

Planning the Grid the Islands Need: Observations on Integrated Grid Planning

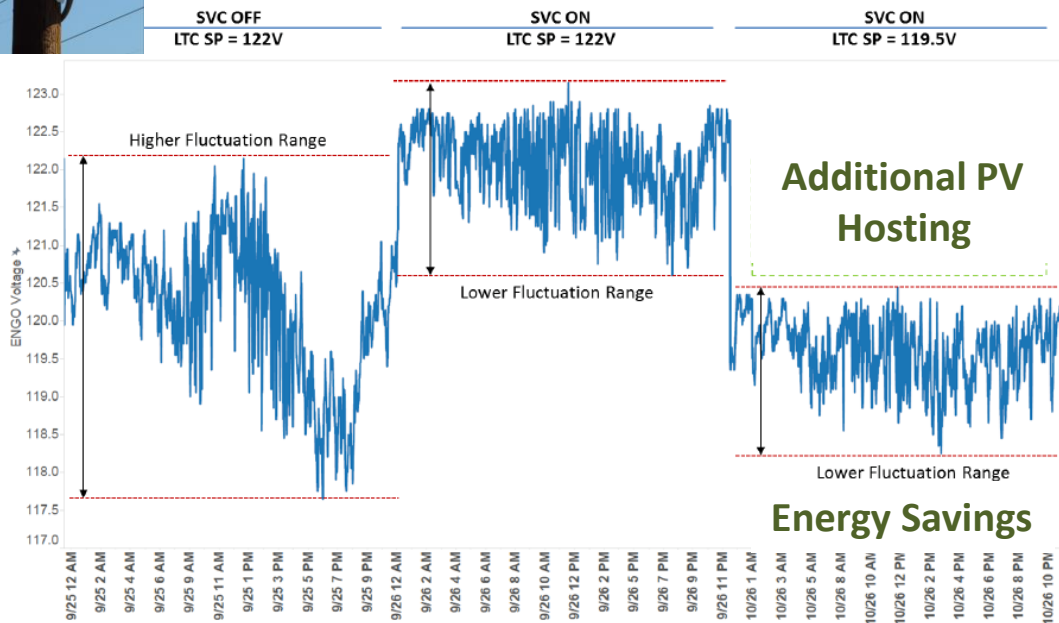
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Integration of Distributed Intelligent Control

- PV & Demand Changes Create Volatility in Low Voltage Distribution
 - Historically Utilities had Little / No Visibility and Control in these Segments
- Keola – Demonstration of Unique Technology for Distributed Intelligent Grid Control: Varentec Low Voltage VAR Controllers (LVVCs or SVCs) ¹
 - LVVCs compressed Fluctuations by Providing sub-cycle VAR Control & Autonomously Swarmed to Move Voltage toward an Operator Set Point

