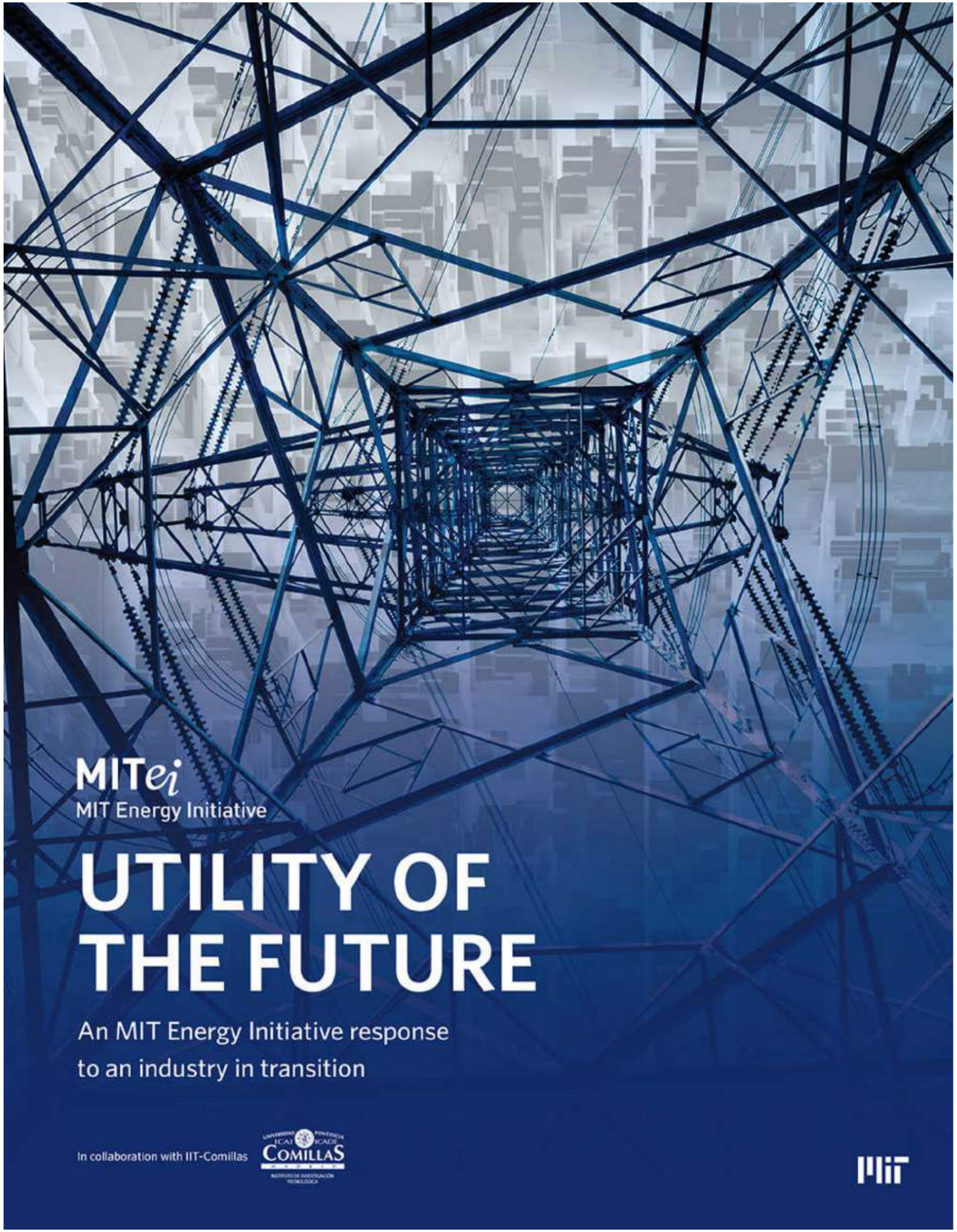


Utility of the Future

Ignacio Pérez Arriaga

Junio 18 y 19, 2018

Santiago de Chile y Lima

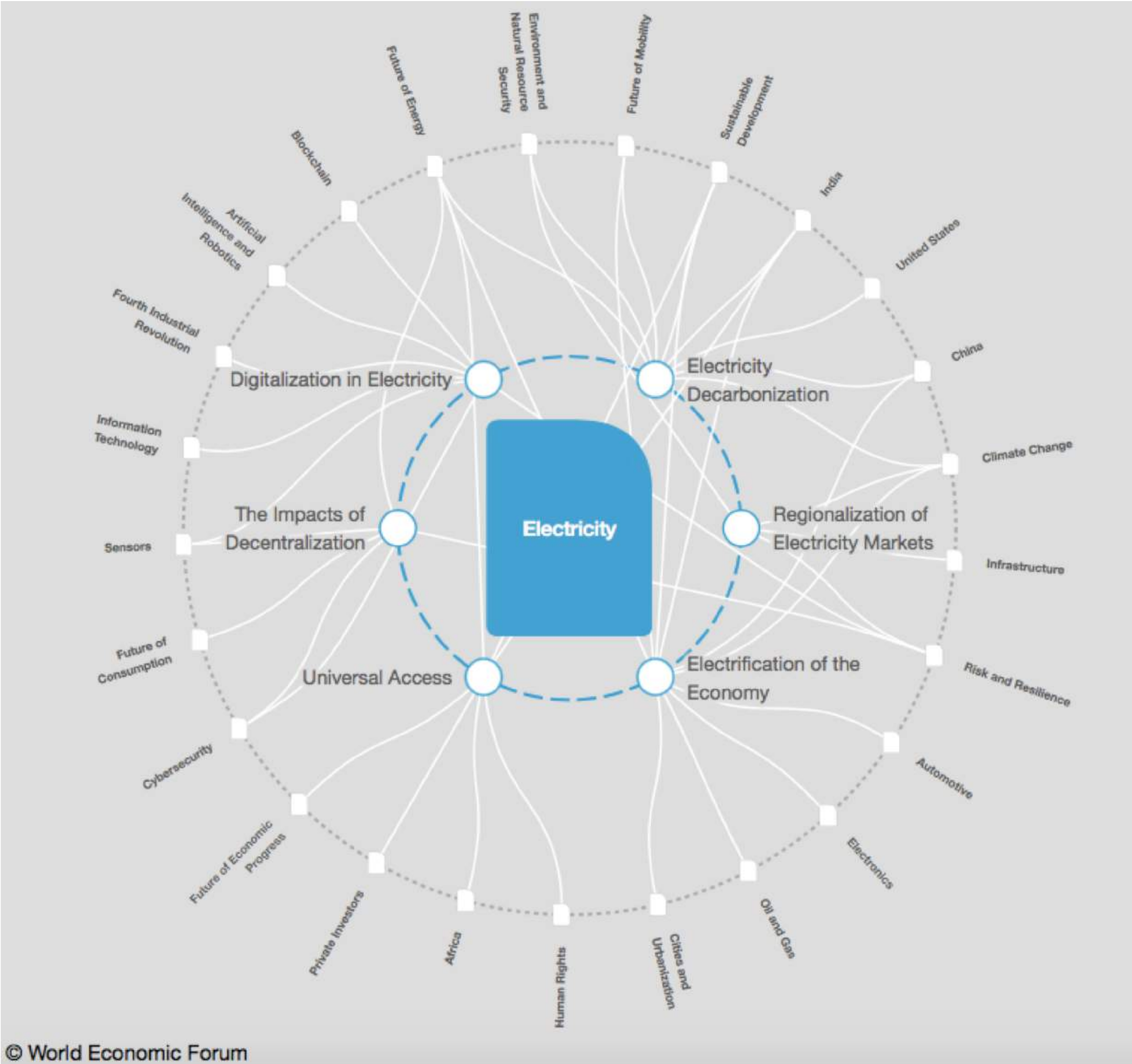
MIT Energy Initiative

Universidad Pontificia Comillas ICAI ICADE Madrid

Instituto de Investigación Tecnológica

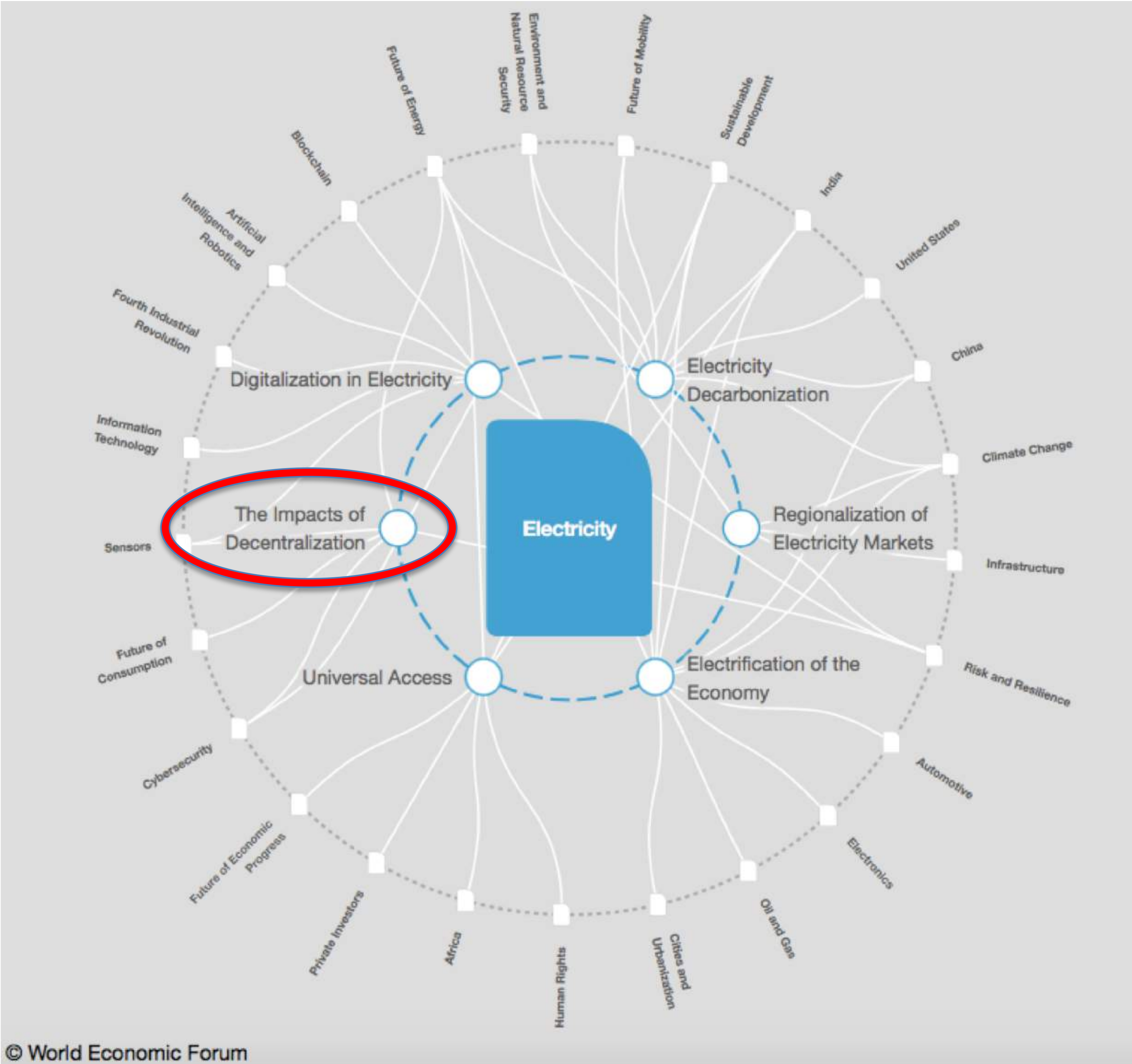
Algo importante **está cambiando** en el sector eléctrico…

… y esta vez es "**bottom up**"


Electricity
Digitalization in Electricity
Electricity Decarbonization
The Impacts of Decentralization
Regionalization of Electricity Markets
Universal Access
Electrification of the Economy
Future of Energy
Environment and Natural Resource Security
Future of Mobility
Sustainable Development
India
United States
China
Climate Change
Infrastructure
Risk and Resilience
Automotive
Electronics
Oil and Gas
Cities and Urbanization
Human Rights
Africa
Private Investors
Future of Economic Progress
Cybersecurity
Future of Consumption
Sensors
Information Technology
Fourth Industrial Revolution
Artificial Intelligence and Robotics
Blockchain
© World Economic Forum

Descarbonization de la electricidad
Electrificación de la economía
Descentralización
Digitalización
Regionalización
Acceso universal

DESCENTRALIZACIÓN



Descarbonization de la electricidad

Electrificación de la economía

Descentralización

Digitalización

Regionalización

Acceso universal

Retos regulatorios en la distribución

- **Remuneración de la distribución** en presencia de "Distributed Energy Resources (DER)"
- **Diseño de tarifas**: precios de energía, cargos de red y otros costes regulados
- **Separación de actividades**: propiedad de la red, operador de la distribución, comercializador
- **Propiedad** de los recursos distribuidos
- Solar y almacenamiento: ¿nivel **distribuido o utility**?
- **Participación de los recursos distribuidos** en la operación y expansión de capacidad de distribución
- El rol de los **agregadores**

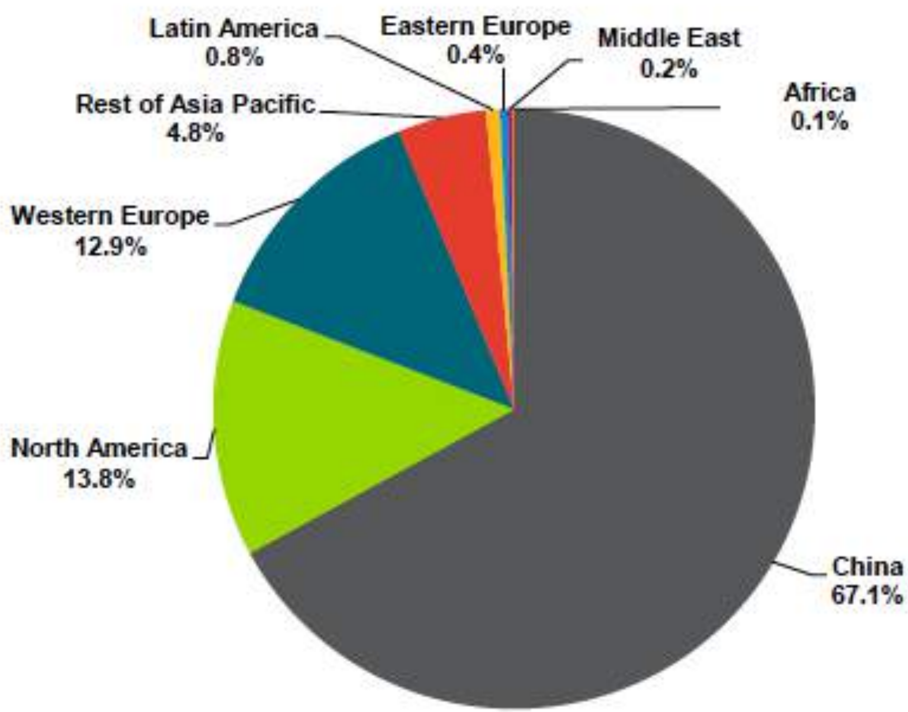
La presencia de recursos energéticos distribuidos…

… y también de contadores avanzados…

1.3 Global Smart Meter Installations

As expected, China continued to lead the global smart electric meter market through 3Q 2016 as the country approaches the tail end of its nationwide rollout. With upwards of 348 million smart meters at the end of 3Q 2016, China accounted for 67.1% of tracked global installations. North America and Western Europe followed at 13.8% and 12.9%, respectively, with the rest of Asia Pacific trailing at around 4.8%. The remaining regions accounted for only 1.5% of tracked smart meter installations.

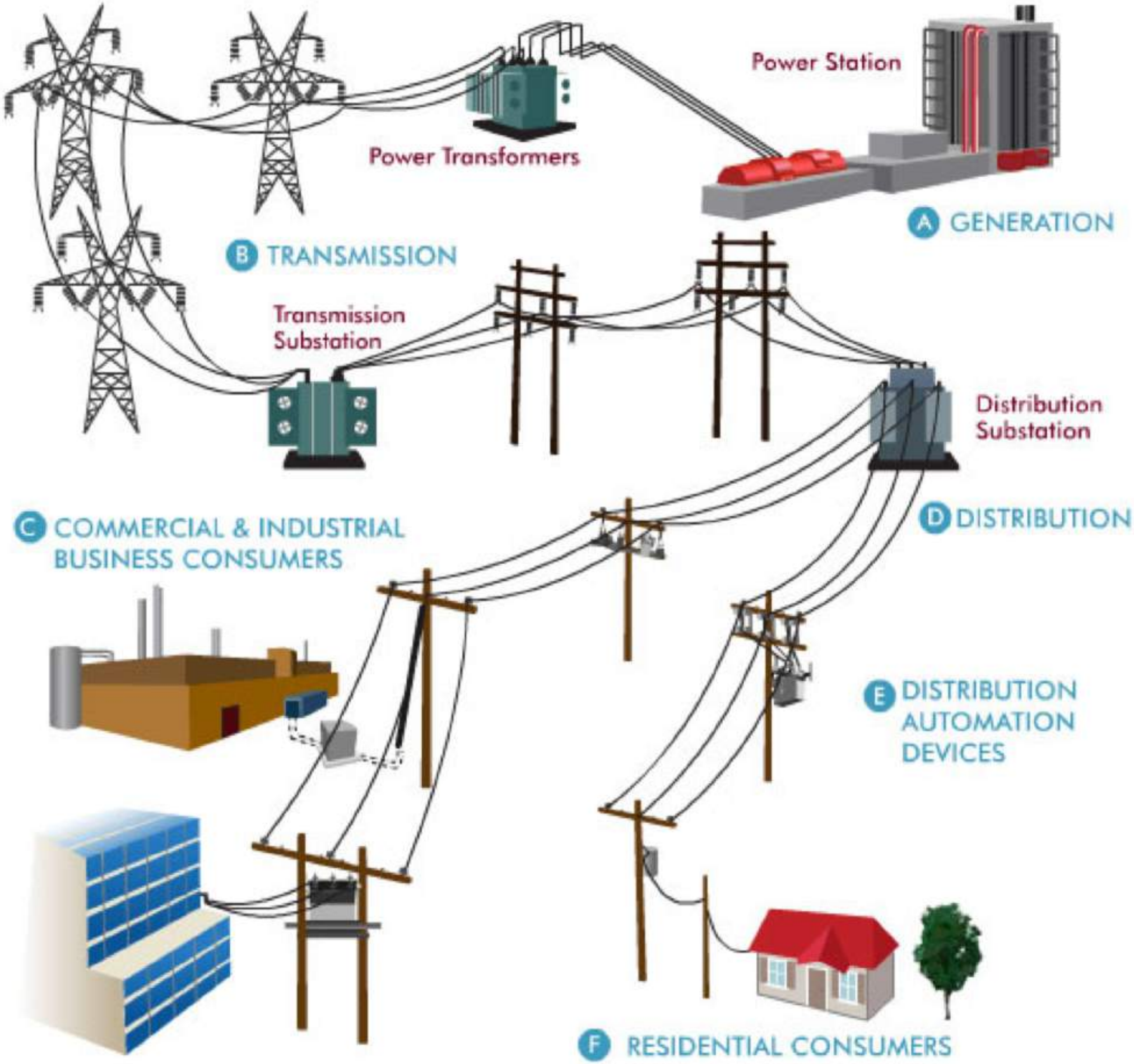
Chart 1.1 Installed Smart Meter Base by Region, World Markets: 3Q 2016



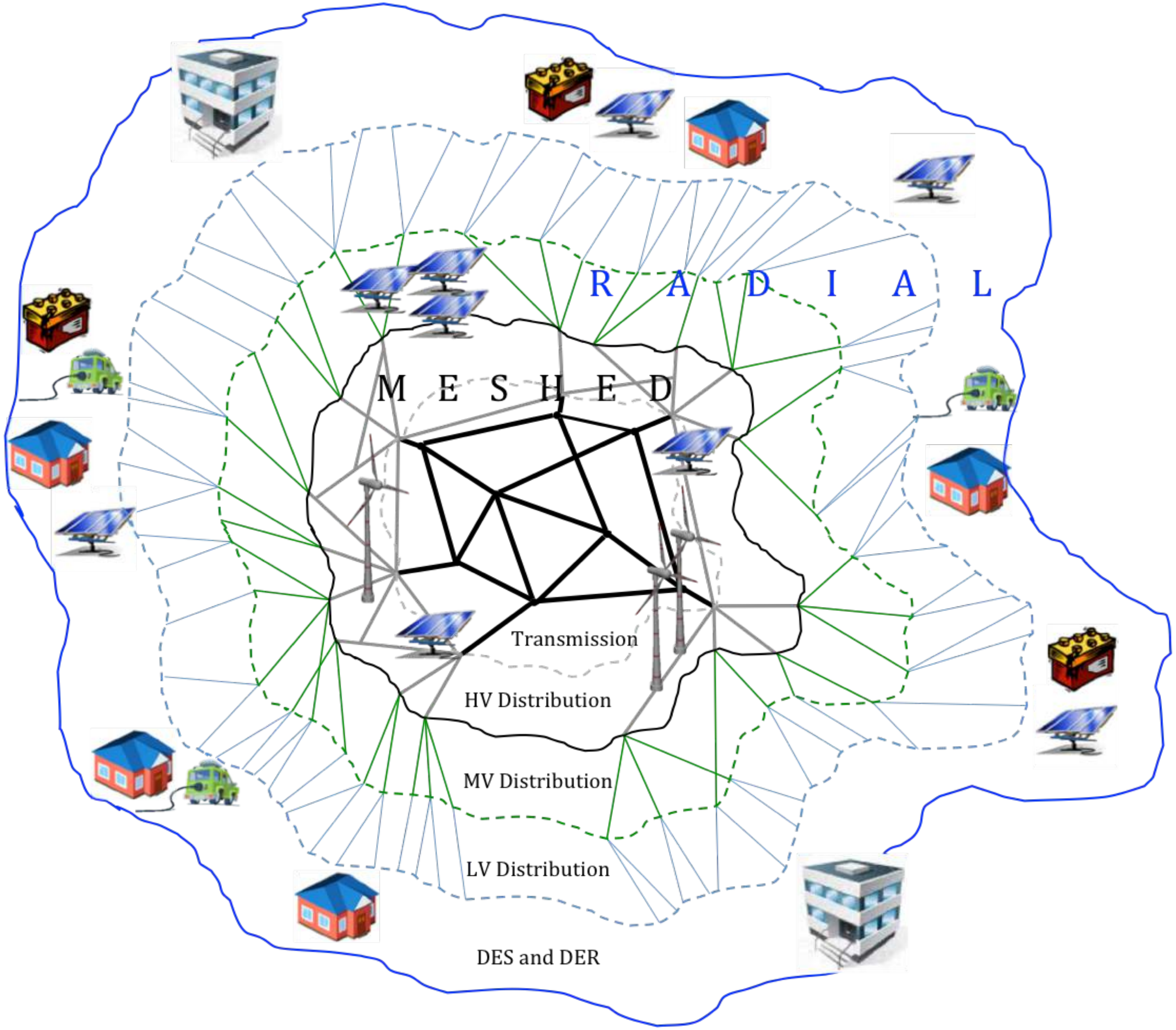
Note: Tracked projects only.

