

# Valuing Distributed Energy Resources (DER) via Distribution Locational Marginal Prices (DLMP)

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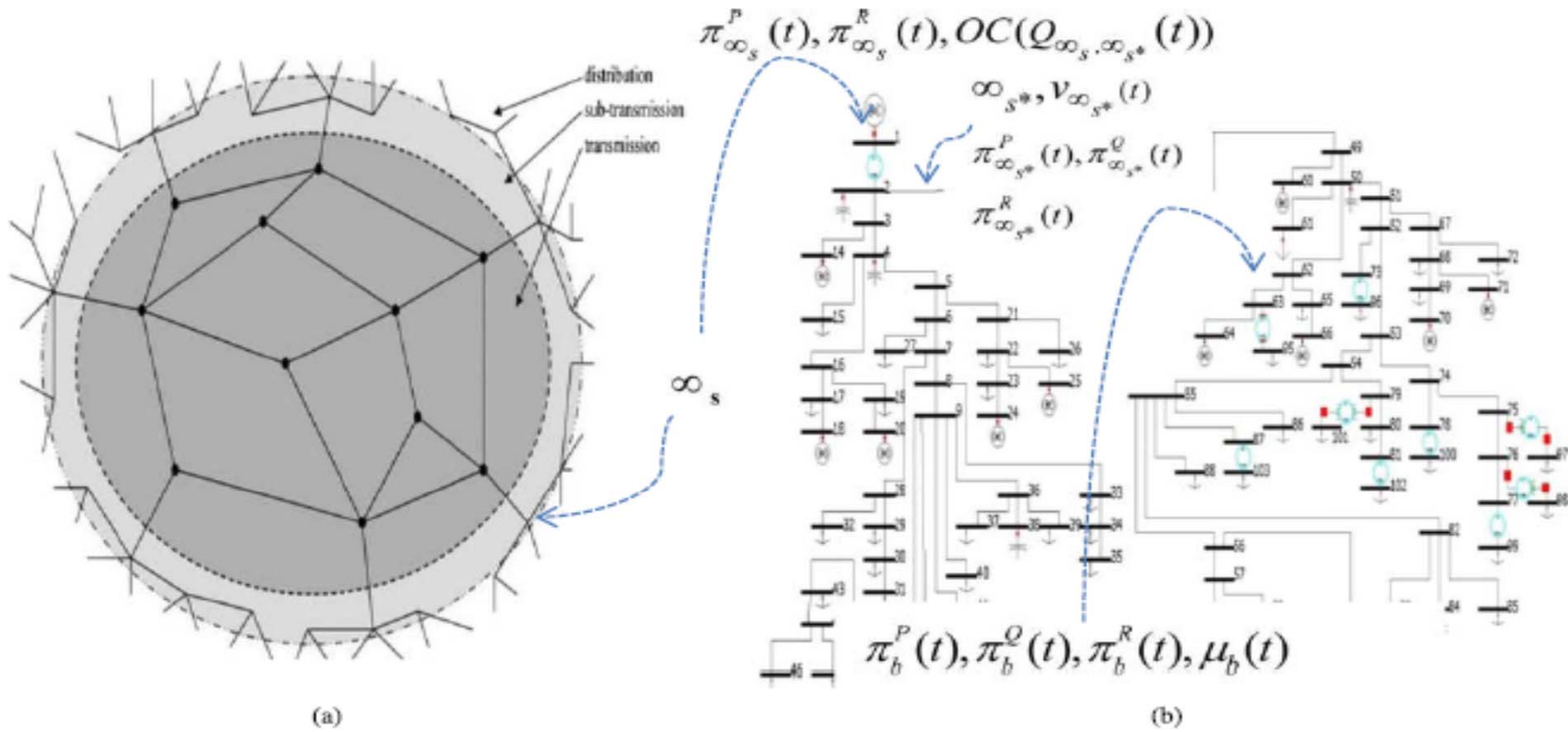
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DOE Electricity Advisory Committee Panel: Transactive Energy

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# LMP from Transmission to the Meter ...



(a) Transmission, subtransmission, and distribution schematic. (b) Expanded distribution feeder schematic.

