



Distributed energy resource services and pricing: A **Caltech** perspective (Adam Wierman)

Goal:

under generation ↔ demand response
over generation ↔ storage
time variability ↔ balancing energy



The Pricing Predicament

What new wholesale DR/DER services should be offered?
... how should they be incorporated into the market?
...and how should they be priced?

Wholesale market prices

Capacity	Energy	Reserves	Regulation
Seasonal	Day-ahead	Day-ahead	Day-ahead
Cap-zones	Real-time	Real-time	Real-time
	Locational	Zonal	Zonal

Goal: Extracting costs & incentivize “good behavior”

Retail Energy Rates

Tiered Time-of-use Coincident-peak-pricing
Real-time-pricing Net-metering

Consumers



Utility Owned
Assets



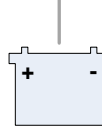
Industrial



Commercial



Generation



Electric
Storage



Transportation



Thermal
Storage



Residential

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DR/DER Services

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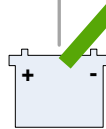
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Wholesale DR/DER services

Balancing energy	Energy (DA/RT/Locational)
Ramping	Ancillary Services
Capacity (Seasonal)	(reserves, regulation)

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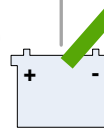
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Ramping	Ancillary Services
Capacity (Seasonal)	(reserves, regulation)

Goal: Provide dispatchable energy services

Retail Energy Rates

Tiered	Time-of-use	Coincident-peak-pricing
	Real-time-pricing	Net-metering

DR/DER Rates

Real-time-pricing	Coincident-peak-pricing
Pay-for-performance	Contract-based
Fixed incentive	Credits for service

Consumers



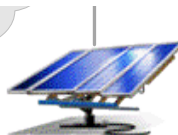
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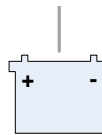
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Separation of services

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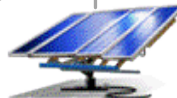
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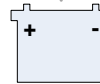
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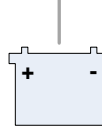
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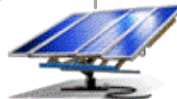
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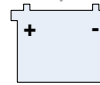
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Residential

(A few) Key Challenges

- 1) **Consumer-side challenges**
- 2) **Social challenges**
- 3) **Utility-side challenges**
- 4) **Economic challenges**

(A few) Key Challenges

- 1) **Consumer-side challenges**
 - Participation must be seamless (& profitable) for the consumer
 - Wide-spread participation requires aggregators/intermediaries
- 2) **Social challenges**
 - Avoid “energy poverty” & the “utility death spiral”
 - Direct control vs. voluntary participation
- 3) **Utility-side challenges**
 - Scalability & decentralized control
- 4) **Economic challenges**
 - What services is “economic control” feasible for?
 - Avoid dangers from magnifying market power

(A few) Key Challenges

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Case study: *Data centers*

Zhenhua Liu, Minghong Lin, Adam Wierman

Eilyan Bitar, Adam Wierman

2) Social challenges

- Avoid “energy poverty” & the “utility death spiral”
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Desmond Cai, Sachin Adlakha, Paul de Martini, Mani Chandy, Steven Low

3) Utility-side challenges

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Yunjian Xu, Adam Wierman

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A case study in consumer-side challenges: Data centers

Zhenhua Liu, Minghong Lin, Adam Wierman, Yuan Chen

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The good: Data centers have huge potential for providing DER/DR services

...they are large loads

...they have significant flexibility

...they are heavily instrumented and monitored

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500 kW-100 MW each
Usage is growing fast

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500 kW-100 MW each
Usage is growing fast

Load can be delayed and/or moved geographically

10% of consumption can be shed in 20min

5% of consumption can be shed in 2 min

[LBNL 2-year case study]

Backup generators & storage are typically on-site

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The bad: But, they tend not to participate in DER/DR programs

- ...big overhead to prepare for active participation
- ...sophisticated programs viewed as too “risky”
- ...not convinced of profitability of programs

