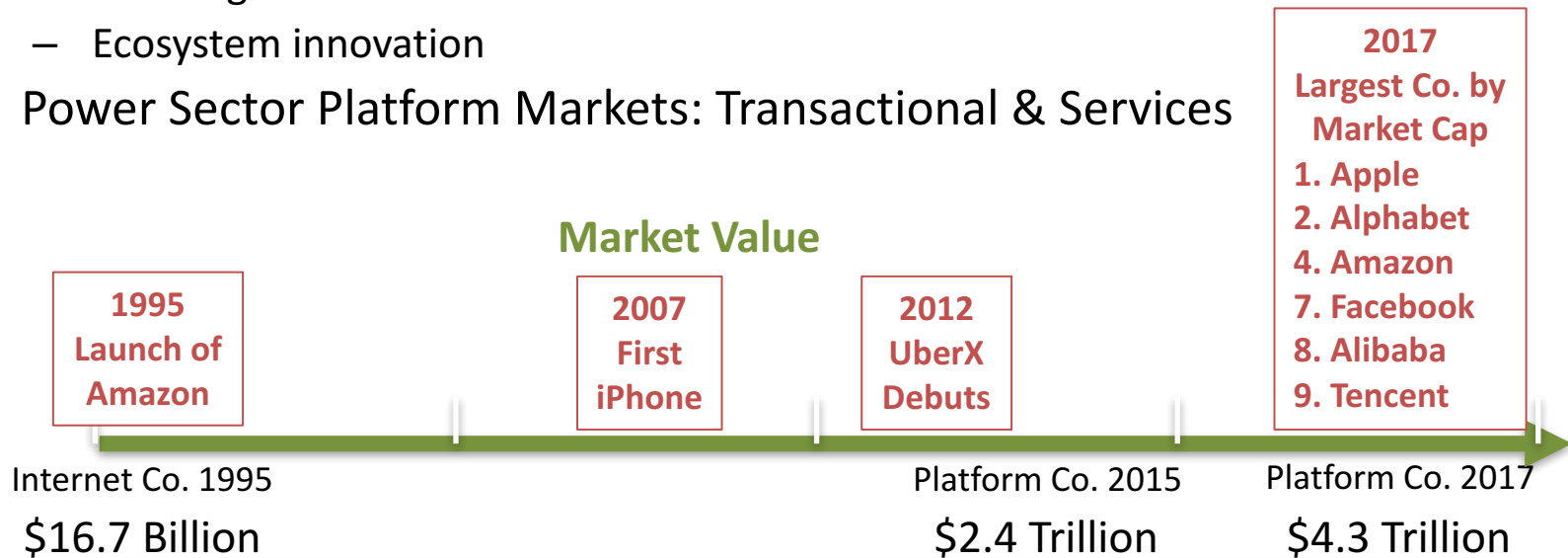
# IoT: Sensors, Analytics, Smart Devices, Machine Learning

- Sensors, Analytics, Smart Thermostats and Building Energy Management Systems:
  - Track occupancy and energy use to reduce wasted energy
  - Use pre-cooling & thermal inertia to reduce peak demand by as much as 50%
- Machine Learning:
  - Verdigris – Using machine learning to disaggregate circuit loads in industry and commercial buildings and to analyze motor performance with simple current sensors at the breaker panel
  - Google Deep Learning – Used machine learning to reduce cooling energy use by 40% and overall use by 15% in already efficient data centers



# Platform Business Models

- **What is a Platform?** The infrastructure of a business ecosystem that matches producers and consumers, who transact using the platform and resources provided by the ecosystem. The platform provides components and rules designed to facilitate interactions and creates value by facilitating matches and providing easy access to useful goods and services<sup>4</sup>
- Platforms combine technology and structure to animate transactions in a larger ecosystem with the potential to produce:
  - Positive network externalities
  - Learning effects
  - Ecosystem innovation
- Power Sector Platform Markets: Transactional & Services



