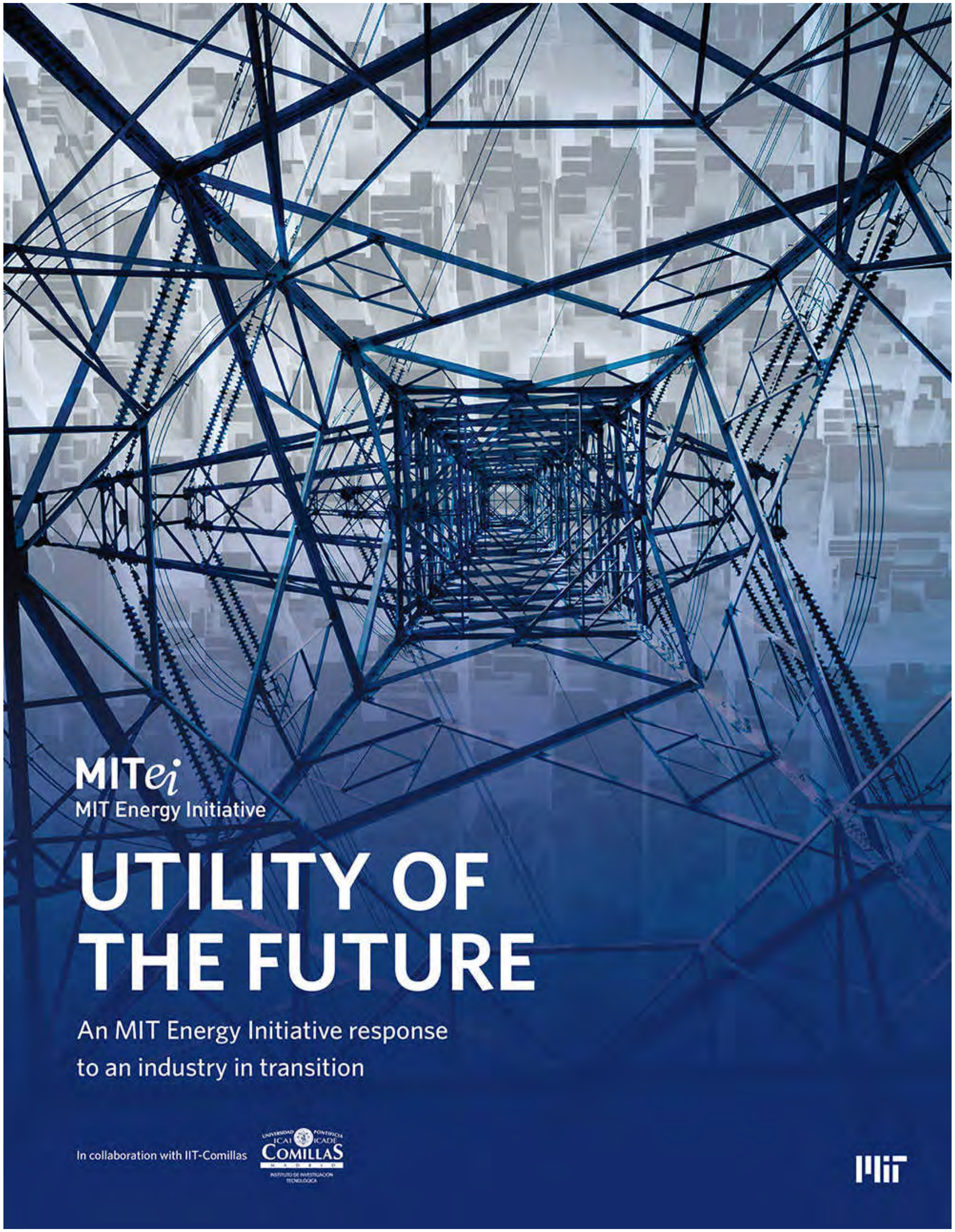


Utility of the Future

December 15th 2016
Washington DC

#UtilityOfTheFuture

The MIT Utility of the Future Study…

… examines how distributed energy resources (DERs) are **changing the provision of electricity services**, with a **focus on the USA & Europe** over the **next decade** & beyond

… & makes **policy, regulatory and market recommendations**…

… to facilitate an efficient, low carbon emission energy system that **encourages optimal utilization of resources** whether centralized or decentralized.

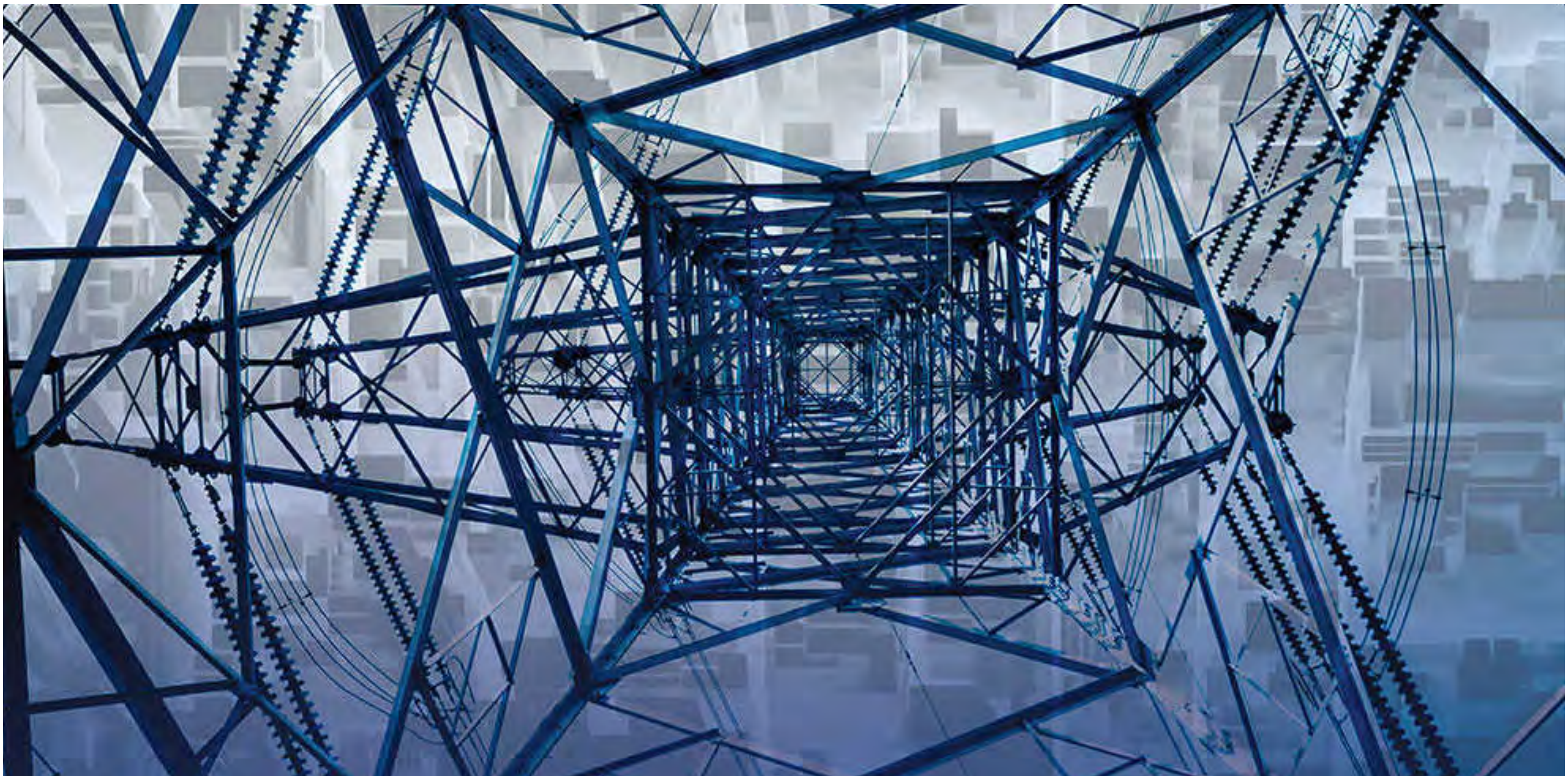
“As for the future, your role is not to foresee, but to enable it”

Antoine de Saint Éxupéry

Predicting the future? Rather a toolkit

- The study presents a **framework for proactive regulatory, policy & market reforms** that is:
  - **robust** to the uncertain changes now underway
  - and capable of facilitating the emergence of an **efficient portfolio of resources**, both distributed and centralized
- The report distills results and findings from more than two years of **primary research**, a review of the **state of the art**, and **quantitative modeling & analysis**

Study Contributors



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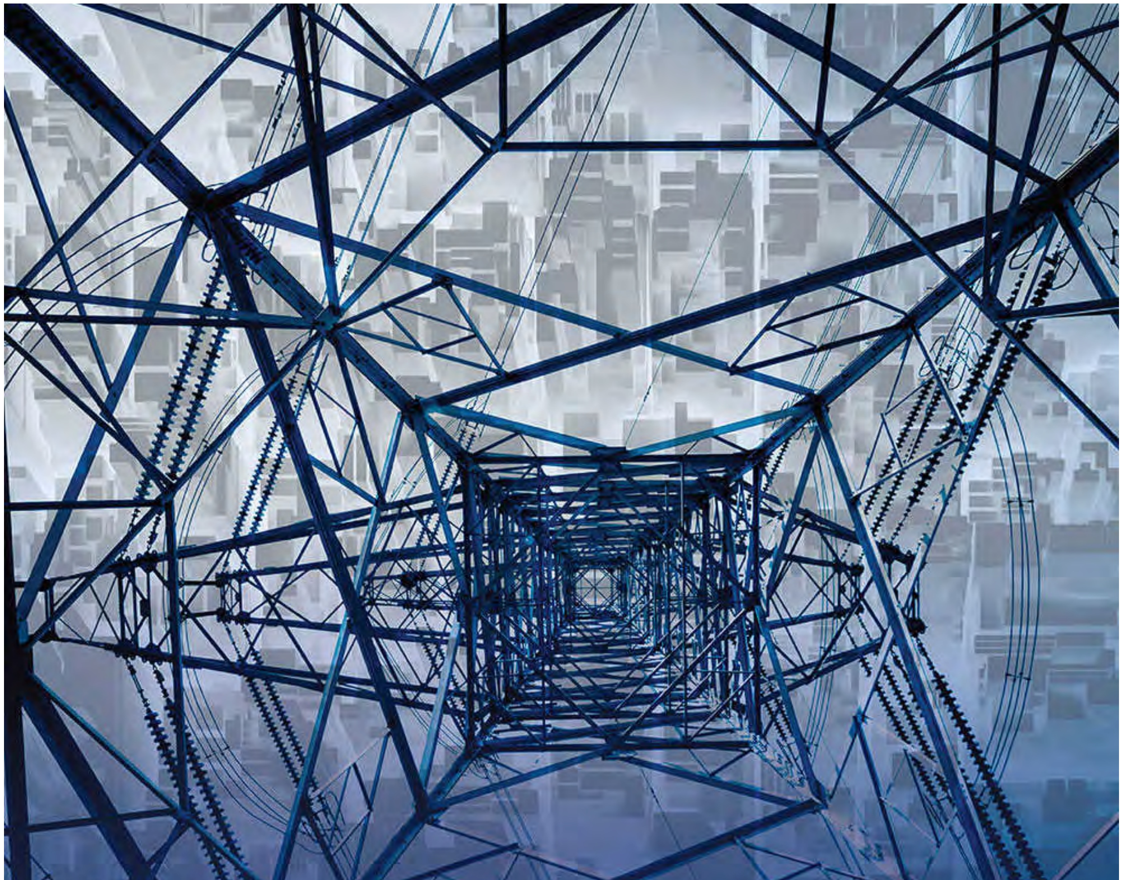


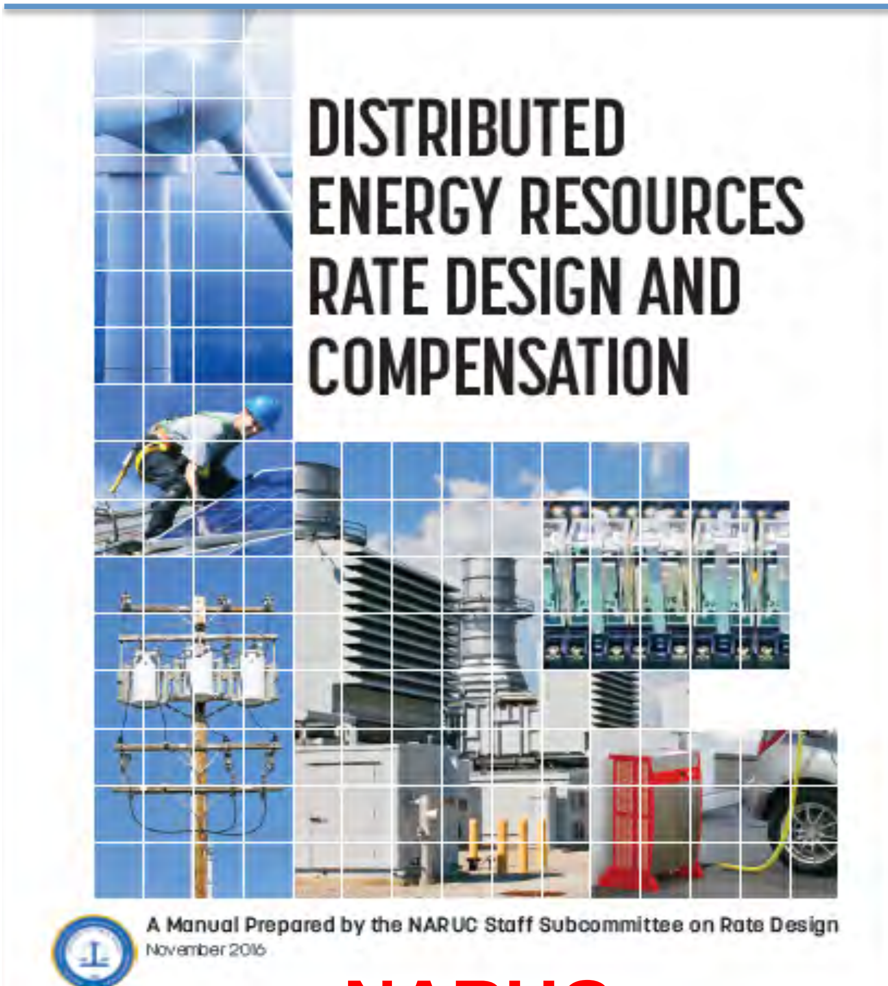
MITei
MIT Energy Initiative

UTILITY OF THE FUTURE

An MIT Energy Initiative response
to an industry in transition

In collaboration with IIT-Comillas

The power sector is changing…



NARUC
NOVEMBER 10

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ENERGY

European Commission >

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Commission proposes new rules for consumer centred clean energy transition

Clean energy for all Europeans

Wednesday, 30 November 2016

The European Commission today presents a package of measures to keep the European Union competitive as the clean energy transition is changing global energy markets.

The Commission wants the EU to lead the clean energy transition, not only adapt to it. For this reason the EU has committed to cut CO2 emissions by at least 40% by 2030 while modernising the EU's economy and delivering on jobs and growth for all European citizens. Today's proposals have three main goals: putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers.

Consumers are active and central players on the energy markets of the future. Consumers across the EU will in the future have a better choice of supply, access to reliable energy price comparison tools and the possibility to produce and sell their own electricity. Increased transparency and better regulation give more opportunities for civil society to become more involved in the energy system and respond to price signals. The package also contains a number of measures aimed at protecting the most vulnerable consumers.

