Energy Market Design in the Smart Grid Era

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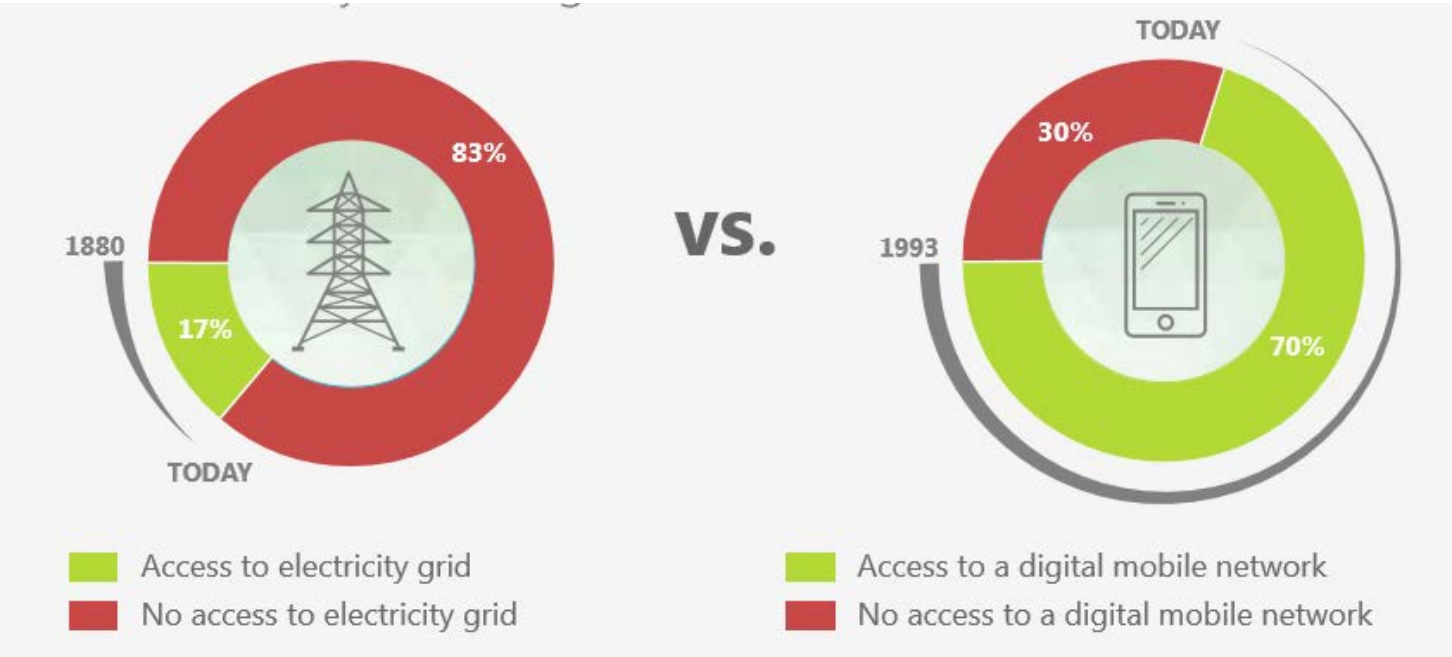
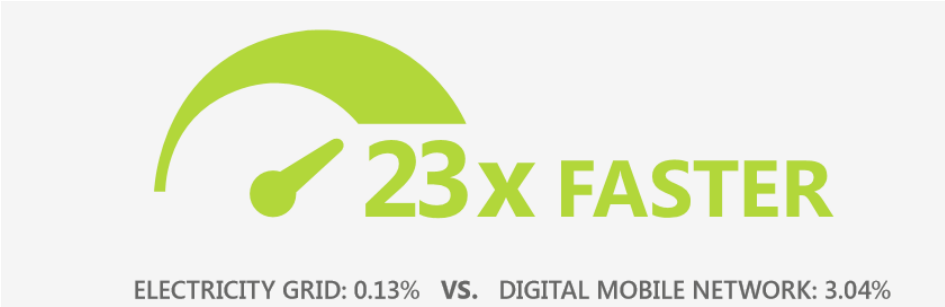
Smart grid= grid + digital ?