} Our research fights these stereotypes

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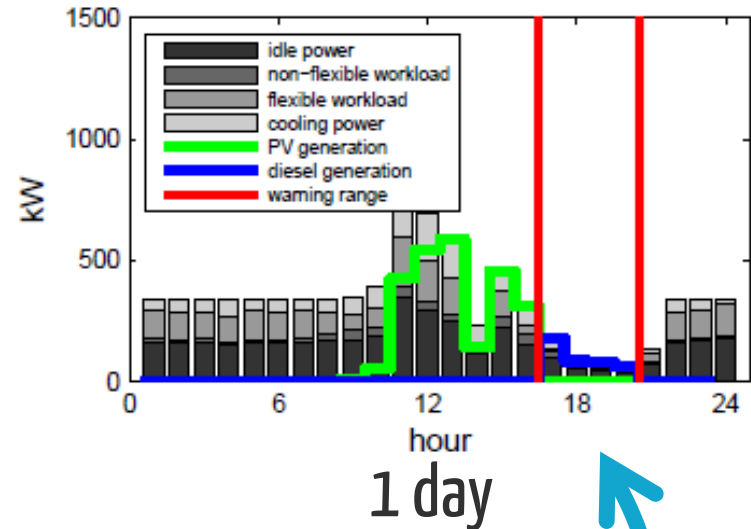
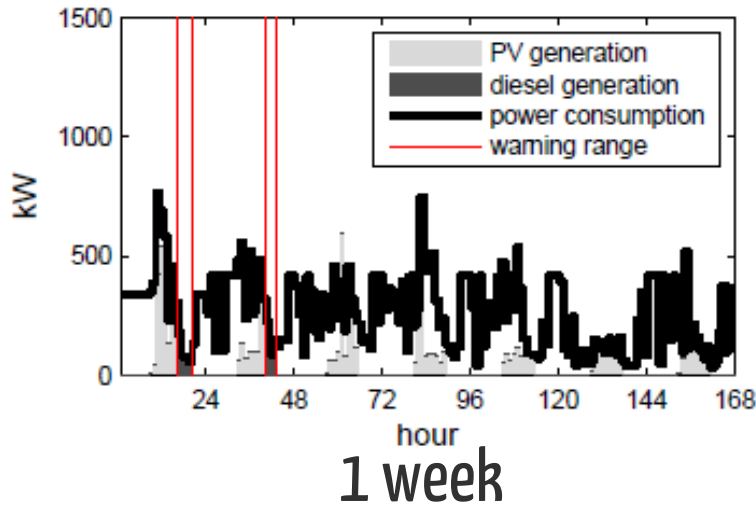
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Active participation in CPP yields
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Our view: Data centers are a great test case for any new market architecture

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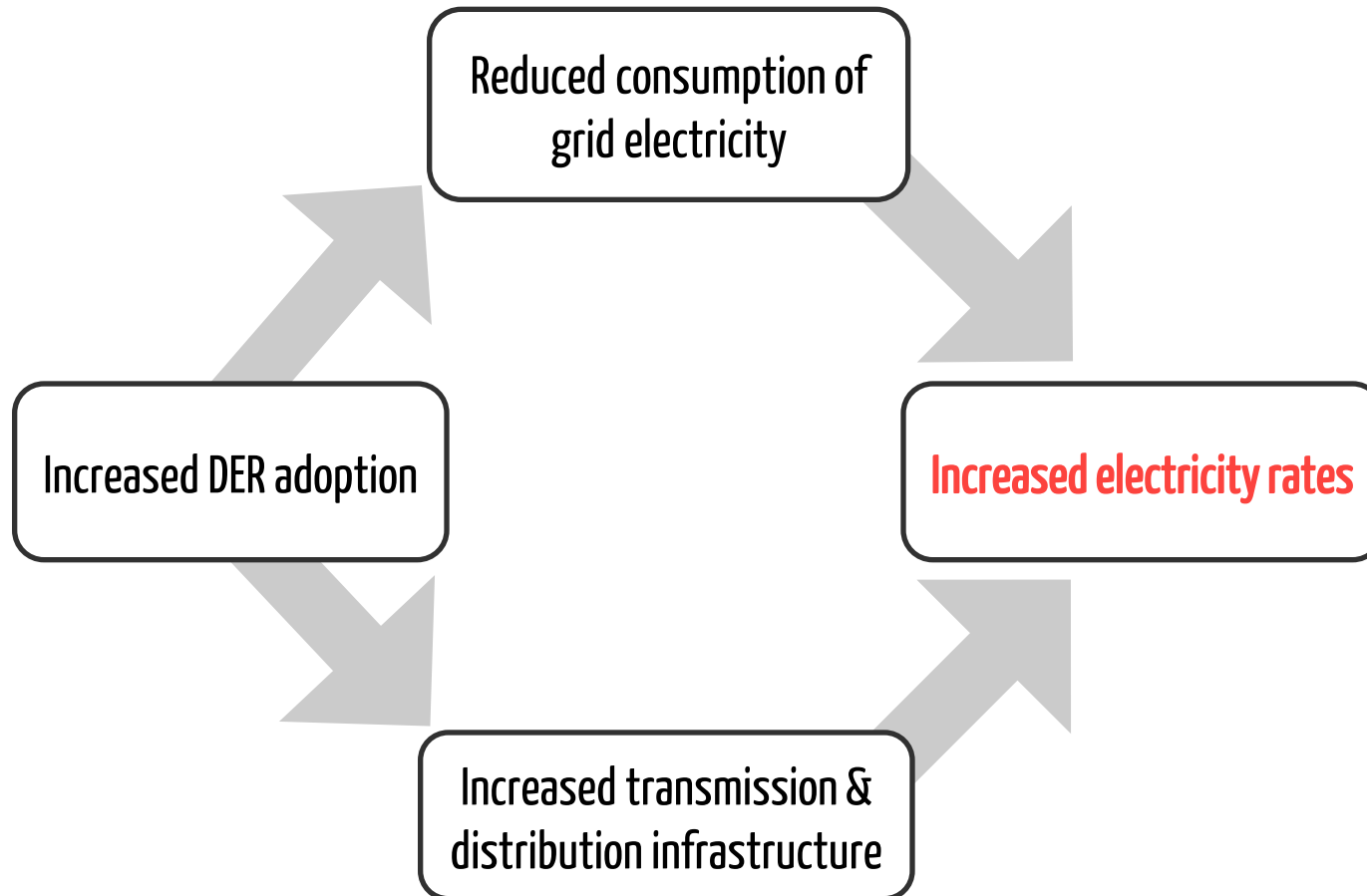