Caramanis, Ntakou, Hogan, Chakraborty and Shoene "Co-Optimization of Power and Reserves in Dynamic T&D Power Markets with Nondispatchable Renewable Generation and Distributed Energy Resources" Invited Paper, Transactions of the IEEE Vol 104, No 4, April 2016



# Core Electric Products from DER (ONLY 3!)

- The 3 Rs
  - Real Energy
  - Reactive Power
  - Reserves
- The 3 Rs require tradeoffs
  - Tradeoff between producing real versus reactive power
  - Tradeoff between committing now to produce real power (now and forward) and being available to provide reserves

Tabors Caramanis Rudkevich “White Paper – Developing Competitive Electricity Markets and Pricing Structures” NYSERDA released April 2016. [HTTP://www.tcr-us.com/projects.html](http://www.tcr-us.com/projects.html)



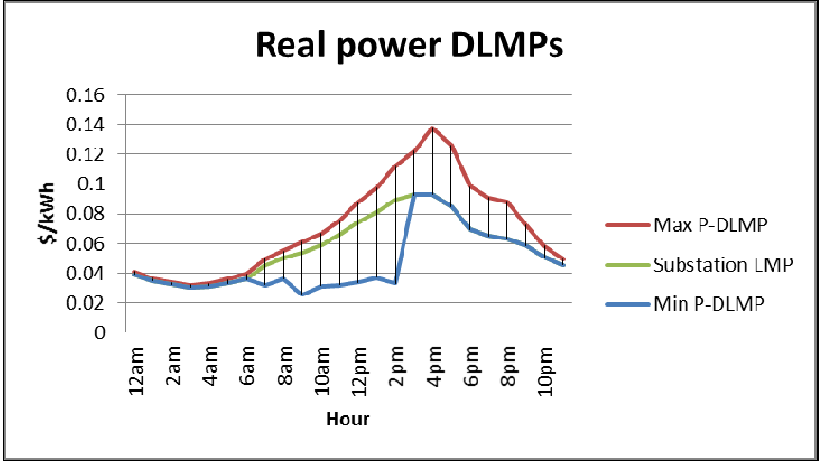
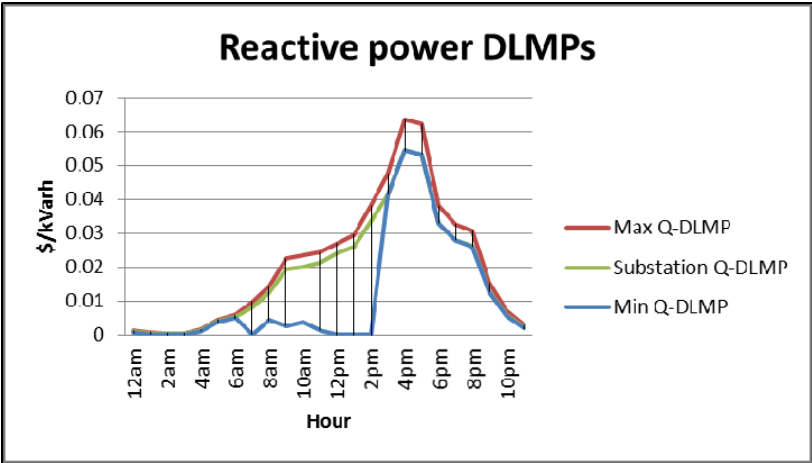
# Valuing DER Core Electric Products