- Sub-Saharan Africa is connected – not to electricity, but to **digital networks**

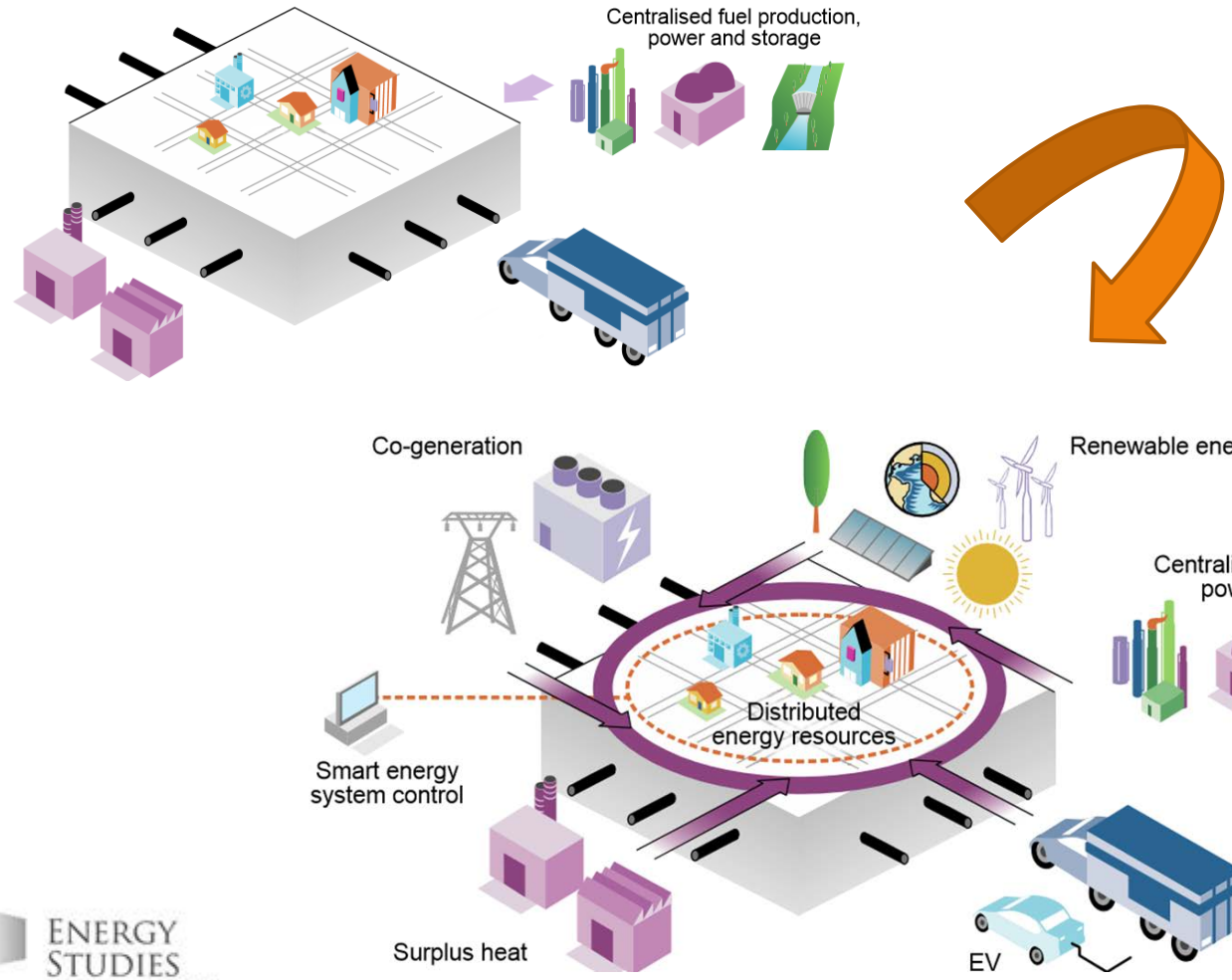




Source: Global e-sustainability initiative report (2016)

System integration is essential

- Smart grid means **a digitally-enhanced, multidirectional and integrated system.**

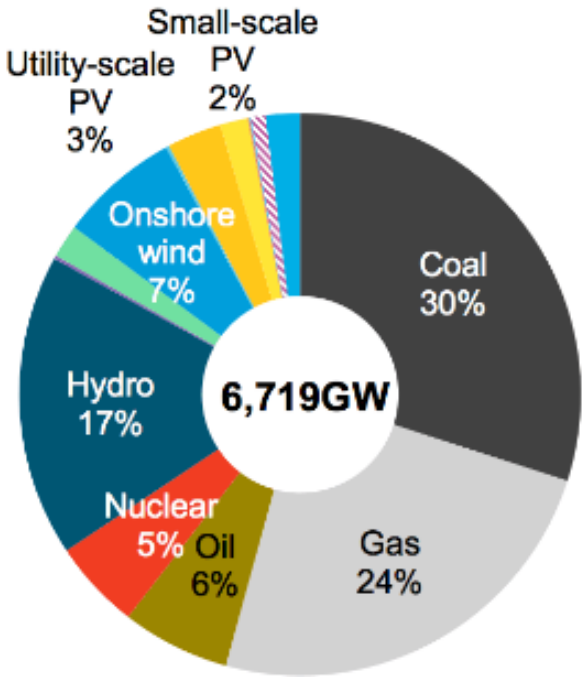


Source: IEA (2017)