A case study in social challenges: The “utility death spiral”

(Desmond Cai, Sachin Adlakha, Paul de Martini, Mani Chandy, Steven Low)

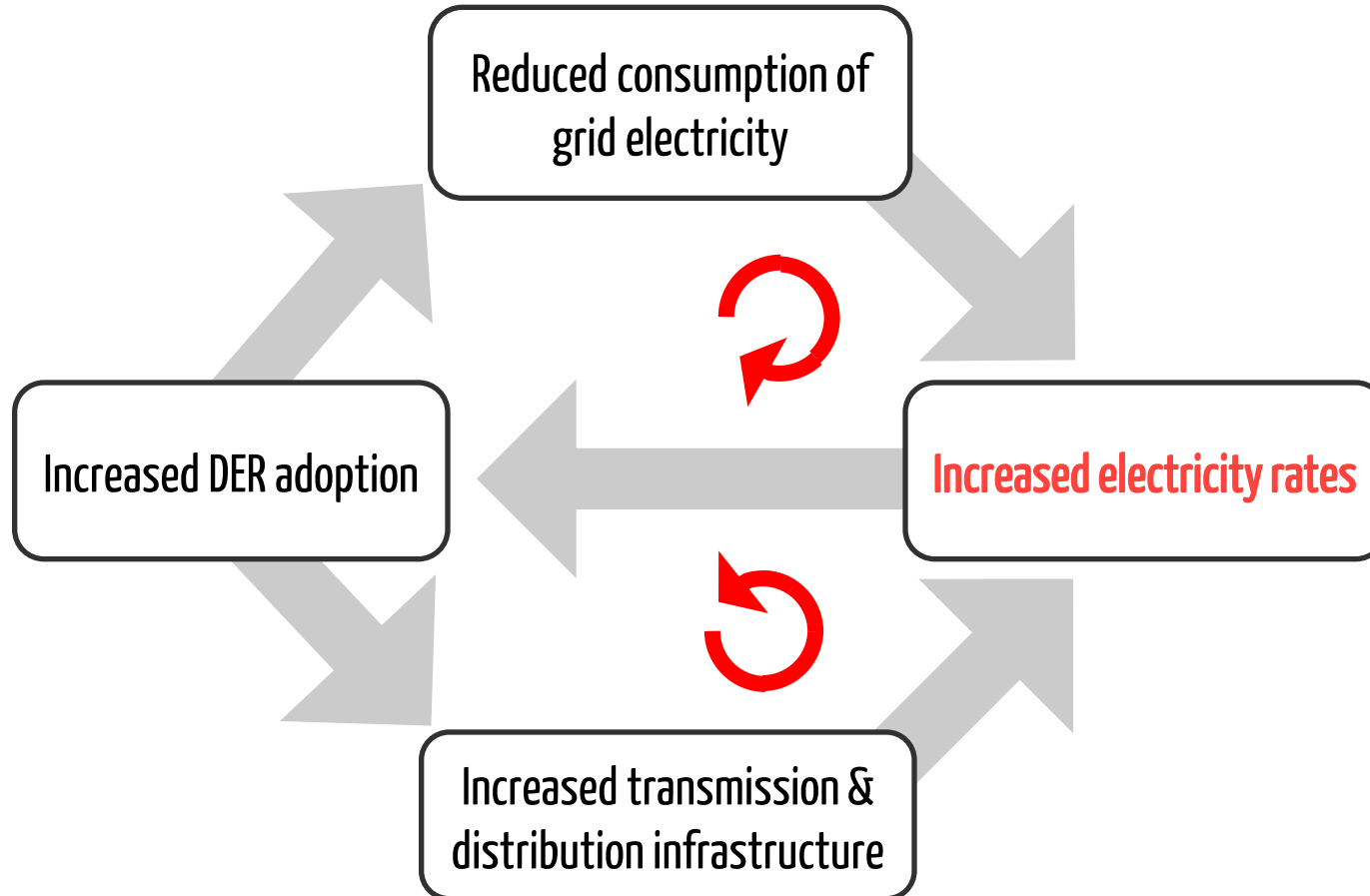
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