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How Changing Energy Production and Storage Costs Affect Network Regulation and Market Design in Electricity Markets

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Some Observations

Three global technology trends bringing disruption to electricity markets:

- electrification,
- decentralisation, and
- digitisation.

Electrification means shifting many end uses of electricity (e.g., transportation and heating) away from fossil fuel sources.
The most promising electrification opportunities are in those segments that are currently responsible for large parts of greenhouse gas emissions: transportation, commercial/industrial applications and residential heating.

Electric Vehicles

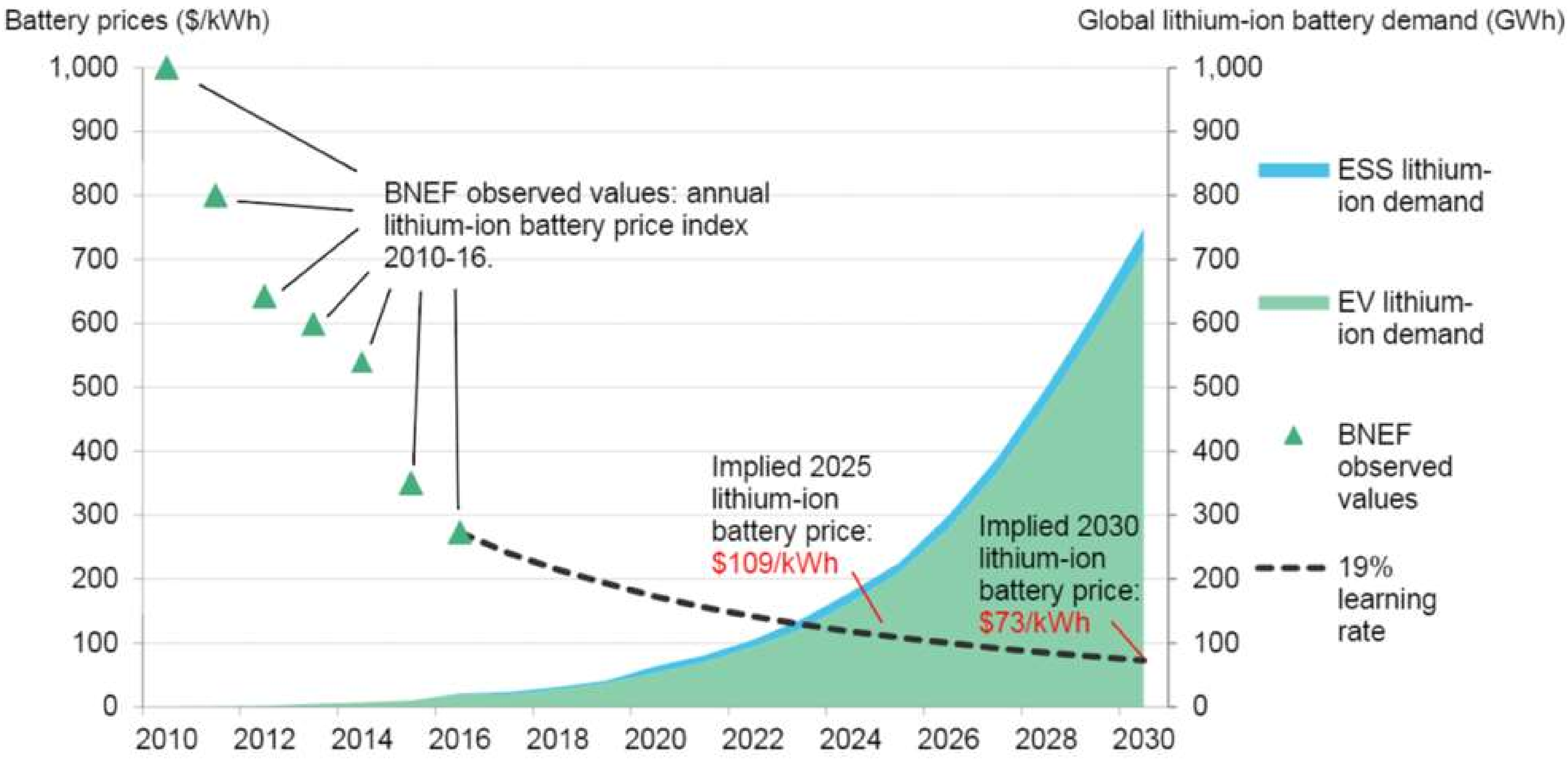
Electric vehicle (EV) technology has evolved rapidly over the past five years.