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Opening ceremony, Energy Awards and more – Tuesday at EU Sustainable Energy Week
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First ever EU-Algeria Energy Business Forum
25 May 2016

EU COMMISSION
NOVEMBER 30

Consumers have **unprecedented choice** regarding how they manage their power supply


TESLA


nest
DONE
AWAY
COOLING
78
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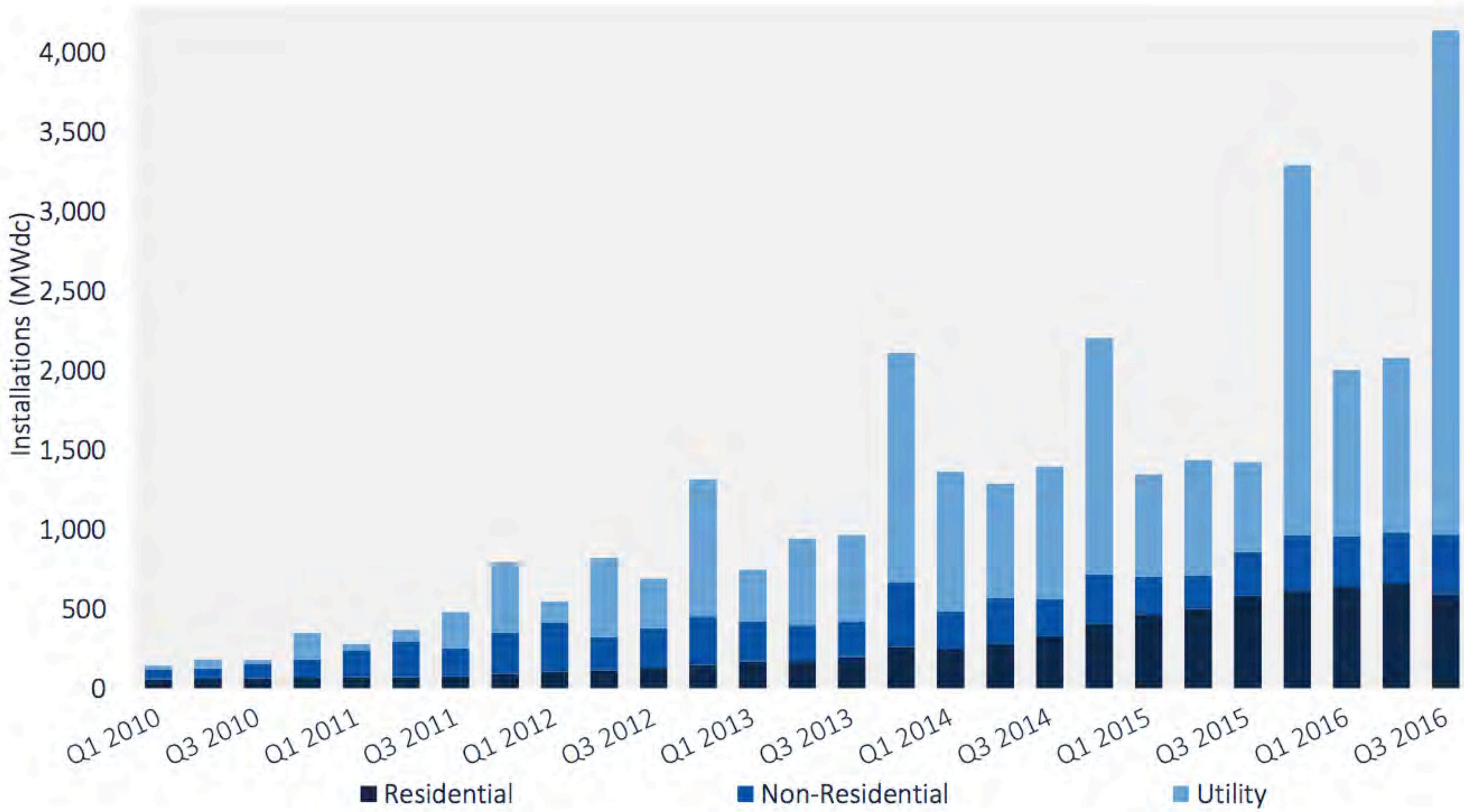
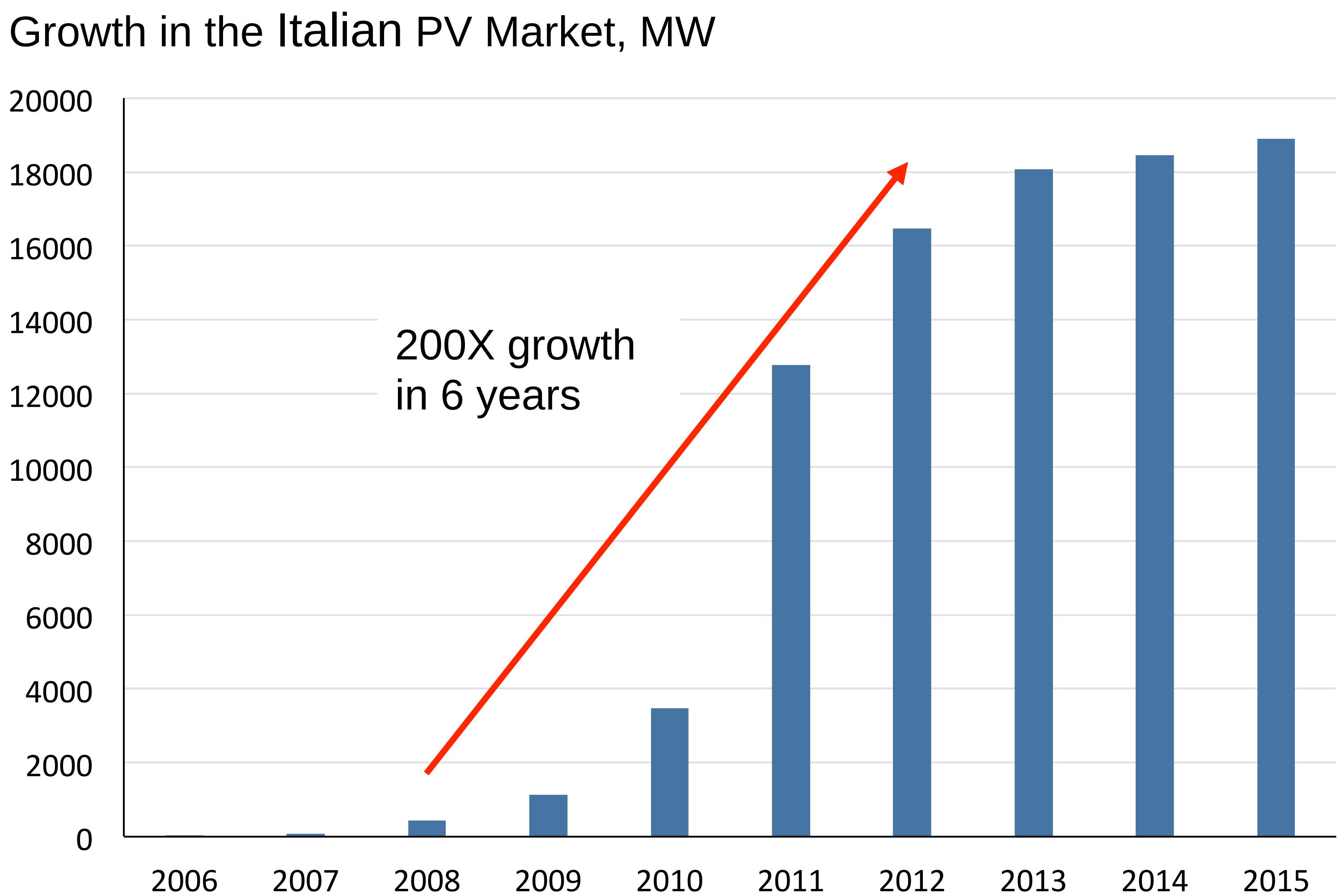
SCHEDULE

The U.S. installed **4,143 MWdc** of solar PV in Q3 2016, **increasing 99%** over Q2 2016 and **191%** over Q3 2015. This is **the largest quarter ever for the U.S. solar industry**.



Customers respond to price signals – and can act *very* fast!



DERs could deliver large savings by **improving the utilization of electricity infrastructure**

*"Over the last three years from 2013 – 2015 on average, **the top 1% most expensive hours accounted for 8%** ($680 million) of Massachusetts ratepayers' annual spend on electricity. **The top 10% of hours** during these years, on average, **accounted for 40%** of annual electricity spend, over $3 billion."*

Source: "State of Charge: Massachusetts Energy Storage Initiative," MA DOER and MassCEC November 2016

ConEd is deferring a $1.2B substation investment for $200M with a portfolio of DERs

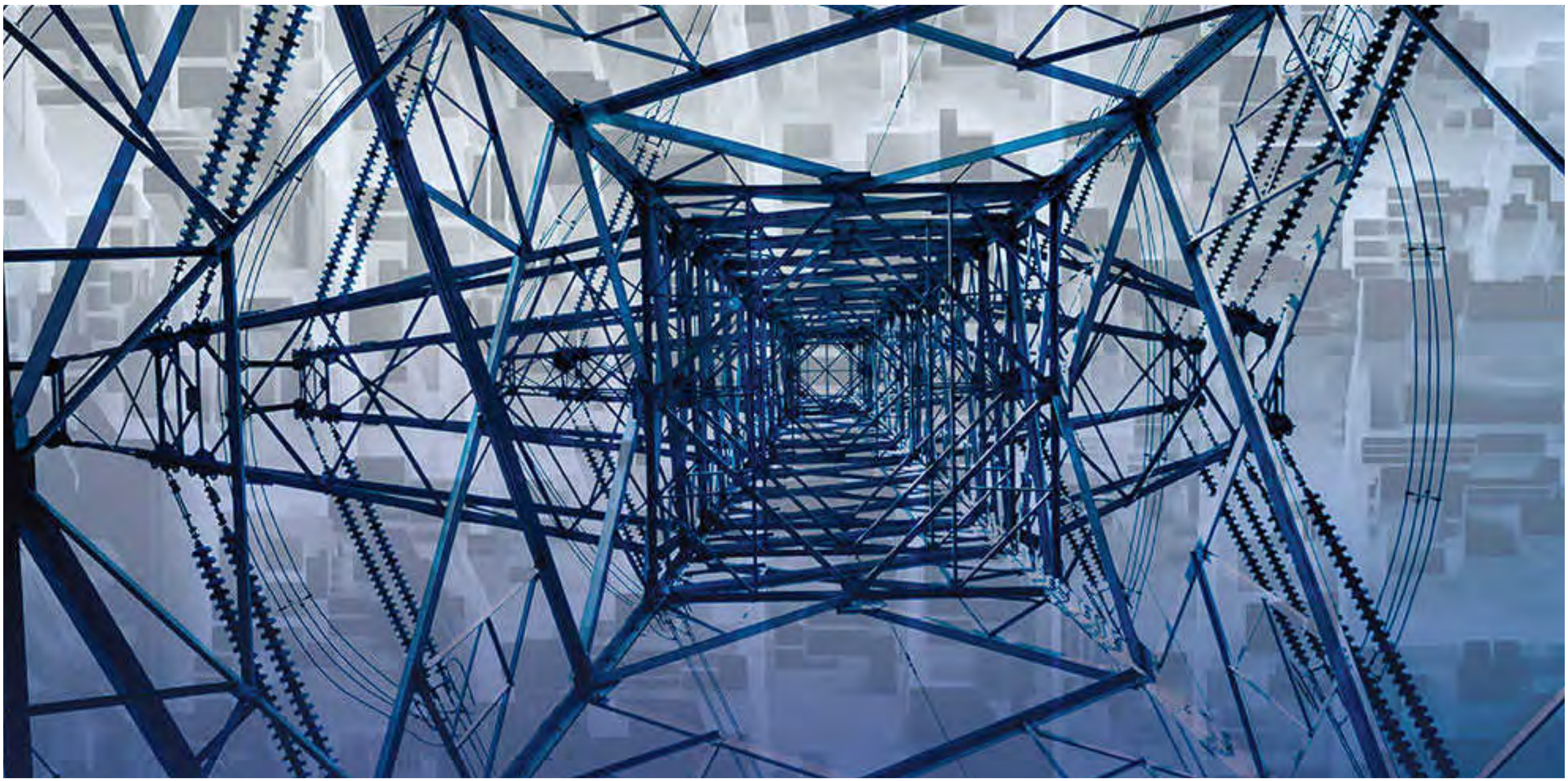
Lack a comprehensive system of efficient prices & regulated charges

for electricity services

Many opportunities to deliver greater value are **left untapped**

Flexible demand & smart thermostats are only useful if able to respond to **changing system conditions**

Our key recommendations



1

“Create a comprehensive & efficient system of prices & charges”

The only way to put all resources – **centralized & distributed**– on a **level playing field** and achieve efficient operation and planning in the power system is to **dramatically improve prices and regulated charges** for electricity services.

2

“Enhance distribution regulation”

The **regulation of distribution utilities must be improved** to enable the development of more efficient & innovative distribution utility business models

3

“Rethink industry structure to minimize conflicts of interest”

The **structure** of the electricity industry should be carefully evaluated to minimize potential conflicts of interest

4

“Allow DERs participate in wholesale markets”

Wholesale market design should be improved to better **integrate** distributed resources, reward greater **flexibility**, and create a **level playing field** for all technologies

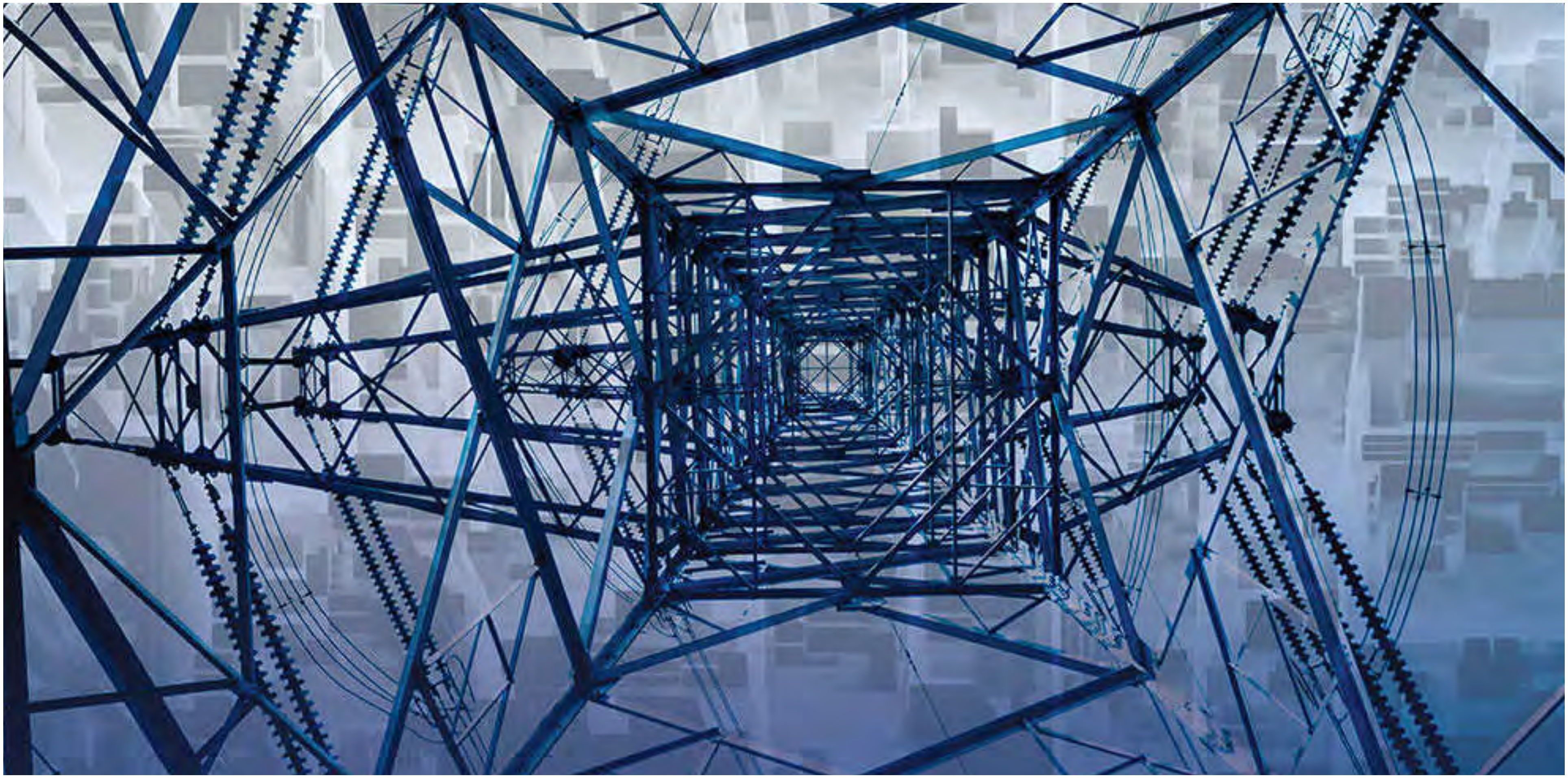
5

“Carefully evaluate the economic opportunities and costs of DERs”

Better utilization of **existing assets** and smarter energy consumption hold great potential for cost savings.