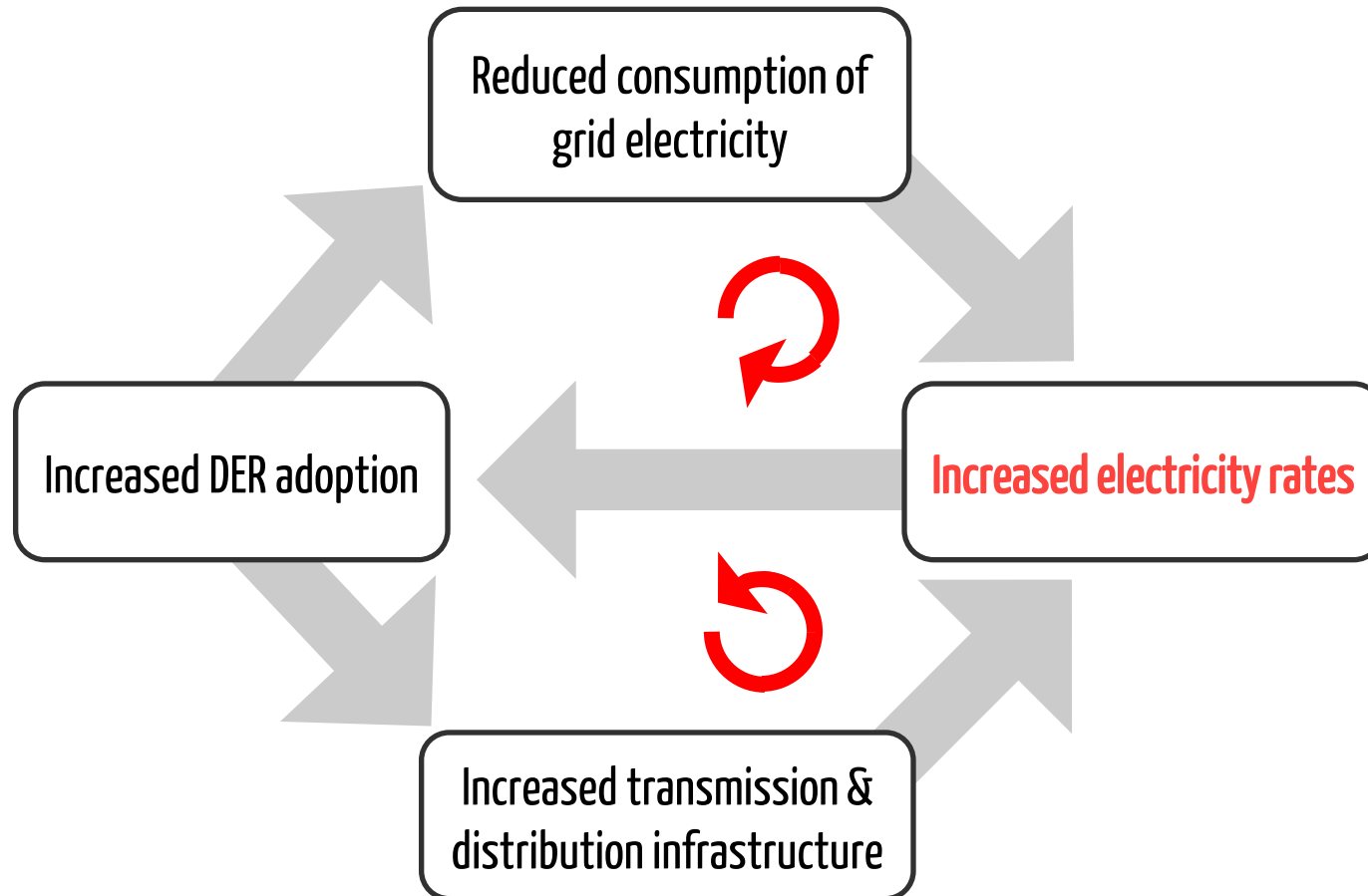
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The goal: Understand how significant this feedback is and understand what tariff/DR structures mitigate this feedback?