Range has roughly tripled from about 150 km up to 450 km for some models.

The cost of batteries has declined from about US$1,000 per kilowatt-hour (kWh) in 2010 to below US$300 in 2015/2016.

Battery costs are expected to decrease to below US$200 per kWh by 2020 (Source: World Economic Forum, 2017).

Electric Vehicles



Source: Bloomberg

Electric Vehicles

According to Bloomberg estimates EVs will represent a 25% share of new car sales globally by 2030 and 35% by 2040.

Sales at this level would mean that EVs could make up 5% to 10% of total vehicle stock by 2030.

EVs also strengthen the economic case for autonomous mobility services such as self-driving taxis, as they offer cost and convenience advantages over conventional vehicles.

A shared car's higher utilisation makes a strong case for it to be electric, given their lower operating costs per mile.

Major auto manufacturers project that fully autonomous vehicles will be available in the next five years, especially if fleet companies such as Uber and Lyft invest heavily in the space.

Plus: Environmental benefits regarding health and air quality.

Further Impacts of Electric Vehicle Diffusion

Adoption of EVs will most likely increase overall electricity demand.

Opportunities for “peak-shaving” and “valley-filling” of electricity demand, implying a better utilisation of assets (both generation and grid).

For that, proper price signals are needed so that EV owners charge their car when either electricity demand is otherwise low or when supply is very high (e.g., windy and sunny times).

Vehicle-to-home/vehicle-to-grid (V2G) technology may develop so that EV-stored electricity is injected back to the home or grid.

EVs as storage facilities may become particularly relevant as the share of fluctuating electricity generation (wind and solar PV) increases.

Public Policy Questions

Slow roll-out of charging stations (slow charging stations cost about $1,200 for a residential charger, $4,000 for a commercial garage charger and $6,000 for a curbside charger).

