Power in Transition – Challenges, and Opportunities Ahead for the Changing Grid

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The contemporary electricity system is experiencing a period of unprecedented change that is bringing with it both challenge and much opportunity

Large-scale generation

- Rapid growth in the deployment of renewables
- Changing operational needs as the generation mix evolves
- New dynamics in wholesale market conditions

The grid

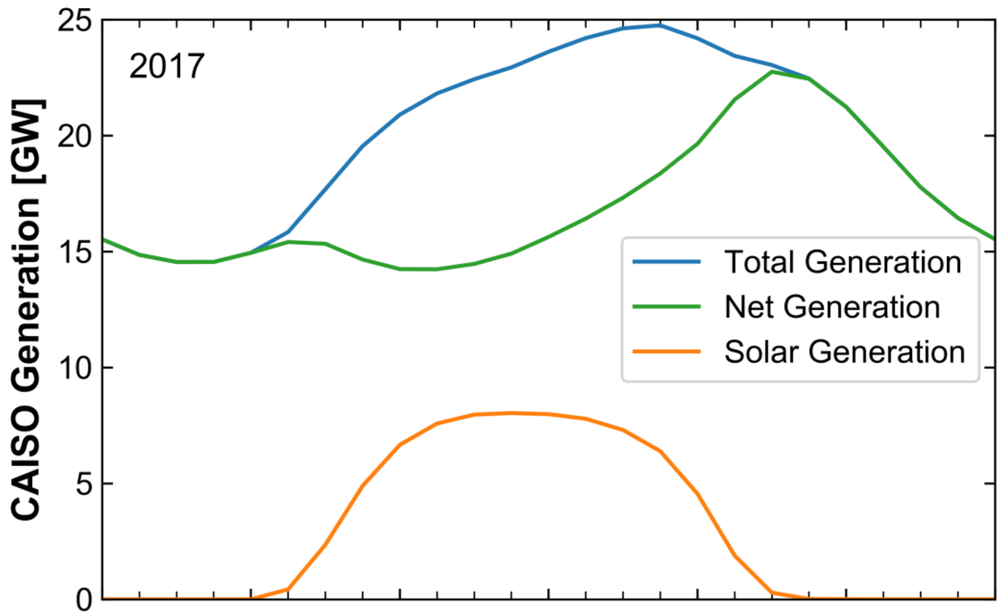
- Rapid expansion in DER adoption – Generally without coordination
- New options to support operational and capacity needs
- A growing role for data and IT in service delivery and reliability

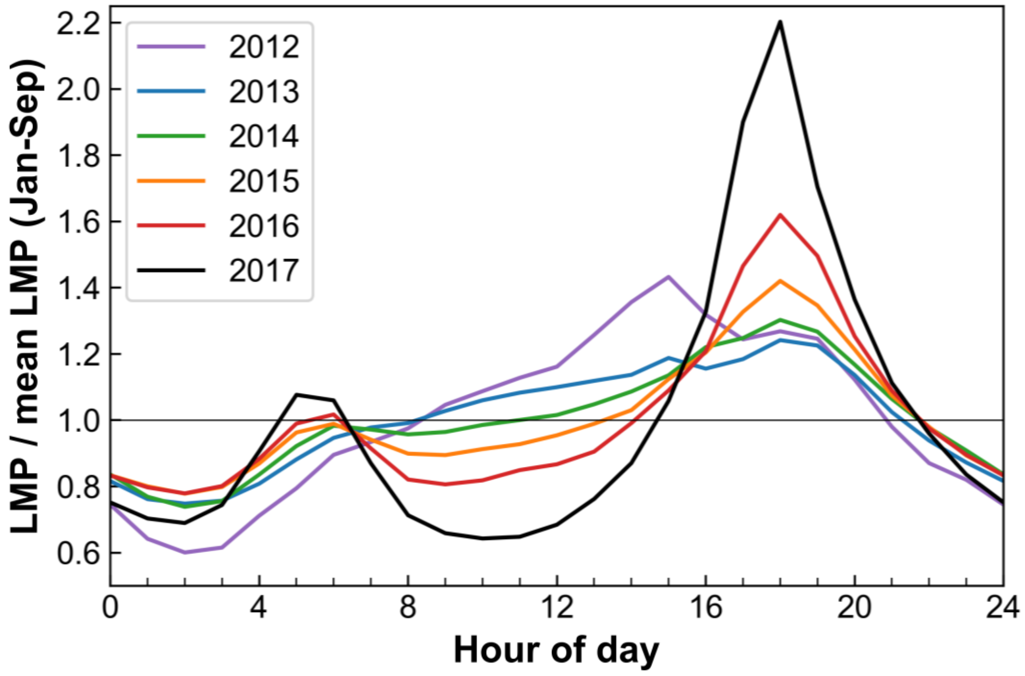
The prosumer paradigm

- Growth of consumer interest in shaping own energy service provision
- Advanced analytics creating new value capture opportunities
- Broader electrification driven by convergence of mobility and the built environment

Source: F. O'Sullivan, MIT Analysis

As the role played by renewables transitions from marginal to meaningful, the bulk power system will have to contend with a plethora of new challenges