(Source: Navigant Research)

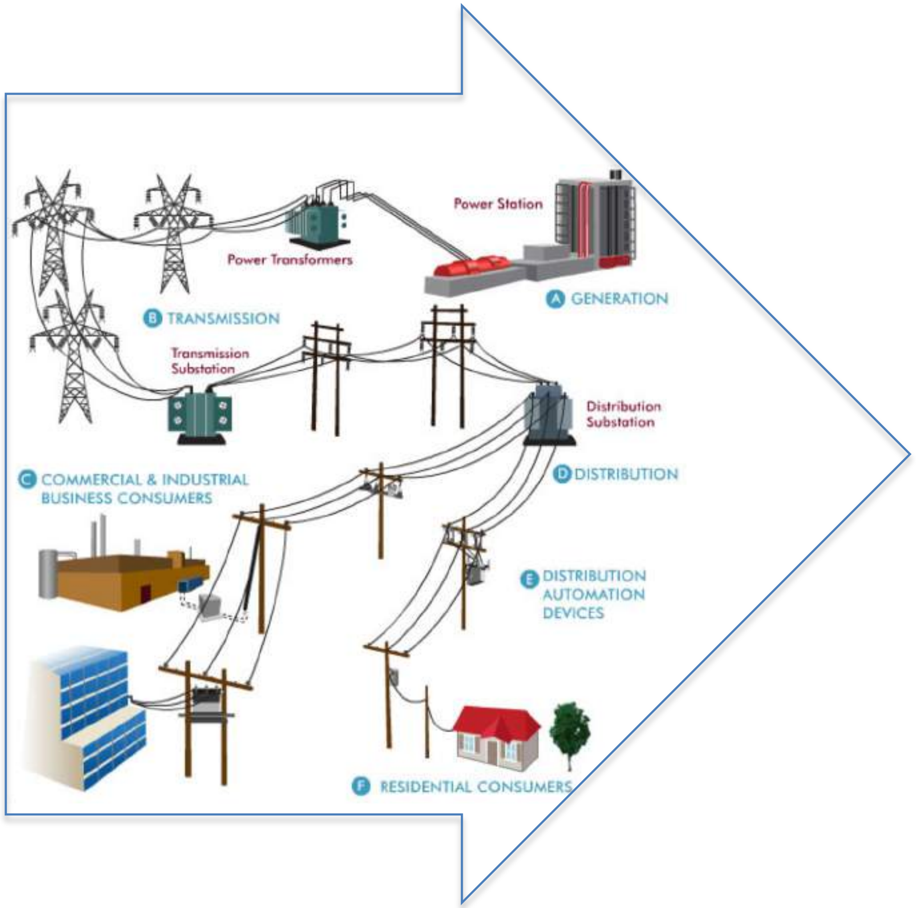
… nos obliga a cambiar la perspectiva “top-down”…

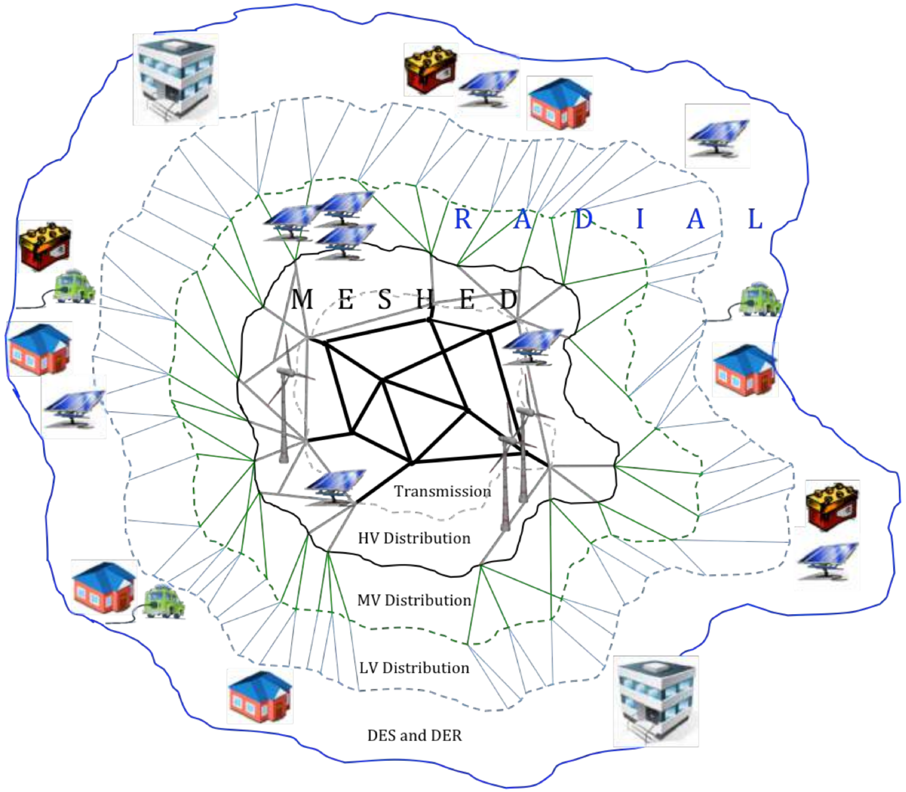


… por otra donde no hay un claro predominio de lo centralizado y lo distribuido



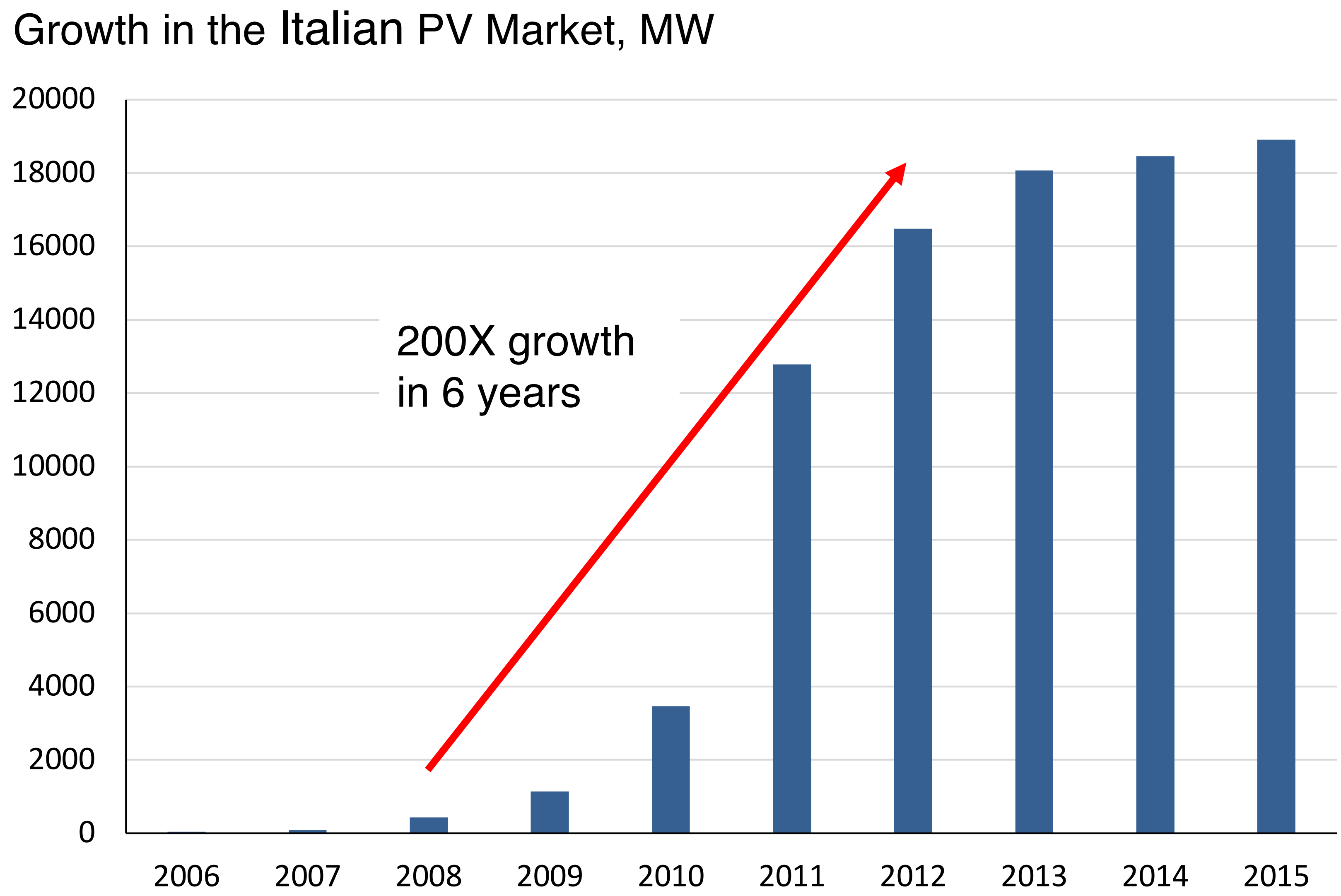
Se trata de un cambio de perspectiva…
… con muchas implicaciones





Los recursos distribuidos se pueden instalar en poco tiempo

Consumidores e inversores responden a las señales económicas... y pueden hacerlo muy rápido!



La utilización de recursos distribuidos puede ahorrar inversiones en otras infraestructuras eléctricas

"En los tres últimos años 2013 – 2015, como promedio, ***el 1% de las horas más caras supuso el 8%*** *($680 million) del costo total annual de la electricidad en Massachusetts. Y el* ***10% de las horas más caras supuso el 40% del costo total, más de*** *$3 billones."*

Fuente: "State of Charge: Massachusetts Energy Storage Initiative," MA DOER and MassCEC
Noviembre 2016

ConEd en NY ha evitado una inversión de $1.2B en una nueva subestación con un portafolio de recursos distribuidos por $200M

Qualifying Neighborhoods in Brooklyn & Queens Program

Los recursos distribuidos proporcionan un nivel de elección a los consumidores sin precedente, para que manifiesten sus preferencias…



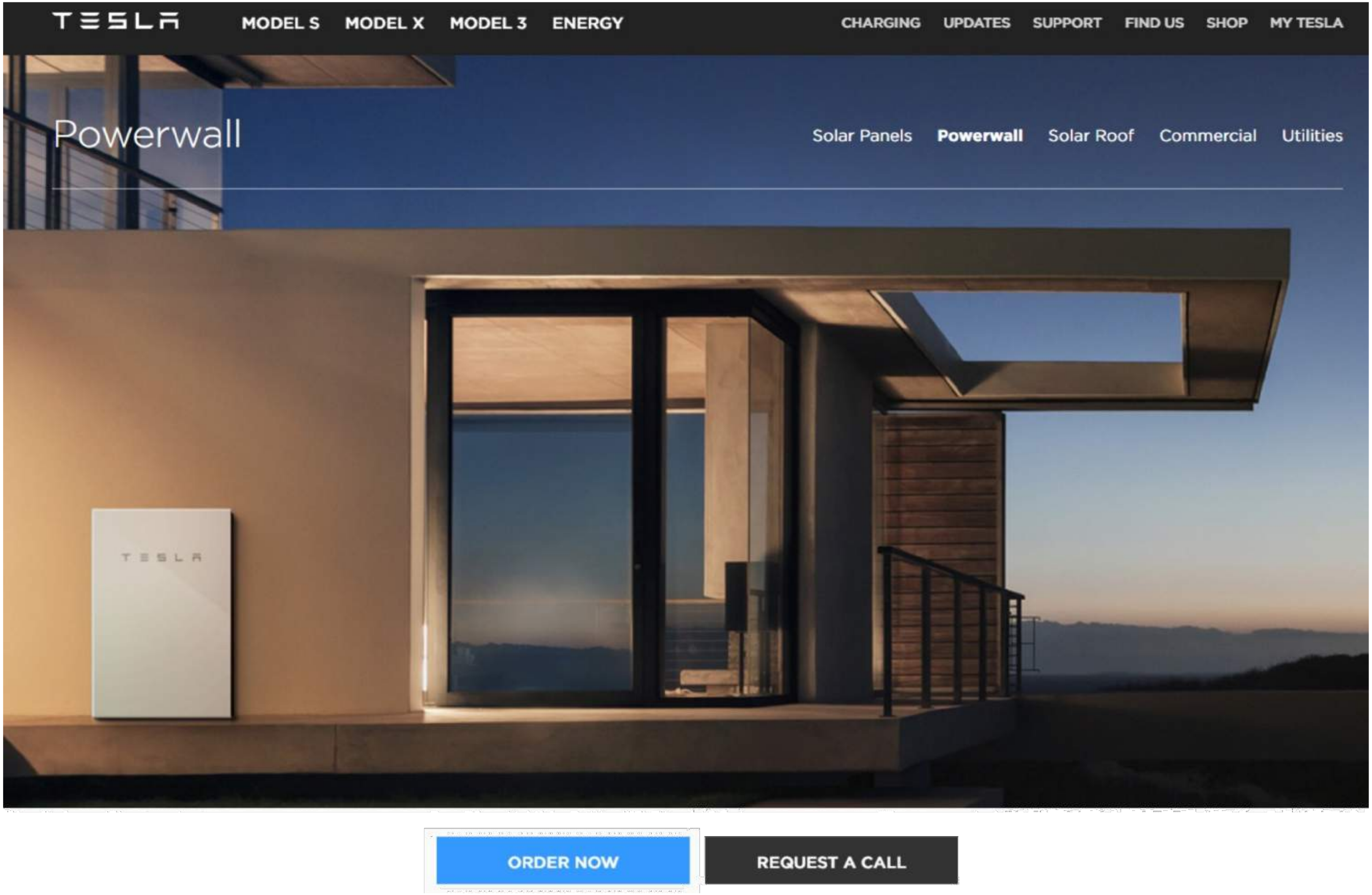
Elegimos la comida…

... y el modelo de teléfono...

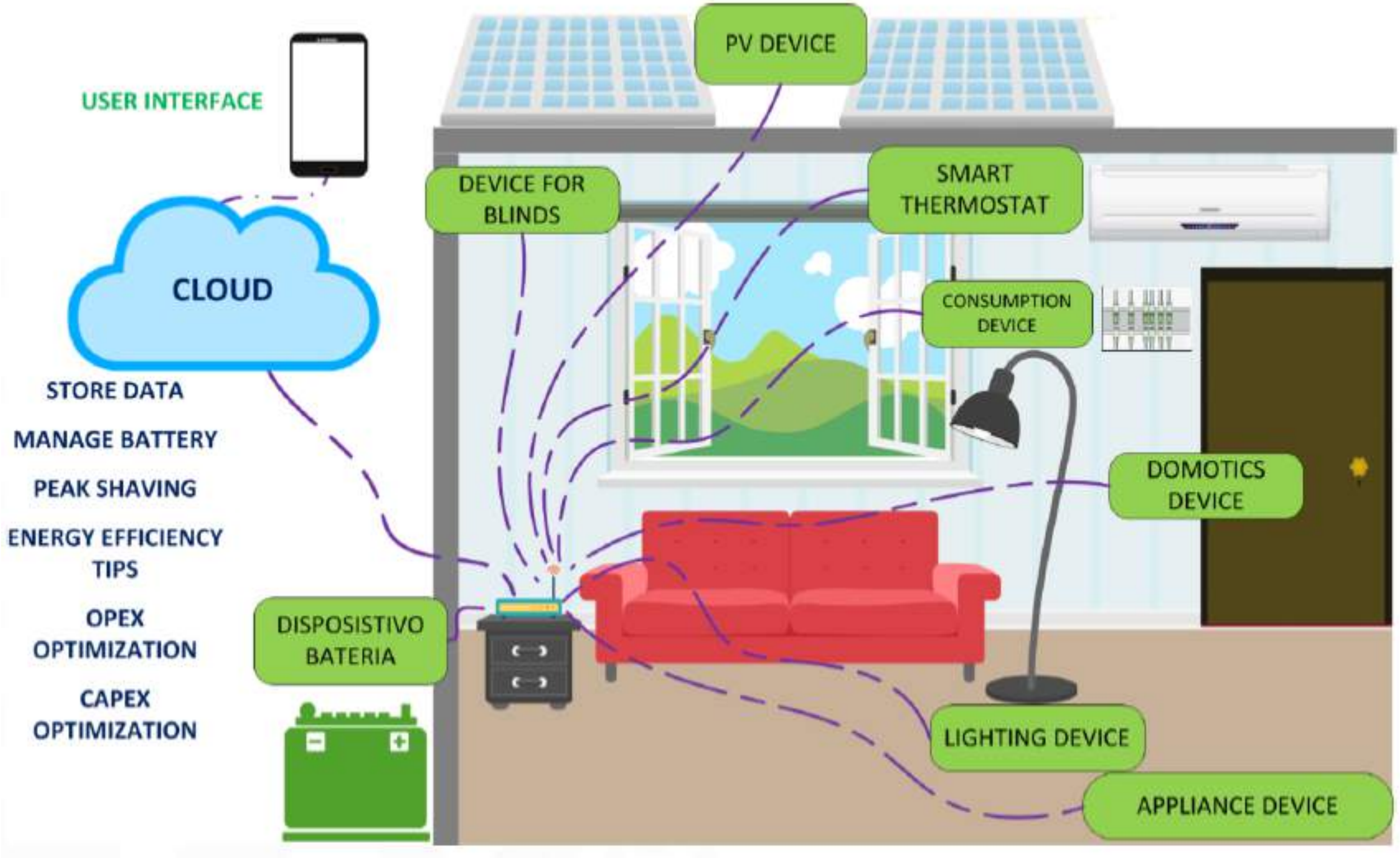
... o el portátil...

... así como el modelo de coche...