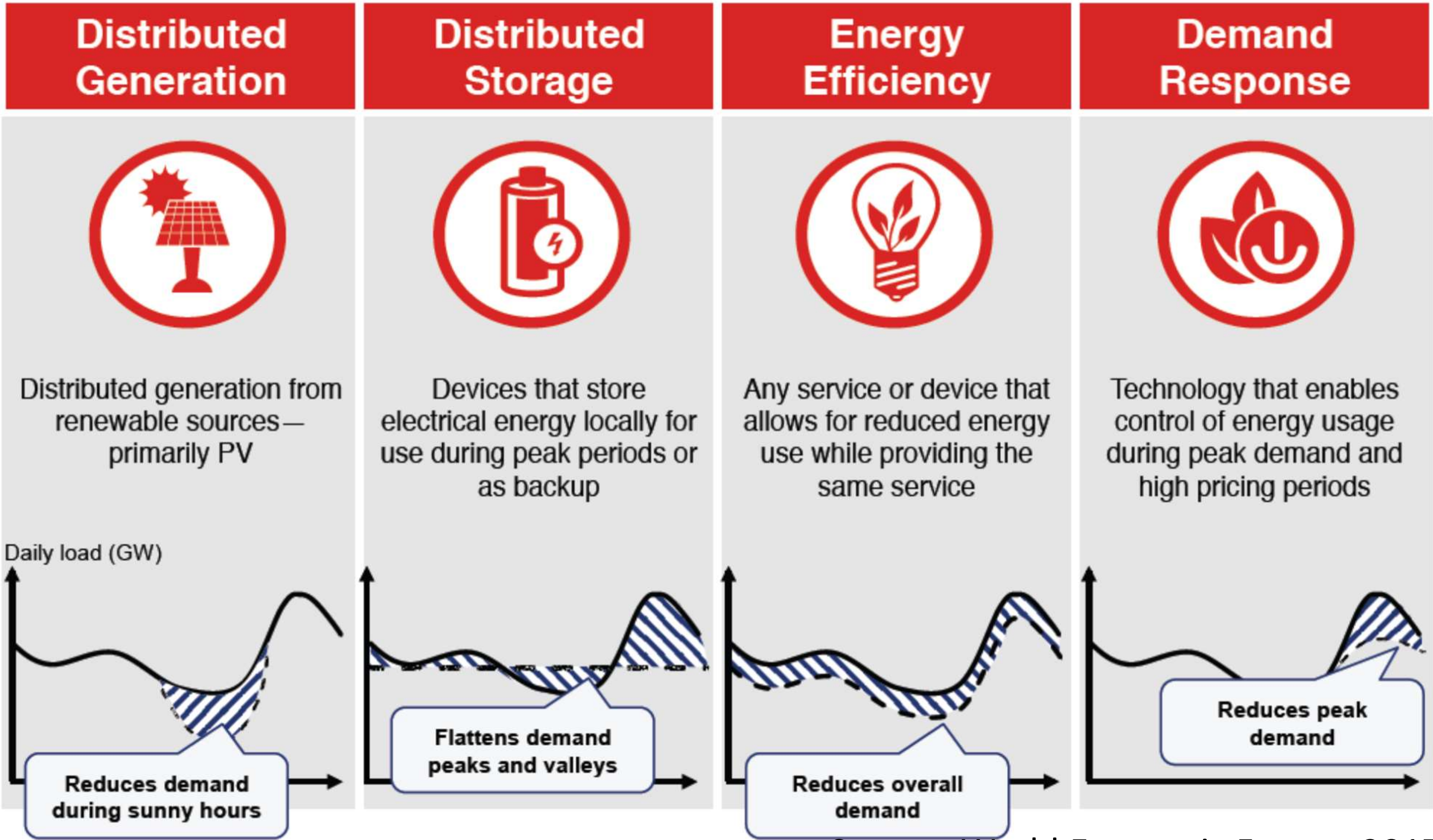
If at all, subsidising infrastructure appears to be better than subsidising car purchases.

Also: price signals should encourage flexible and smart charging.

For example, if all of California's EVs by 2020 were charged during peak hours, it could increase peak load by 13%, requiring significant new investments in peak generation assets and reduce overall utilisation of generation assets.

In addition: regulations and laws will have to evolve to allow and encourage driverless vehicles.

Decentralisation



Source: World Economic Forum, 2017

Distributed Generation

Incentive programmes to encourage distributed generation in the form of rooftop solar PV technologies have been extremely effective in many cases (even though economically inefficient).

Deployment of solar PV panels has increased dramatically in recent years with global installed capacity reaching 260 GWp (gigawatt-peak) in 2015 and expected to surpass 700 GWp by 2020.

Increasing number of “active consumers”

Change in the load/residual demand profile as demand from the central generation is reduced.

With distributed generation, distribution networks become active and see power flowing in both directions. Change from pure “delivery networks” to platforms.

Policy/Regulatory Issues

Changes in network charging structures.

As distribution networks become platforms (two-sided markets) it becomes less clear who should pay for network services, generators or consumers.

Structure of network charges (fixed and variable component) needs to be adjusted.

Concerns about security of supply → capacity mechanisms.

Distributed Storage

As more renewables come online, the need for storage will become increasingly acute.