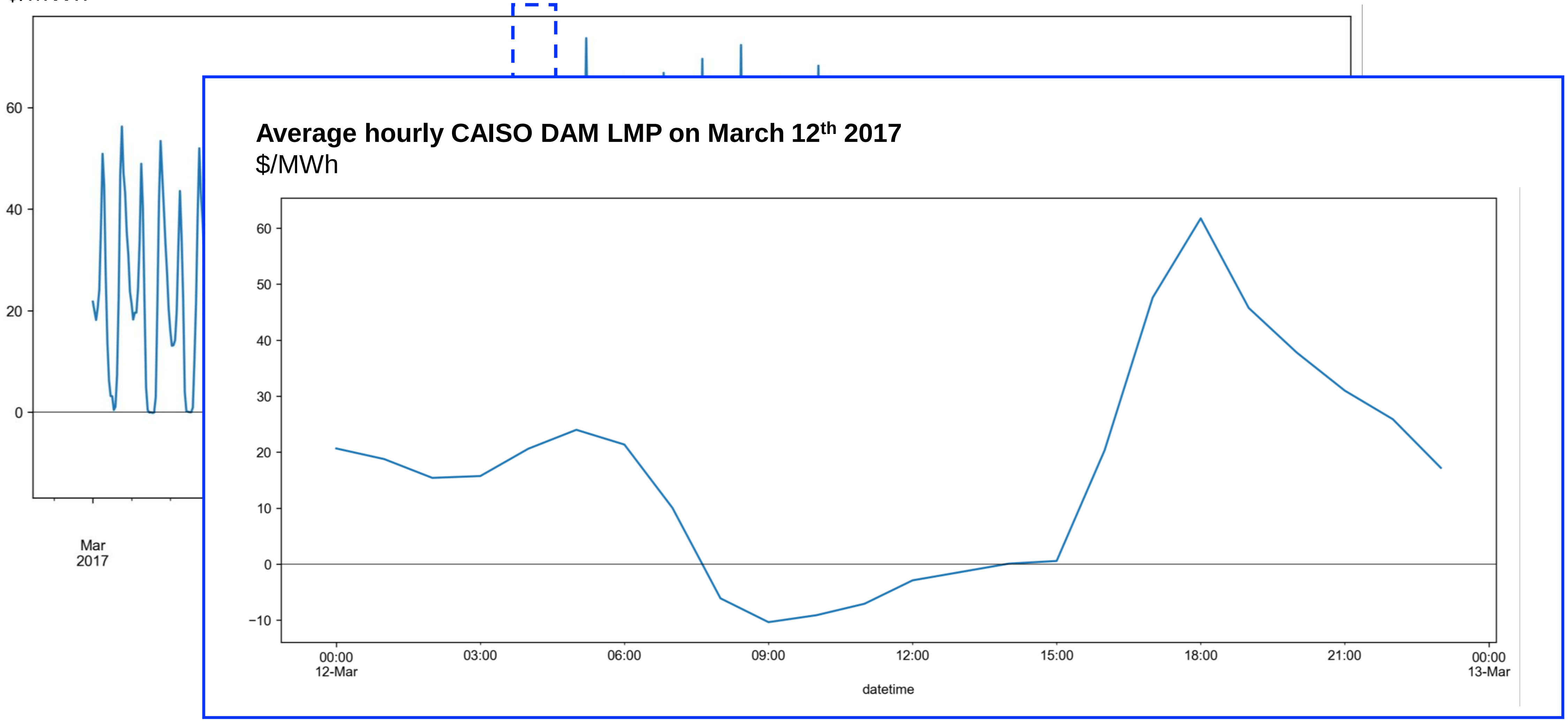


Source: P. Brown, F. O'Sullivan, CAISO

Growing instances of negative power prices raise issues regarding how fit-for-purpose existing wholesale electricity market structures are

Average hourly CAISO DAM LMP in March 2017
$/MWh

Average hourly CAISO DAM LMP on March 12th 2017
$/MWh



Source: P. Brown, F. O'Sullivan, CAISO

One issue around which there is no debate is the fact that tomorrow's power system will have to be more flexible to ensure the efficient, reliable and resilient delivery of services