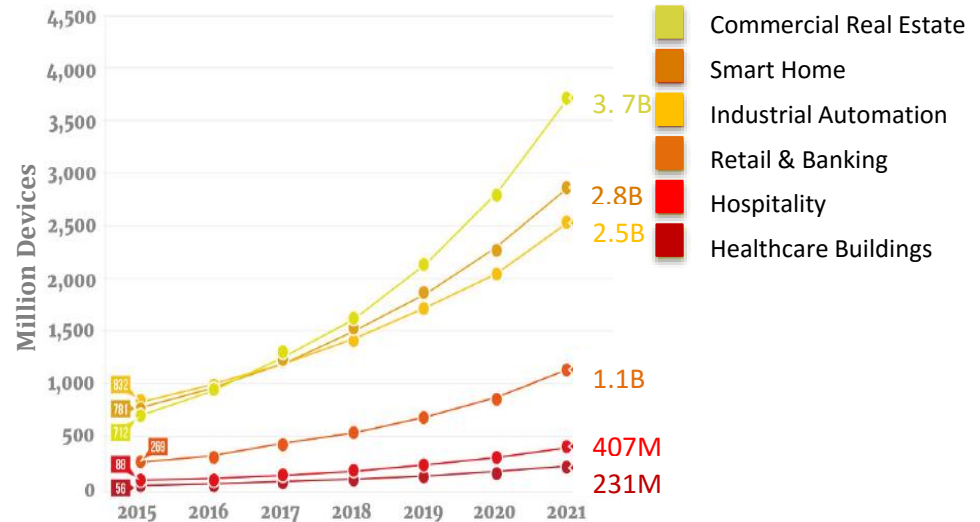


- LVVCs Can Provide:
 - Added Hosting Capacity
 - Ramping Flexibility
 - Up to 5%+ Energy & Demand Savings at 1¢ to 2.5¢ per kWh Saved
- Smart Inverter Promising, with Unresolved Issues:
 - Lack LVVC Precision
 - Limited Testing
 - Integration Questions

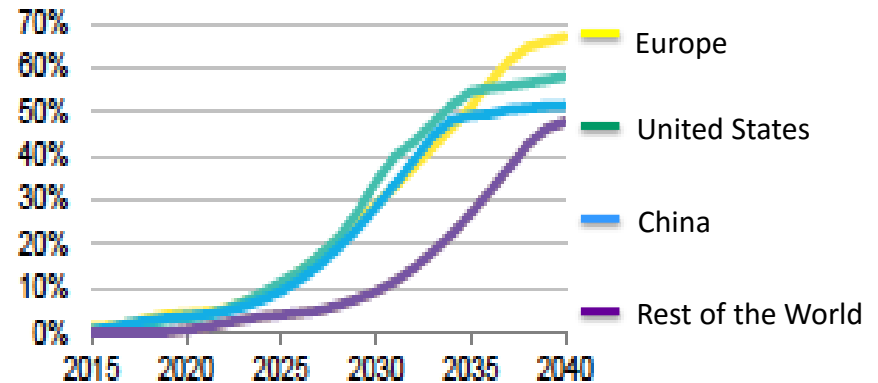
Integration of Intelligent Demand

- Growth in Intelligent Demand
 - Internet of Things leverages Building Thermal Inertia, Storage, & Flexible Demand
 - EVs reach a Tipping Point:
 - EVs As Percent Vehicles Sold: Hawaii >2X Mainland
 - Price competitive by 2025
 - Connecting Multiple Services
- Smart Devices Continuously seek to Optimize tradeoff of Anticipated, Real-time, Location-specific Prices & Individual Preferences
- Incompatible with Existing Demand Response Programs
 - Dispatch of Large Numbers is Computationally Intractable
 - No Representative Baselines