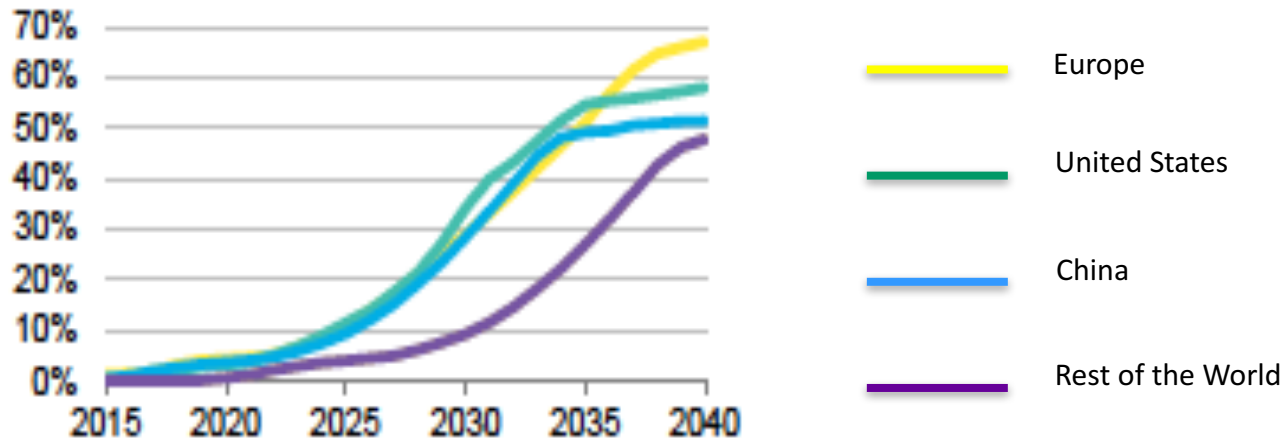


# Blockchains & Smart Contracts

- ***Rapidly evolving, potentially groundbreaking technology***
  - Development backed by billions of dollars of investment
- Blockchain – *Secure distributed data*: provides consensus-based authentication and cryptographic security for sequential updating, synchronization, and replication of data in a network of computer databases and a permanent, auditable ledger of transactions and changes in the recorded data
- Smart Contracts – *Secure distributed computation*: automates contractual relationships with blockchain authentication and cryptographic security
- Fundamental change in data management & market structures:
  - Everyone in the network – even in different organizations – can see the same transactions and data on their systems at the same time
  - Extraordinary level of data security
  - Permanent audit trail
  - Does not depend on the use of a trusted third party (bank, exchange, or RTO)

# EV Development

- Based on expanded production and incremental improvements only :
  - UBS estimates EVs can achieve cost parity in U.S. by 2025 <sup>7</sup>
  - Bloomberg New Energy Finance projects unsubsidized EVs start to be cost competitive by 2025, account for majority U.S. new car sales in early 2030s <sup>8</sup>



Source: Bloomberg New Energy Finance

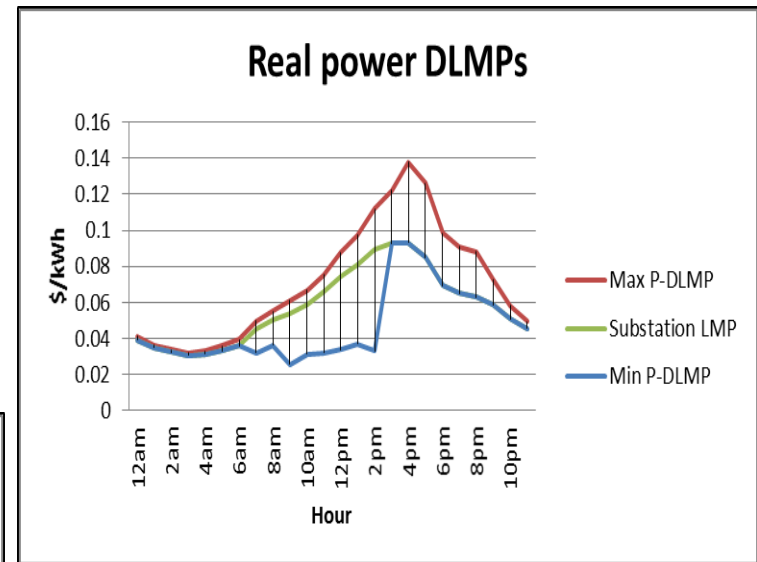
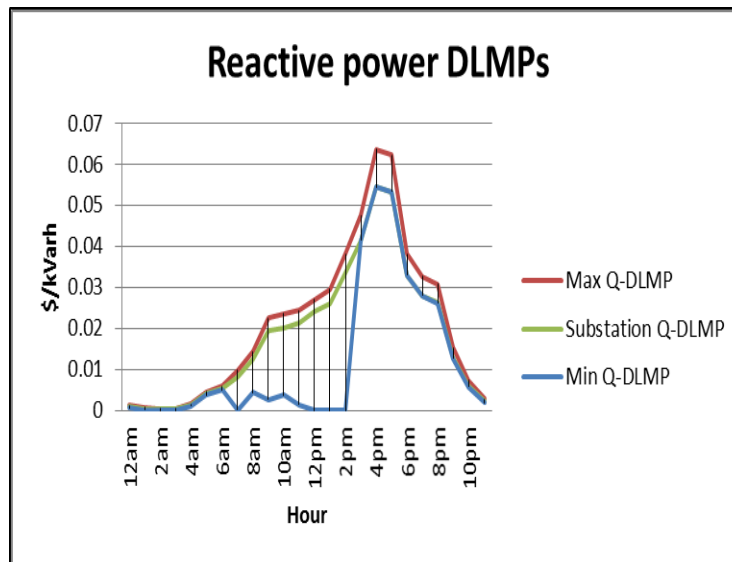
- China, India, U.K., France, & Norway plan to phase out fossil fuel vehicles
- Solid-state electrolyte batteries, which Toyota plans to use by the early 2020s, could improve safety, greatly reduce costs, and / or extend range.

# Demand-Side of U.S. Power Market Today

- More than 16 million customers participate in wholesale or utility demand response or time-varying rate programs<sup>9</sup>
- Distributed generation and storage:
  - Combined Heat and Power = Over 8% of total U.S. generating capacity (>80GW)<sup>10</sup>
  - Over 14 million net metering customers supply power back into the grid<sup>11</sup>
  - U.S. distributed PV capacity nearly doubled from 2014 (7GW) to 2017 (13GW)<sup>12</sup>
  - Millions more consumers maintain back-up generators or are implementing energy storage systems
- Over 600,000 electric and hybrid electric vehicles in the U.S.

# Market Valuation: DLMPs<sup>4</sup>

*Modeling Results: Summer Day, High DER Scenario for an Illustrative 800 Bus Commercial / Residential Distribution Feeder*



- Cost of EV charging 42% lower
- Cost of Commercial Space Conditioning reduces 12% with 20% flexible demand
- PV revenue increases 6% with reactive power sales

*DER value is time- and location-specific, changes with load and network state, and can erode with additional DER on a feeder*

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