Transmission capacity

Flexible dispatchable generation

Energy storage

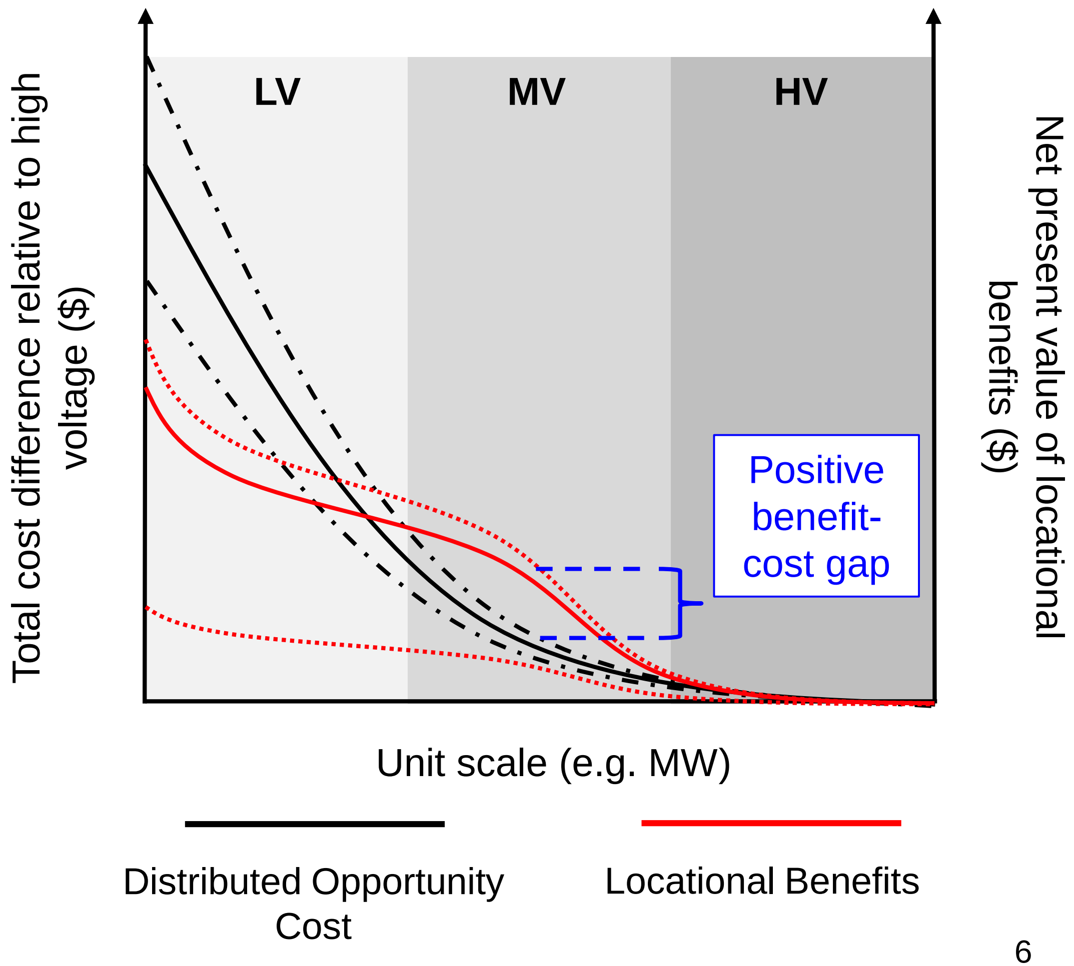
Active demand management

Distributed resources, particularly those that are digitally integrated will certainly play a bigger role in delivering tomorrow’s electricity services

Locational & non-locational services offered by DER

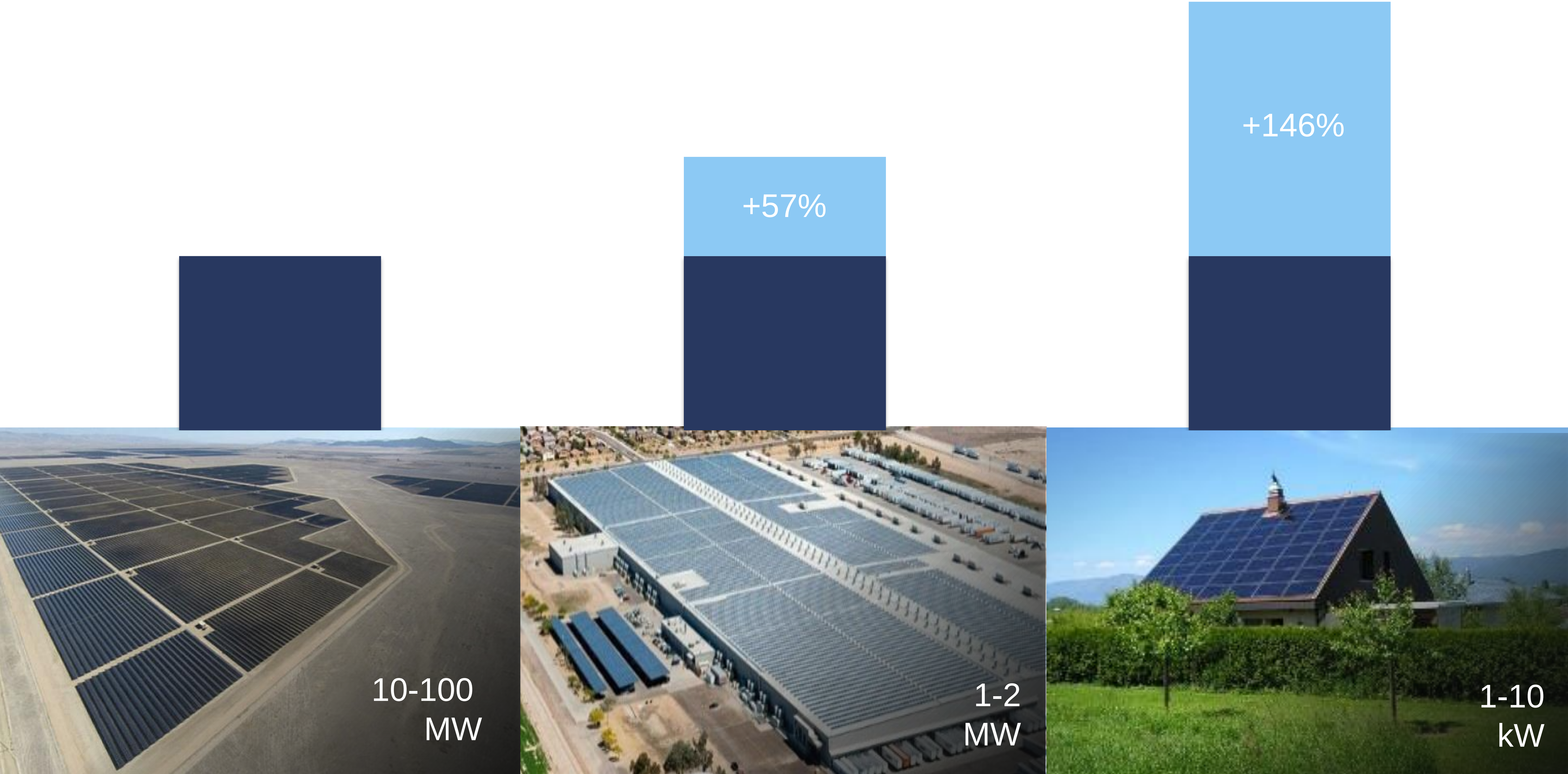
Locational	Non-locational
- Network capacity	- Energy
- Constraint mitigation	- Firm capacity
- Loss reduction	- Operating reserves
- Voltage control	- Price suppression
- Power quality	- Price hedging
- Reliability and resiliency	
- Land use	- Emissions mitigation
- Employment	- Energy security