5X Increase in Smart Building Connected Devices by 2021 ²



New Car Sales: Percent Electric Vehicles ³



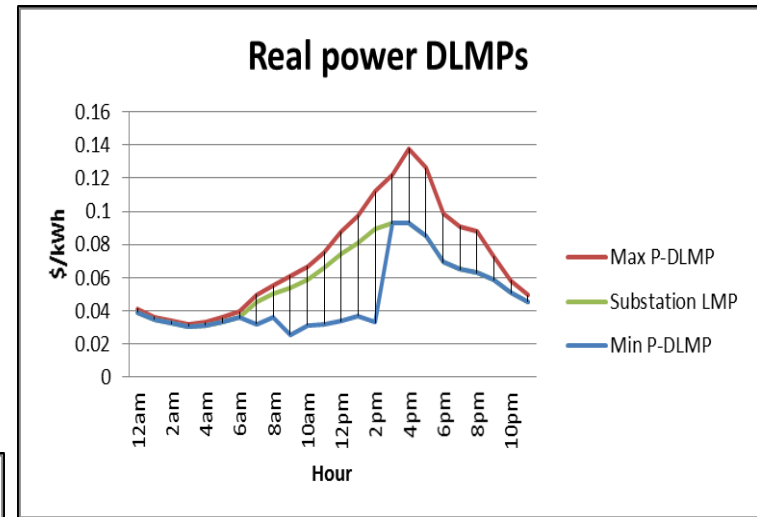
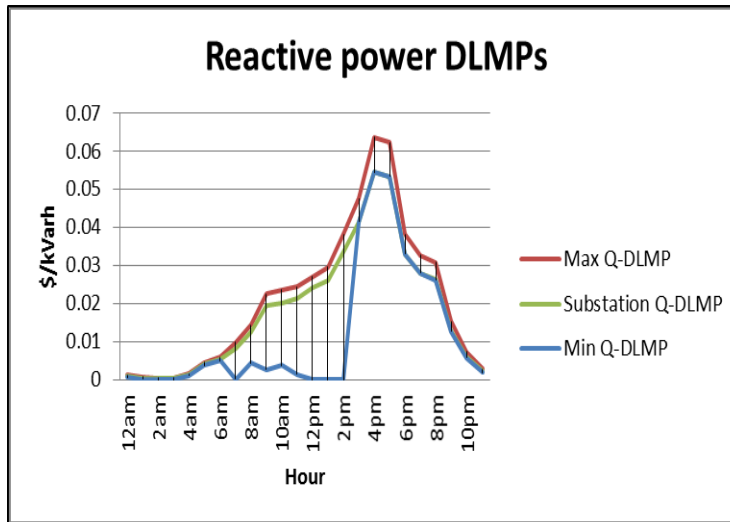
Source: Bloomberg New Energy Finance

Dynamics of Net Value / Benefits & Costs

- Total Resource Cost \neq Net Value: TRC Assumes fixed requirements
 - Generalize: Consider net benefits, “*in the context of value for customers*”¹
 - Value is the Result of Delivering & Using Electrical Products that DER Can Provide Operating at Appropriate Times and Locations
 - DER can provide **only 3** Core Electrical Products
 - Real Energy
 - Reactive Power
 - Reserves (in various forms)
 - Generally a unit of capacity can provide **only 1** such product at a time
 - Tradeoffs between Products can be dynamically Optimized
 - System Value is time-, location-, and grid topology-specific
 - Value can be customer-specific, e.g. varying customer outage costs
 - **No single distribution value of DER**
 - System-wide marginal costs are a poor estimate of value of individual DER
-

Distribution Locational Marginal Prices Reflect Value

**New York REV Study
Modeling Results: Summer
Day, High DER Scenario for
an Illustrative 800 Bus
Commercial / Residential
Distribution Feeder** ⁴



DLMPs Can Reduce Total Costs:

- 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

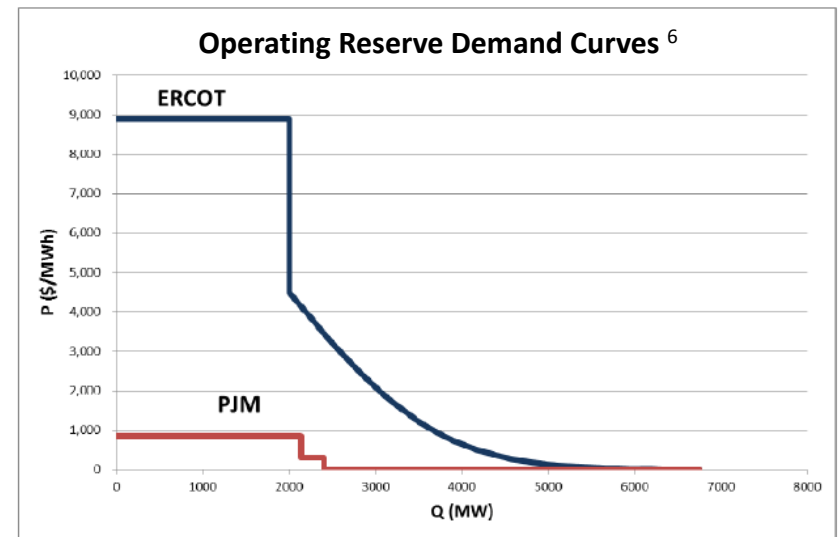
DER value is time- and location-specific, changes with load and network state, and can erode with additional DER on a feeder