Economies of scale still matter, and the distributed deployment of **solar PV** or energy **storage** is not cost-effective in all contexts and locations

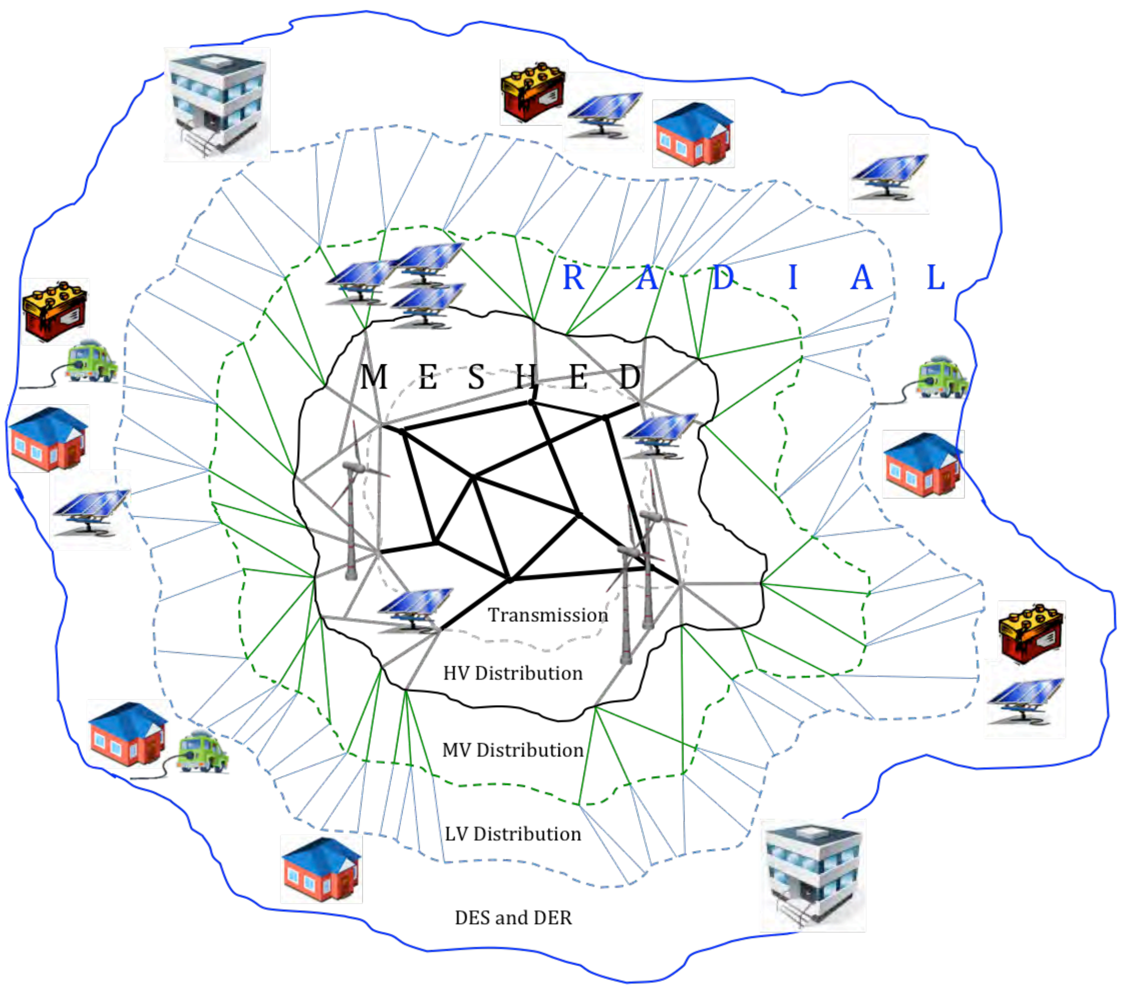
How to do it?



1

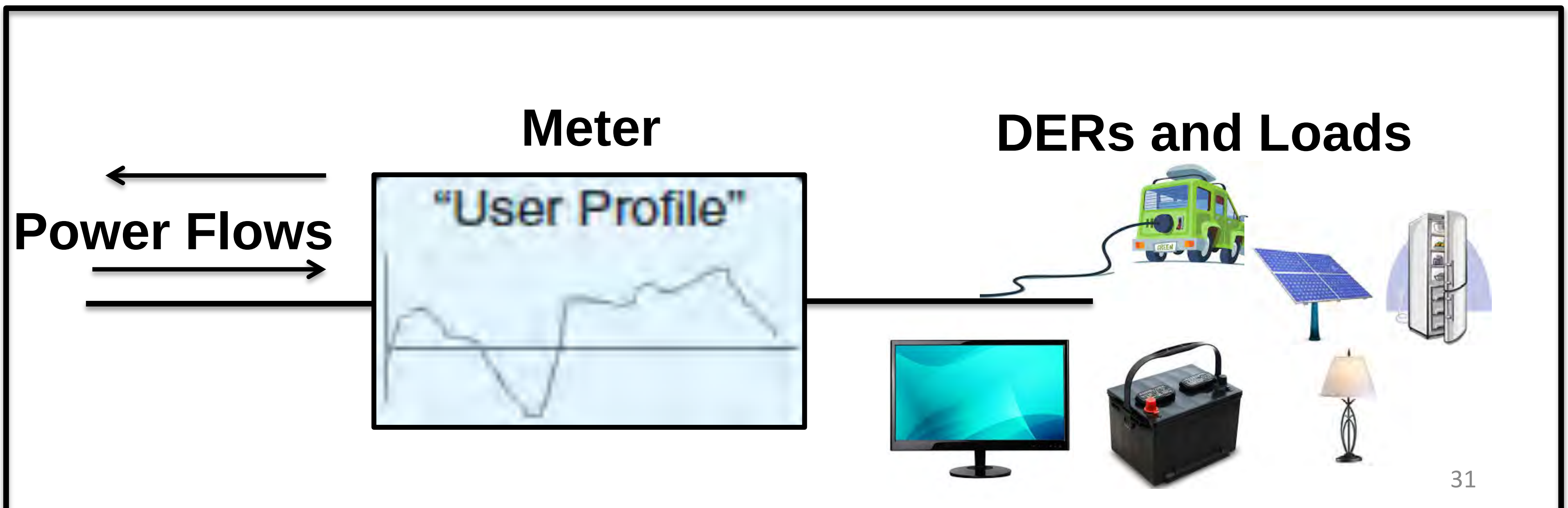
Create a comprehensive & efficient system of prices & charges

Create a comprehensive & efficient system of prices & charges *(Like a nervous system, reaching every corner of the power system)*



Any **cost-reflective** component of prices & charges should be exclusively based on the **individual injection & withdrawal profiles** at the network connection point & should be **symmetrical**.

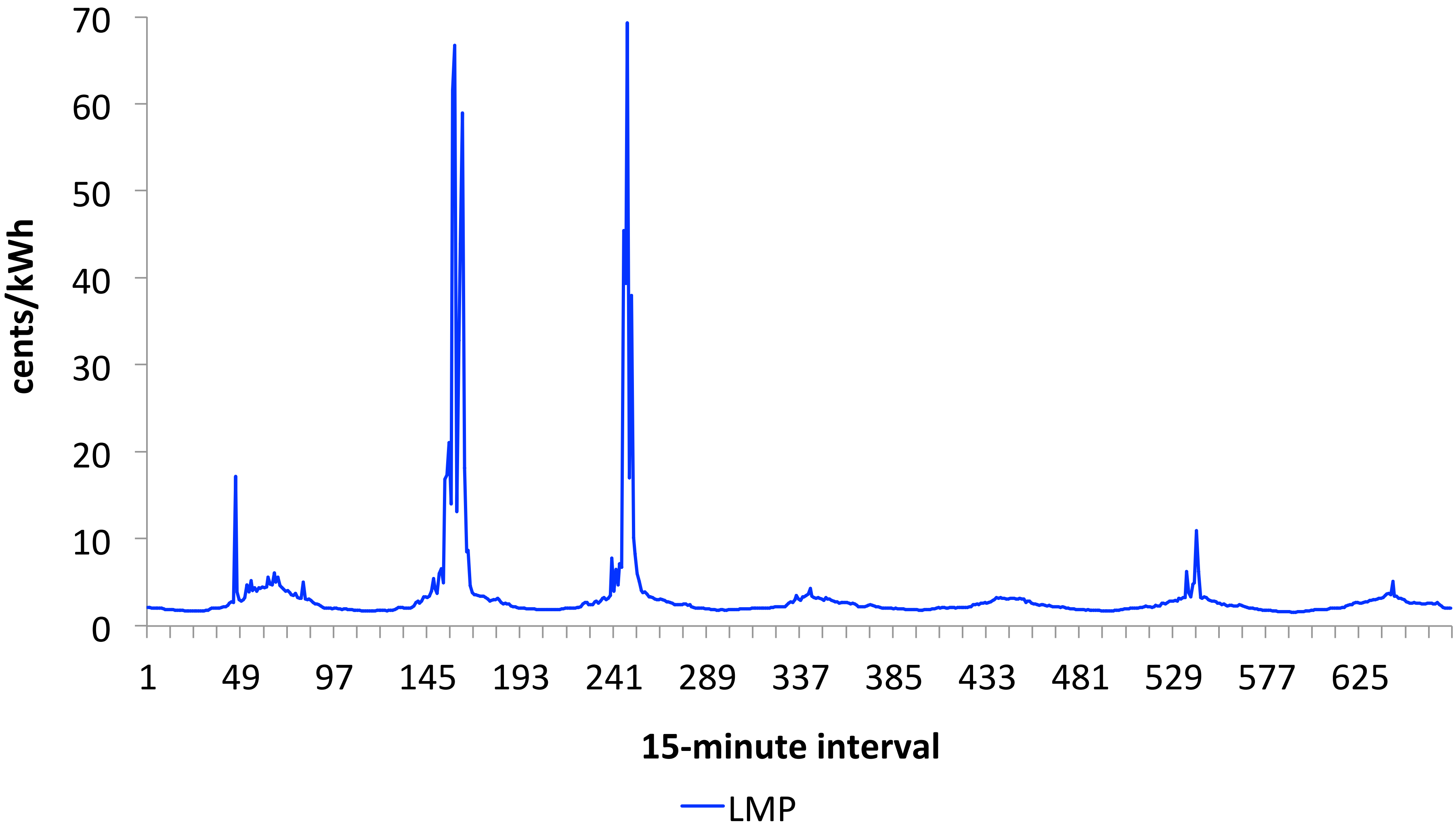
This requires the use of **advanced meters**



Let's do it one step at a time…

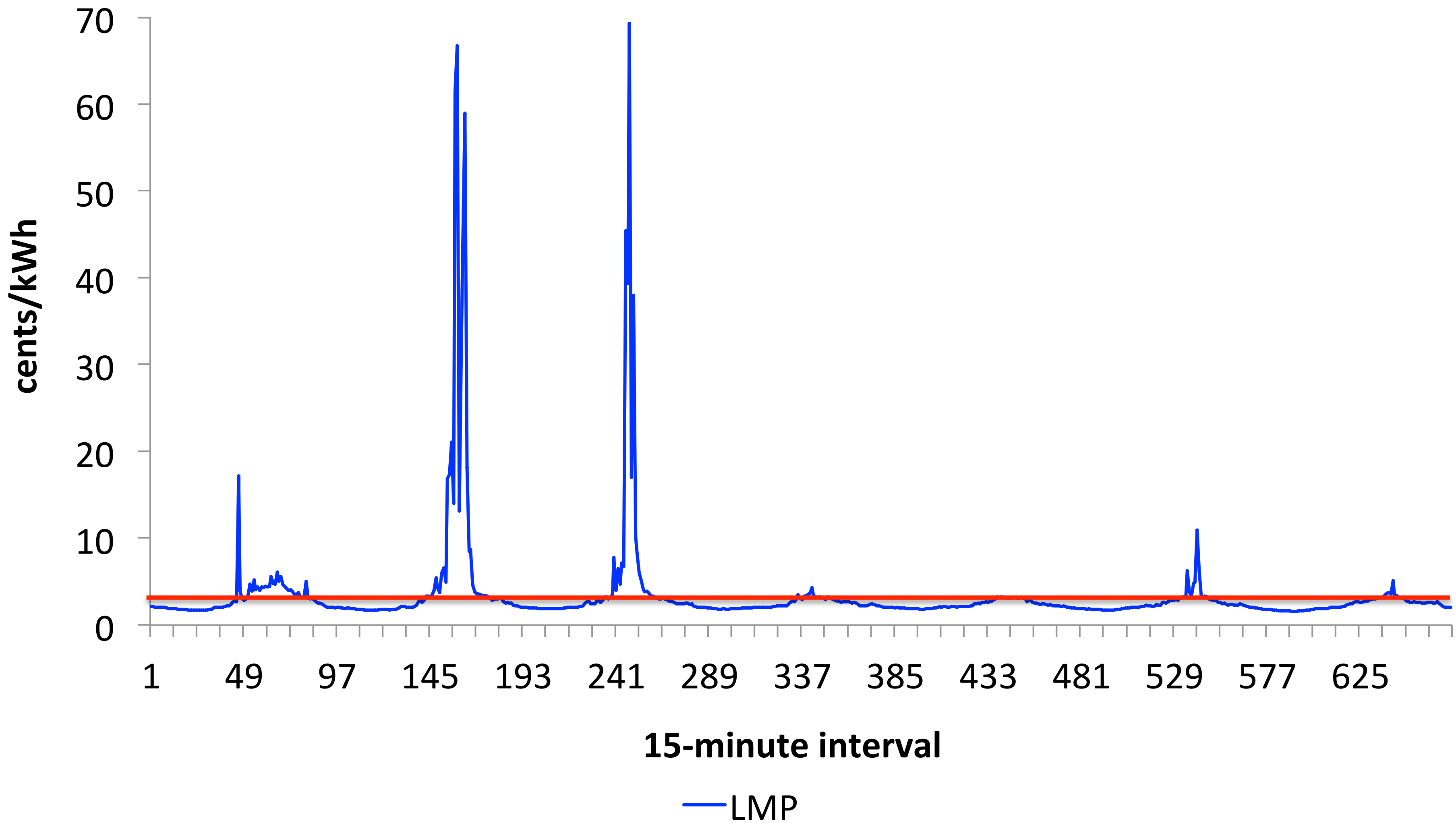
Reflect **time differentiation** in the energy charges

E.g. capture the wholesale energy price evolution in time



(one week in July 2015 in Austin, ERCOT)