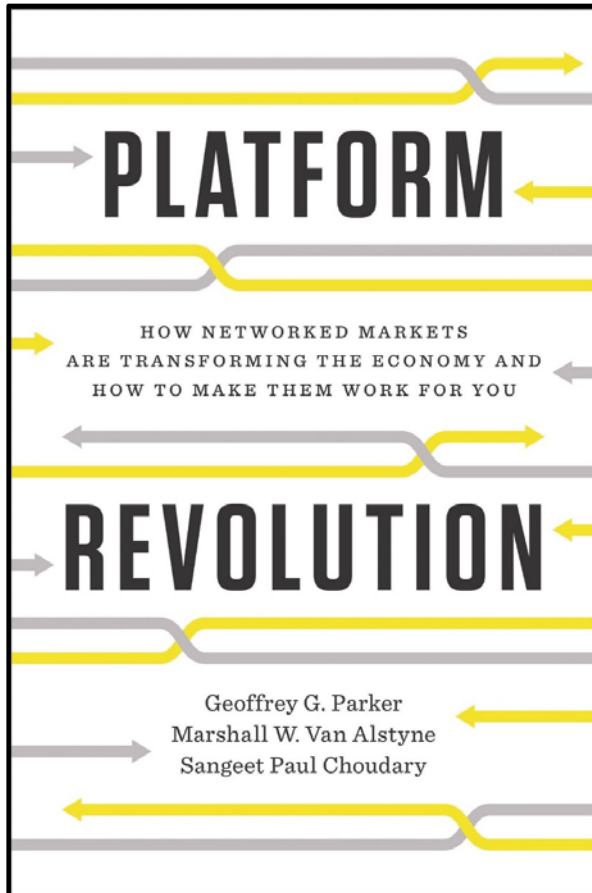
- Market based valuation via Distribution Locational Marginal Prices (DLMP) versus administrative valuation approaches (e.g. LMP +D, feed-in tariff, net metering retail rate credits)
- What is the difference?
  - DLMP is a **granular, market measure** of the utility's short run marginal cost (SRMC) at the specific *time and location* of the core electric product's use
  - LMP+D and similar approaches are **average, administrative** estimates of the "avoided cost" of the core electric product. For example LMP (i.e. nodal, or wholesale value, of real energy) plus D (an administratively estimate of average avoided distribution system costs).



# Granular Pricing: The Benefit of DLMP in increased economic efficiency

*Modeling Results: Summer Day High DER Scenario. Maximum DLMPs, Minimum DLMPs and LMPs*





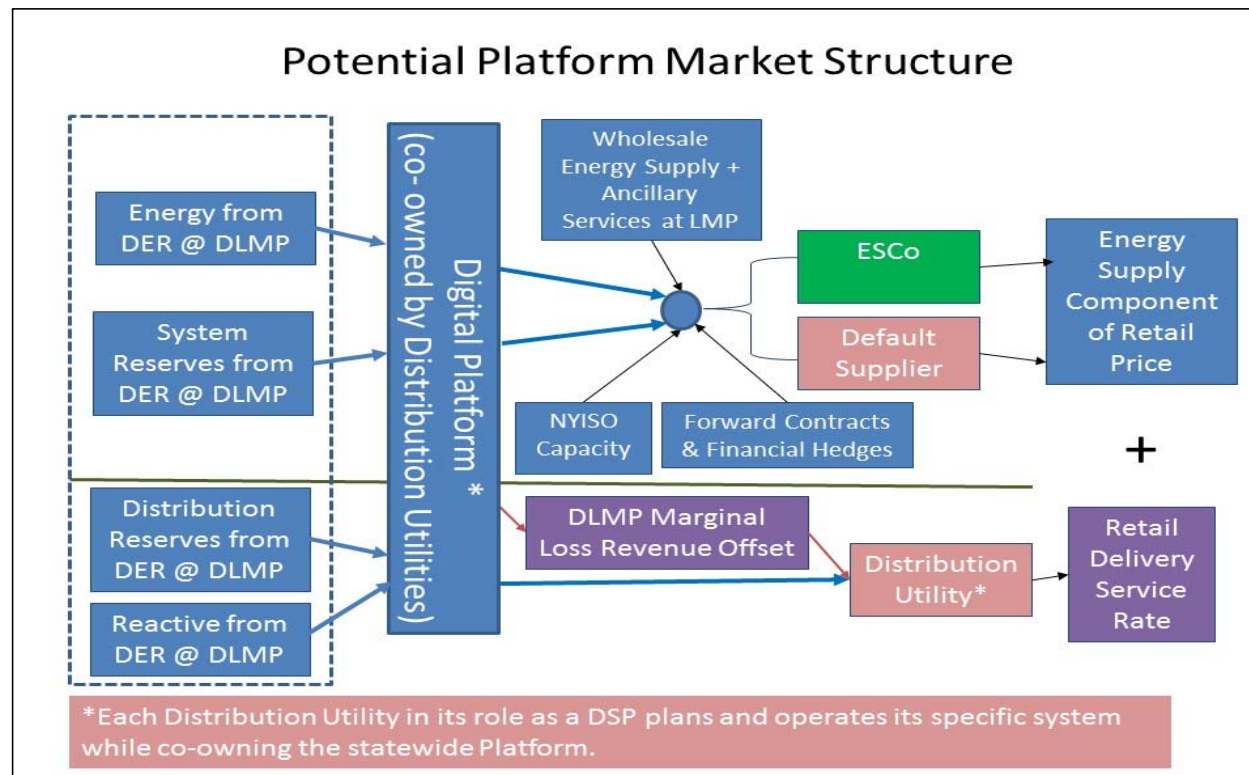
## What is an *ECONOMIC* Platform?