Locational benefits > distributed opportunity cost in certain deployment

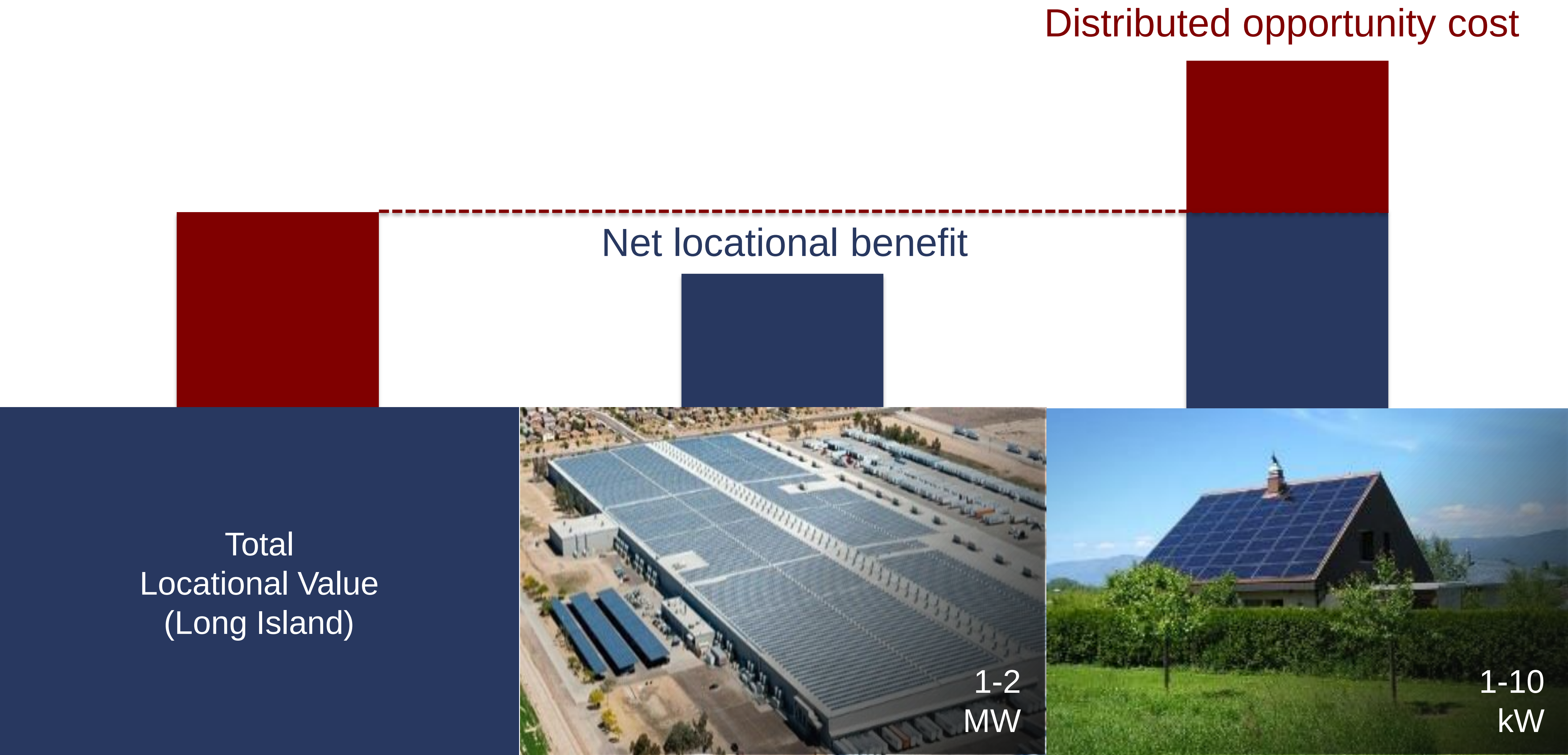


Source: MIT Analysis, MIT Utility of the Future Study Group

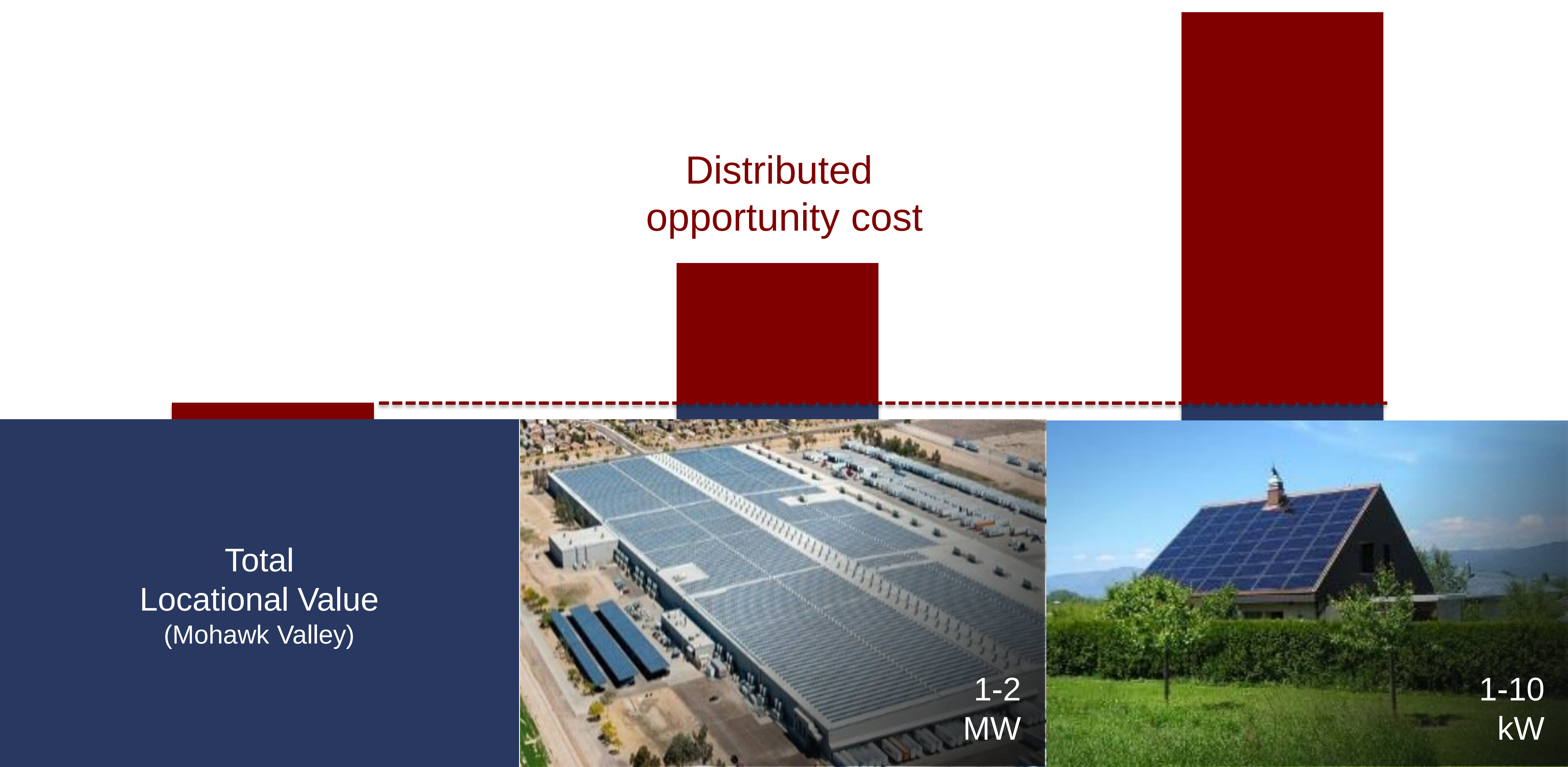
Of course it critical to appreciate that economies of scale still matter and the relative value of a DER solution will depend on both spatial and temporal factors