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A case study in economic challenges: The dangers of market power

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Traditional electricity markets: **Danger of market manipulation is extreme**



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Traditional electricity markets: **Danger of market manipulation is extreme and identifying “market power” is difficult**

Inelastic supply

&

Inelastic demand

Expensive storage

Limited price responsiveness

Limited short-run capacity

Limited exposure to real-time prices

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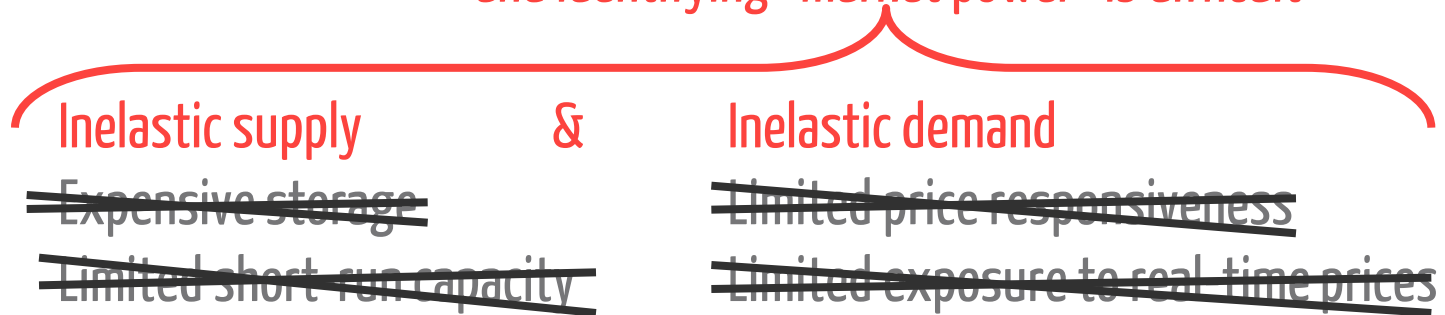
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Moving forward: **Will DER/DR reduce or magnify market power?**

A case study in economic challenges: The dangers of market power

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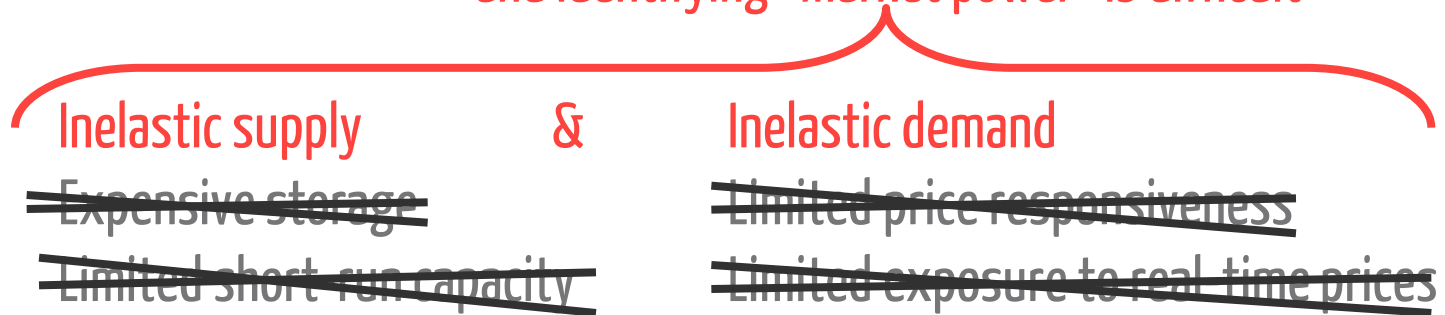