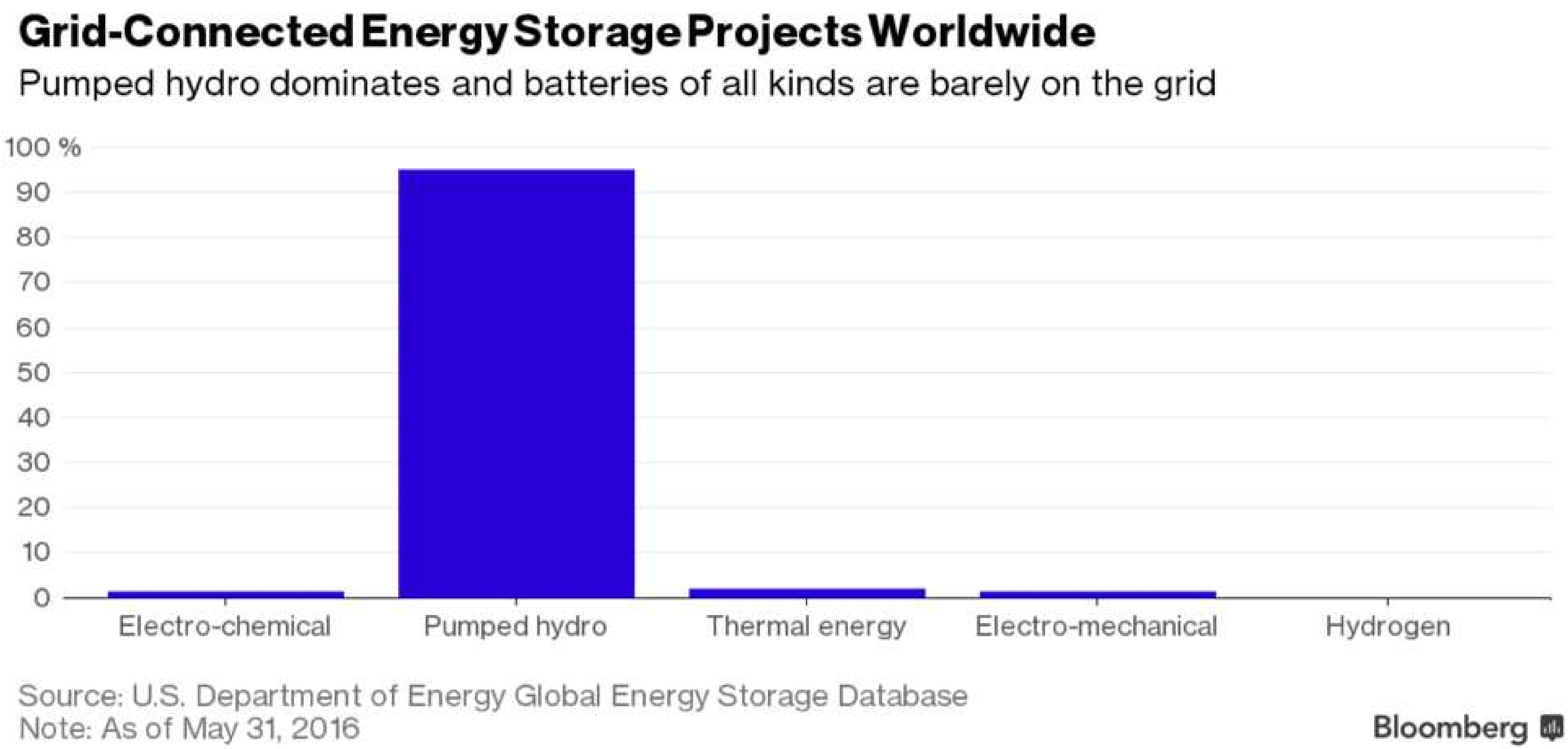
As price variance increases, investment in storage becomes more interesting.

Storage is becoming cheaper as a result of advances in battery technologies and is achieving higher capacities that will allow for larger scale deployment.

Currently, most storage is still pumped hydro, but predictions are out that the cost of storage may reach grid parity in the late 2020s.

In the future, providers of distributed energy storage may combine big data, predictive analytics and advanced energy storage to reduce electricity costs for customers and simultaneously aggregate these assets to provide capacity to the grid.

Distributed Storage



Policy/Regulatory Issues

Lack of (real-time) price signals in many countries to encourage distributed storage.

No clear definition of storage as an asset.

Lack of clear regulatory grid access/connection requirements for distribution companies.