New York offers a useful example… On Long Island commercial scale solar offers a cost-effective pathway to provide incremental service



However, in uncongested regions like upstate NY, distributed assets are not currently cost effective

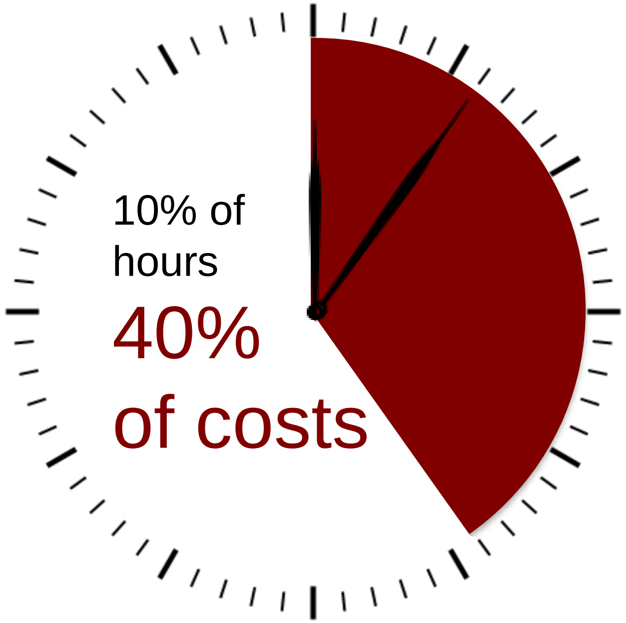


The key to achieving and effective and efficient balance between centralized and distributed systems lies in how we structure our rates