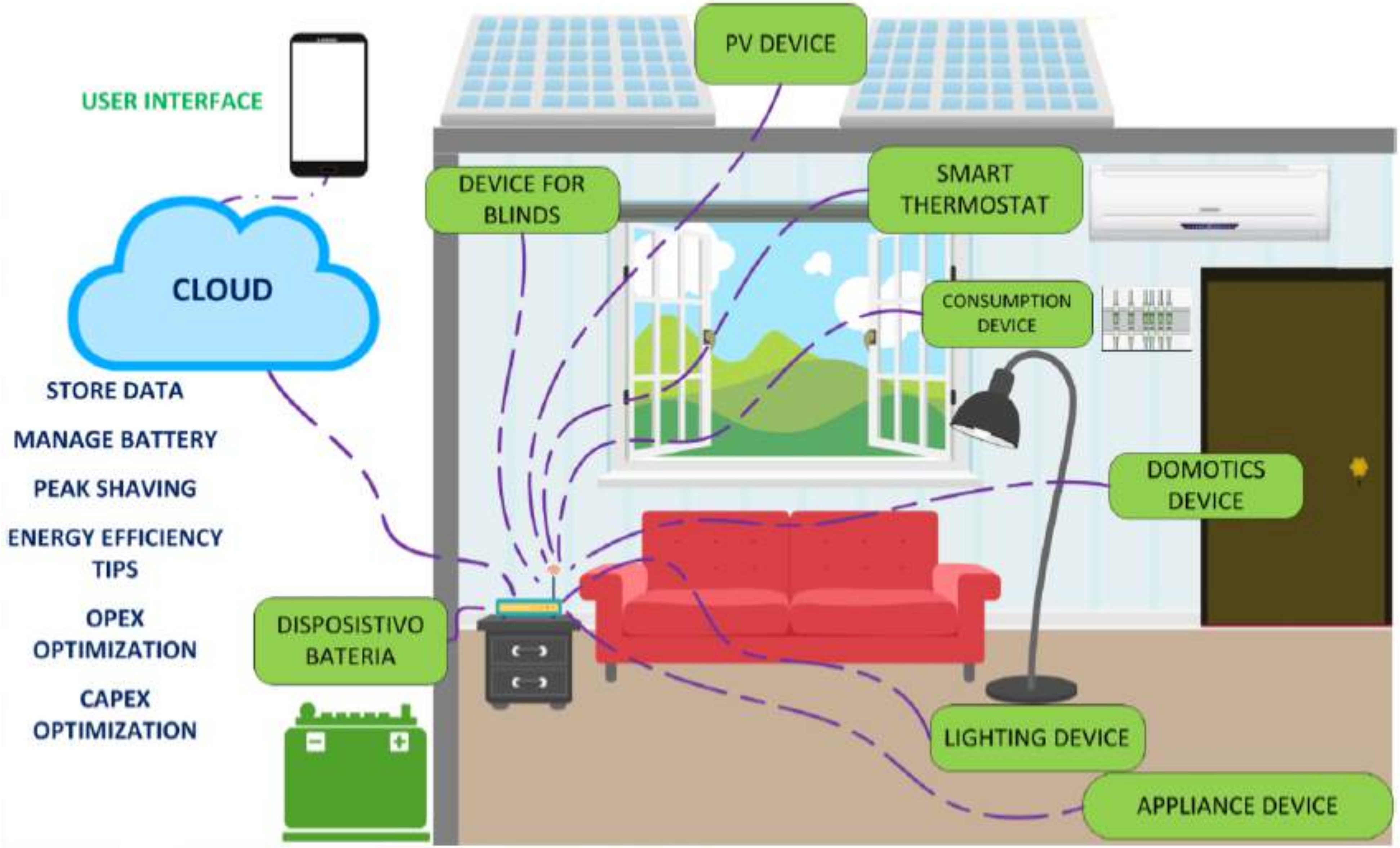
… aunque solo sea para lucirlo…



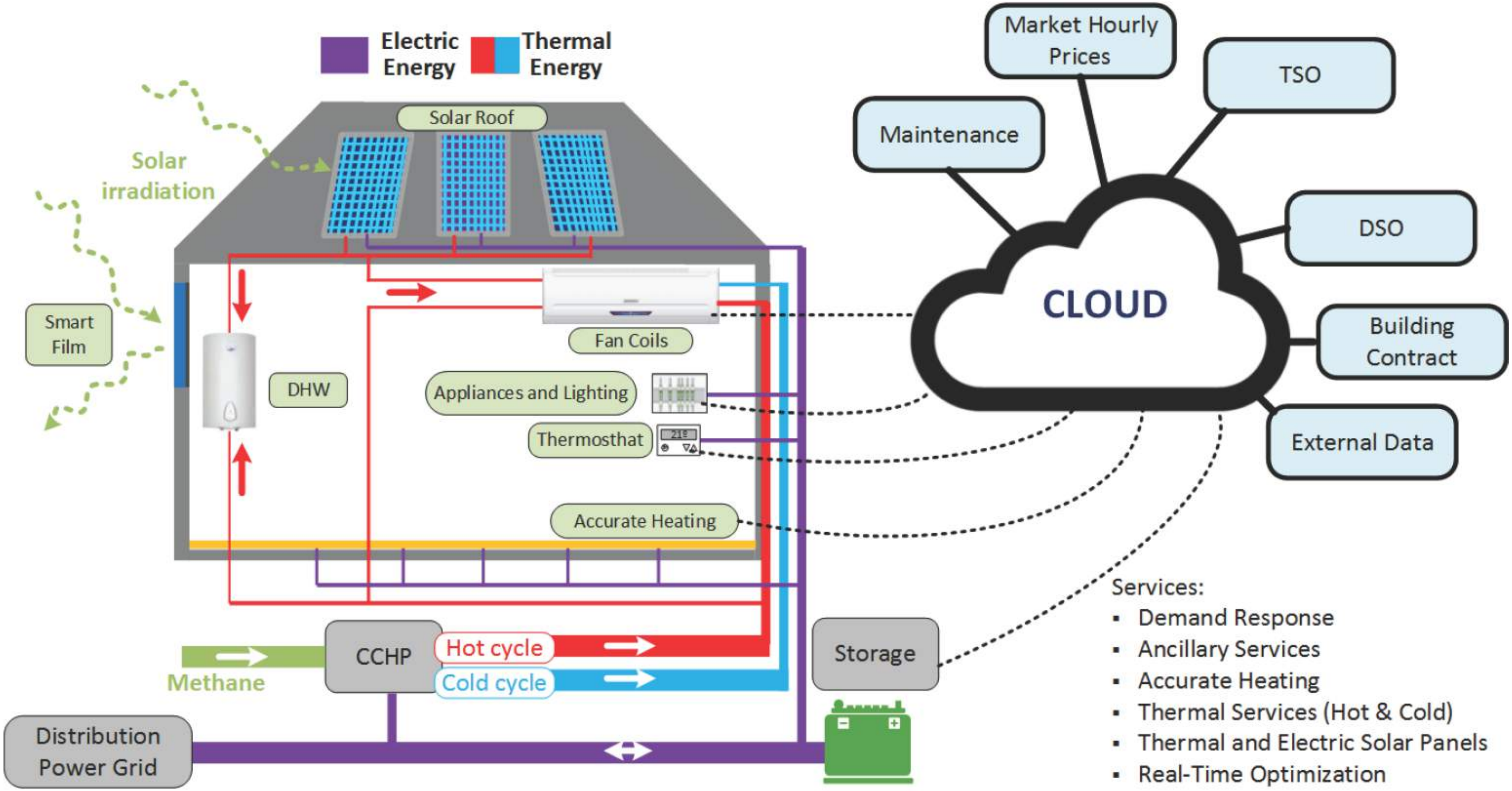
… ahora disponemos de las tecnologías que nos permiten controlar nuestro uso de la energía



… y las tecnologías ya están disponibles para elegir cómo utilizar la energía…



… y cómo relacionarse con el resto del sistema eléctrico y otros sectores



Pero **muchas oportunidades** de los DERs de proporcionar valor al sistema eléctrico **no se utilizan**

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

What is missing?

A comprehensive system of efficient prices & regulated charges

for electricity services


MITei
MIT Energy Initiative
UTILITY OF THE FUTURE
An MIT Energy Initiative response to an industry in transition
In collaboration with IIT-Comillas
COMILLAS
MIT

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

“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**

Las preguntas

¿Cómo crear un campo de juego nivelado para que los recursos energéticos centralizados y distribuidos puedan competir y colaborar eficientemente?

¿Cómo crear un campo de juego nivelado para que los recursos energéticos centralizados y distribuidos puedan competir y colaborar eficientemente?

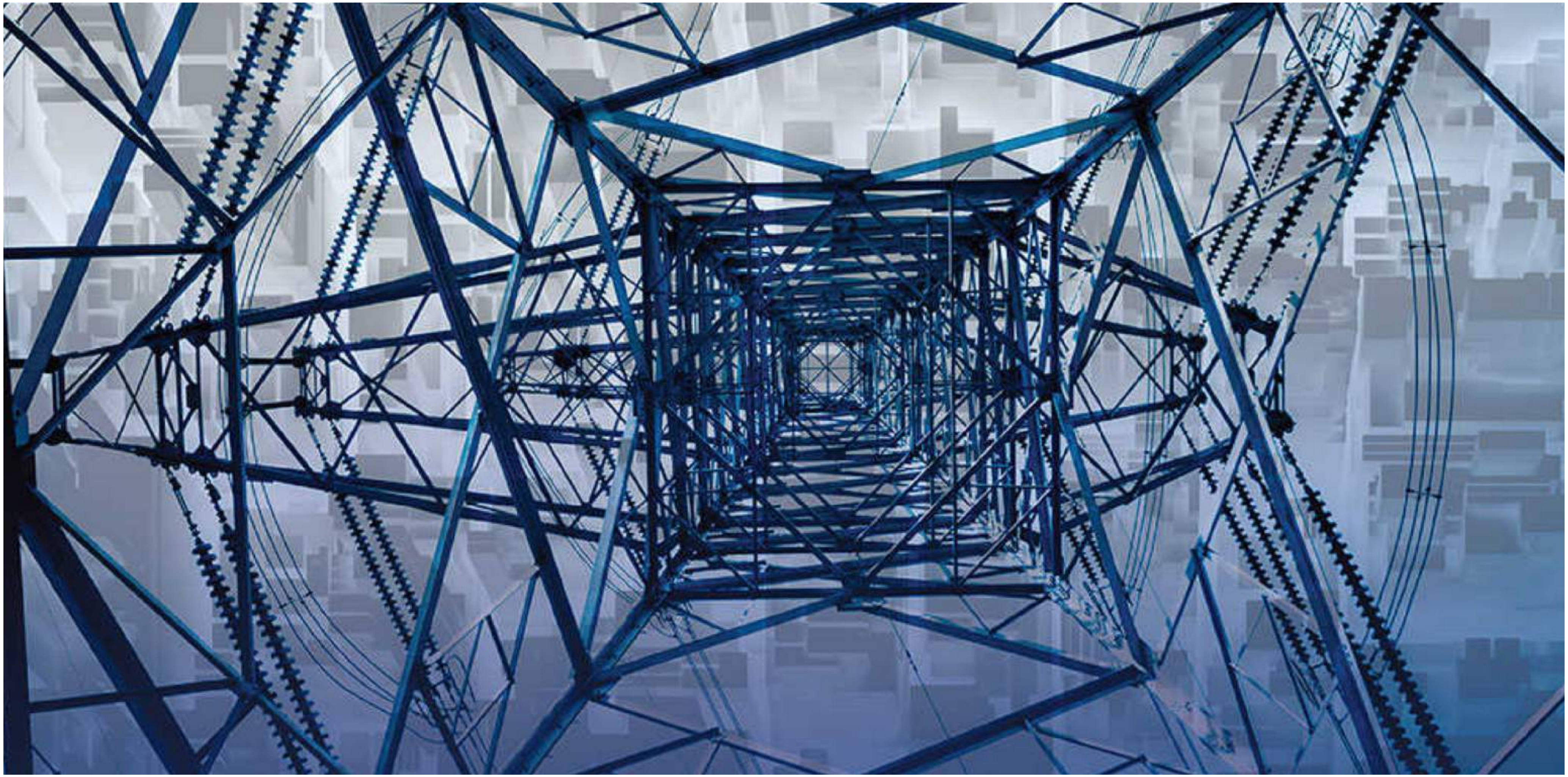
¿Cómo revelar el valor de cada tipo de recurso en la provisión de cada tipo de servicio eléctrico?

¿Cómo crear un campo de juego nivelado para que los recursos energéticos centralizados y distribuidos puedan competir y colaborar eficientemente?

¿Cómo revelar el valor de cada tipo de recurso en la provisión de cada tipo de servicio eléctrico?

¿Cómo debe actualizarse la regulación de las empresas de distribución para adaptar su remuneración a las nuevas condiciones creadas por los recursos distribuidos y para fomentar la innovación?

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

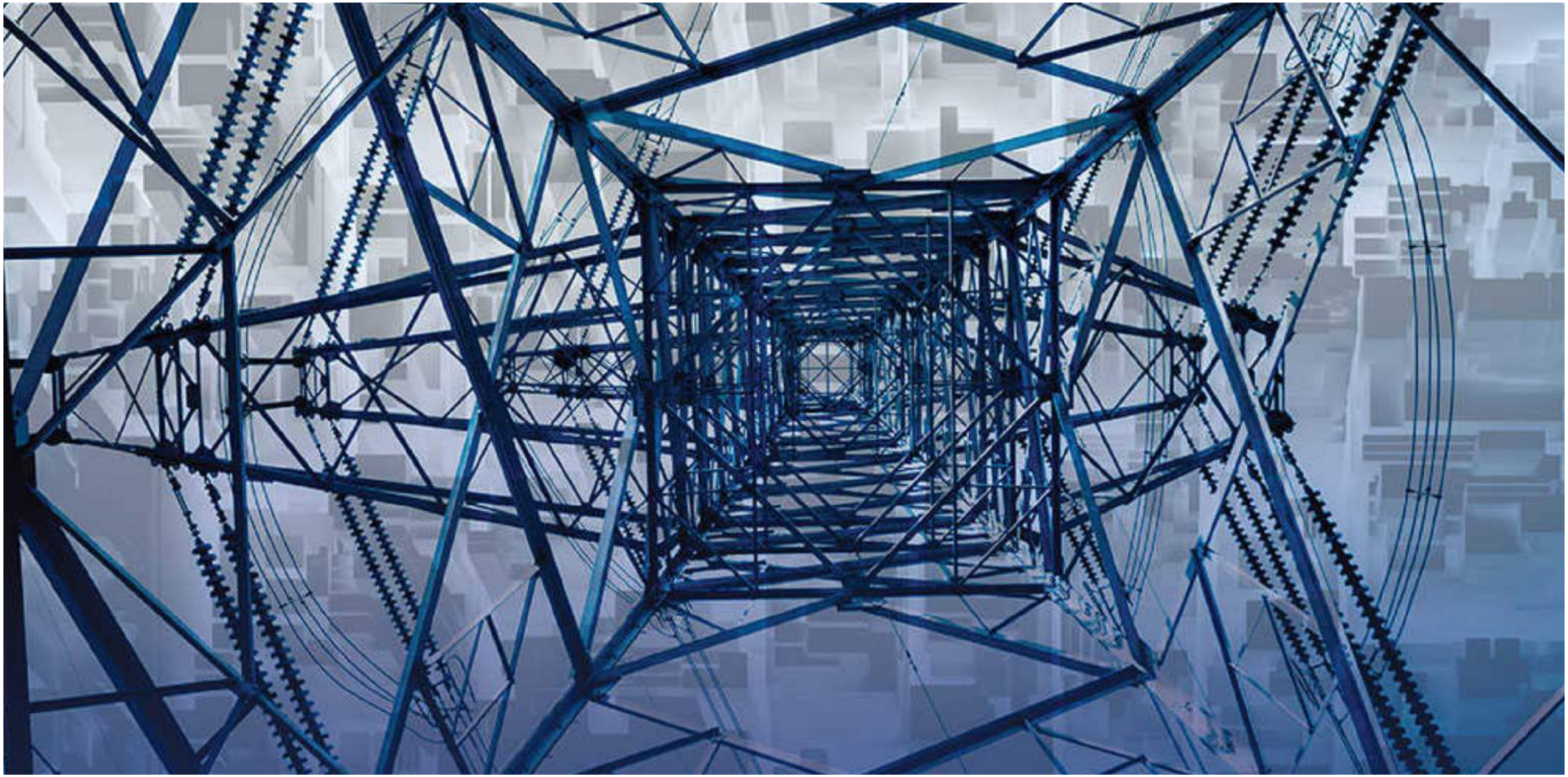
5

"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

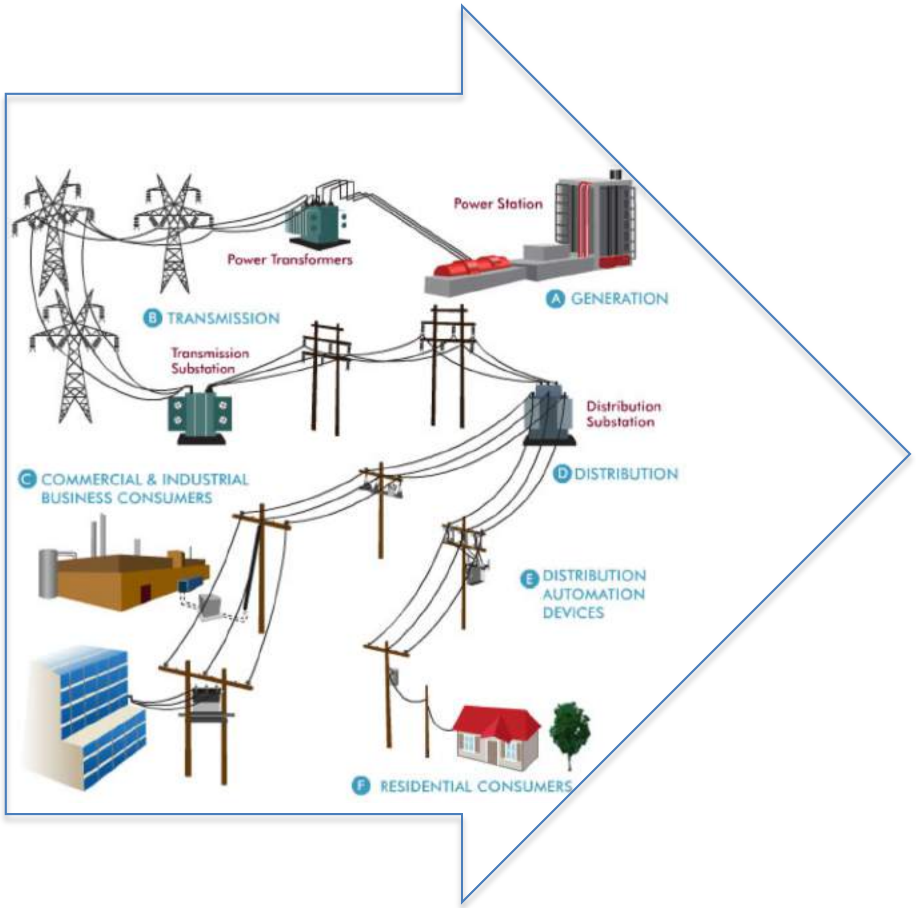
How to do it?

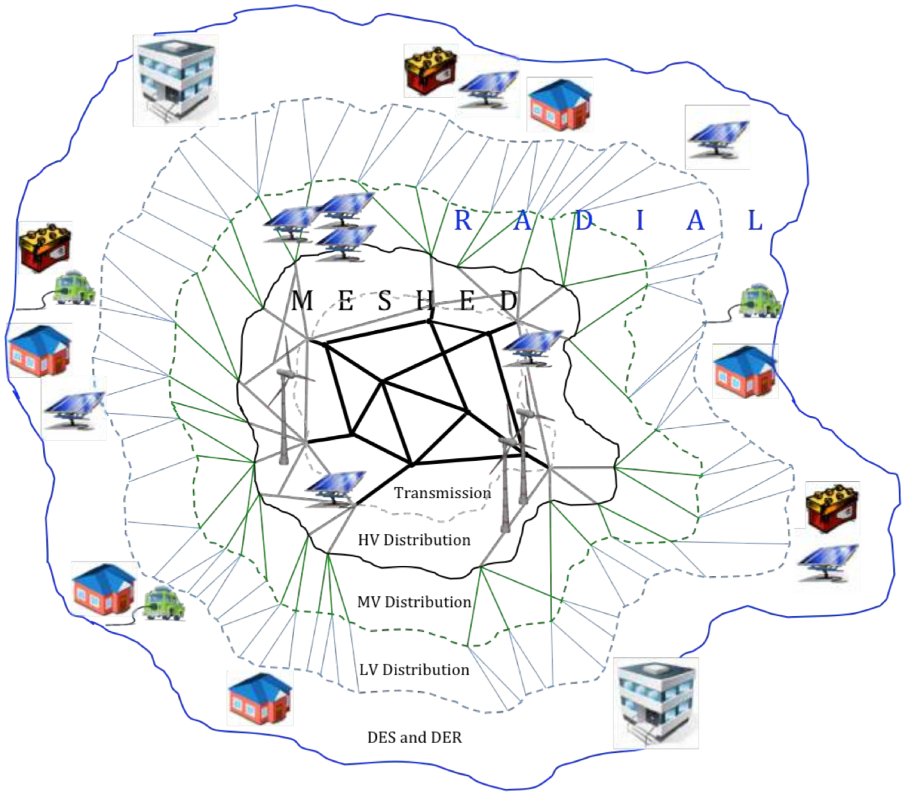


1
Crear un sistema eficiente y global de precios y cargos regulados

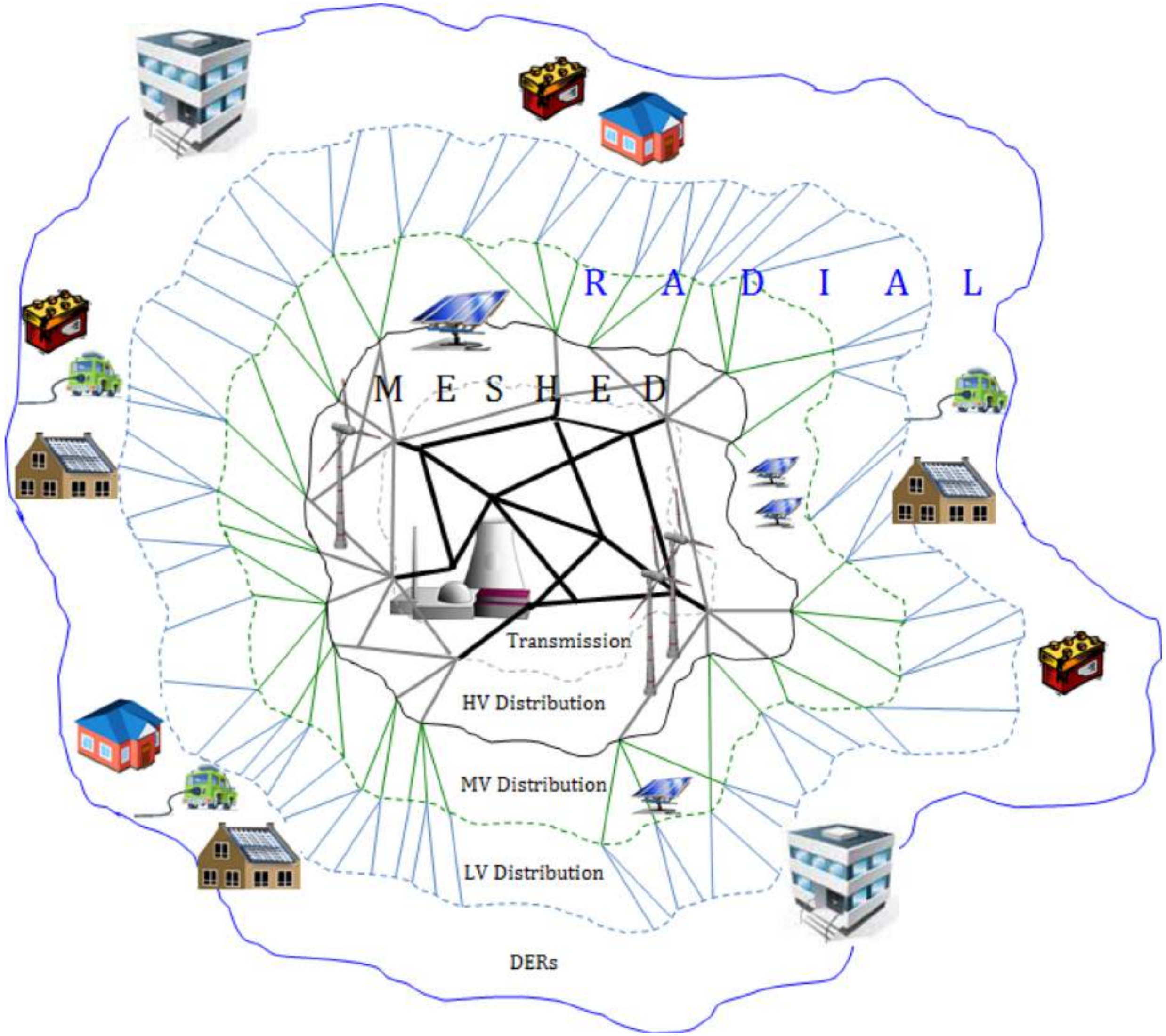

Prices & signals are
the nervous system
of the electricity sector,
reaching everywhere