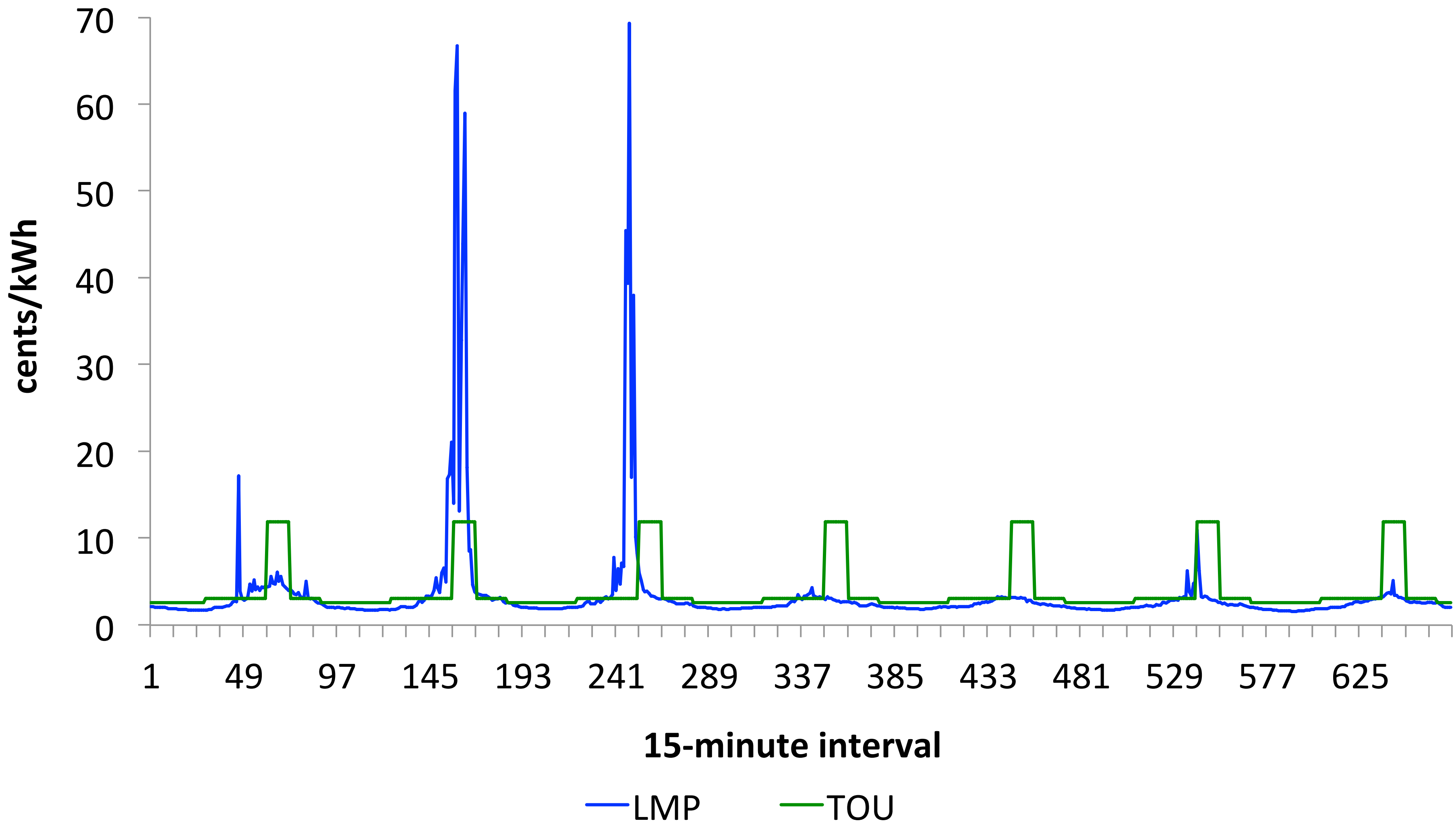
… compared to the usual constant rate…



(one week in July 2015 in Austin, ERCOT)

… or to Time of Use (ToU) pricing

(one week in July 2015 in Austin, ERCOT)

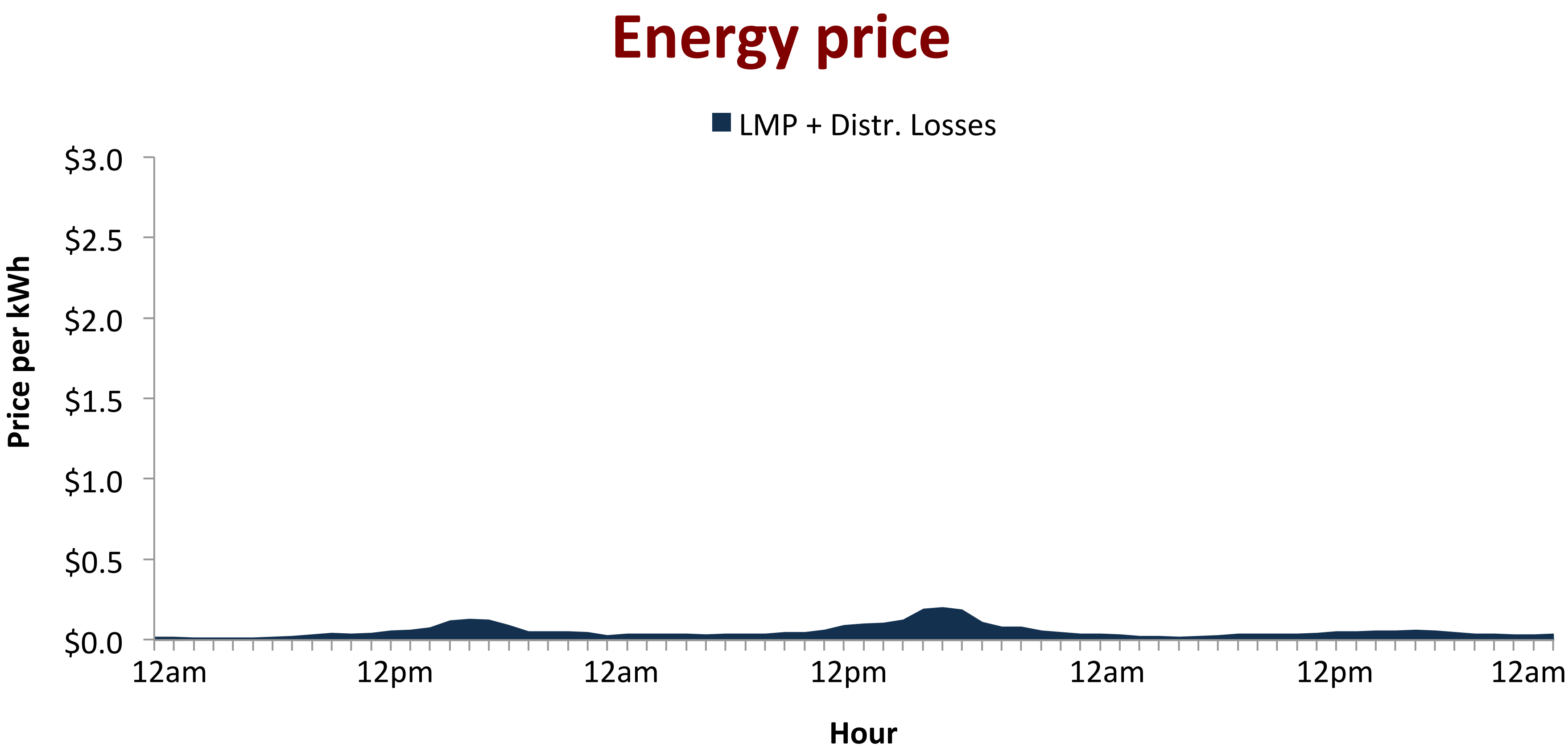


(one week in July 2015 in Austin, ERCOT)

Let's do it one step at a time…

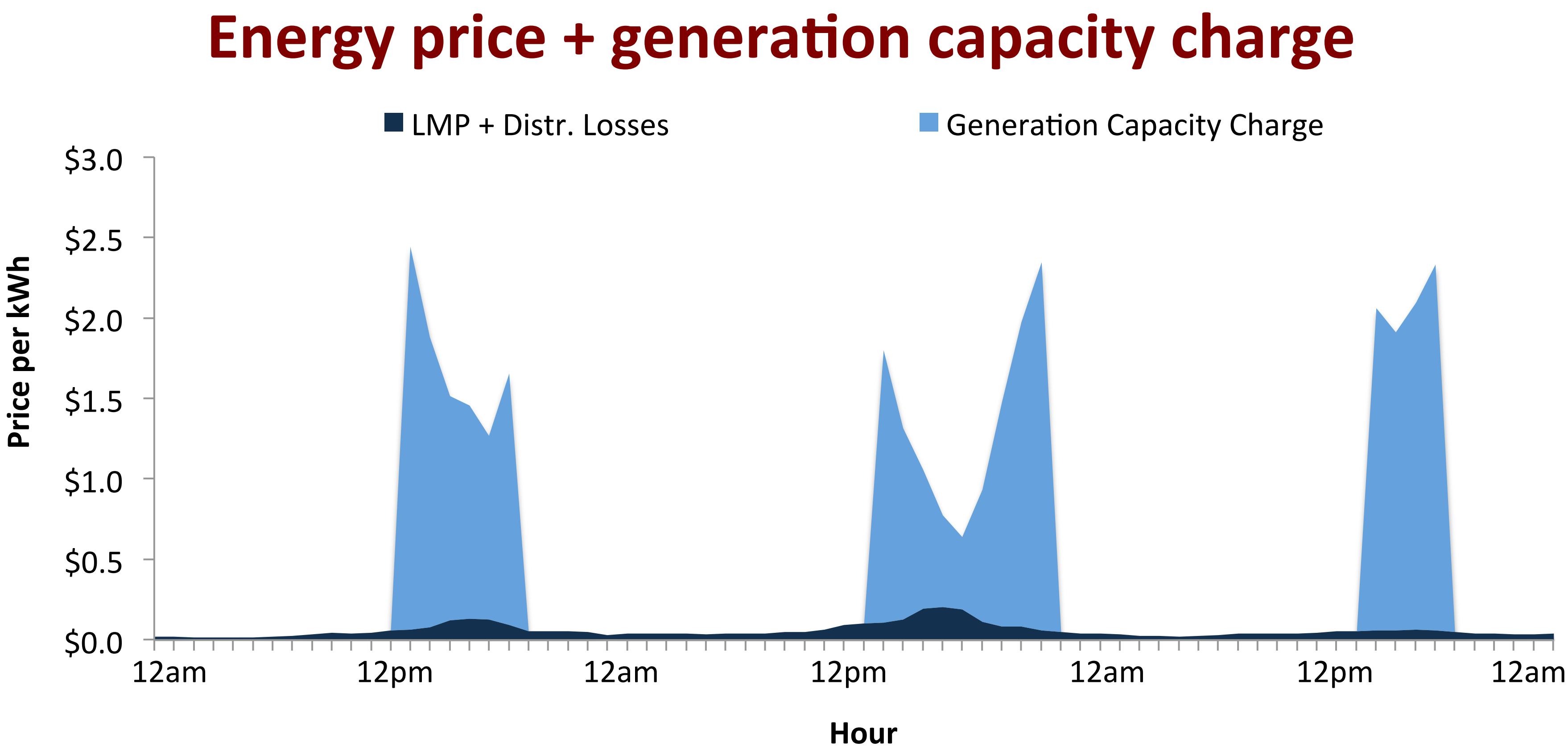
- Reflect **time differentiation** in the energy charges
- Apply forward-looking **peak-coincident capacity charges** for networks & firm generation capacity *(if this is the case)*

Add **peak-coincident** consumption and injection **capacity charges** for **network** & **firm generation**



Example cost-reflective tariff for Westchester, New York; Four days in July.
Source: Huntington & Jenkins, MIT *Utility of the Future* study.

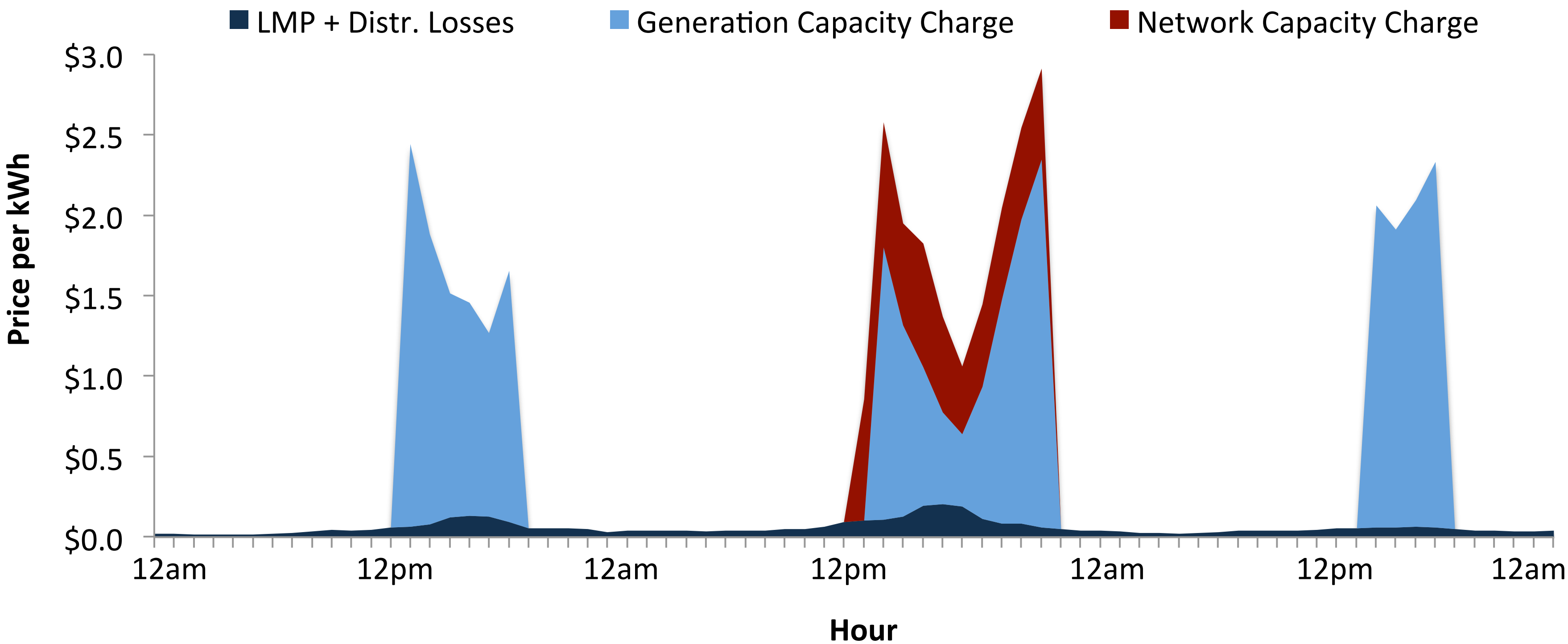
Add **peak-coincident** consumption and injection **capacity charges** for **network** & **firm generation**



Example cost-reflective tariff for Westchester, New York; Four days in July.
Source: Huntington & Jenkins, MIT *Utility of the Future* study.