Contemporary rates – Time invariant and volumetric

Total Amount Due by 12/29/16	$119.89
Electric Account Summary	
Amount Due on 11/30/16	$129.57
Last Payment Received 11/25/16	-$129.57
Balance Forward	$0.00
Current Charges or Credits	
Electricity Supply Services	$60.30
Delivery Services	$59.59
Total Current Charges	$119.89
Total Amount Due	**$119.89**

Total Charges for Electricity		
Supplier (Eversource)		
Generation Service Charge	600 kWh X .10050	$60.30
Subtotal Supply Services		$60.30
Delivery (Rate 32)		
Customer Charge		$3.73
Distribution Charge	600 kWh X .06721	$40.33
Transition Charge	600 kWh X .00264	$1.58
Transmission Charge	600 kWh X .02025	$12.15
Renewable Energy Charge	600 kWh X .00050	$0.30
Energy Conservation Charge	600 kWh X .00250	$1.50
Subtotal Delivery Services		$59.59
Total Cost of Electricity		$119.89
Total Current Charges		$119.89

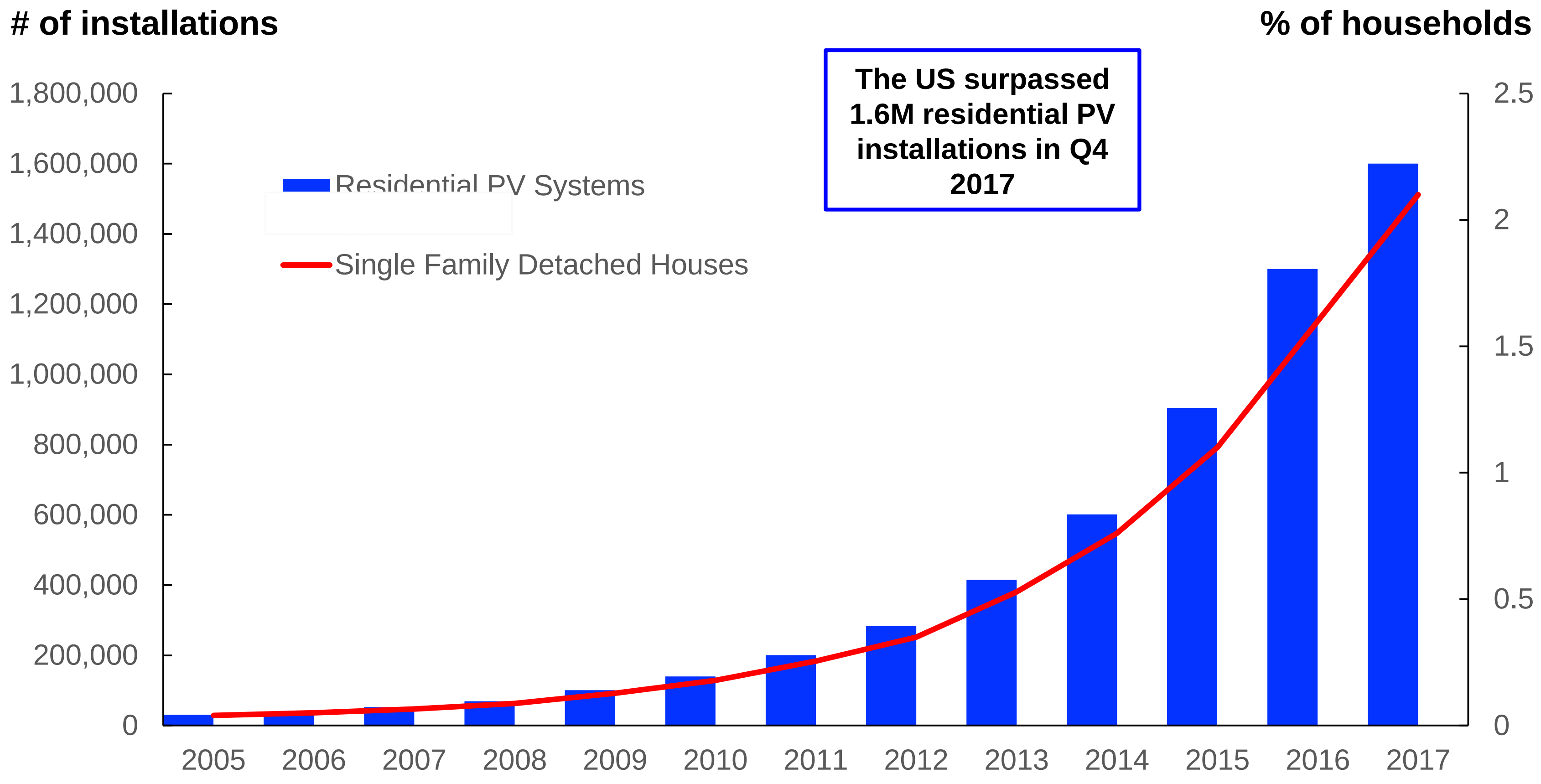


The ideal future involves a system of rates that reflect the marginal cost of each service as they vary temporally and spatially