A mindset change



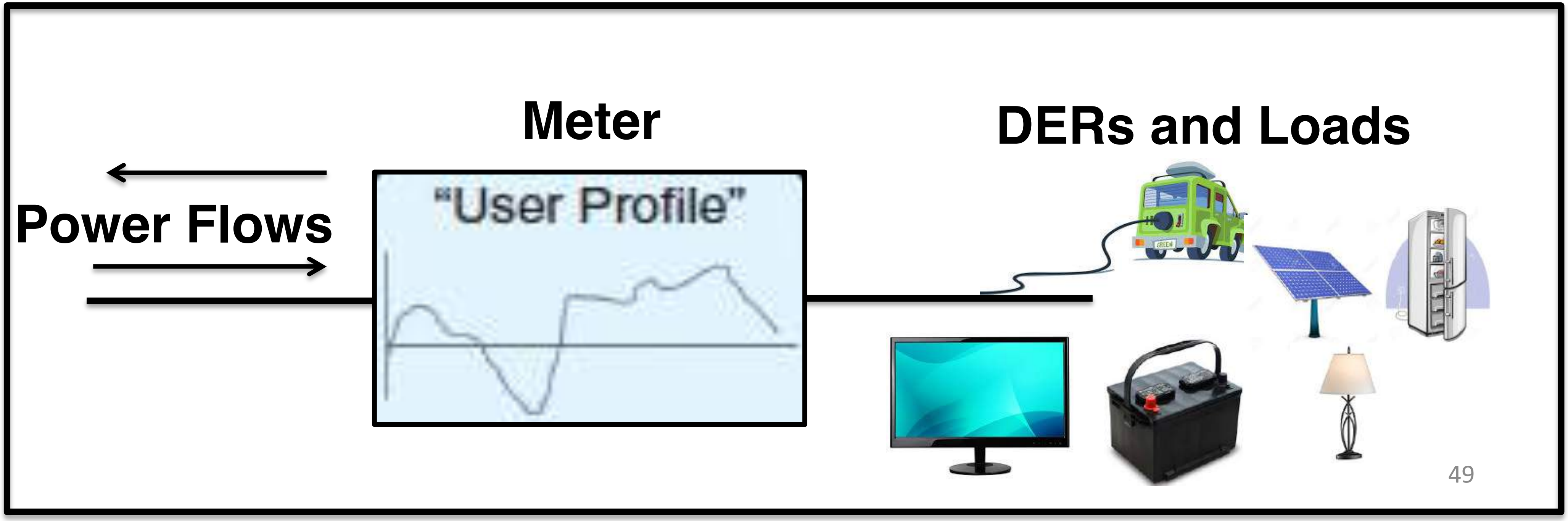


Create a comprehensive & efficient system of prices & charges *(Like a nervous system, reaching every corner of the power system)*



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**.

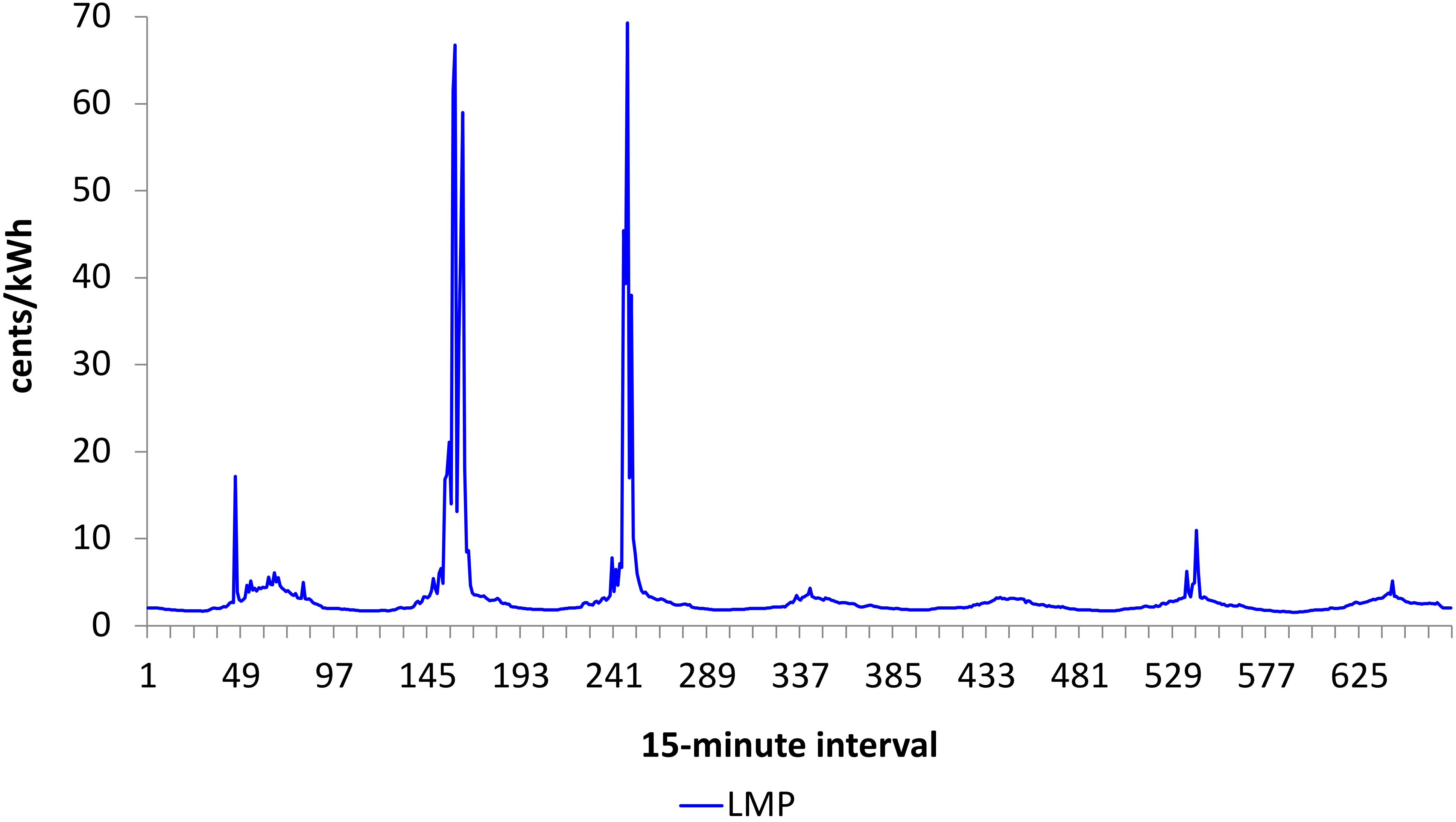
This requires the use of **advanced meters**



Let's do it one step at a time…

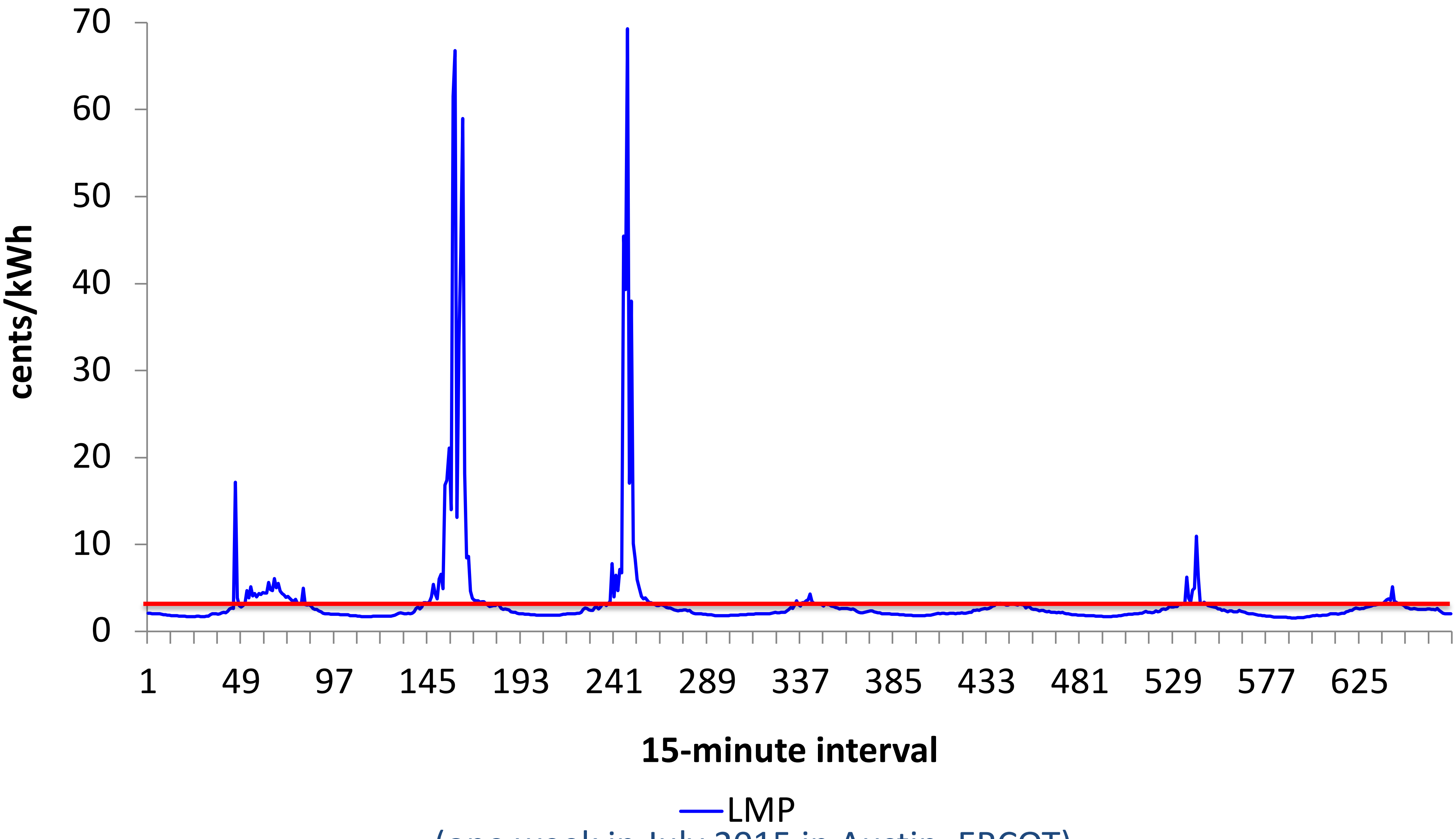
➡ Reflect **time differentiation** in the energy charges

Capture the wholesale energy price evolution in time



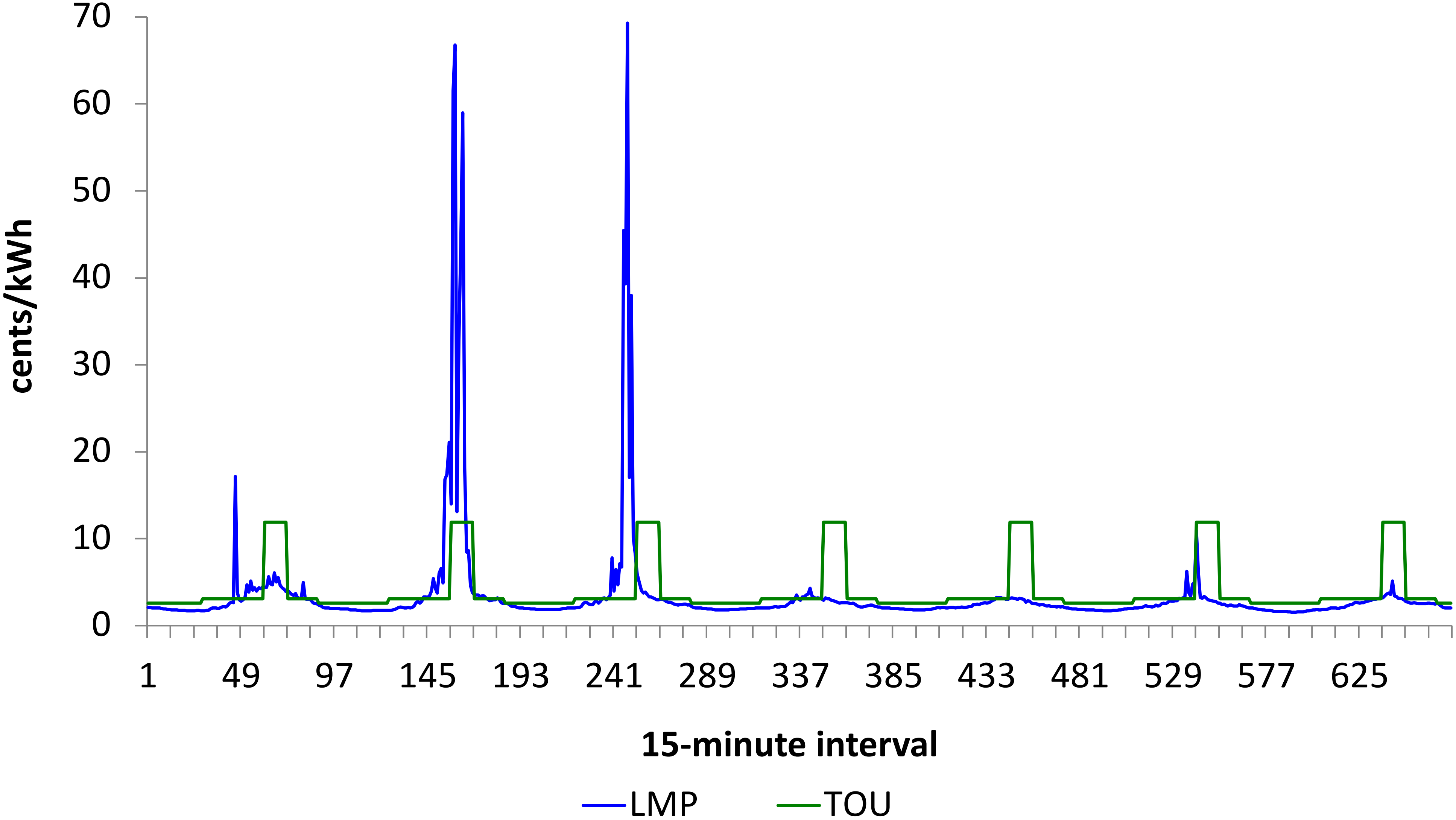
(one week in July 2015 in Austin, ERCOT)

… 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)



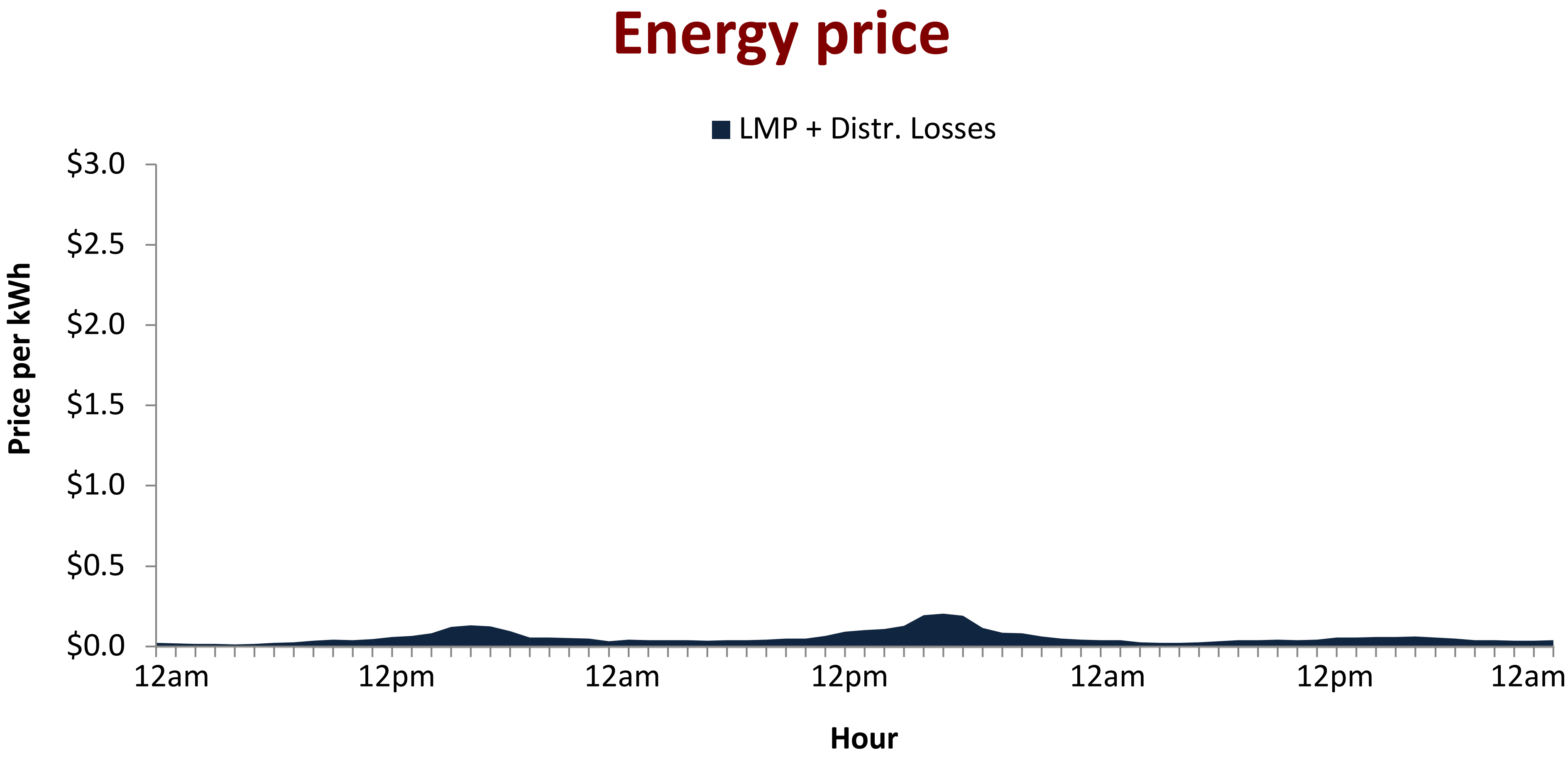
(one week in July 2015 in Austin, ERCOT)

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)*

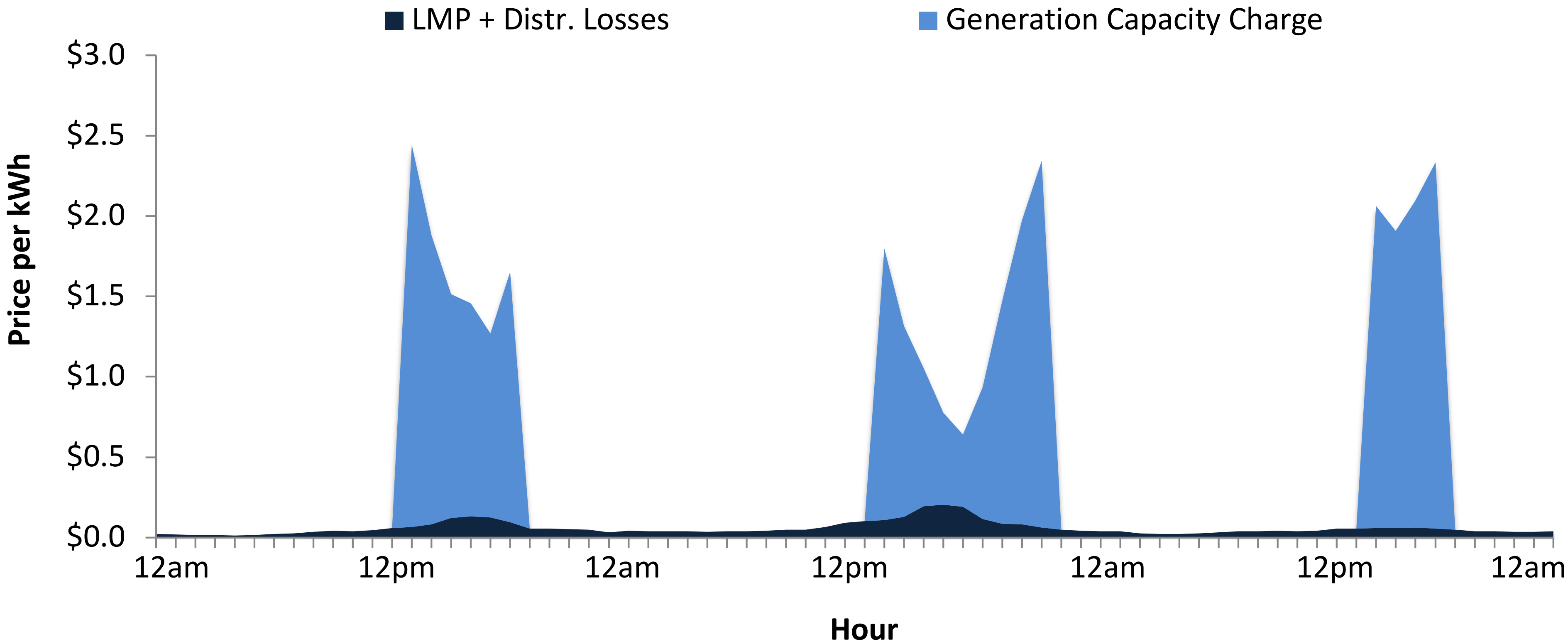
Add peak-coincident consumption and injection capacity charges for network & firm generation