Add **peak-coincident** consumption and injection **capacity charges** for **network** & **firm generation**

Energy price + Generation & Network capacity charges



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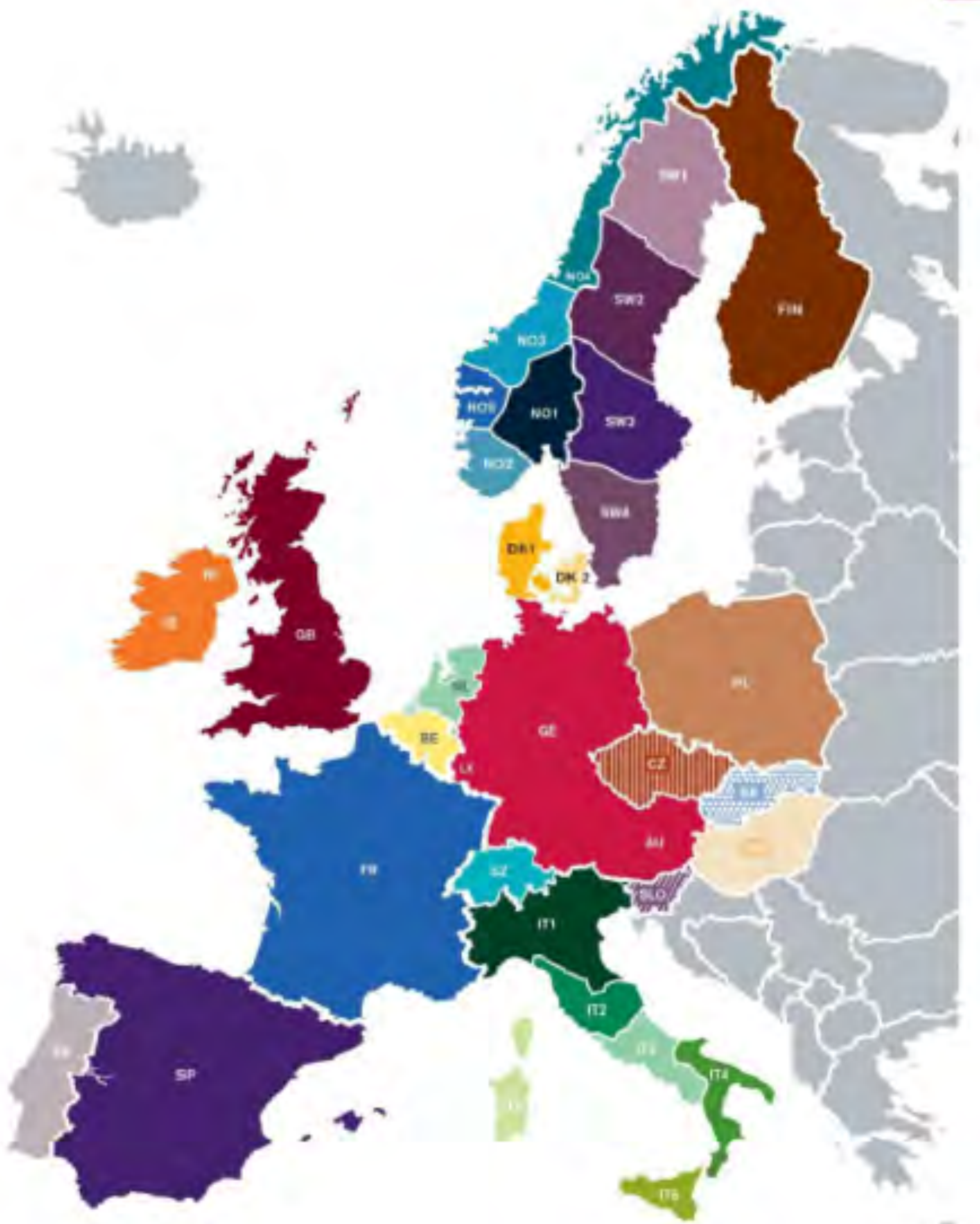
Let's do it one step at a time…

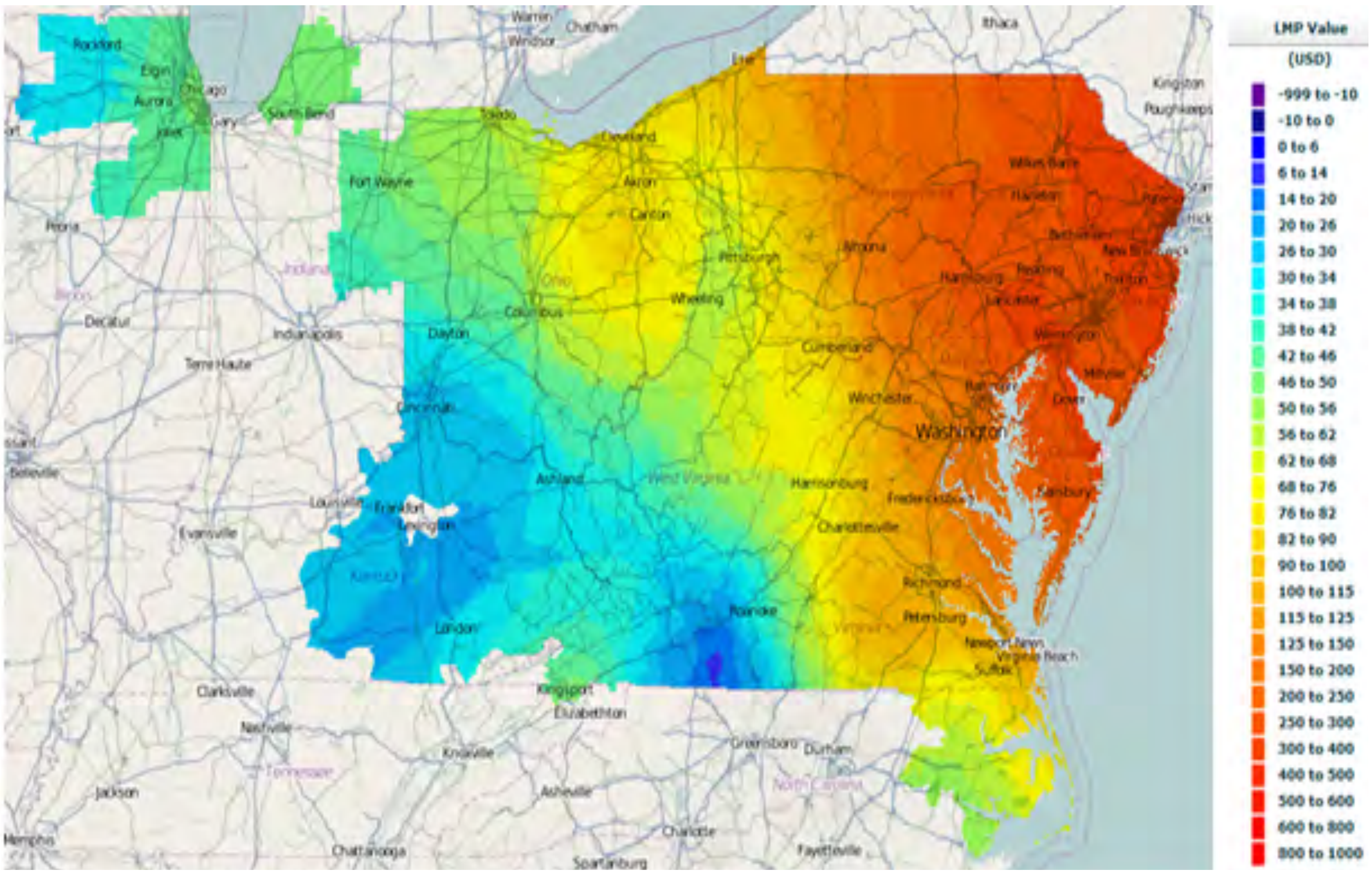
- Reflect **time differentiation** in the energy charges
- Apply forward-looking **peak-coincident capacity charges** for networks & firm generation capacity *(if this is the case)*

➡ Progressively increase the **locational component** of prices & charges

Bidding zones in European market coupling



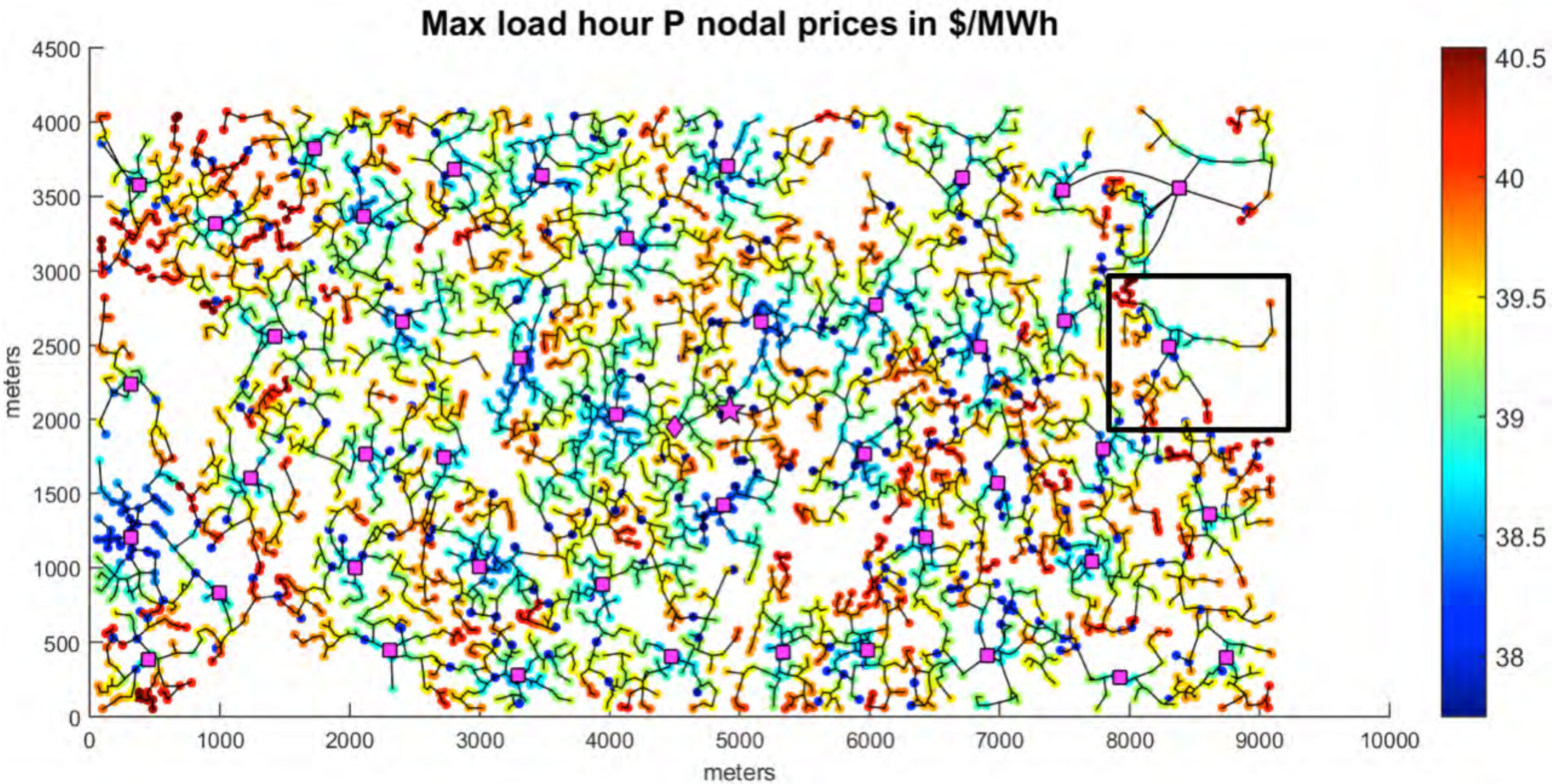
Energy prices at transmission level may vary significantly if there are binding network constraints



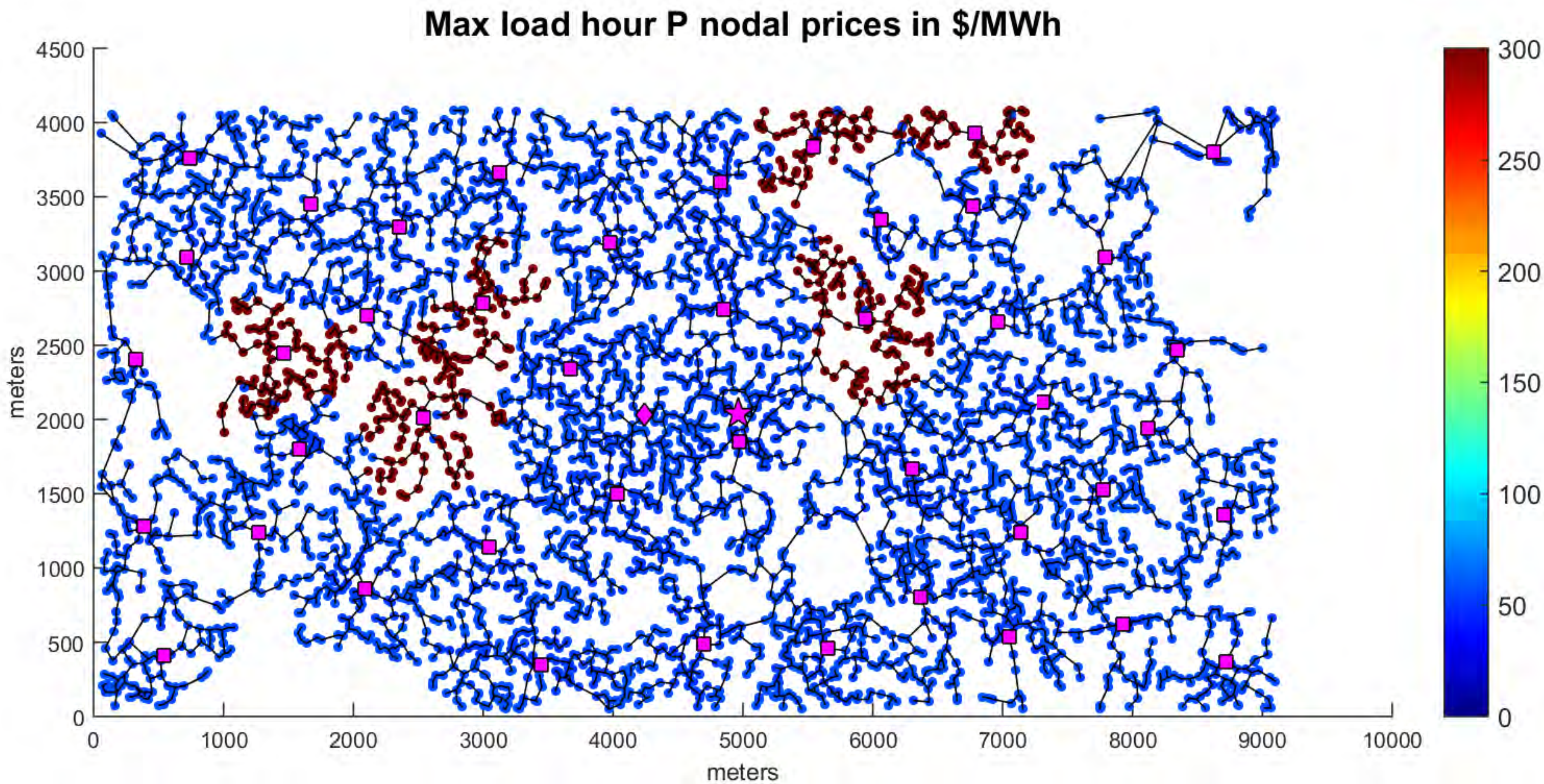
Wholesale LMP variation across more than 11,000 PJM nodes on July 19, 2015, at 4:05 pm

Getting deep into distribution

(just losses)



Getting deep into distribution
(losses & network constraints)