Introduction of capacity mechanisms discourages investment into storage.

Energy Efficiency

Product innovations have made most consumer and industrial power products dramatically more (energy) efficient.

Avoiding a kilowatt-hour of demand is typically cheaper than supplying that demand by any other available resource.

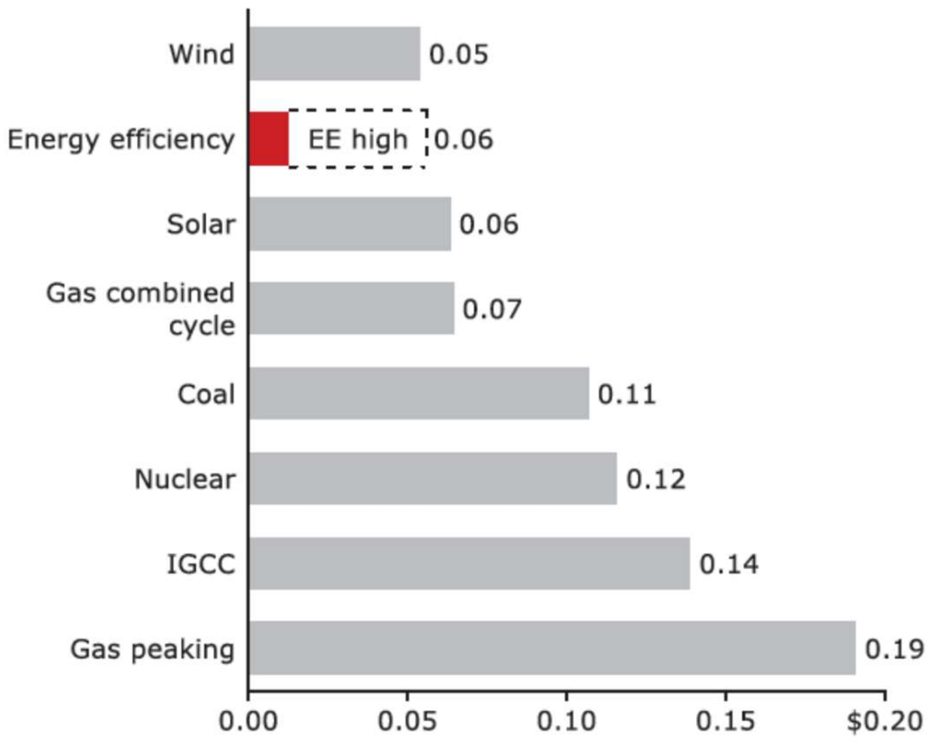
With an average price of about 2 to 3 cents per kWh including participant costs, energy efficiency is a cost-effective resource and is significantly less expensive than investing in additional generation

Nevertheless, adoption of energy efficient products takes time due to long replacement cycles for appliances and equipment (nine or more years). For example, it will take more than 25 years to replace the refrigerators in the US with more efficient ones.

Once again: Importance of prices as scarcity signals.

Energy Efficiency

LCOE by resource ($/kWh)



- Energy efficiency is **cheaper than investing in additional generation**
- A range of studies tags the **average price of EE around ~2 cents per kWh**
- Participant costs of EE programs **may add ~40%** (e.g., customer installation costs)
- Average cost of **generating power from new sources can be many times that amount**

Demand Response

Energy policies around the world increasingly acknowledge the importance of demand response and are beginning to address the challenges that hinder its full uptake.

By some estimates demand-response programmes could reduce necessary annual investments in US grid infrastructure by 10%.

New smarter devices, such as pre-cooling air conditioners, smart refrigerators and shallow lighting can respond to automated price signals, as well as the progress of digitalization that is enhancing the technical capabilities of aggregation, are helping make demand response programmes easier even for residential customers.

Demand flexibility also can help providers, in some cases, to avoid or defer investments in central generation, transmission and distribution, and peaker plants.

Digitisation

Digital technologies increasingly allow devices across the grid to communicate and provide data useful for customers and for grid management and operation.