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

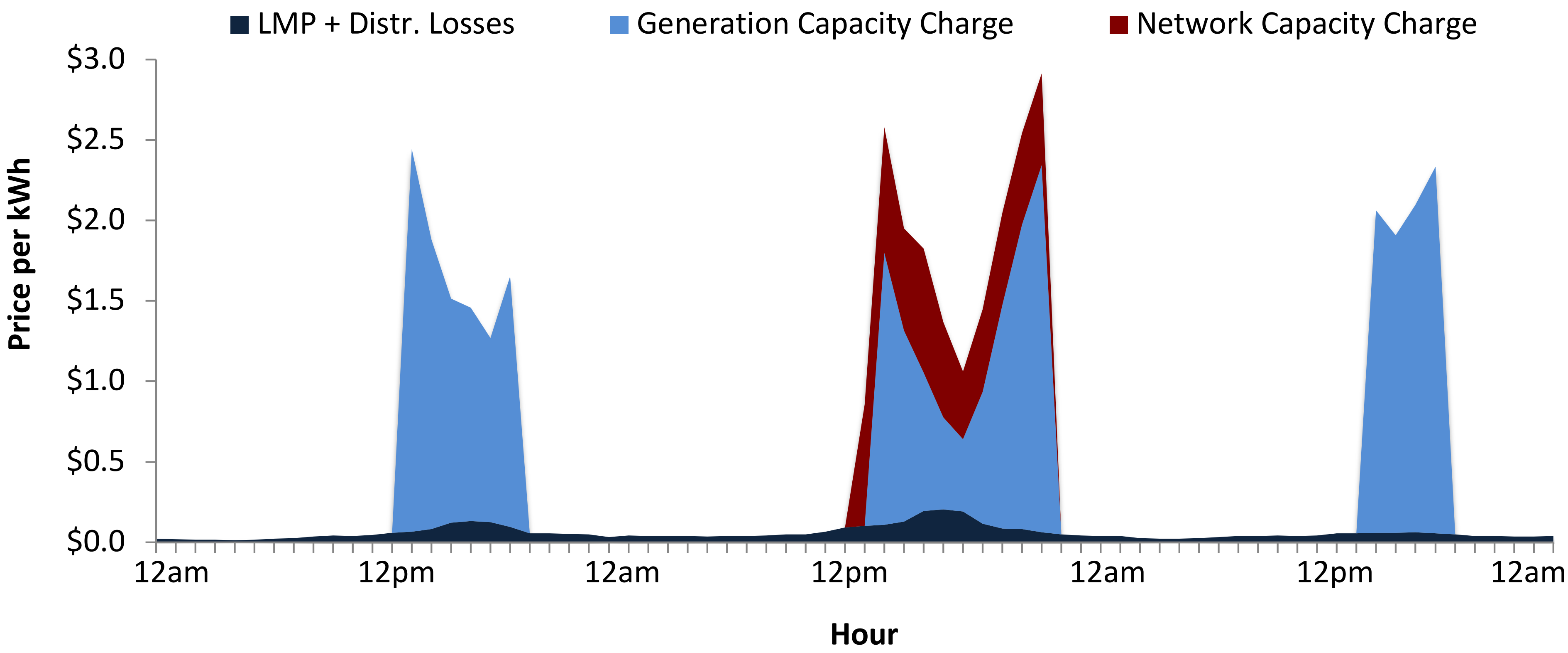
Energy price + generation capacity charge



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



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

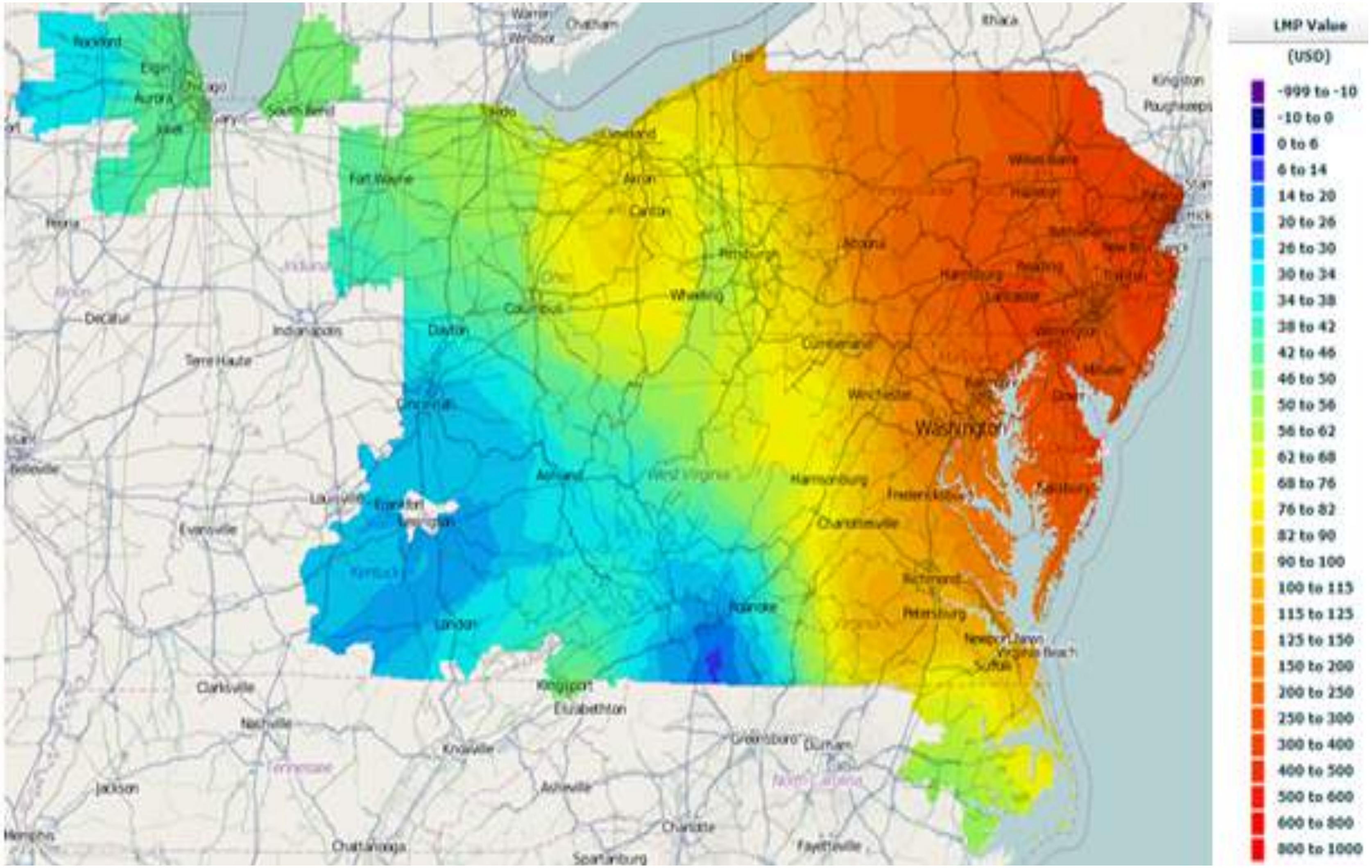
Let's do it one step at a time…

- 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

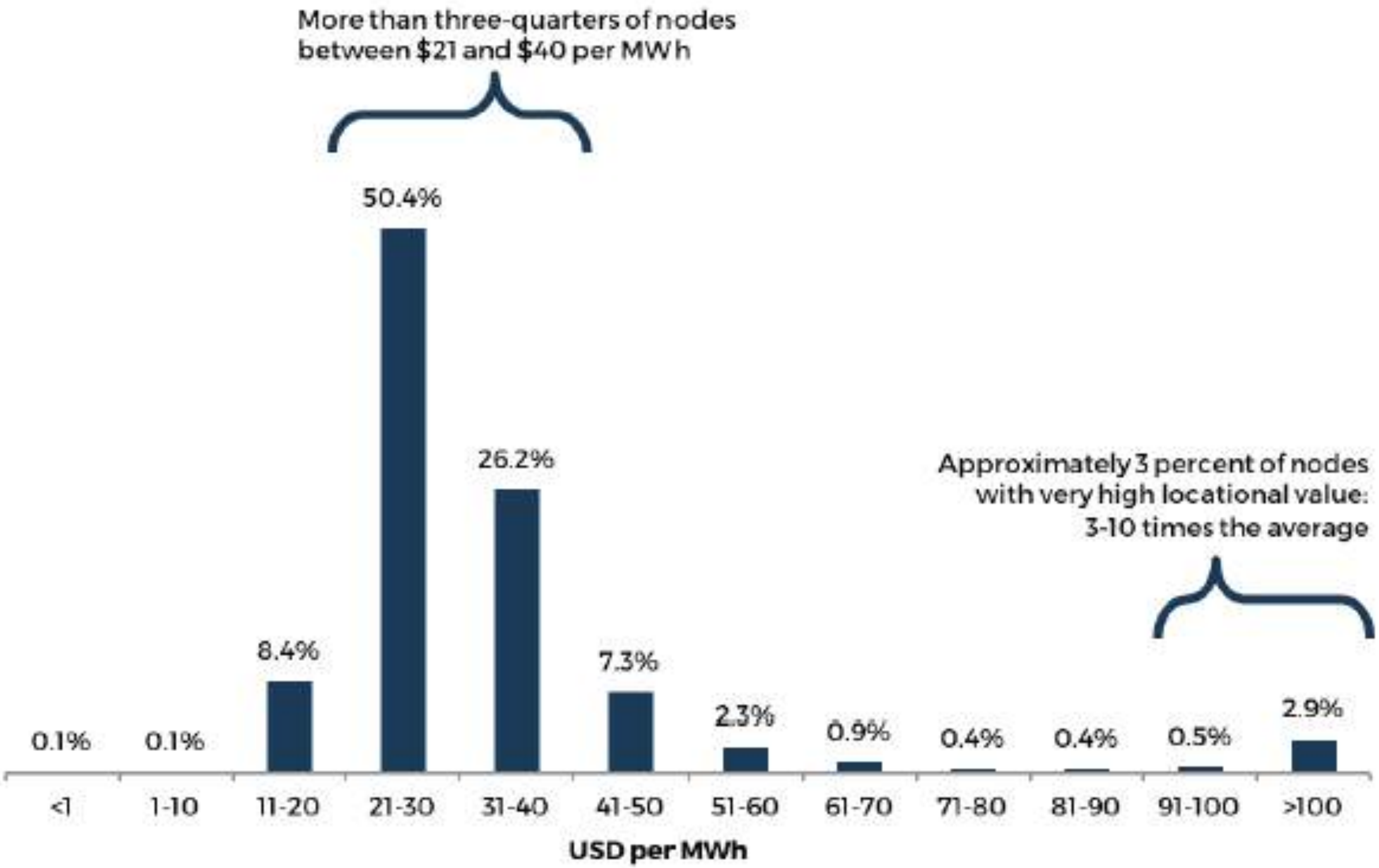
Bidding zones in European market coupling

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

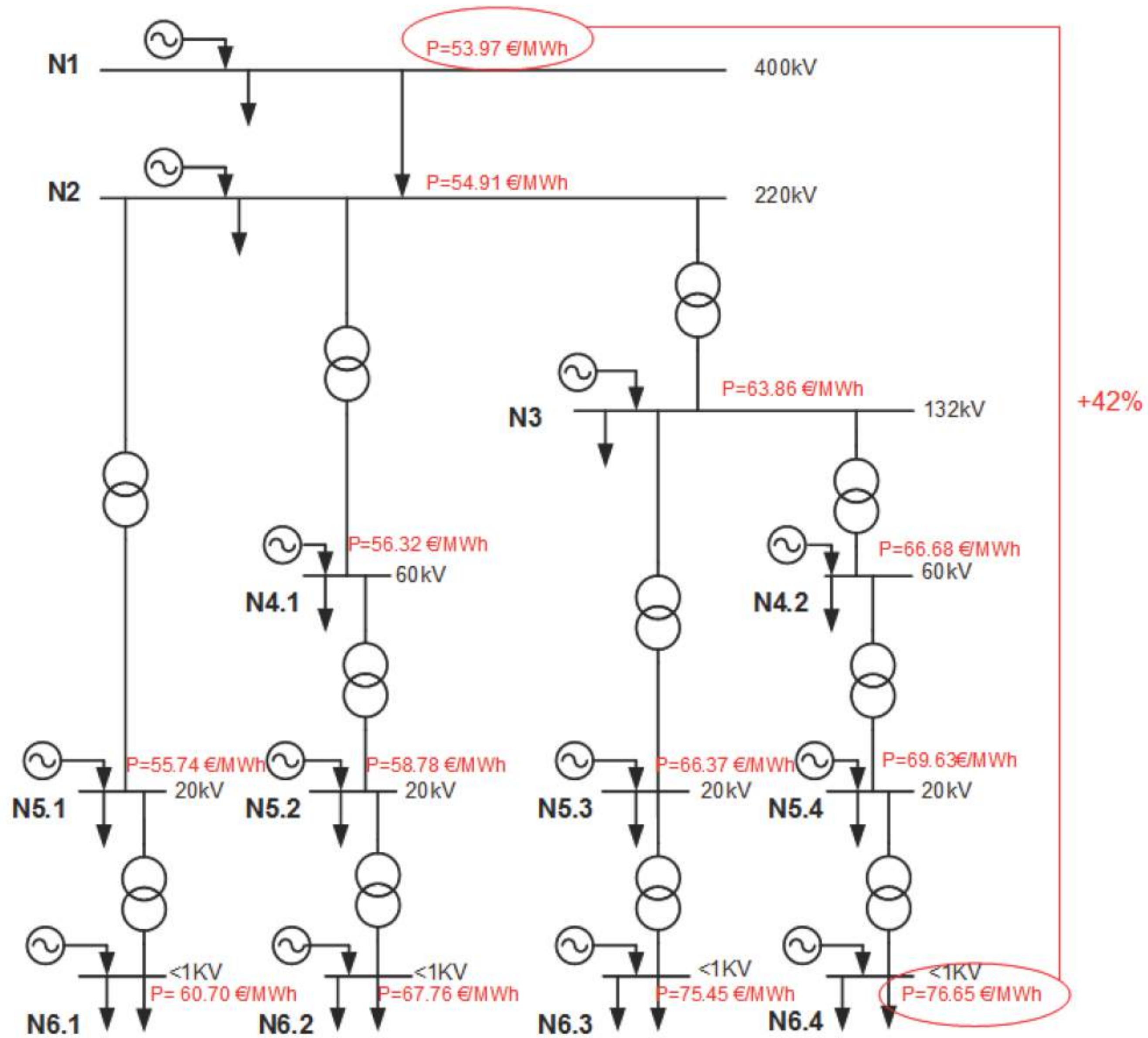


Wholesale LMP variation across more than 11,000 PJM nodes on July 19, 2015, at 4:05 pm

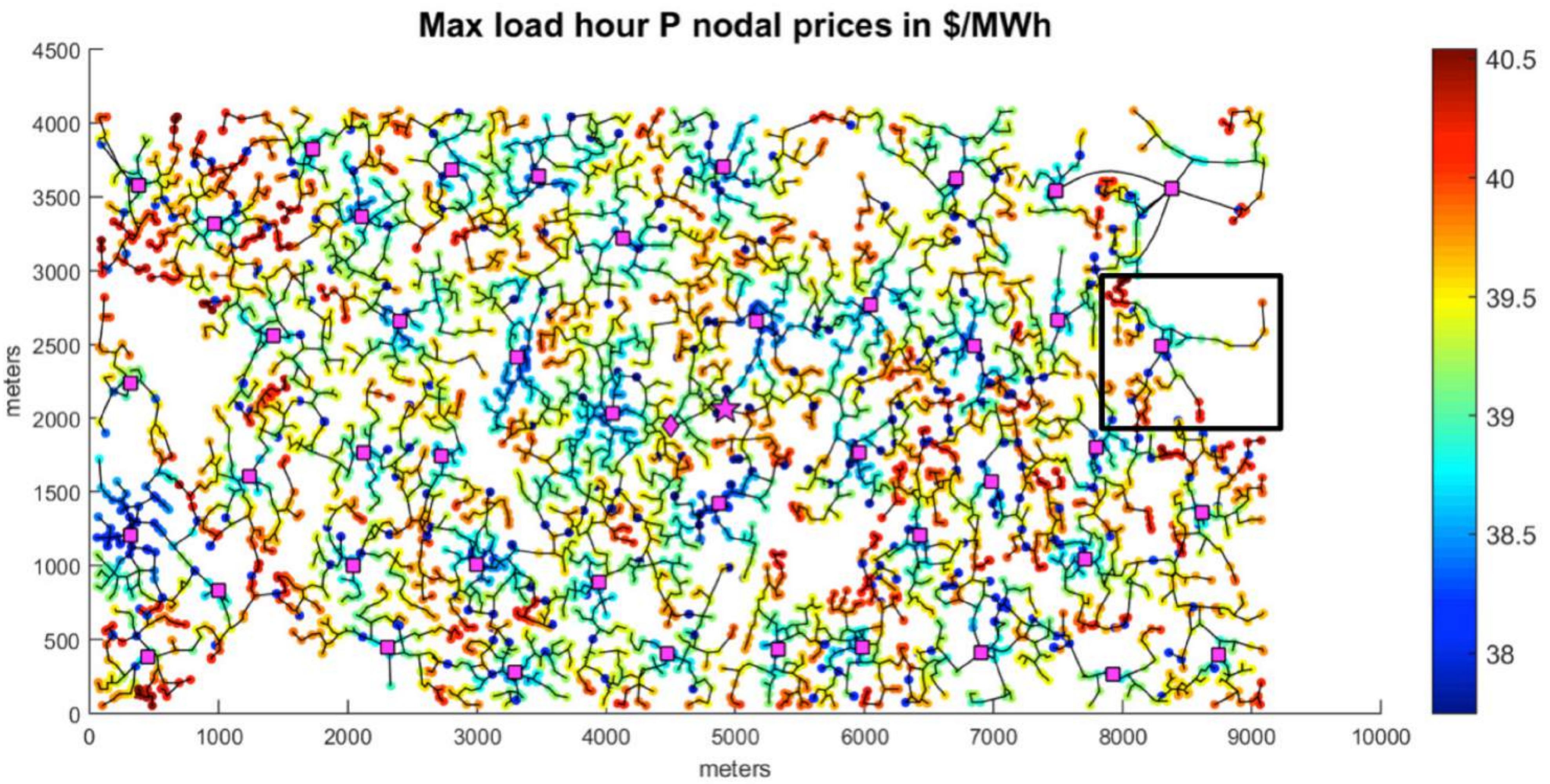
Distribution of 2015 Average Nodal LMPs in PJM