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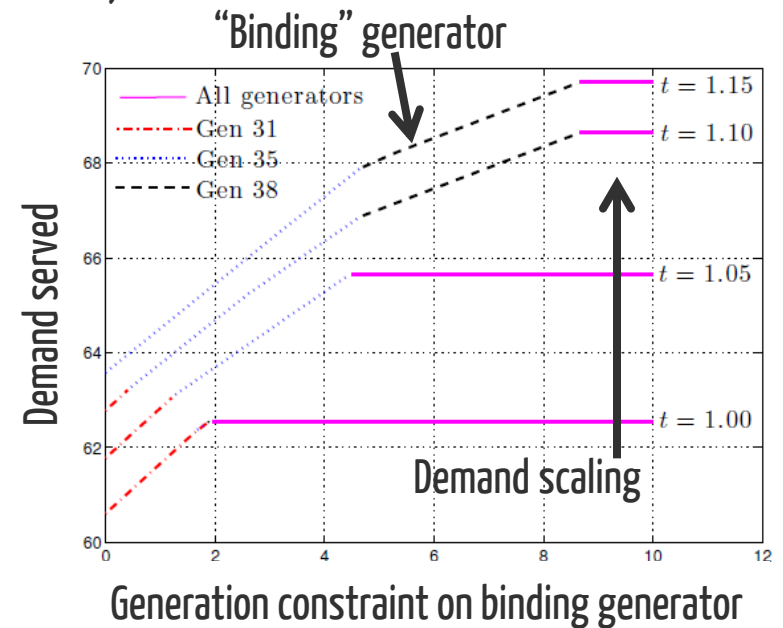
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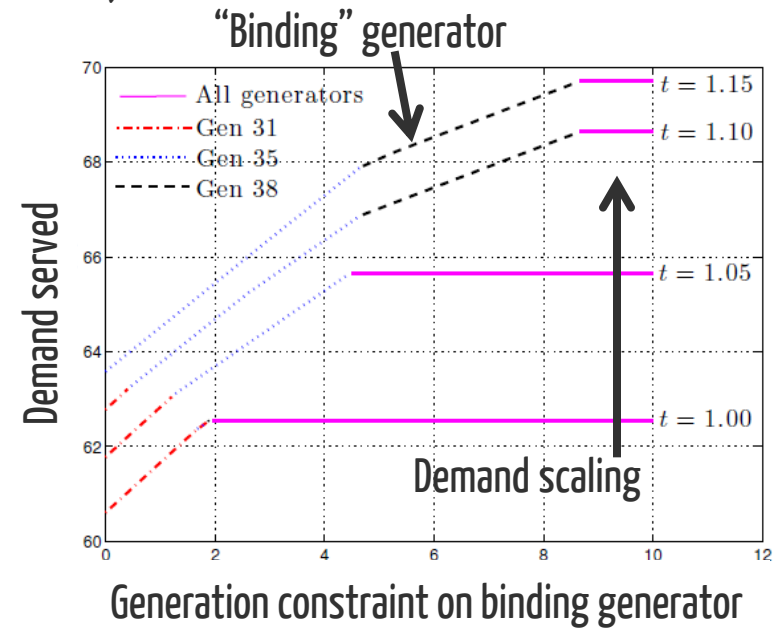
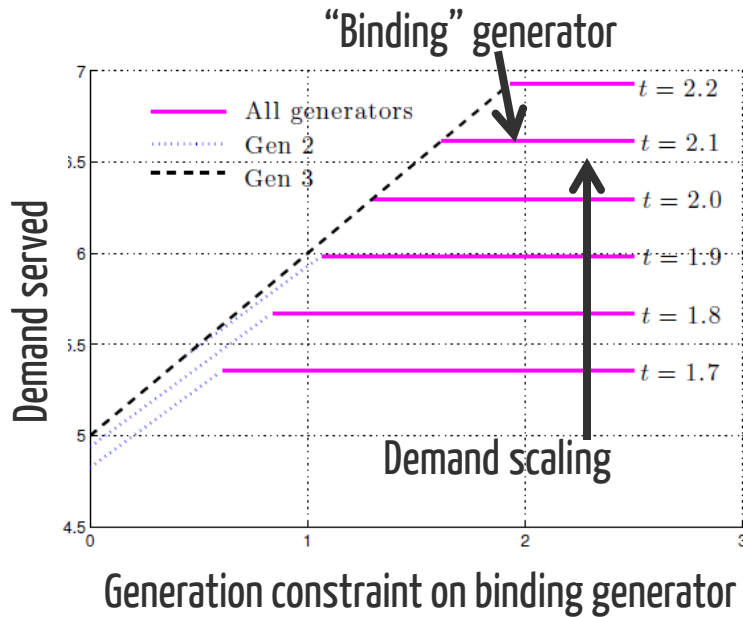