A platform is a business ecosystem that matches producers with consumers, who transact directly with each other using resources provided by the ecosystem itself. The platform ecosystem provides outside parties with easy access to useful products or services through an infrastructure and a set of rules designed to facilitate interactions among users. A platform's overarching purpose is to consummate matches among users and to facilitate the exchange of goods and services, thereby enabling value creation for all participants.

(see: Parker, Van Alstyne and Choudary, *Platform Revolution*, W.W. Norton & Co. 2016)



# Platform Market Structure



# The Value Proposition of a DER Platform / Platform Market

- Supports development and operation of a new, competitive market for core electric products, i.e., well-defined products, transparency, multiple buyers and sellers can enter and exit the market freely.
- Enables granular, economically efficient prices that reflect the time- and location-specific value of real energy, reactive power and reserves
- Minimizes transaction costs or friction associated with sale and purchase of core electric products and price discovery
- Expands DER access to markets for their core electric products
  - Real Energy (kWh)
  - Reactive Power (KVARh) in order to maintain voltage within an acceptable band
  - Reserves (a commitment to deliver real or reactive power in the future)
- Animates emergence of new products and services
  - Combinations of services and energy products from competitive suppliers that minimize customer costs
  - Value added services:” price forecasts, analytics, smart technology
- Improves distribution system efficiency: local source of Volt / VAR control





# What could a DER Platform look like??

- Single regional-level platform
  - Efficiencies in scale and scope
  - Able to take full advantage of any network externalities
  - Reduction in transaction costs along multiple paths
- Distribution Utilities within the region could jointly own the Platform as “sponsors”
  - Own Intellectual Property
  - Set the market rules, subject to PSC approval
- Professional / Independent entity operates the platform and manages the market as “provider”
  - Operates / administers all markets on the Platform



# Market Structure for Core Electric Products

- **Forward market (*ex ante*)**
  - Continuous, bilateral transactions: location- and time-based bids and offers are matched and price formation occurs
  - Closes immediately prior to the time of simultaneous production and consumption of electricity
  - Forward options contracts enable Distribution Utilities to avoid distribution system investments by obtaining advance commitments from DER to provide location-specific resources (e.g., voltage support, operating reserves)
- **Clearing or Balancing Market (*ex post*)**
  - Needed to clear imbalances between scheduled energy deliveries and actual energy consumed
  - DSOs provide the Platform with relevant data on imbalances, including actual “real time” consumption, production, load flows and distribution system topology
  - Platform runs a mathematical load flow calculation, with the substation LMP as the reference price, to determine a clearing price for energy and reactive power at each traded distribution node.

*Prices would become more granular in phases, starting at existing, sub-zonal transmission nodes (“enhanced LMP” or eLMP) and moving to Distributed LMP (DLMP), as utilities implement interval measurement of real and reactive power at sufficient points to estimate distribution power flows.*