Source: MA State of Charge Report 2016, S. Burger, F. O'Sullivan

A salient theme in today's power sector is that of the rise of the "engaged" customer, and the adoption of residential PV is often used to illustrate this

Cumulative residential-scale PV installations in the United States

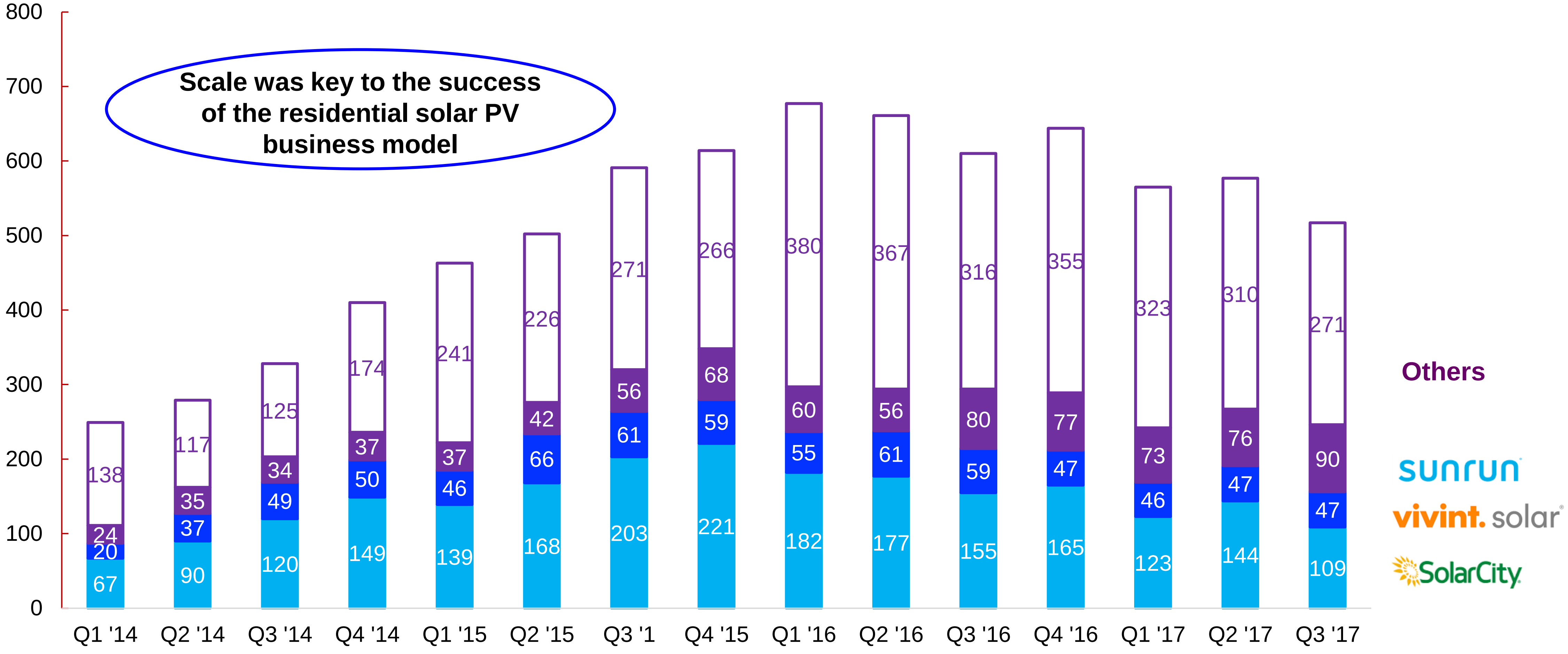


Though only 2.1% of US single family households have PV, in some markets levels are much higher: HI 31%, CA 11%, AZ 9%

Source: MIT Analysis, NREL, F. O'Sullivan

The reality is that these dynamics are exquisitely sensitive to changes in policy and regulation… with rates structures being central

Quarterly US residential PV installations by installer
MW



Source: US Department of Energy, Company Filings

Fully realizing the potential offered by a more distributed and customer-active system will demands a set of technology agnostic rate structures

- **The more widespread adoption of smarter devices means customer can no longer be lumped into broad classes**