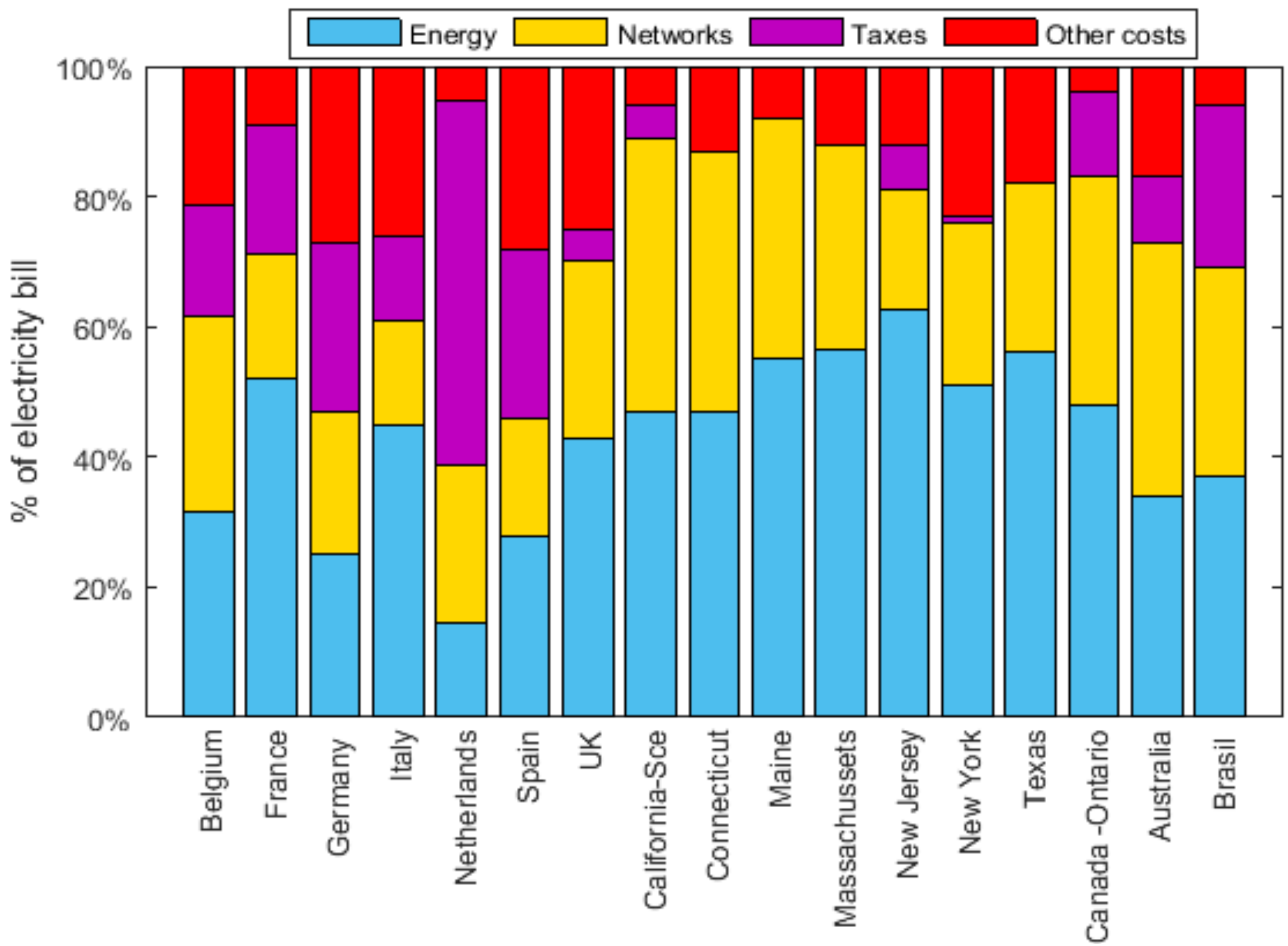
And the most important one…

Let's do it one step at a time…

- Reflect **time differentiation** in the energy charges
- Apply forward-looking **peak-coincident capacity charges** for networks & firm generation capacity *(if this is the case)*
- Progressively increase the **locational component** of prices & charges

Policy & residual network costs should be charged **minimizing distortion** of cost-reflective signals

Policy costs & residual network costs **should not be recovered with volumetric charges** ($/kWh). We recommend a **fixed annual charge** distributed in monthly installments.



Breakdown of residential electricity bills in different jurisdictions in 2014-2015

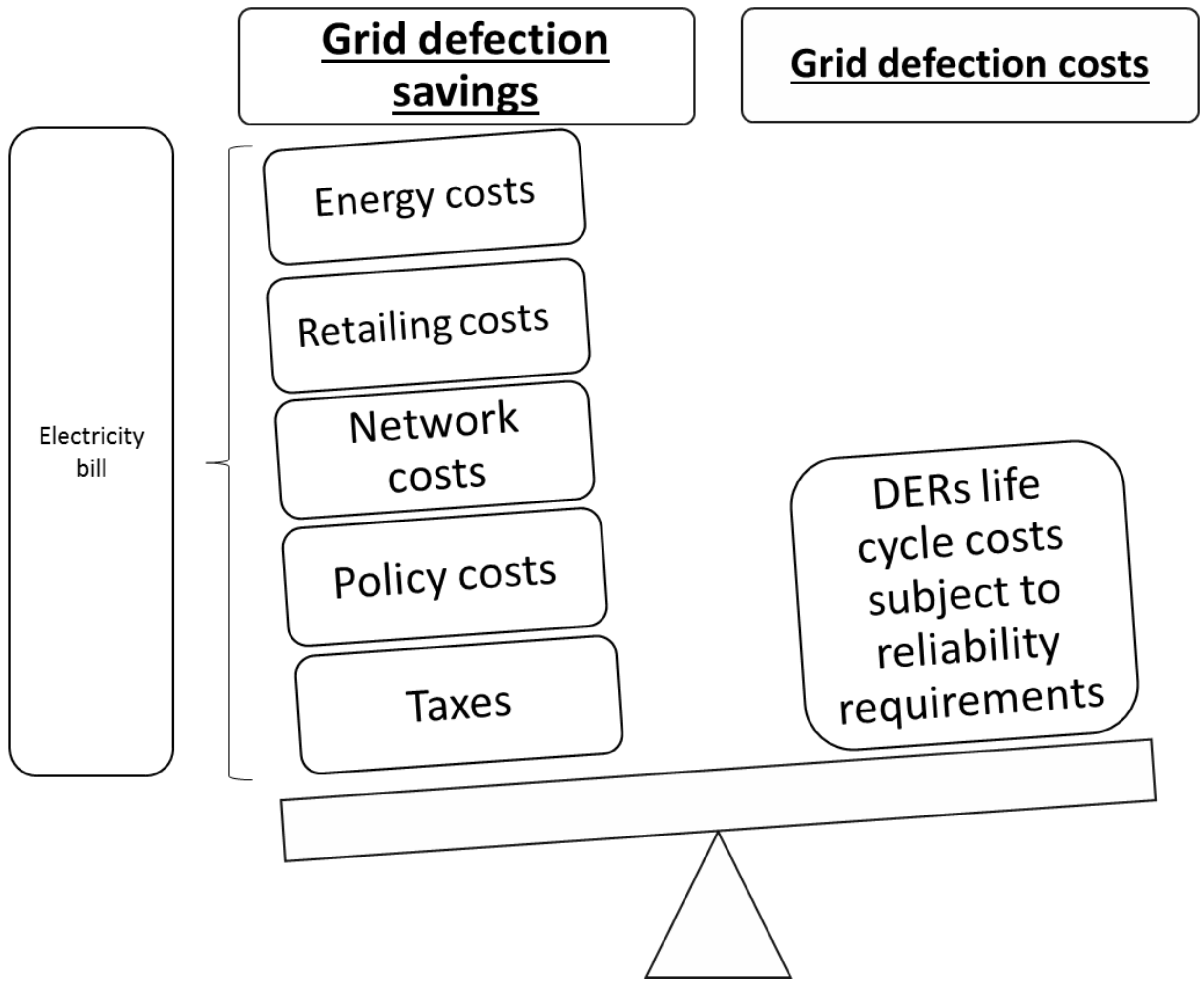
And as a consequence…

Let's do it one step at a time…

- Reflect **time differentiation** in the energy charges
- Apply forward-looking **peak-coincident capacity charges** for networks & firm generation capacity *(if this is the case)*
- Progressively increase the **locational component** of prices & charges
- **Policy & residual network costs** should be charged **minimizing distortion** of cost-reflective signals

→ Reconsider **which costs are included** in the electricity tariff if inefficient **grid defection** is a serious threat

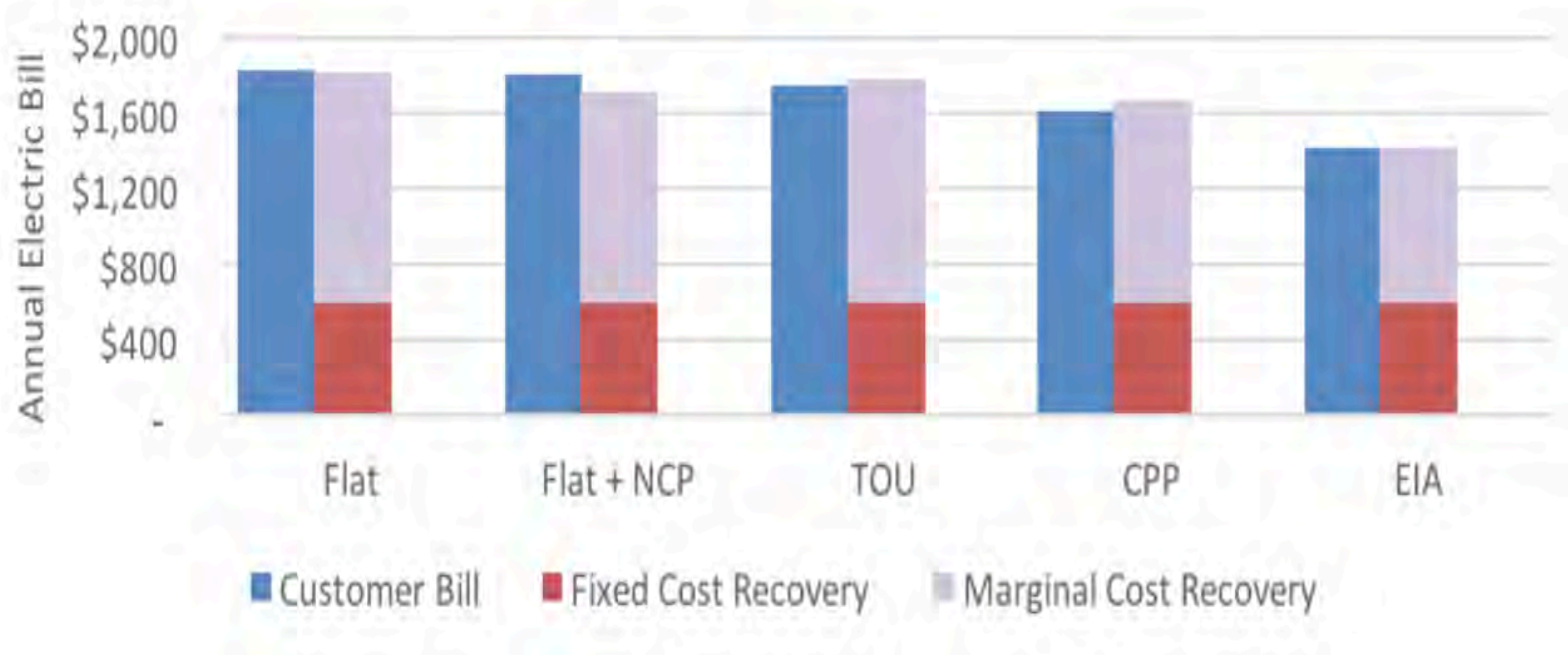
Depending on the seriousness of the **threat of grid defection**, which costs are included in the electricity tariff must be carefully considered



How important is to increase temporal & spatial "granularity"?

Granularity matters: progressively improving tariffs can unlock efficient consumption, value DERs, and lower cost of power systems.

A case study of a residential household in Westchester, NY with flexible air conditioning responding to different tariff schedules…



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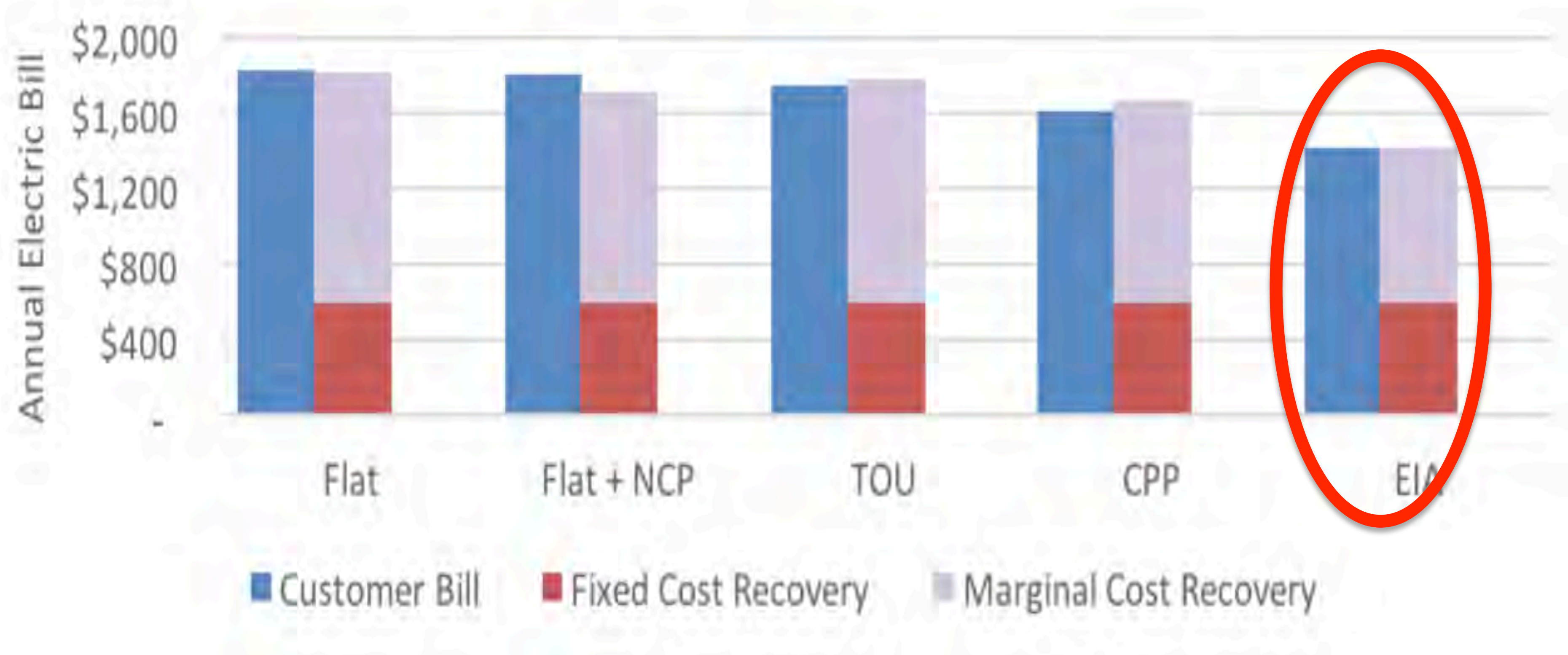
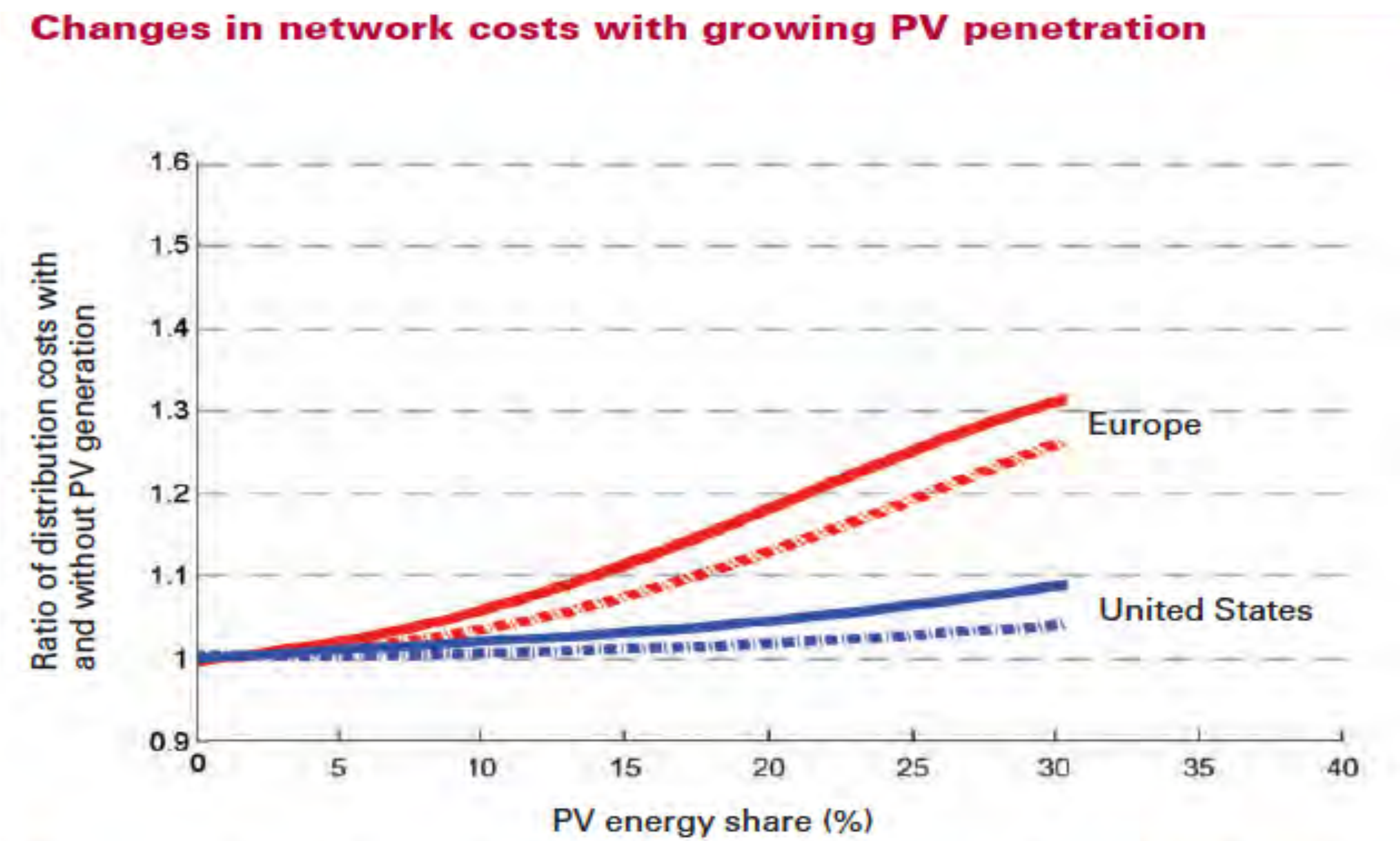


Too much complexity for the small & medium customers?