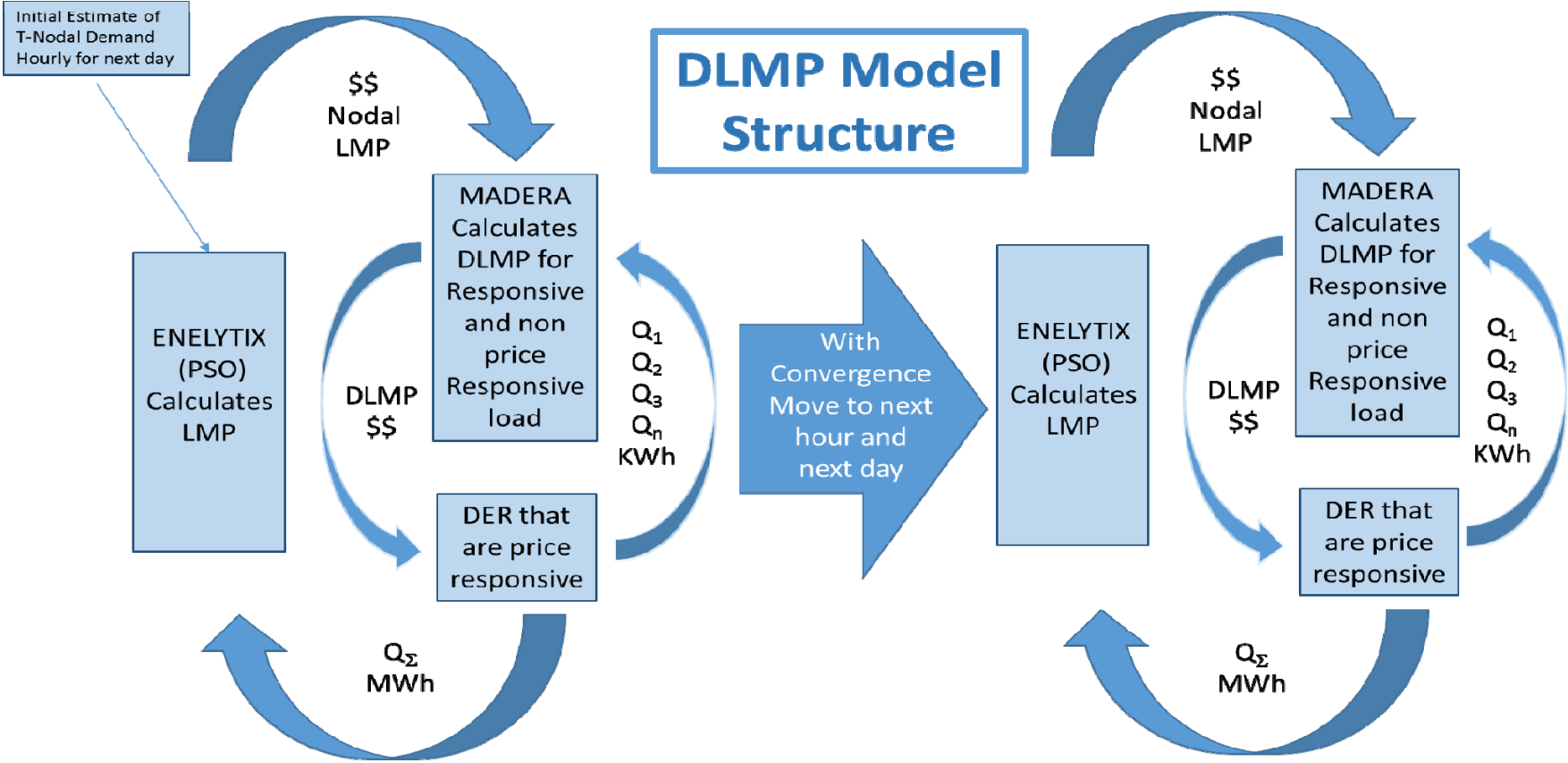
# The Architecture of Grid Control: The likely End Point of the Transition

- **Predominantly local control / local response through:**
  - Automated price response of Commercial Buildings and residences
  - Intelligent price responsive charging and discharging of distributed storage including electric vehicles
  - Adaptive system response of and to distributed generation
- **Peer to Peer and Feeder to Feeder communications**
  - Vertical and horizontal information flows for localized, optimal decision making
- **Secure and Efficient Power System Operations through:**
- Dynamic Network Management (Kranning, Chu, Lavaei and Boyd “*Dynamic Network Energy Management via Proximal Message Passing*”)
  - Localized response for “*Homeostatic Control*” of frequency and voltage for system stability (Schweppe, Caramanis, Tabors, Bohn *Spot Pricing of Electricity* Kluwer Academic Press 1989)

*All of the above developments imply only minimal (local emergency only) centralized control of distribution in the End State*



# Modeling and Analyzing DLMP Benefits: How can/would you do it?



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