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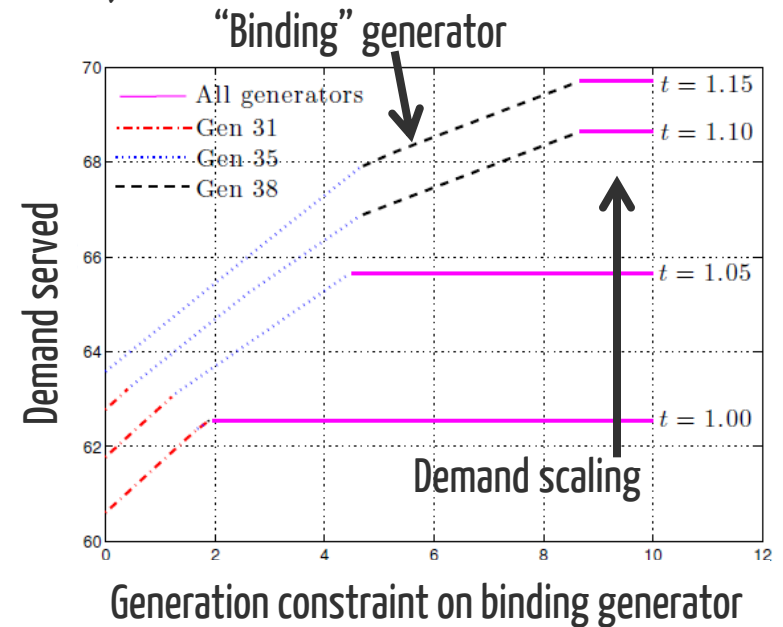
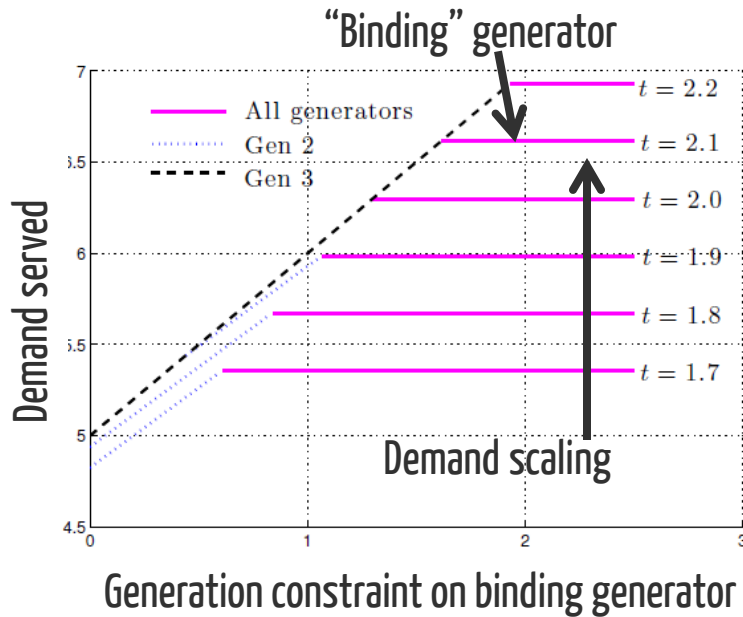
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The goal: Develop new measures for market power that are appropriate DER/DR & incorporate the transmission system