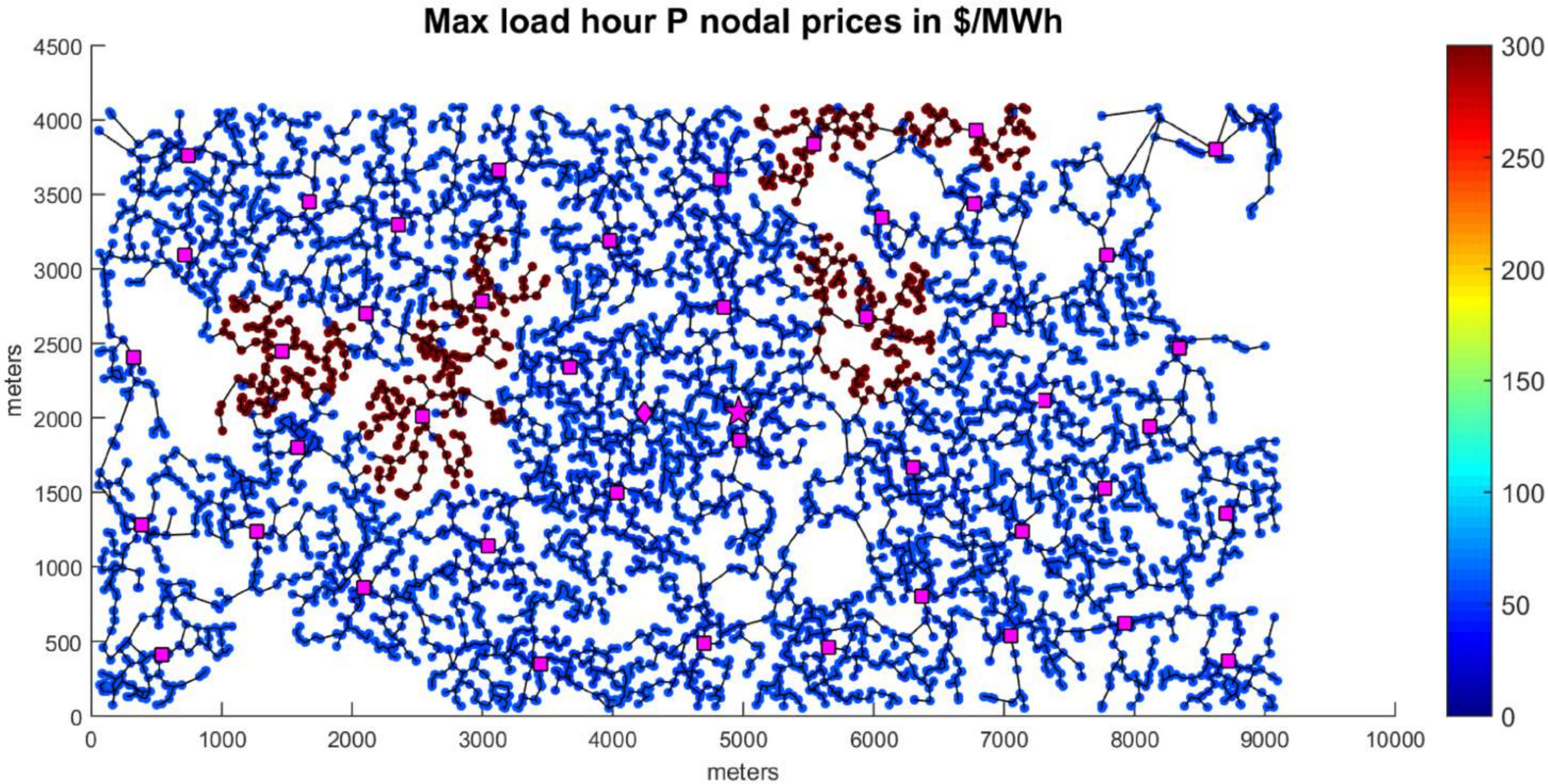
The marginal impact of losses on LMPs at distribution level may create significant price differences



Getting deep into distribution
(just losses)



Getting deep into distribution
(losses & network constraints)



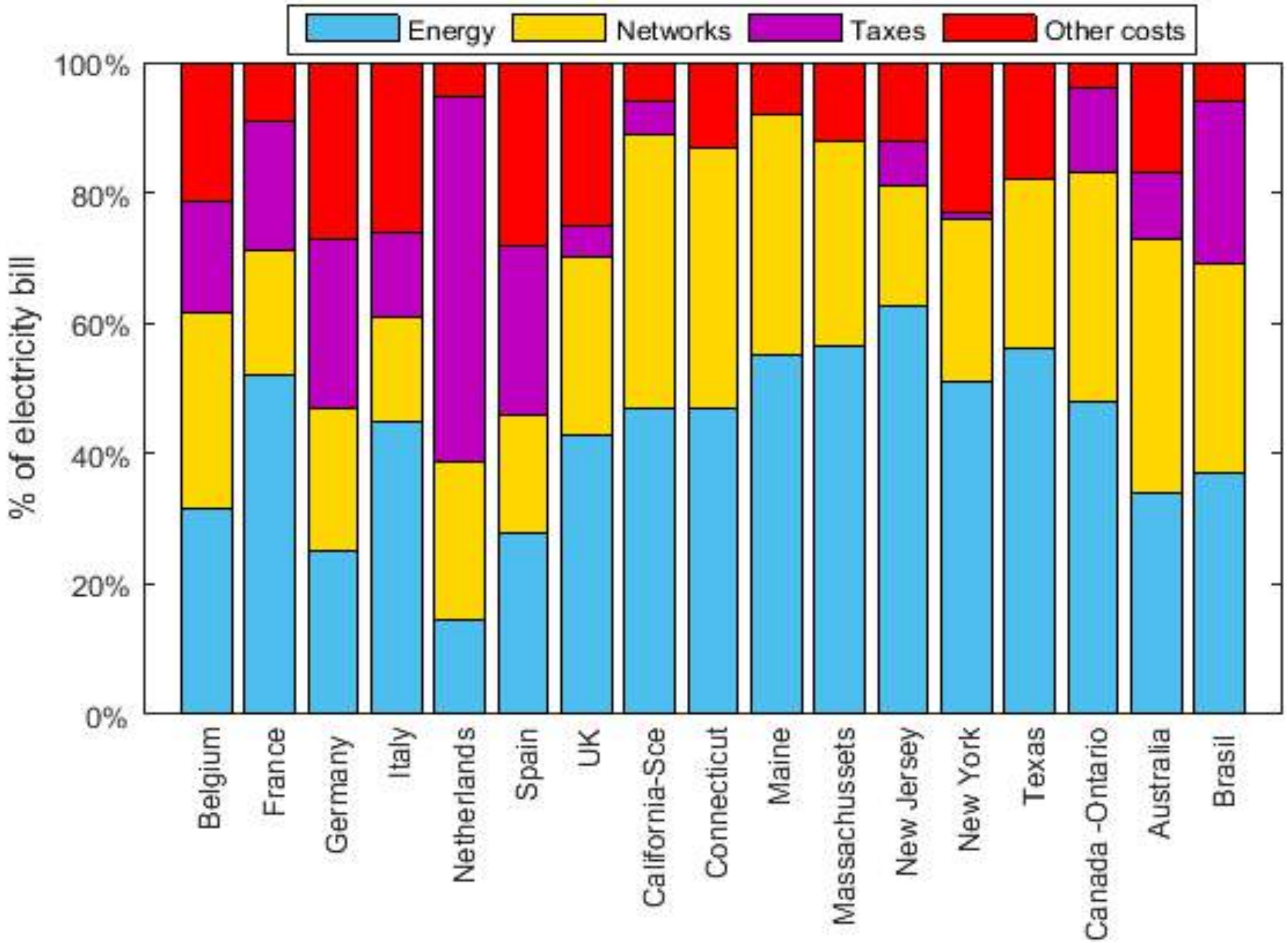
And the most important one…

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

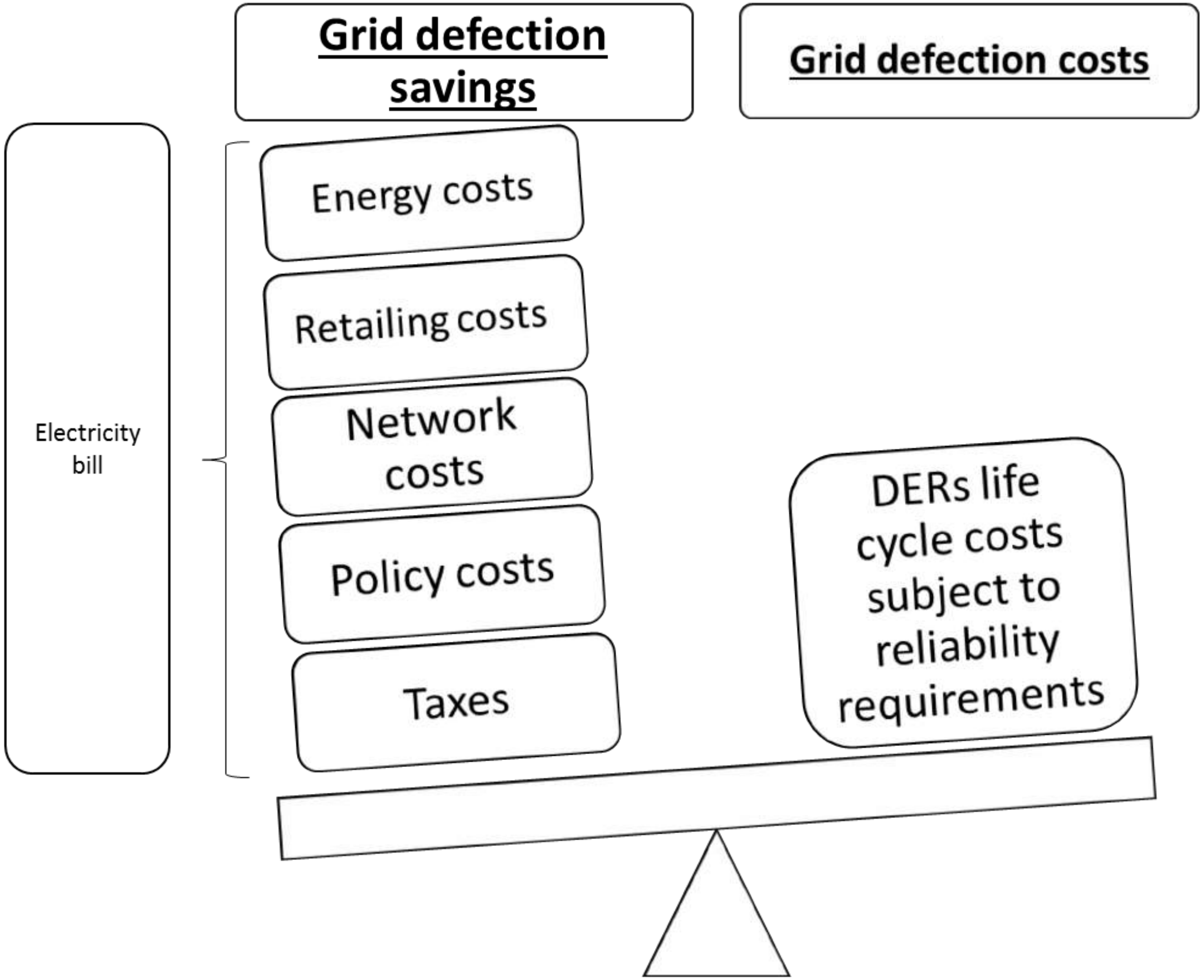
And as a consequence…

Let’s do it one step at a time…

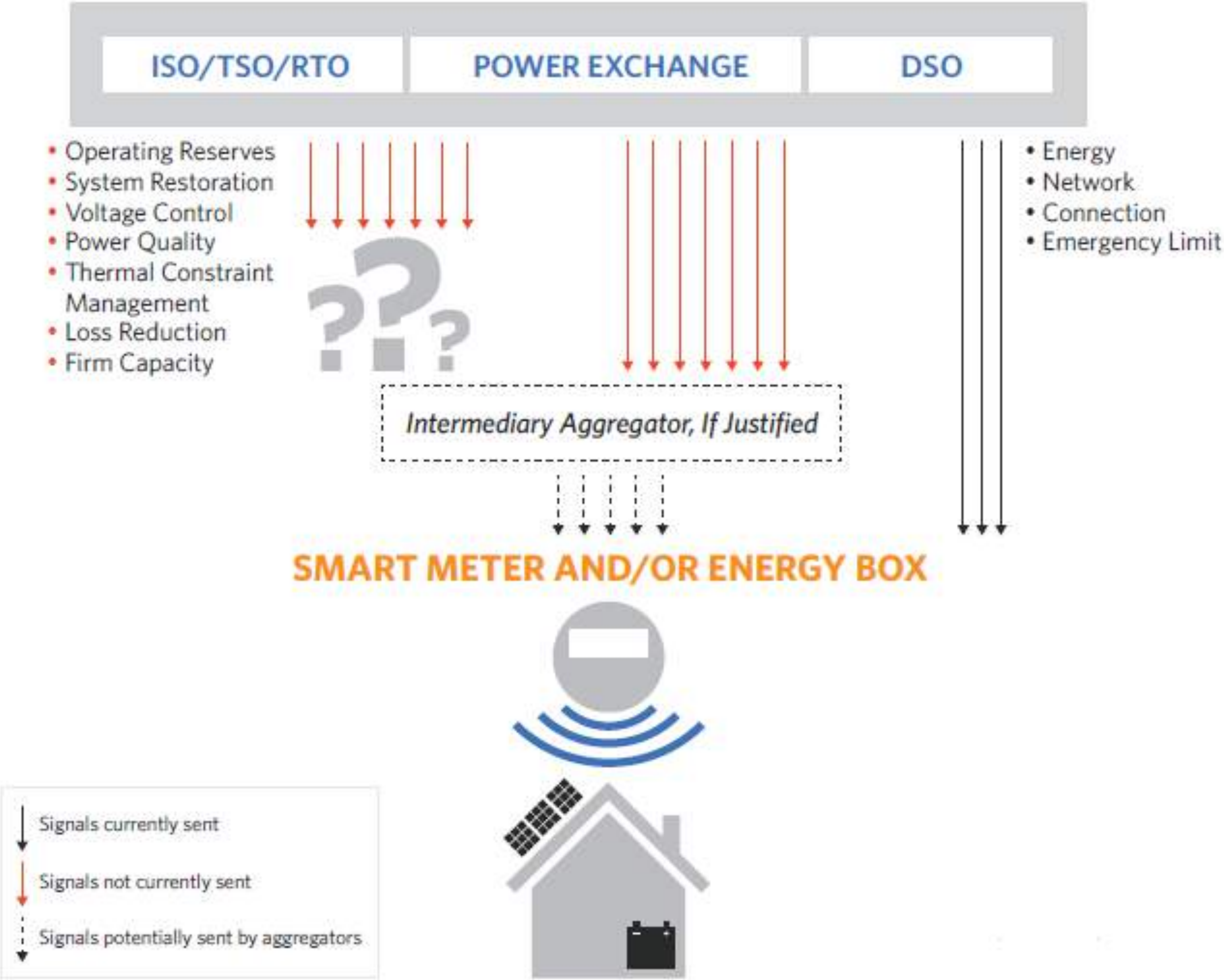
- Reflect **time differentiation** in the energy charges
- Apply forward-looking **peak-coincident capacity charges** for networks & firm generation capacity *(if this is the case)*
- Progressively increase the **locational component** of prices & charges
- **Policy & residual network costs** should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



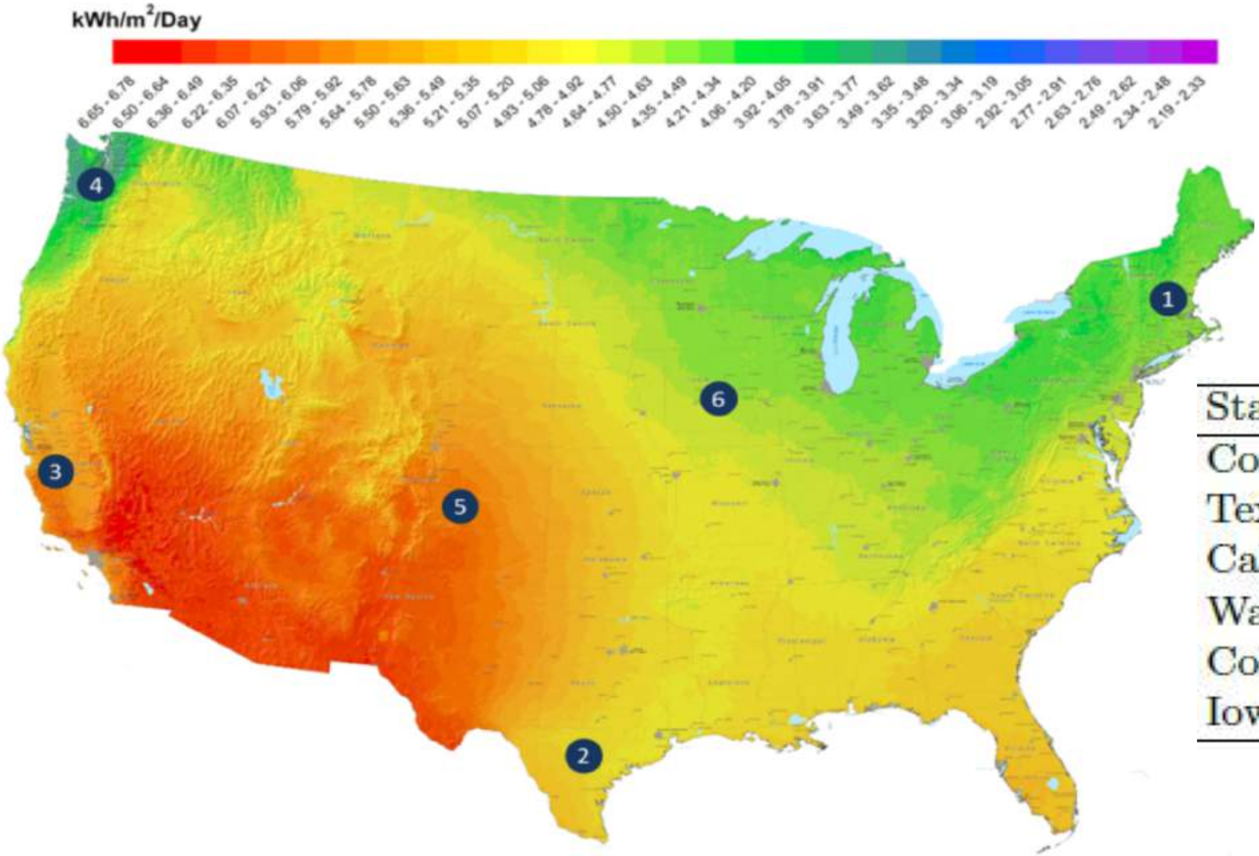
Too much complexity for the small & medium customers?


ISO/TSO/RTO
POWER EXCHANGE
DSO
• Operating Reserves
• System Restoration
• Voltage Control
• Power Quality
• Thermal Constraint Management
• Loss Reduction
• Firm Capacity
• Energy
• Network
• Connection
• Emergency Limit
Intermediary Aggregator, If Justified
SMART METER AND/OR ENERGY BOX
Signals currently sent
Signals not currently sent
Signals potentially sent by aggregators

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

2
Enhance distribution regulation

Case example to study the impact of distributed solar PV on total network costs

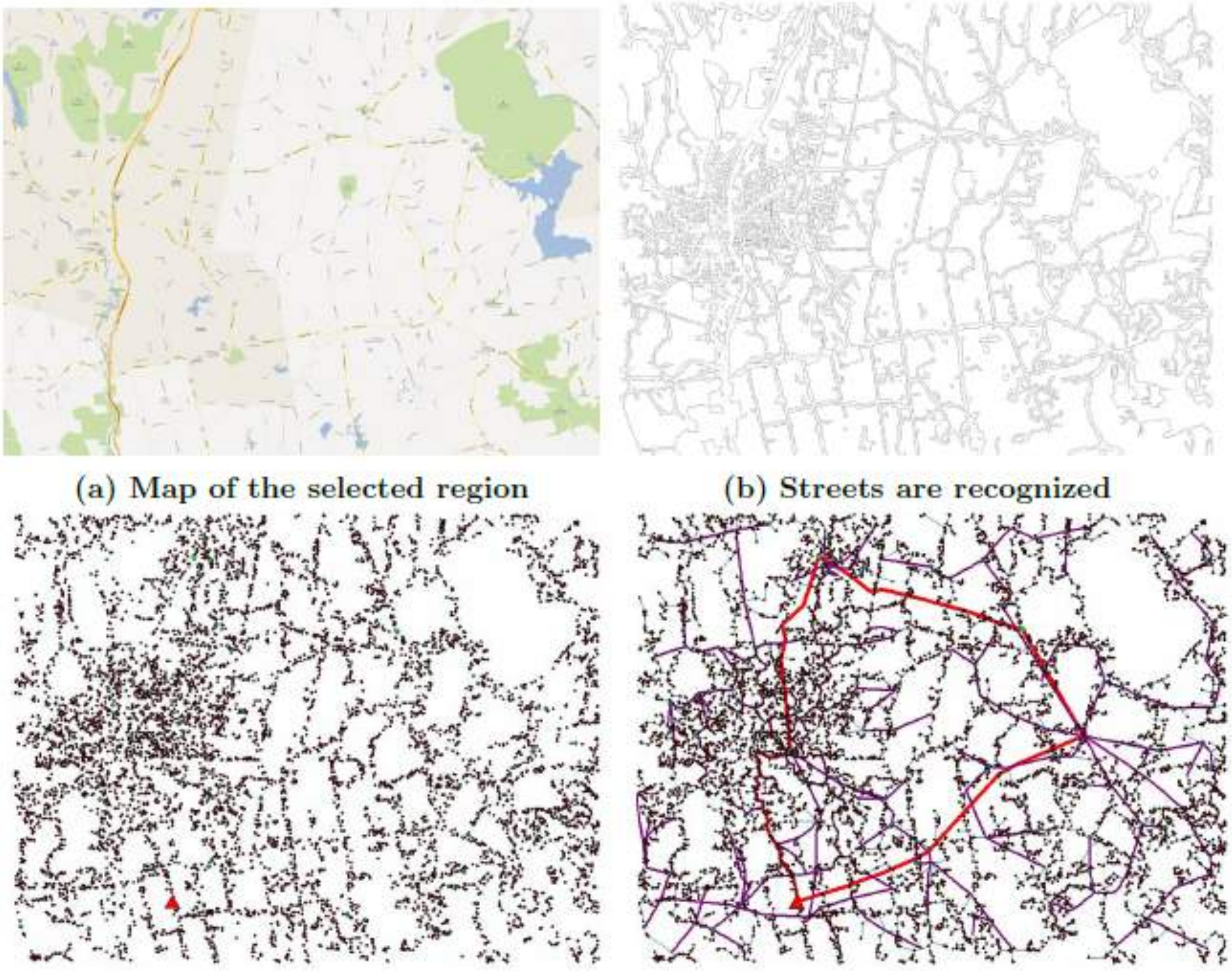


State	Rural	Urban
Connecticut	Torrington	Hartford
Texas	San Marcos	Austin
California	Lancaster	Los Angeles
Washington	Covington	Seattle
Colorado	Eaton	Boulder
Iowa	Altoona	Des Moines