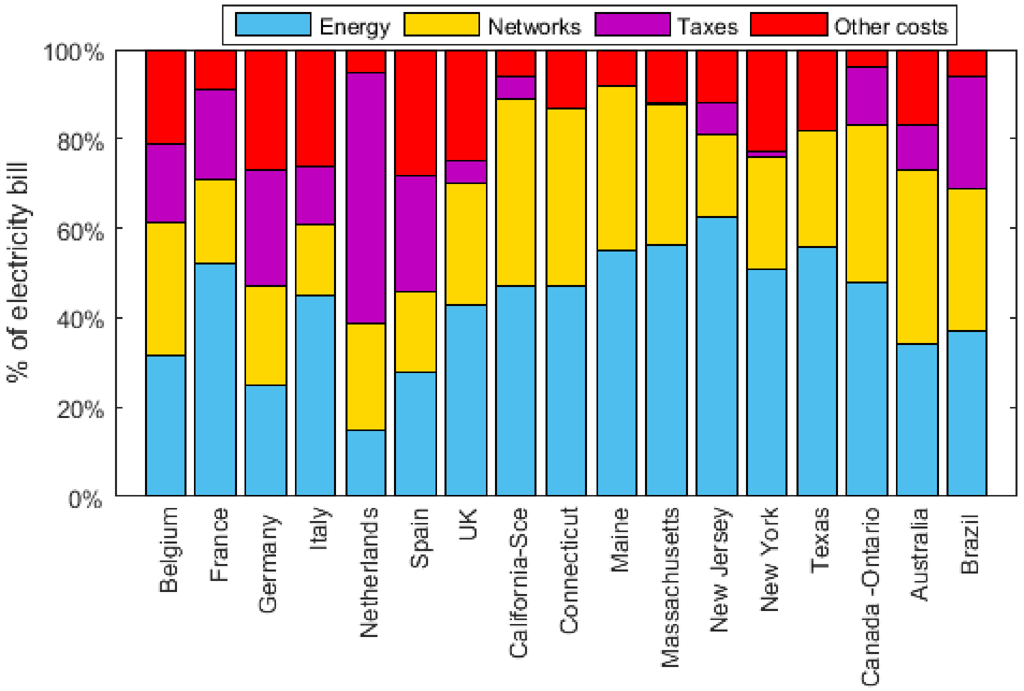
- **The definition of rates specific to individual technologies is an untenable approach that must be avoided**

- **Rate design efforts should simply focus on charging or remunerating specific *services,* regardless of what technology is used**

- **The potential for regulatory arbitrage should be avoided through ensuring symmetrical rates for injection and withdrawal**

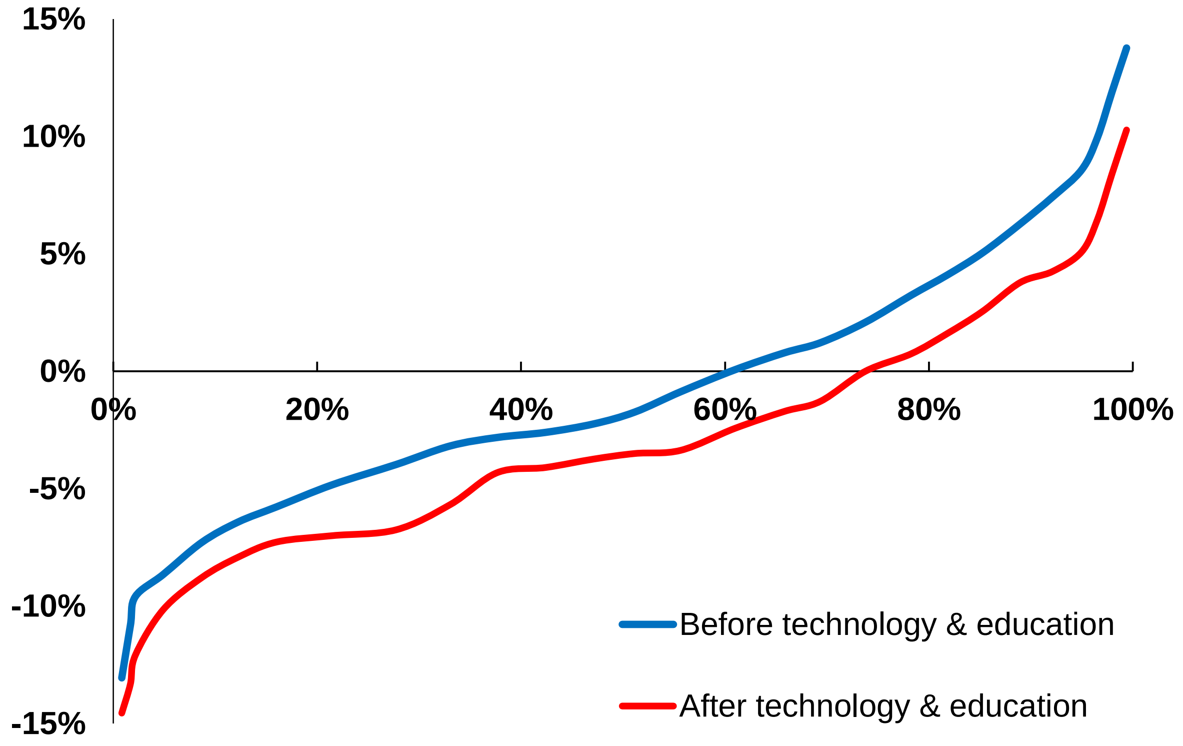
Source: MIT Utility of the Future Study, F. O'Sullivan

Of course, with these profound changes comes a range of challenges regarding equity and negative impacts on certain ratepayer groupings



Residual costs should be recovered in a manner not tied to volumetric energy consumption

Impact of transition to efficient tariffs on customer average bill



Efficient tariffs will yield more winners than losers, and techniques are available to mitigate distributional impacts

Source: MIT Utility of the Future Study, S. Burger, F. O'Sullivan

“The future, you do not need to foresee it, but enable it”

Antoine de Saint Exupéry