How much should the toaster know?
Is it worth sending prices & charges to it?

2
Enhance distribution regulation

From the MIT “Future of Solar Study”



An enhanced distribution business model

➡ Forward-looking, **multi-year revenue trajectory** with **profit sharing** mechanisms

An enhanced distribution business model

- Forward-looking, **multi-year revenue trajectory** with **profit sharing** mechanisms
- “State of the art” regulatory tools to **manage uncertainty**

An enhanced distribution business model

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- **Outcomes-based** performance incentives

An enhanced distribution business model

- Forward-looking, **multi-year revenue trajectory** with **profit sharing** mechanisms
- "State of the art" regulatory tools to **manage uncertainty**
- **Outcomes-based** performance incentives

→ Incentives for long-term **innovation**

Widespread connection of distributed energy resources, smart appliances, & more complex electricity markets **increase the importance of cybersecurity** & heightens **privacy** concerns

There is no silver bullet but several useful pro-active measures should be adopted

- Develop **risk management culture**
- **Share information** about cyber threats
- Deploy **skilled teams** to detect and respond to anomalous cyber activity
- Increase **system resilience**
- Adopt **advanced cybersecurity technologies**

3

Rethink electricity industry structure to minimize conflicts of interest

*“**Market platforms, network providers,** and*
***system operators** perform three critical functions that sit at the center of all transactions in electricity markets.”*

*“A **data hub or data exchange** may constitute a fourth critical power system function…”*

Establish independence between the DSO & agents performing activities in markets and if independence is legal or functional, apply significant regulatory oversight and transparent mechanisms to provide services

4

Allow DERs participate in wholesale markets

How to remove inefficient barriers?

Wholesale markets should **enable transactions** to be made **closer to real time**

How to remove inefficient barriers?

- Wholesale markets should **enable transactions** to be made **closer to real time**
- Wholesale **market rules** *(such as bidding formats)* **should be updated** to reflect the operational constraints of new resources

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- **Aligning reserves & energy markets** & establish the flexibility requirements for participation

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- Wholesale **market rules** *(such as bidding formats)* **should be updated** to reflect the operational constraints of new resources
- **Aligning reserves & energy markets** & establish the flexibility requirements for participation

Minimize the interference of support mechanisms for clean technologies in electricity markets

5

Unlock the individual value of each DER & be aware of their locational component & economies of scale

Understand the locational value of services provided by DERs

Electricity services values

	Locational	Non-locational
	Energy?	

Electricity services values

	Locational	Non-locational
	• Energy	
	Firm generation capacity?	

Electricity services values

	Locational	Non-locational
	• Energy	• Firm generation capacity
	Network constraint mitigation?	

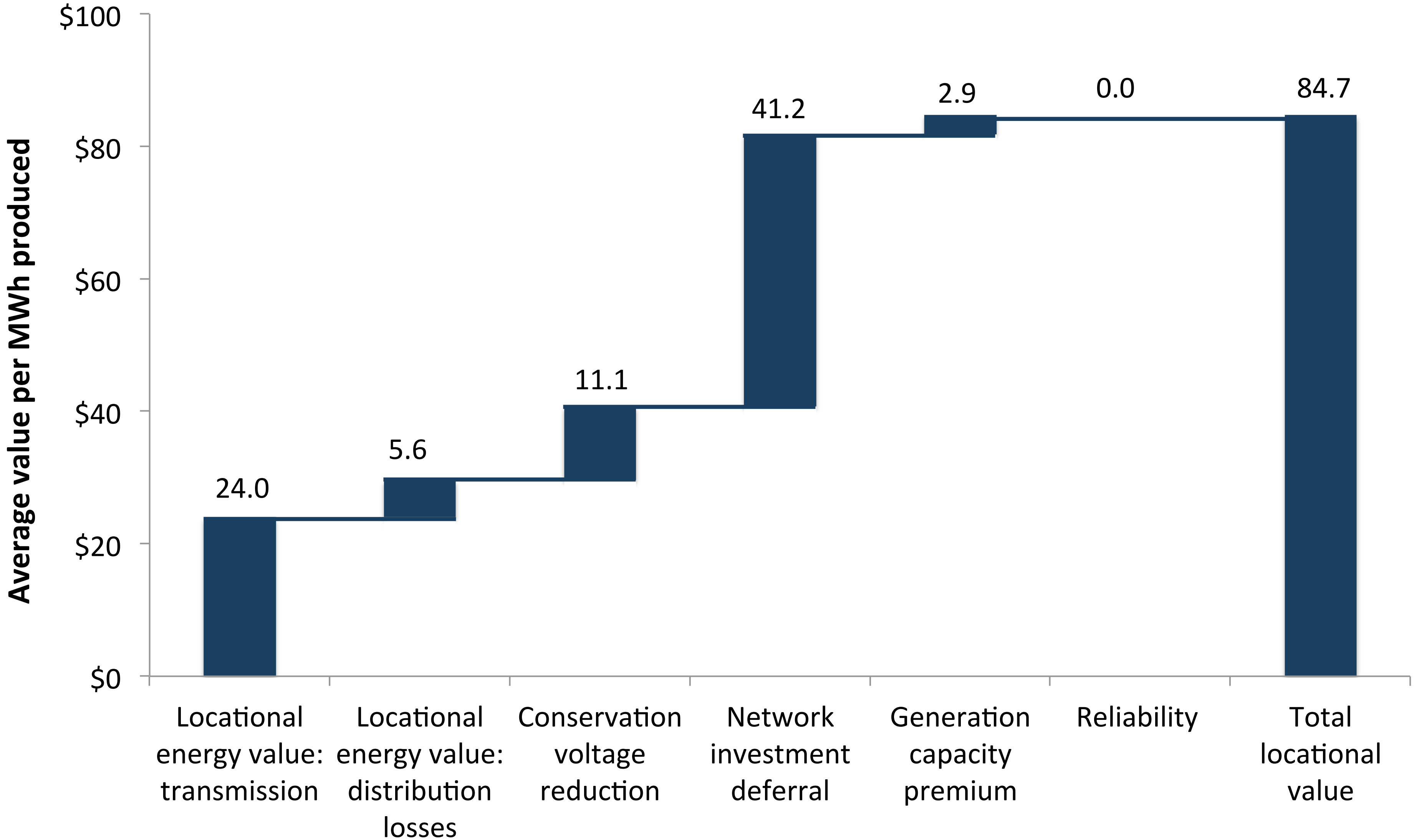
Electricity services values

	Locational	Non-locational
	• Energy • Network constraint mitigation	• Firm generation capacity
	Operating reserves?	

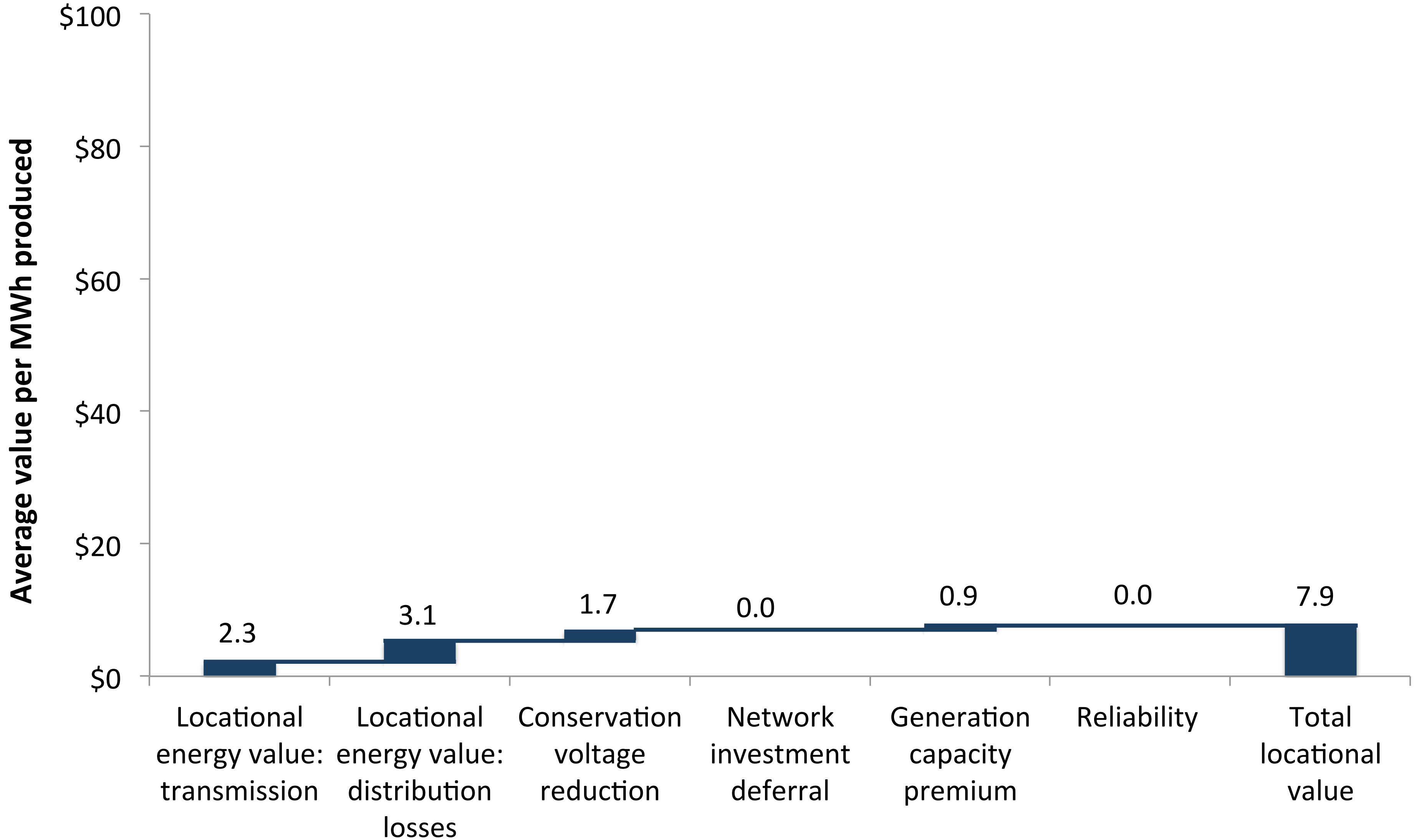
Electricity services values

	Locational	Non-locational
	• Energy • Network capacity margin • Network constraint mitigation • Power quality • Reliability and resiliency • Black-start	• Firm generation capacity • Operating reserves • Price hedging
	• Land use • Employment • Premium values*	• Emissions mitigation • Energy security
	* Private values; do not need to be reflected in prices and charges	

Locational Value of Distributed Solar PV: Long Island, New York Example, High Value Case



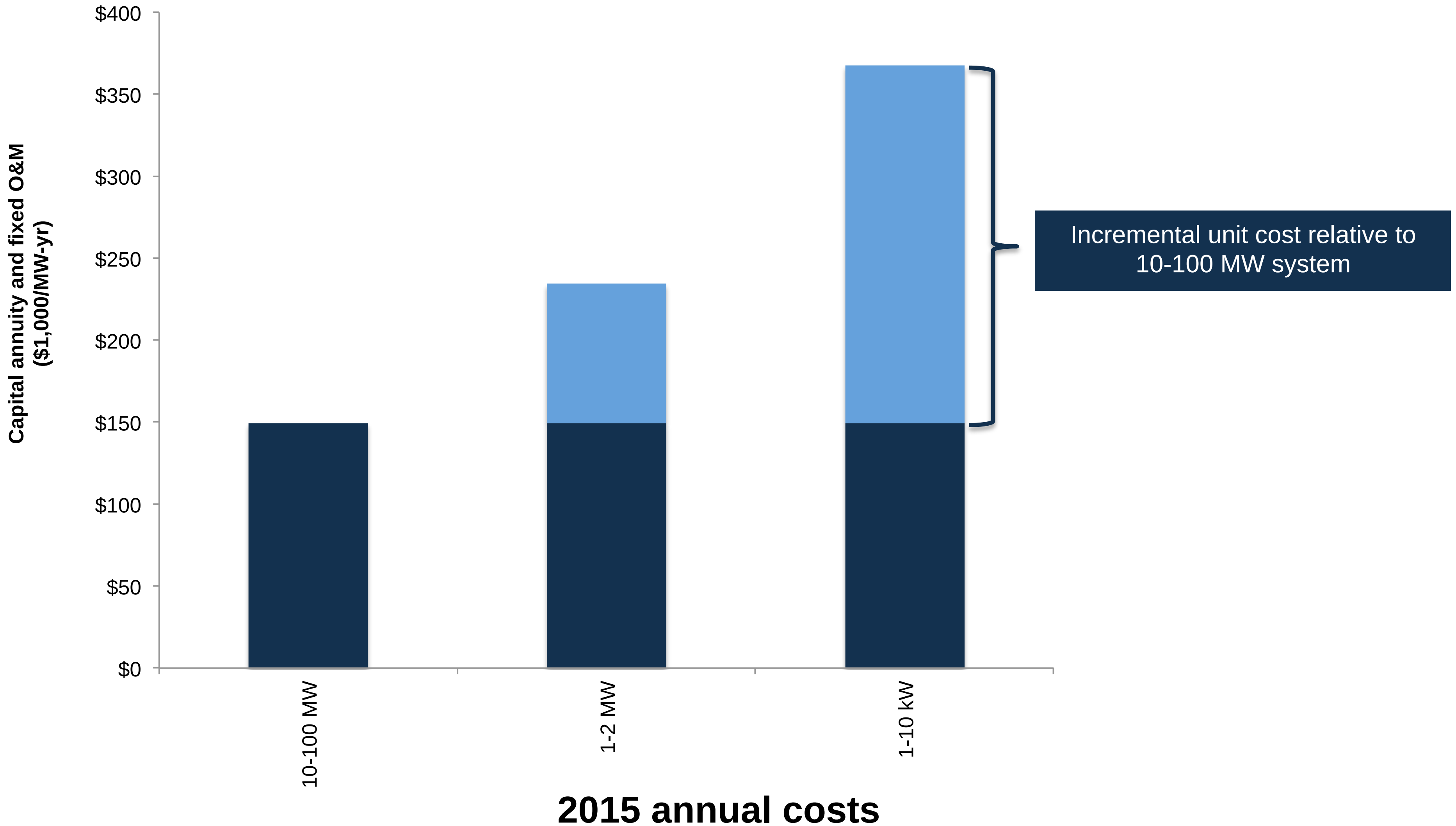
Locational Value of Distributed Solar PV: Mohawk Valley, New York Example, Avg. Value Case