6 locations x 2 cities/location x 3 load hypotheses/city x 8 solar penetration scenarios /load hypothesis = 288 cases

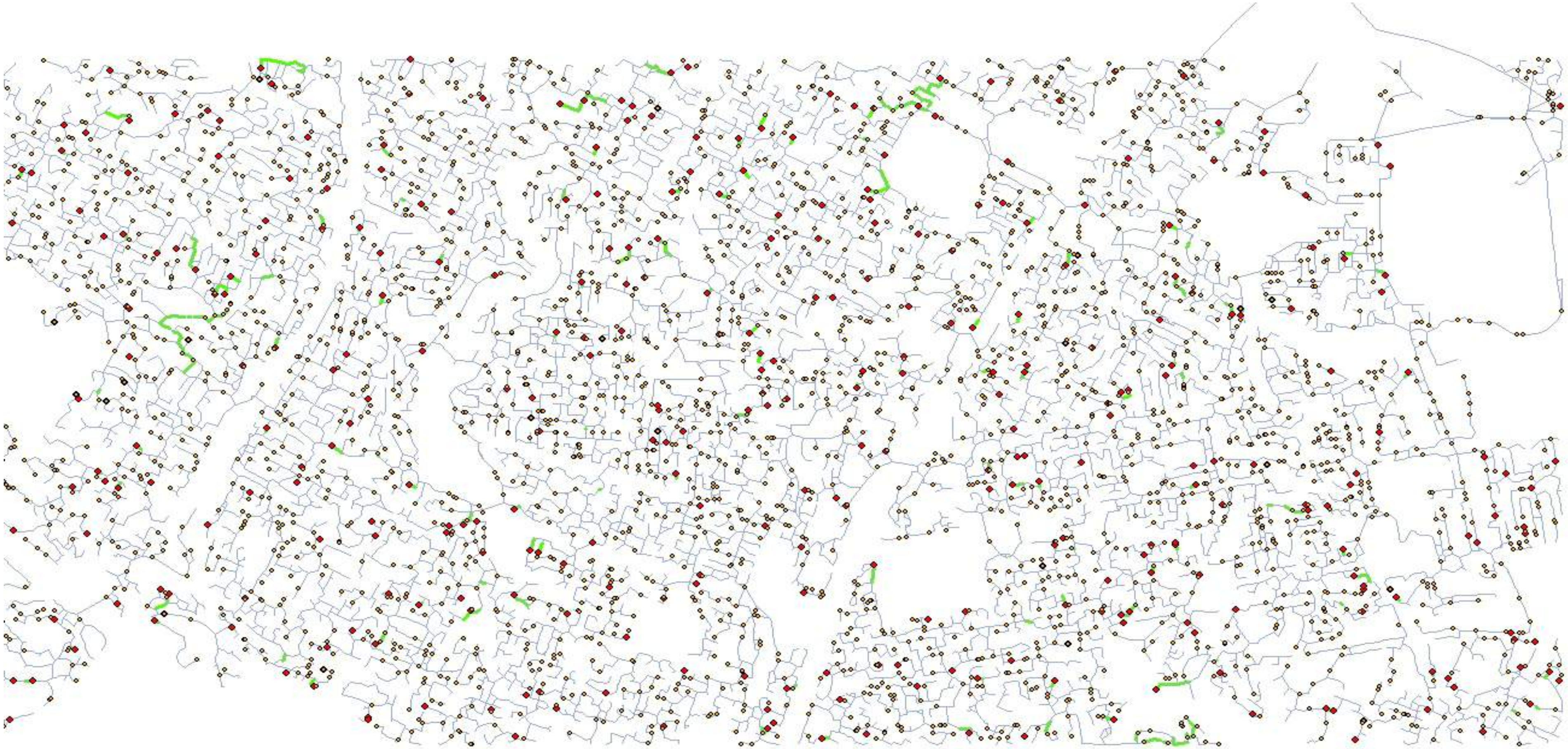
(*) From "MIT Future of Solar Study", with participation of IIT-Comillas

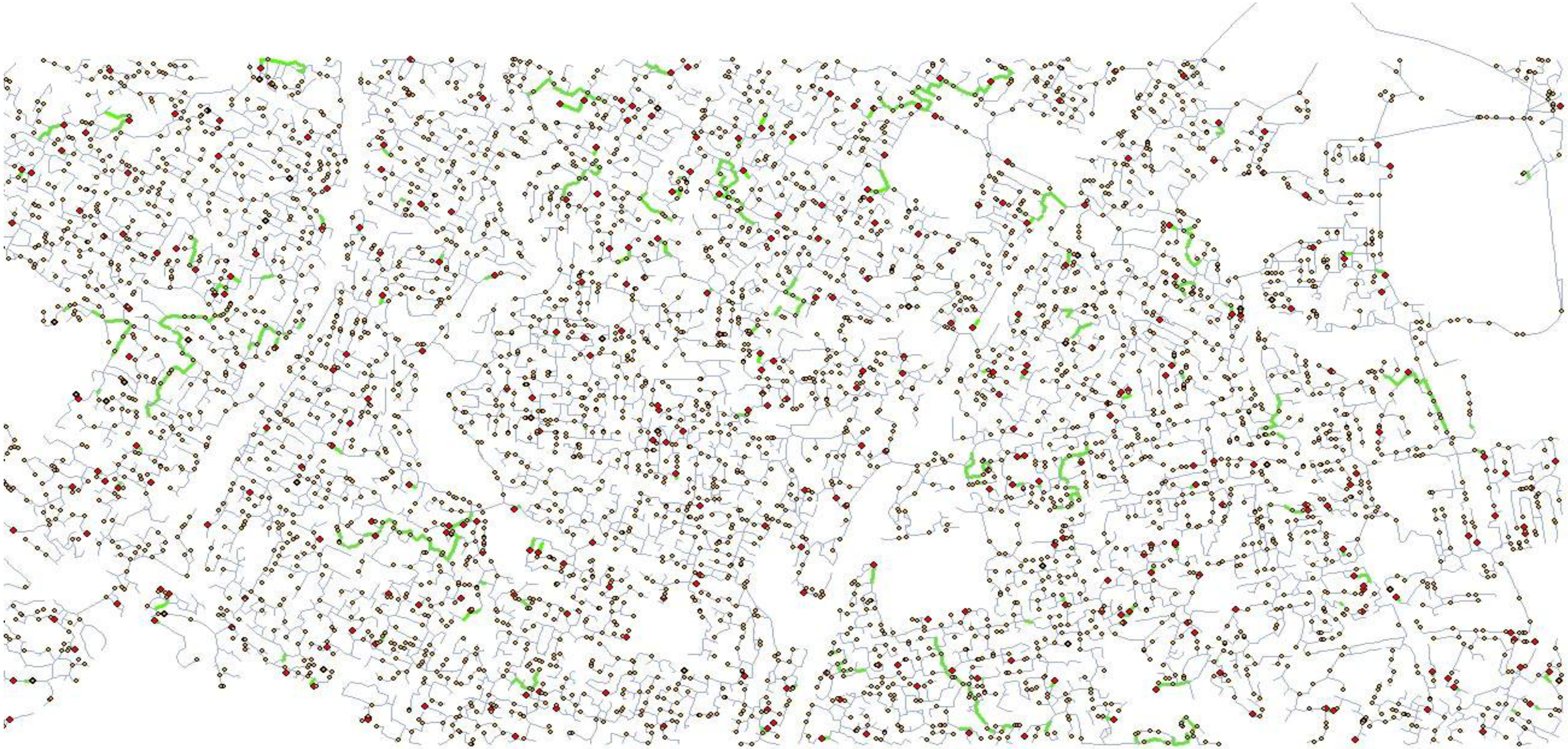
Construction of the reference cases

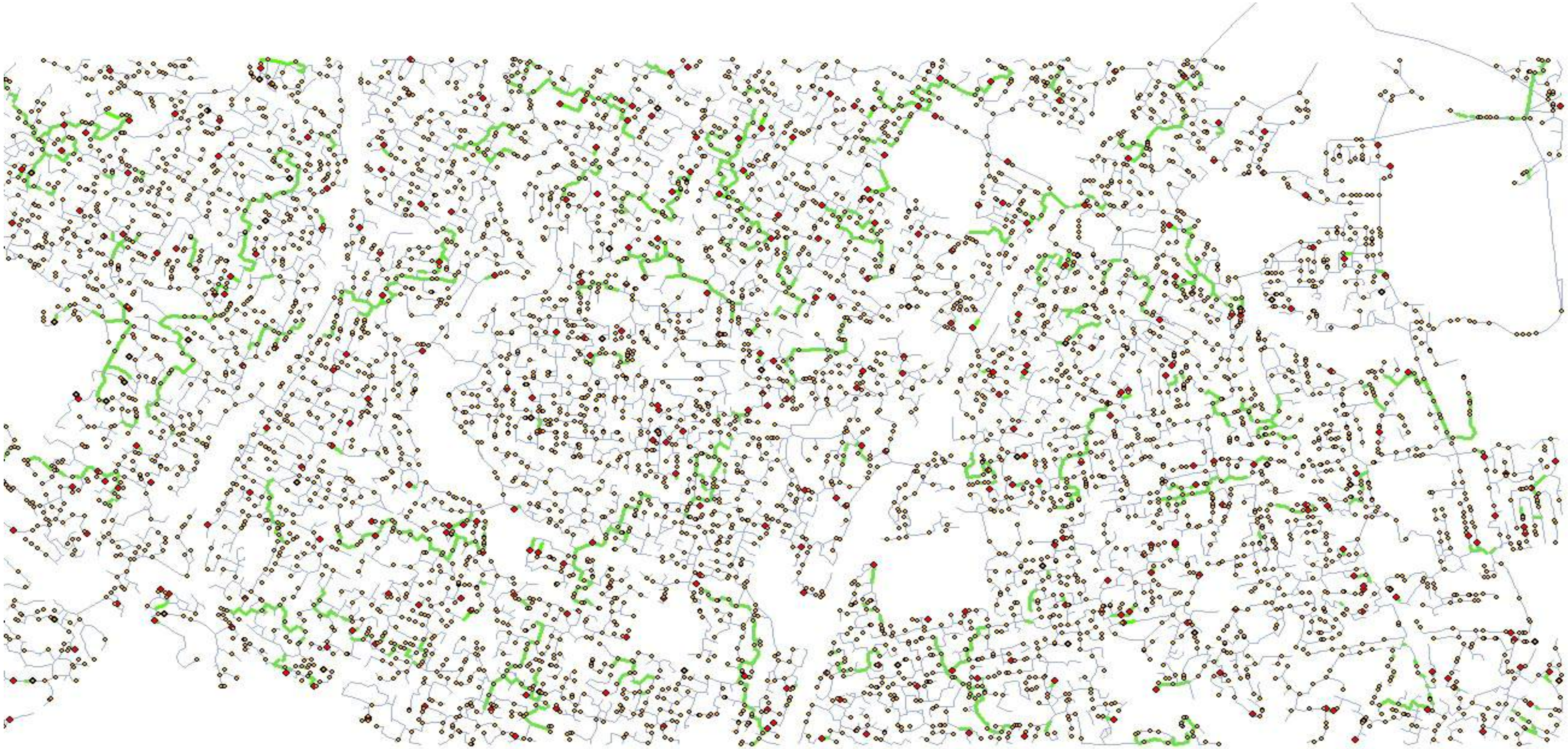


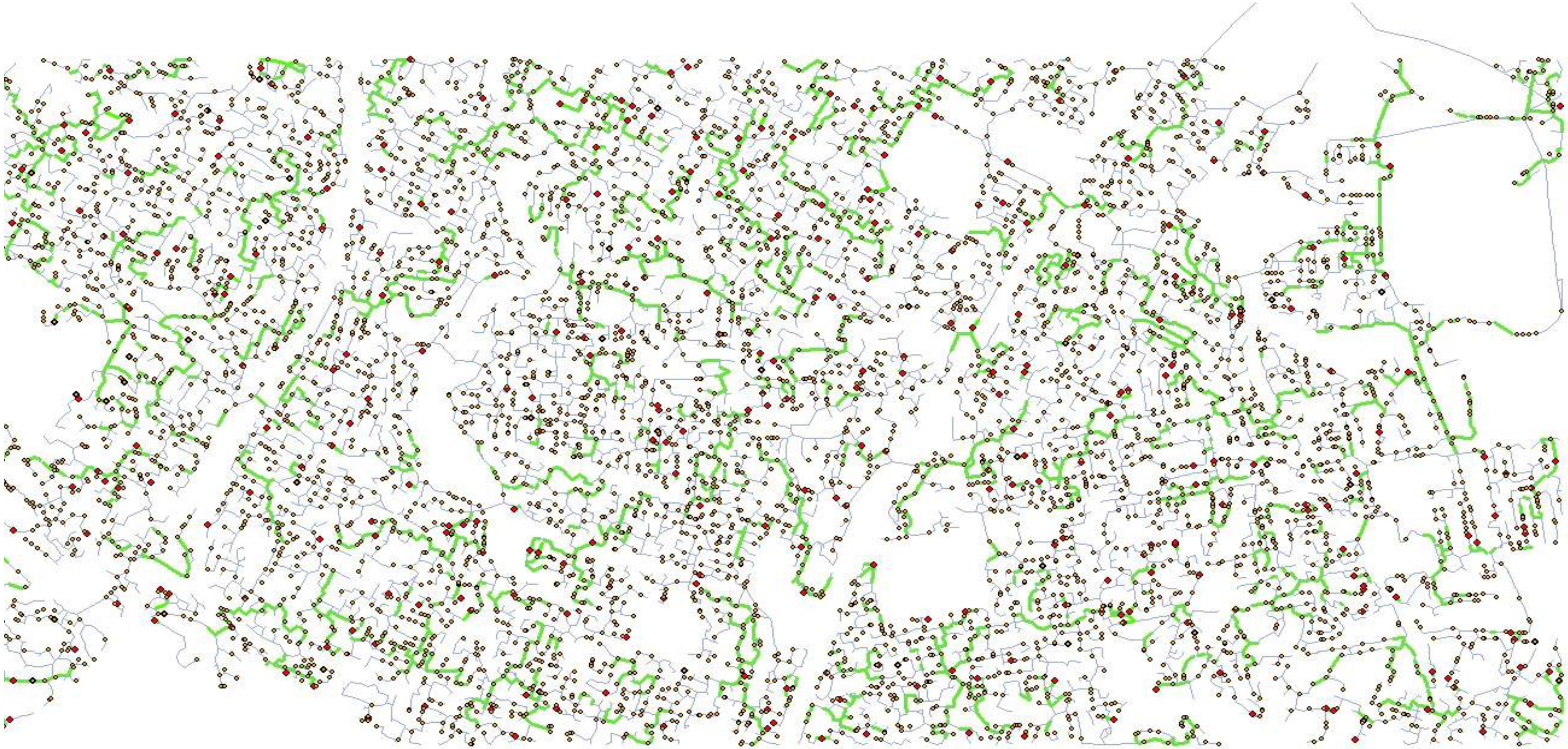
(a) Map of the selected region (b) Streets are recognized

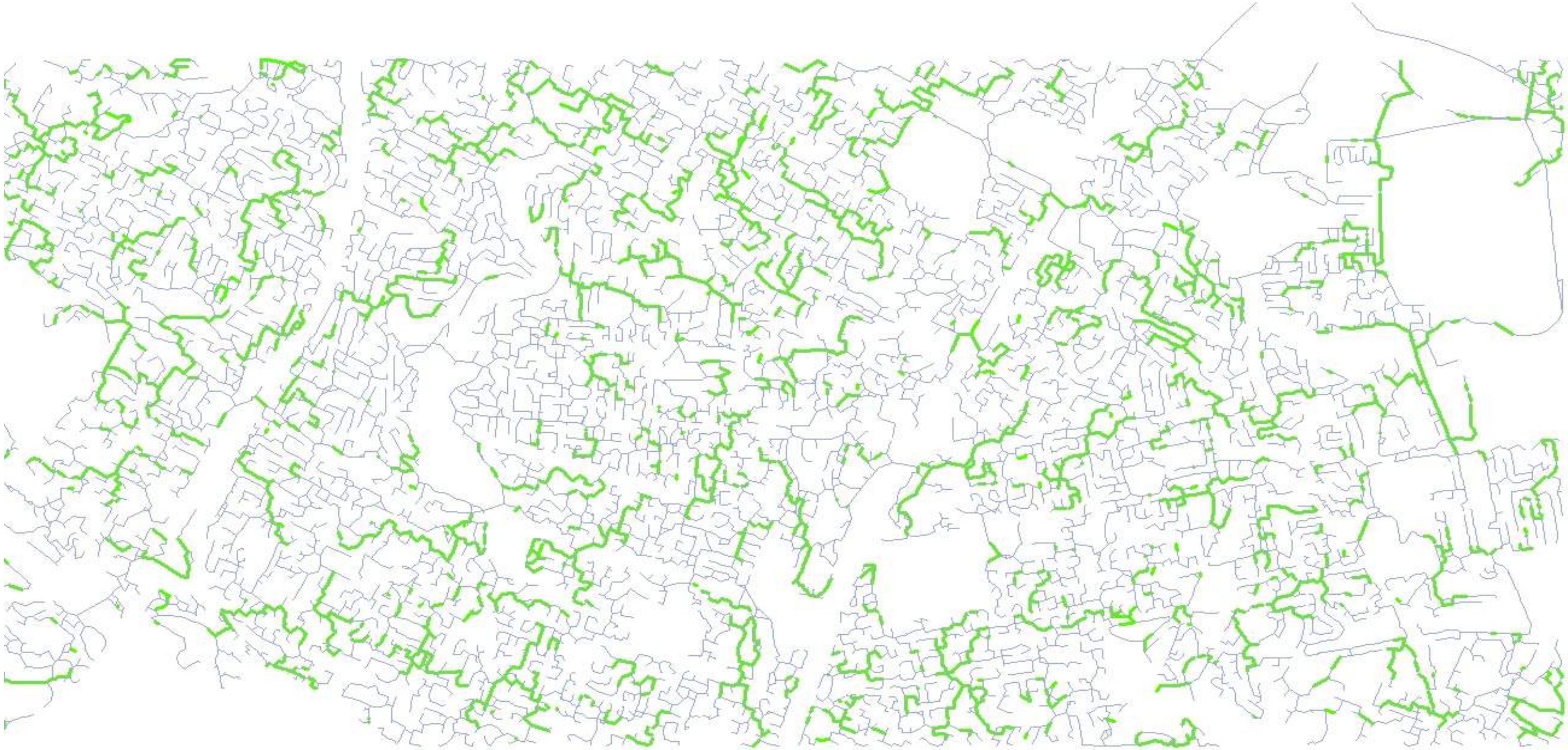
(c) Customers and substations (d) Base network



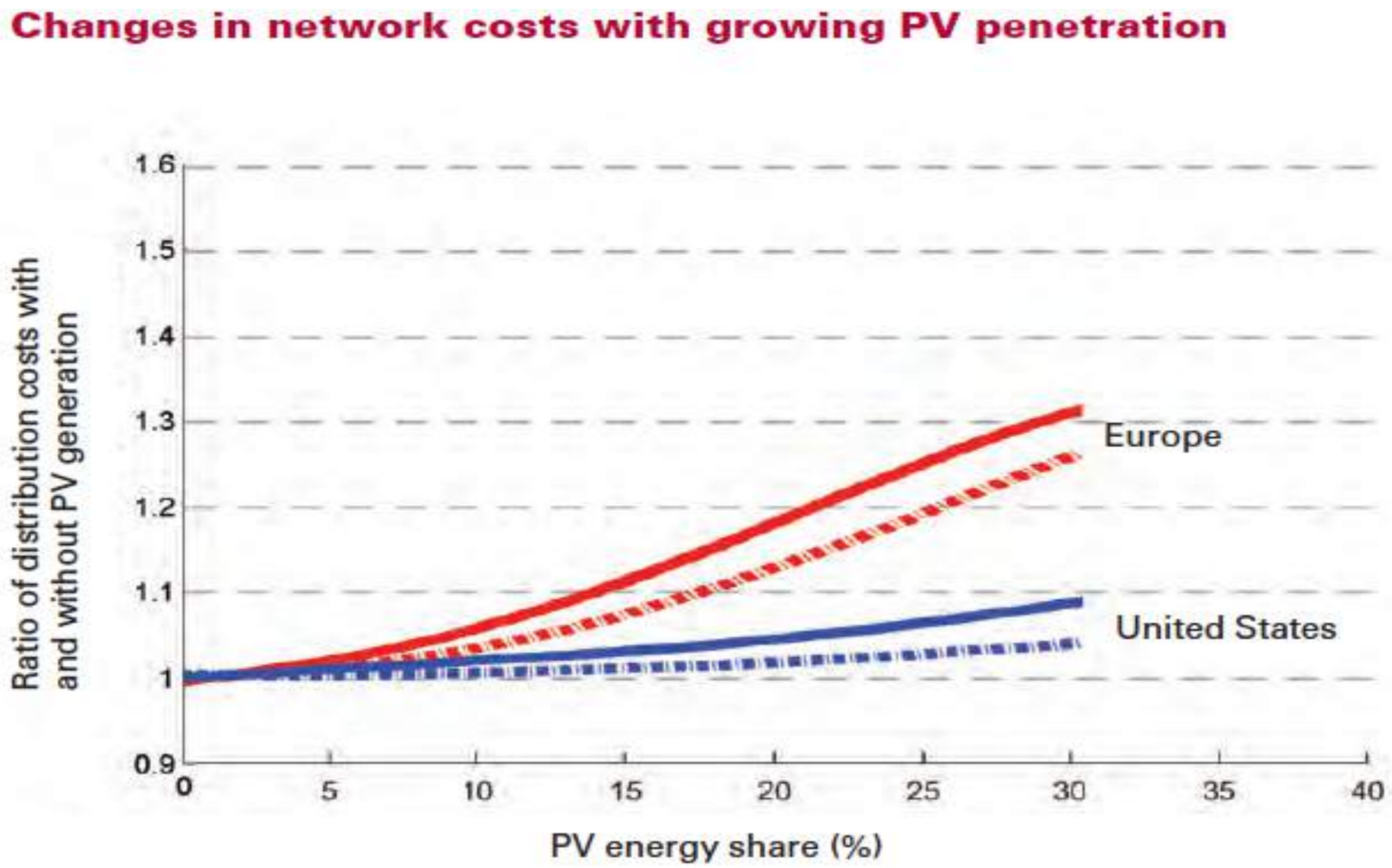








From the MIT "Future of Solar Study"



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

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

➡ **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**

3
Rethink 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

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

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

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
- **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 *(when applicable)*

Some DERs can only be deployed at a specific scale level…

… while others can be deployed at different scales

Utility Scale

C&I Scale

Residential Scale

Let us understand first 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?	