Smart meters, new smart/IoT sensors, network remote control and automation systems, and digital platforms that focus on optimisation and aggregation, allow for real-time operation of the network and its connected resources and collect network data to improve situational awareness and utility services.

Data from smart devices and distributed resources in general will be critical to new business models and to facilitate customer engagement and adoption of grid edge technologies

Digitisation

Deployment of digital technologies in the network can be hindered by outdated regulation though.

The capability to exploit data (for automated outage detection, locational targeting for DERs, or improved demand forecasting) may be a challenge.

Distribution companies may lack incentives for research in data innovation, while external players are often barred from accessing the full integrated data sets they may need.

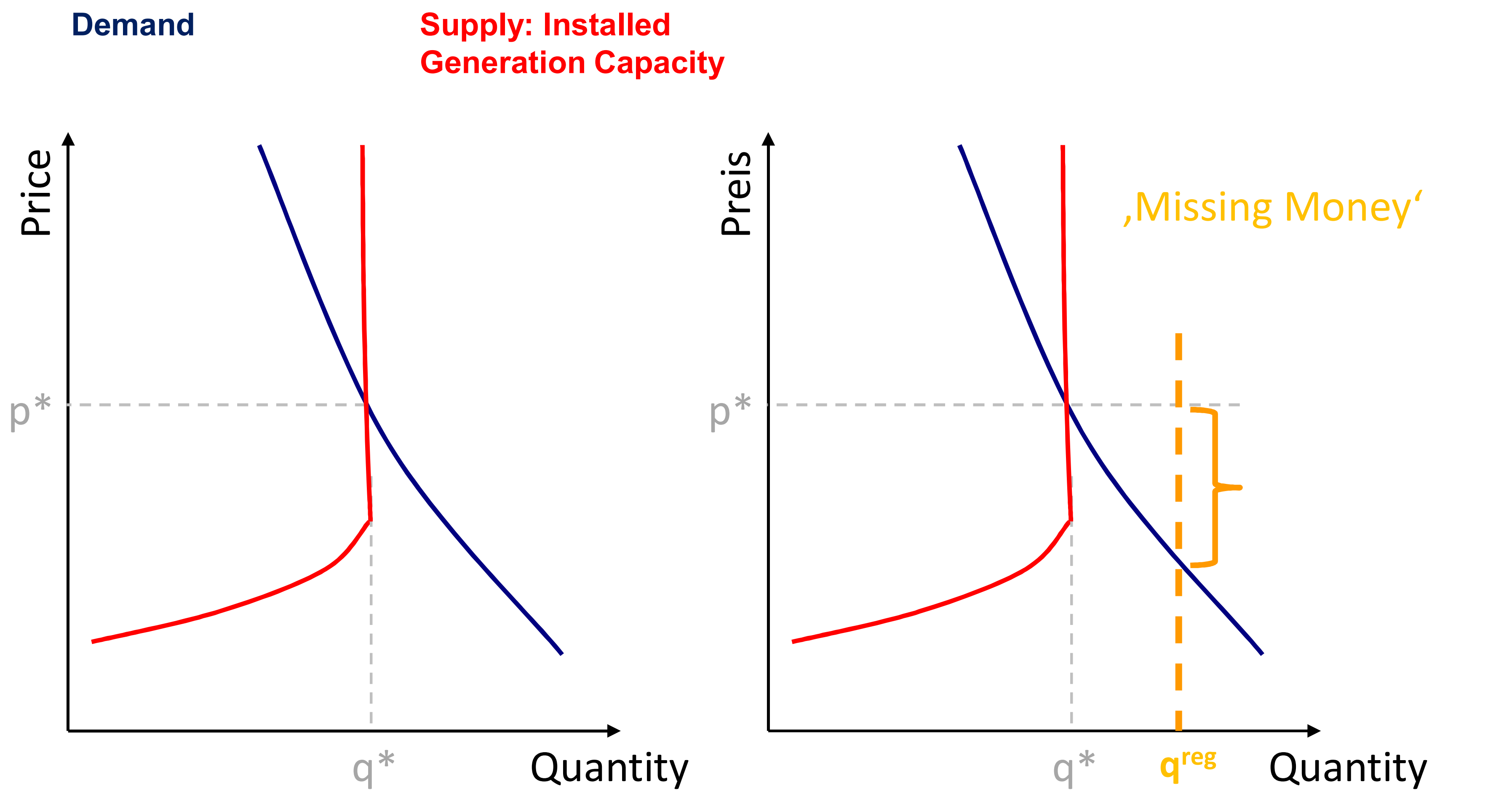
Market Design: A View on Capacity Markets