Transition to Dynamic Rates & Prices

- NY REV Policy Direction: Develop increasingly granular prices, as markets, advanced meters, & the ability to respond become available
- TCR Report Recommendations⁴ :
 - Start by Pricing Wholesale Settlements at Bulk Power Nodal, Interval LMPs
 - Evaluate how far to extend LMP into Distribution (DLMPs)
 - Develop Multi-Sided Platform Markets for Forward & Real-time Transactions and Customer Services (e.g. Integration of Connected Homes)
- NY Staff Report & Recommendations in the Value of Distributed Energy Resources Proceeding⁵ : *“Achieving perfectly efficient, optimally granular, and instantaneously dynamic pricing is a necessary goal”*
 - *“Effective and efficient investment in and utilization of DERs ... will require more granularity in valuation and pricing along key dimensions that differentiate value in planning and operating the electricity system, including timing, location and performance.”*

Transition to Dynamic Rates & Prices

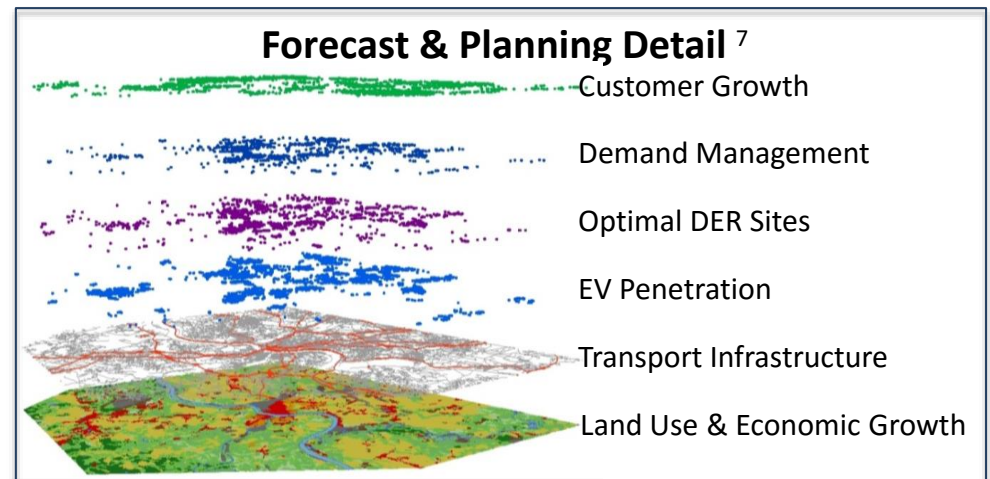
- Risks of Incremental Transition:
 - Uncoordinated 3rd Party Aggregation: Resource or Demand Response Locations and Products Change Independent of Distribution Operations
 - Tariff / Program Compensation that Fails to Track Value Dynamics: Increases Total Costs & Creates Policy Inertia
- Key Questions – How best to:
 - Engage & Incent Efficient Responses from DER and Flexible Demand
 - Price Operating Reserves based on the Probability of Scarcity & Local Constraints
 - Compensate the Provision of System Inertia



Regulation of Grid Planning

- Significant DER & Bi-directional Power Flows Create Complexity in:

- System Visibility
- Distribution Reliability
- Topology & Asset Mgt.
- Resource Interactions
- Equipment Degradation
- System Protection
- Safety
- Phase Balance



- Planning has to consider: local (e.g. line segment) impacts, probabilistic forecasts, and investment under uncertainty
- Regulators & 3rd Parties subject to significant information asymmetries
 - Limits on Sharing Data from which PII and CIP information can be derived
- Consider Flexible Model, focusing on Performance Metrics & Incentives
 - Disinterested Knowledgeable Advisory Committee is a possible Option

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