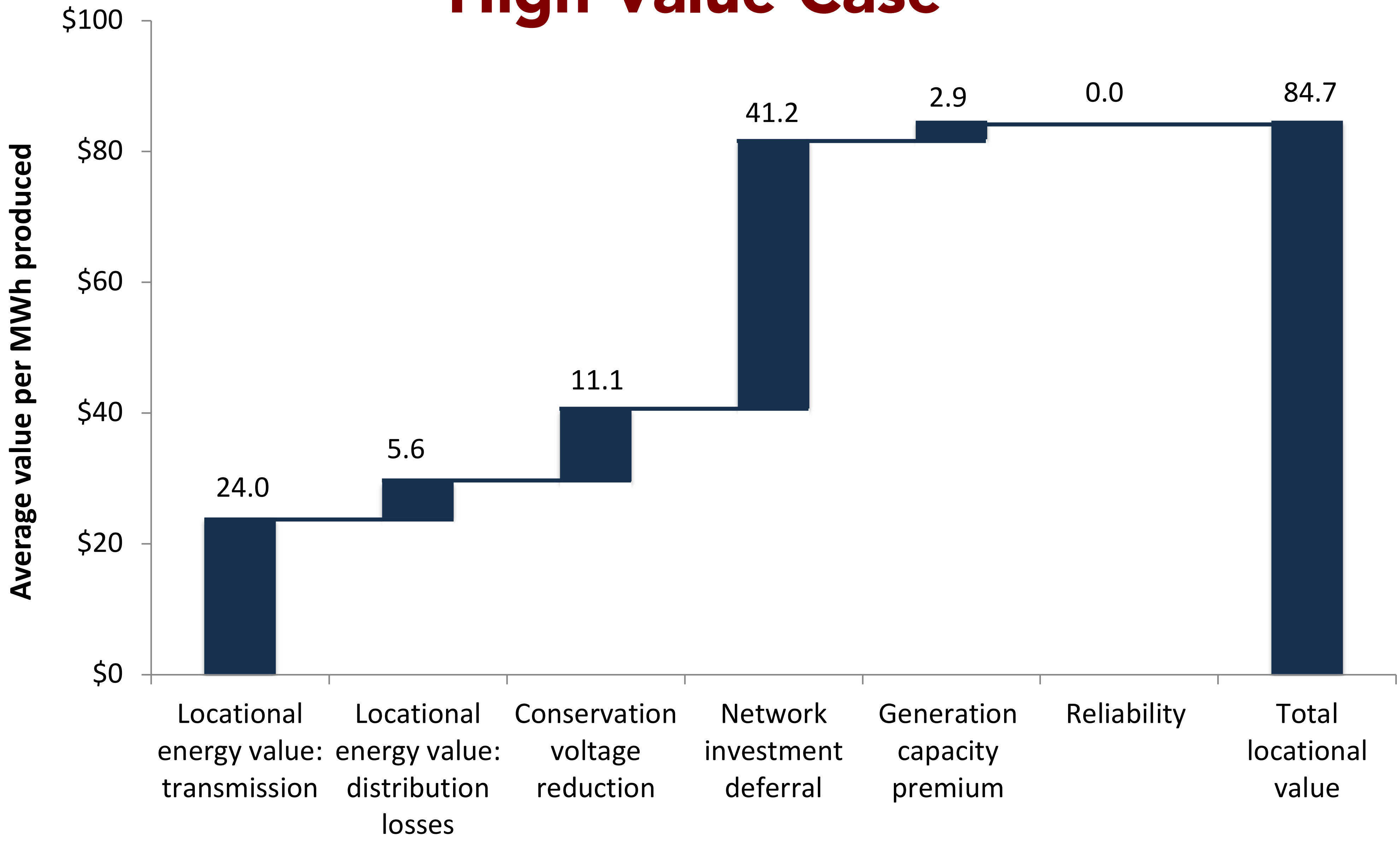
Electricity services values

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

Electricity services values

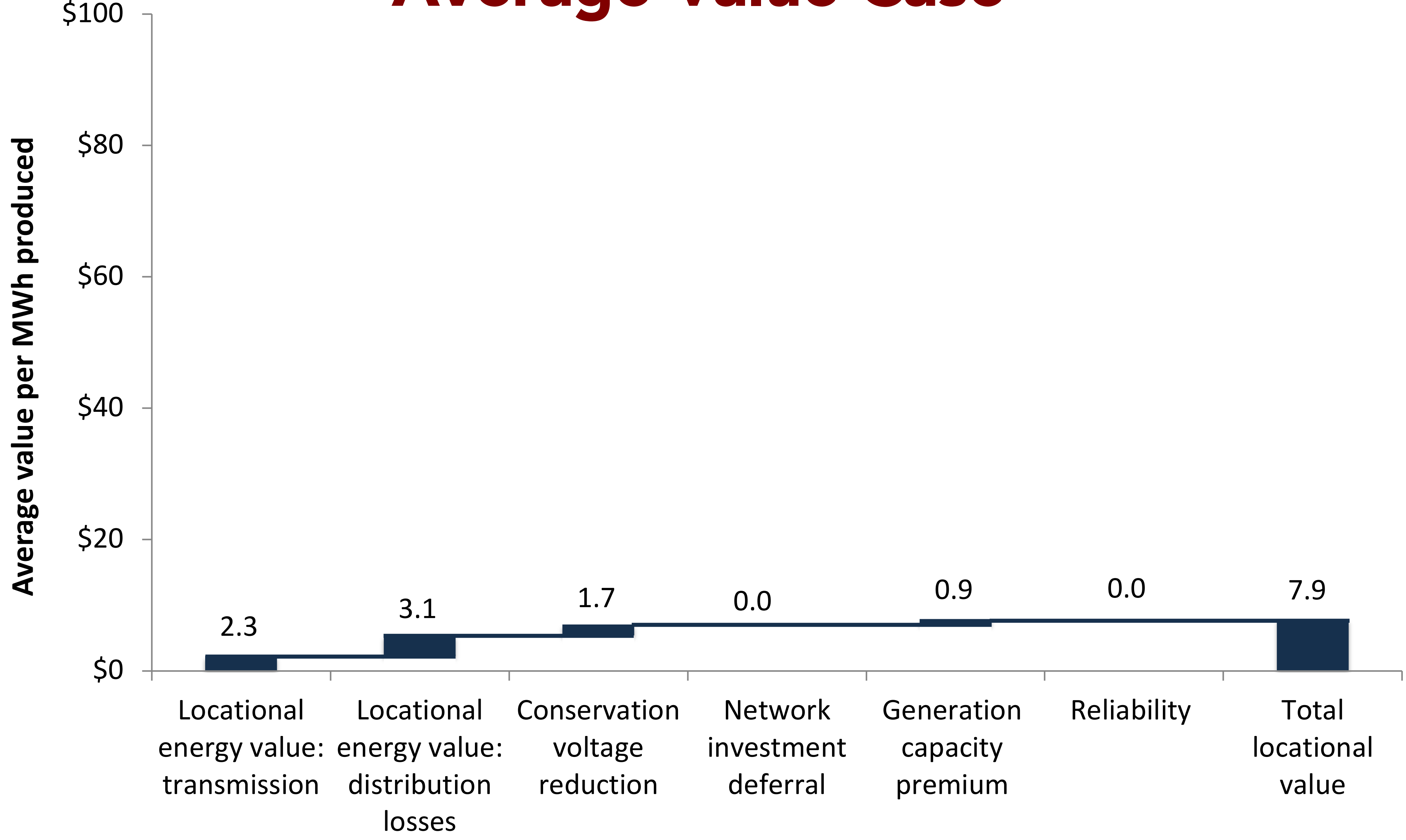
	Locational	Non-locational
	• Energy • Network capacity margin • Network constraint mitigation • Power quality • Reliability and resiliency • Black-start	• Firm generation capacity • Operating reserves • Price hedging
	• Land use • Employment • Premium values*	• Emissions mitigation • Energy security
	* 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

Average Value Case

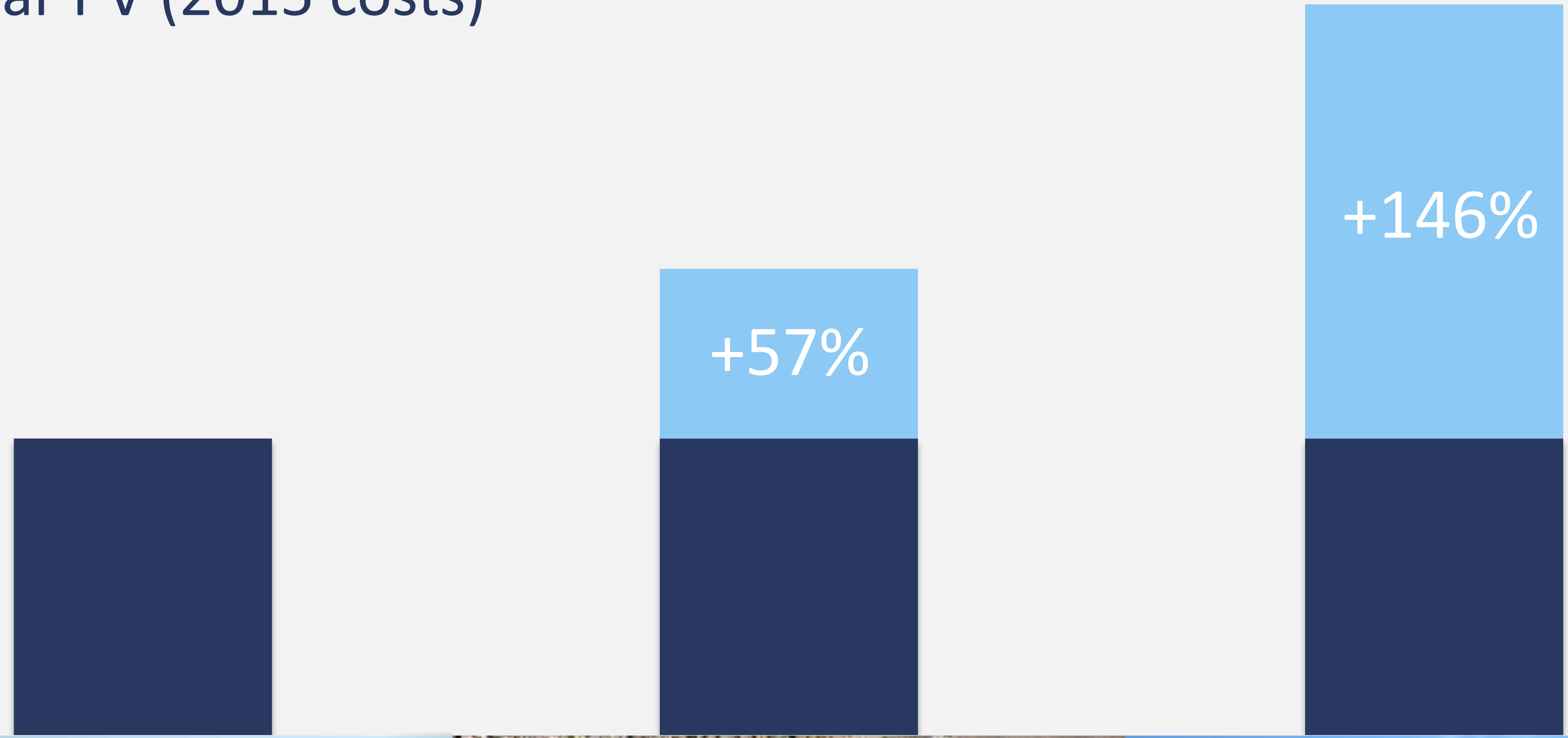


For DERs that can be deployed at different scales (e.g. solar PV, storage)…

Locational value competes with economies of scale

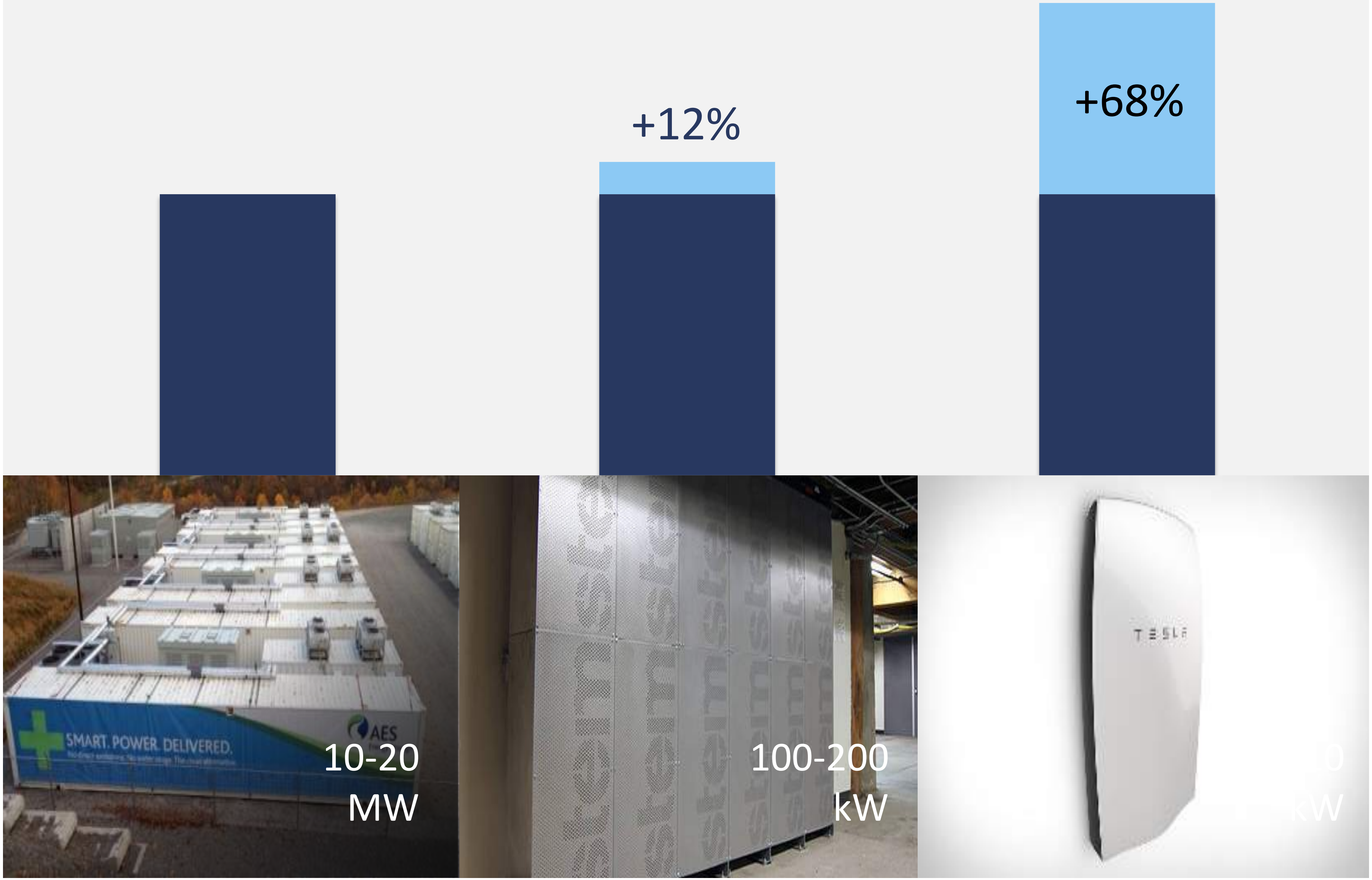
Economies of Unit Scale Still Matter

Solar PV (2015 costs)



Economies of Unit Scale Still Matter

Lithium-ion Energy Storage (2015 costs)



Distributed or centralized?

- From a **societal viewpoint**, the locational value *versus* the incremental cost due to loss of economies of scale determines the best option
- From the **customer viewpoint**, *the locational value enhances the economic viability of the distributed resource*, which will be a factor among others to make a decision

In summary, what the study proposes…

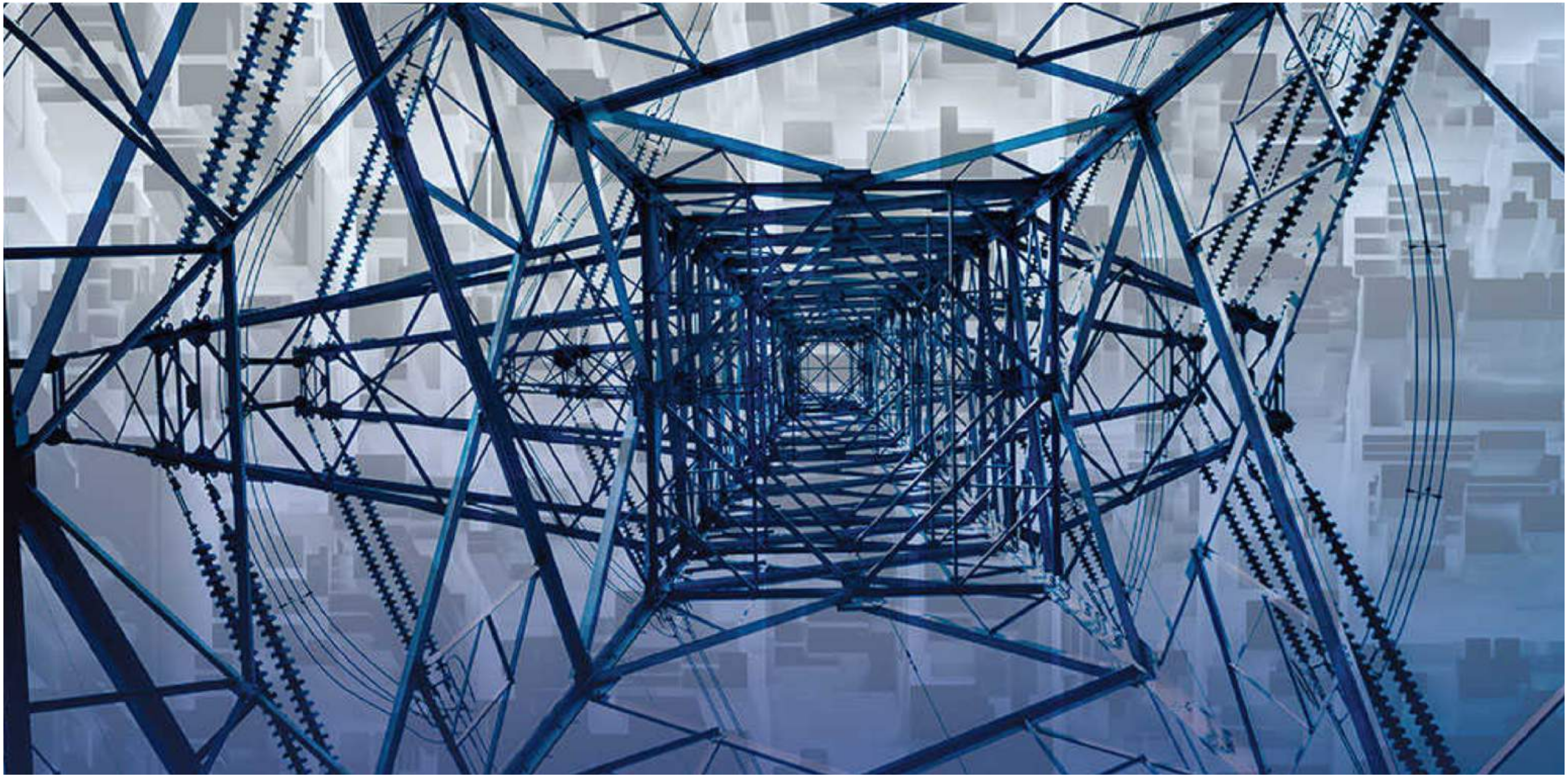
- **can be implemented** with existing technology & reasonable regulatory measures,
- creates the conditions for **centralized and distributed** resources to compete and collaborate on a **level playing field**
- & provides a framework that will **enable an efficient outcome regardless of how technologies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

The report was released on Dec-15-2016

http://energy.mit.edu/uof

Or just browse "MITEI utility of the future"

Study Contributors



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4. Visit: http://energy.mit.edu/research/utility-future-study/

Thank you