In many countries a debate around the necessity and proper design of capacity mechanisms has merged or they have been introduced.

Concern about security of supply if (a) demand exceeds supply **and** (b) demand is not reduced even though prices increase (significantly).

Paul Joskow (2013):
„The revenue adequacy or ‚missing money' problem arises when the expected net revenues from sales of energy and ancillary services at market prices provide inadequate incentives for merchant investors [...] to invest in sufficient new capacity to match administrative reliability criteria at the system and individual load serving entity. "

Market Design: A View on Capacity Markets



Market Design: A View on Capacity Markets

Paul Joskow (2013)
„The revenue adequacy or ‚missing money‘ problem arises when the expected net revenues from sales of energy and ancillary services at market prices provide inadequate incentives for merchant investors [...] to invest in sufficient new capacity to match administrative reliability criteria at the system and individual load serving entity. [...] **The economic rationale for establishing these criteria are at best mysterious.**“

So is there any evidence of market failure of the EOM?

What to look for?

Market Design: A View on Capacity Markets

Is there any market failure? Here come the main arguments:

1. The wholesale price is not inducing sufficient demand responses as many consumers do not pay real time prices. However: It is sufficient that some consumers react, not all of them.

2. The necessary price peaks induce regulatory/Government intervention, also because it is difficult to distinguish between market power and scarcity rents.
   However: Wholesale price caps are a regulatory failure that can be remedied by removing them, no market failure.

Market Design: A View on Capacity Markets

PJM State of the Market Report (2012, p. 132 f.):

" [...]The result is that any supplier that owns more capacity than the difference between total supply and the defined demand is pivotal and has market power. In other words, the market design for capacity leads, almost unavoidably, to structural market power. Given the basic features of market structure in the PJM Capacity Market, including significant market structure issues, inelastic demand and tight supply-demand conditions, the relatively small number of nonaffiliated LSEs and supplier knowledge of aggregate market demand, the MMU concludes that the potential for the exercise of market power continues to be high. Market power is and will remain endemic to the existing structure of the PJM Capacity Market. This is not surprising in that the PJM Capacity Market is the result of a regulatory/ administrative decision to require a specified level of reliability and the related decision to require all load serving entities to purchase a share of the capacity required to provide that reliability. It is important to keep these basic facts in mind when designing and evaluating capacity markets. The PJM Capacity Market is unlikely ever to approach a competitive market structure in the absence of a substantial and unlikely structural change that results in much more diversity of ownership.”

Market Design: A View on Capacity Markets

3. Security of supply has public good characteristics, as it insures everybody against blackouts induced by lack of generation capacity.
   Note: This is not completely wrong. We still have to consider expected costs and benefits though.

Also note though that in in case of a shortage of generation capacity, rolling blackouts/brownouts are more likely.

And: Elasticity of demand is endogenous at least in the medium term.

Market Design: A View on Capacity Markets

Economic costs of capacity markets:

„Capacity markets often lead to over-capacities, are complex and carry the risk of regulatory failure.“ – from official justification papers for Germany‘s energy market law.

The view that a capacity market – once designed – will have a stable design with stable rules is an illusion.

Lesson No 1 from international experience: Capacity market rules will never ever be stable but fluctuate and change rather quickly

This in turn makes lobbying very attractive.

Capacity markets perpetuate the problems, as they discourage distributed generation, storage and demand response.

Conclusions

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Thank you for your attention!

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