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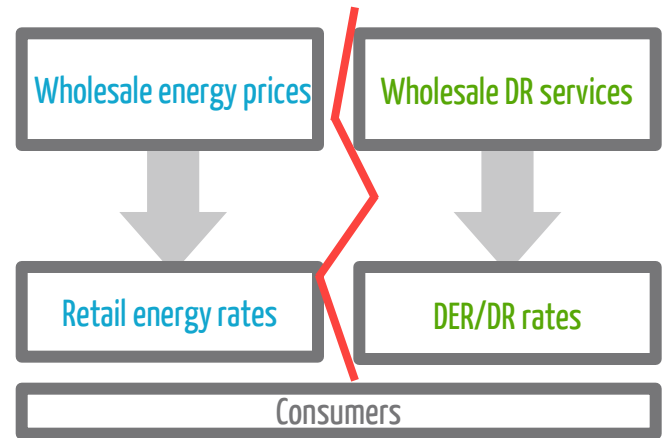
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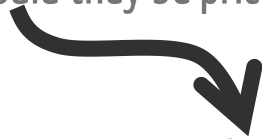


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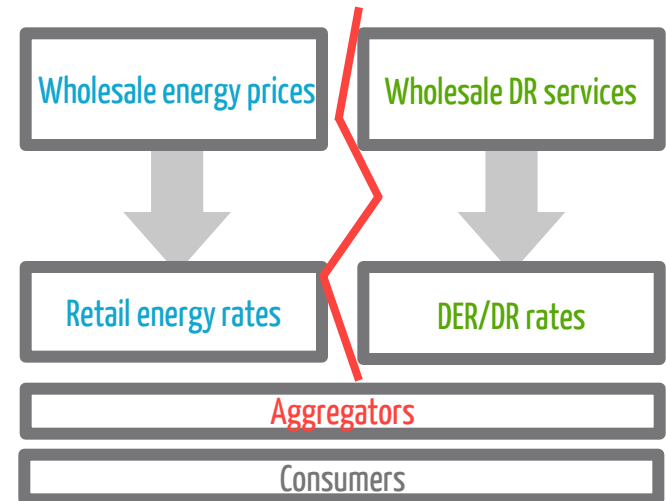


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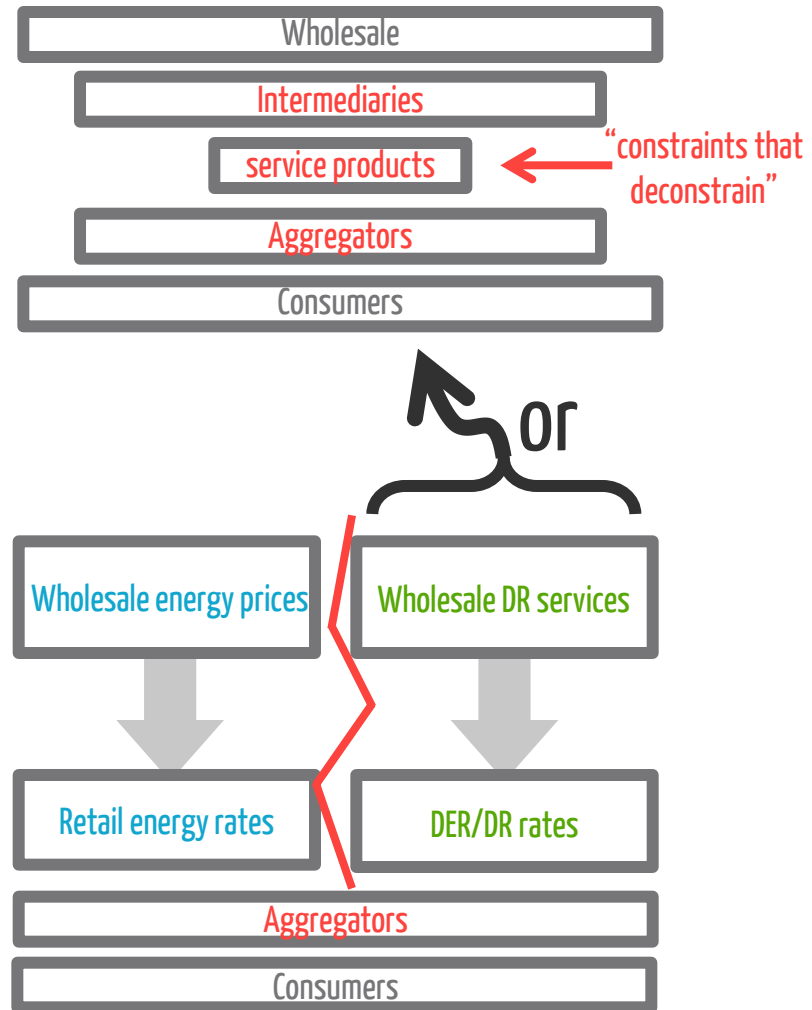


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