For DERs that can be deployed at different scales (e.g. solar PV, storage)…

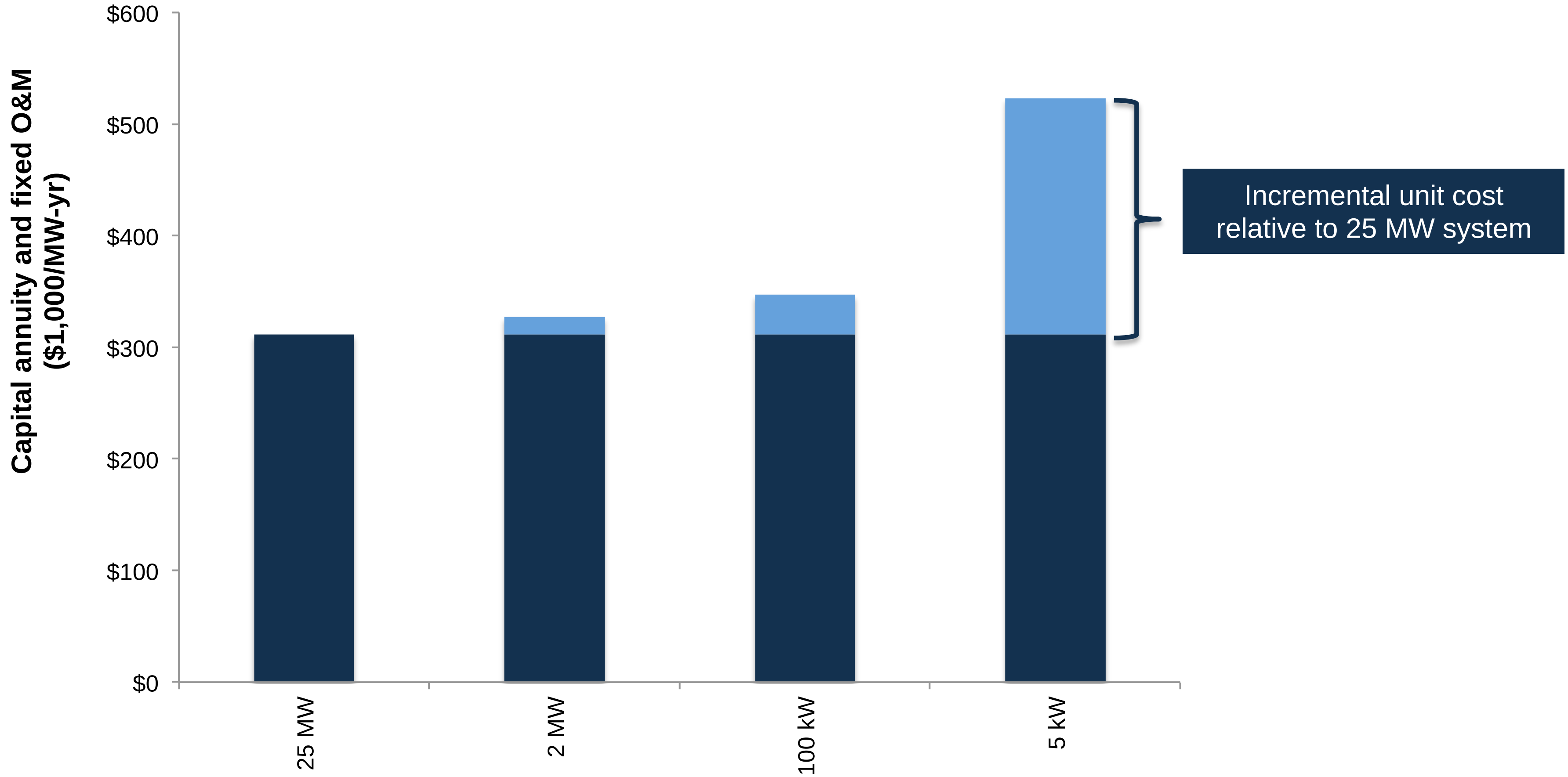
Locational value competes with economies of scale

Estimated Economies of Unit Scale for Fixed-tilt Solar PV Systems



Source: Author's estimates, forthcoming (part of MIT Utility of the Future Study)

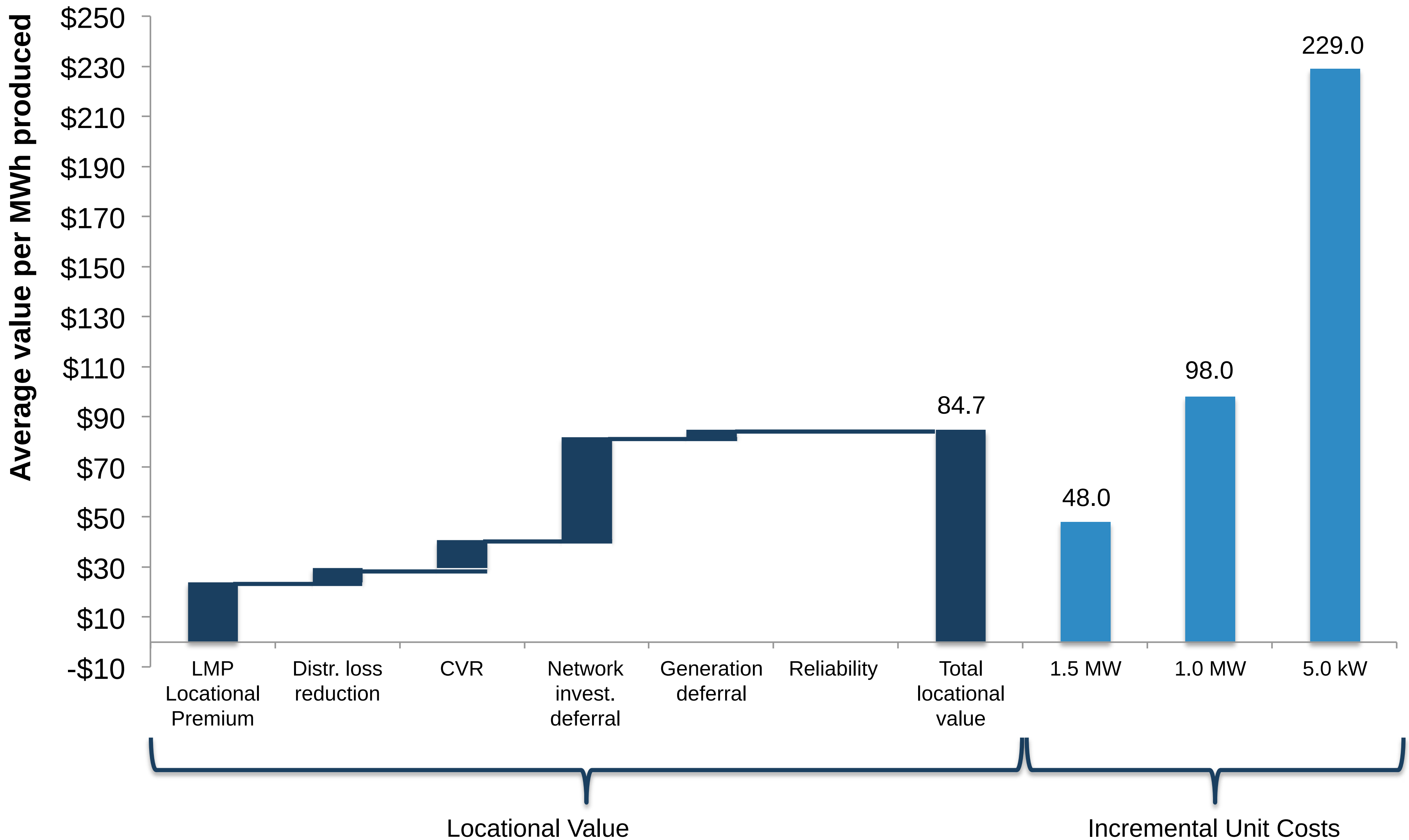
Estimated Economies of Unit Scale for Lithium Ion Energy Storage Systems



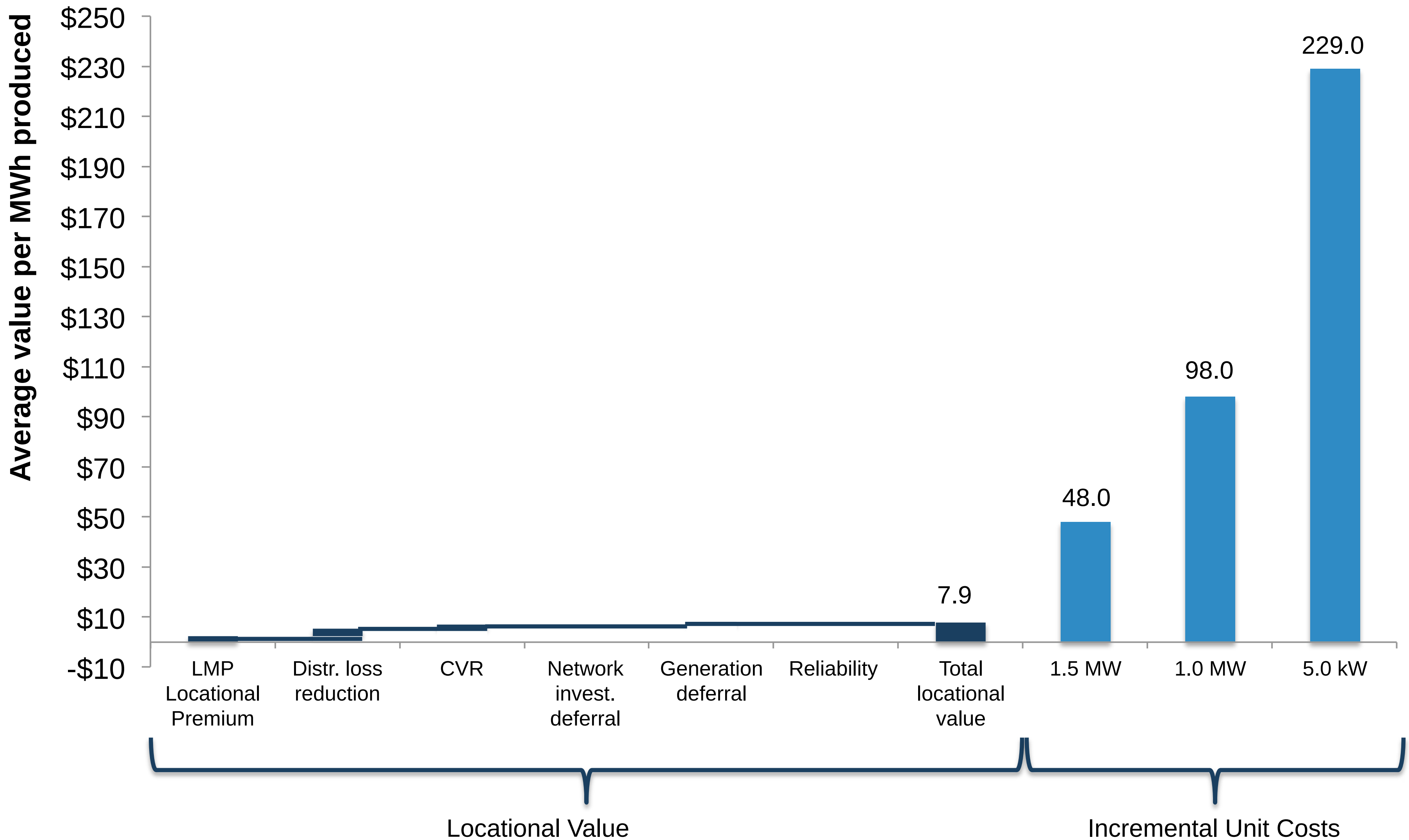
1:2 power/energy ratio; 2015 annual costs

Source: Author's estimates, forthcoming (part of MIT Utility of the Future Study)

Locational Value and Incremental Unit Cost of Distributed Solar PV: Long Island, New York



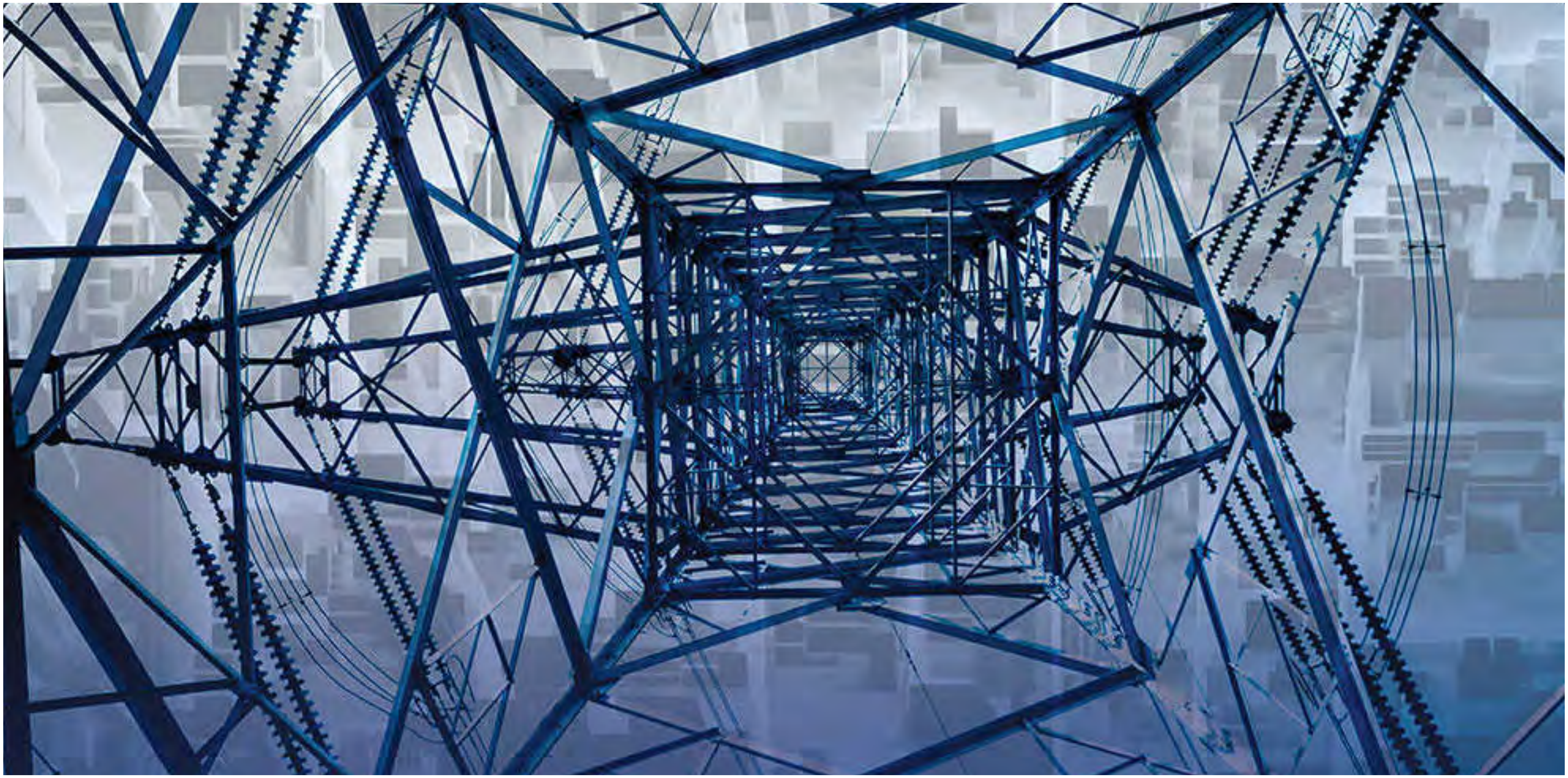
Locational Value and Incremental Unit Cost of Distributed Solar PV: Mohawk Valley, New York



In summary, what the study proposes…

- **can be implemented** with existing technology & reasonable regulatory measures,
- creates the conditions for **centralized and distributed** resources to compete and collaborate on a **level playing field**
- & provides a framework that will **enable an efficient outcome regardless of how technologies or policy objectives develop** in the future.

Thank you



The report has been released today (Dec-15)

http://energy.mit.edu/uof

Or just browse "MITEI utility of the future"