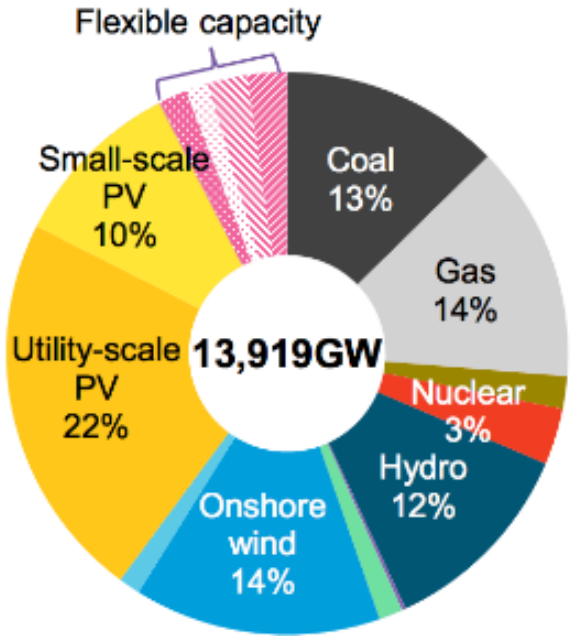
More renewables, more flexibility

- Turning intermittent energy into baseload power

Global cumulative installed capacity: 2016



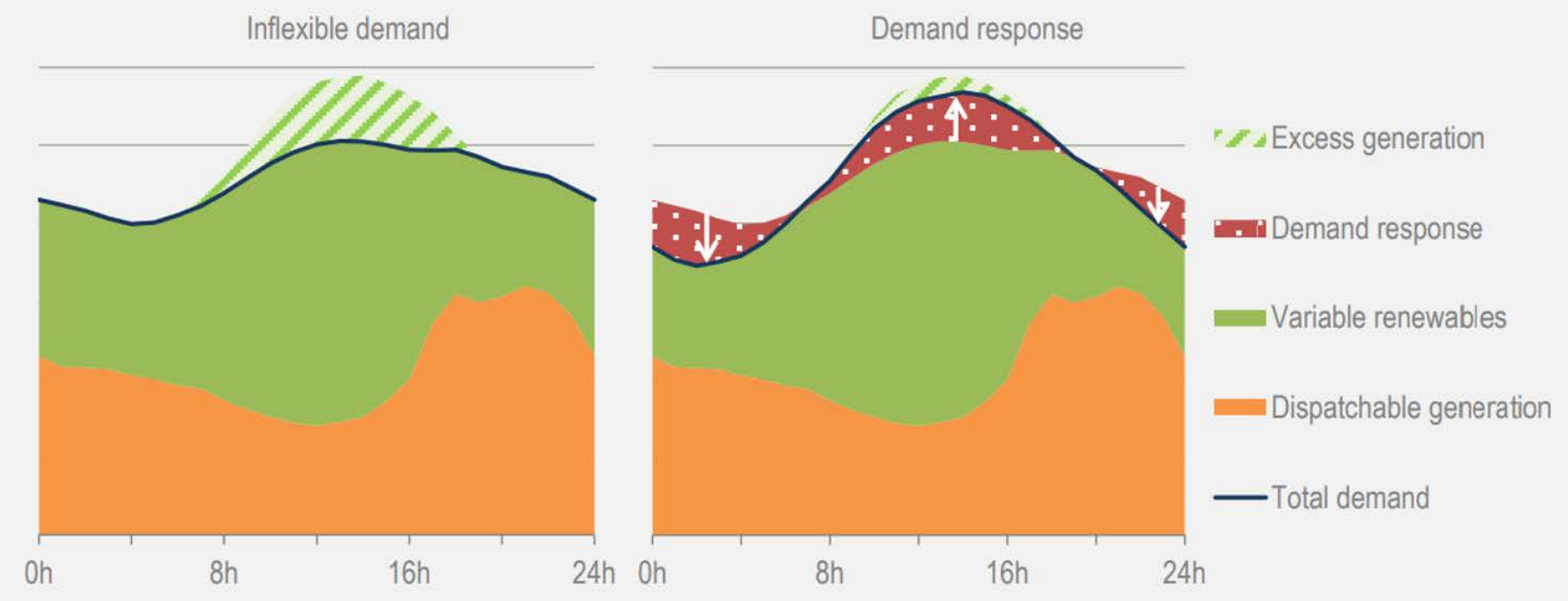
Global cumulative installed capacity: 2040



Source: Bloomberg New Energy Outlook (2017)

Demand response enabling system wide flexibility

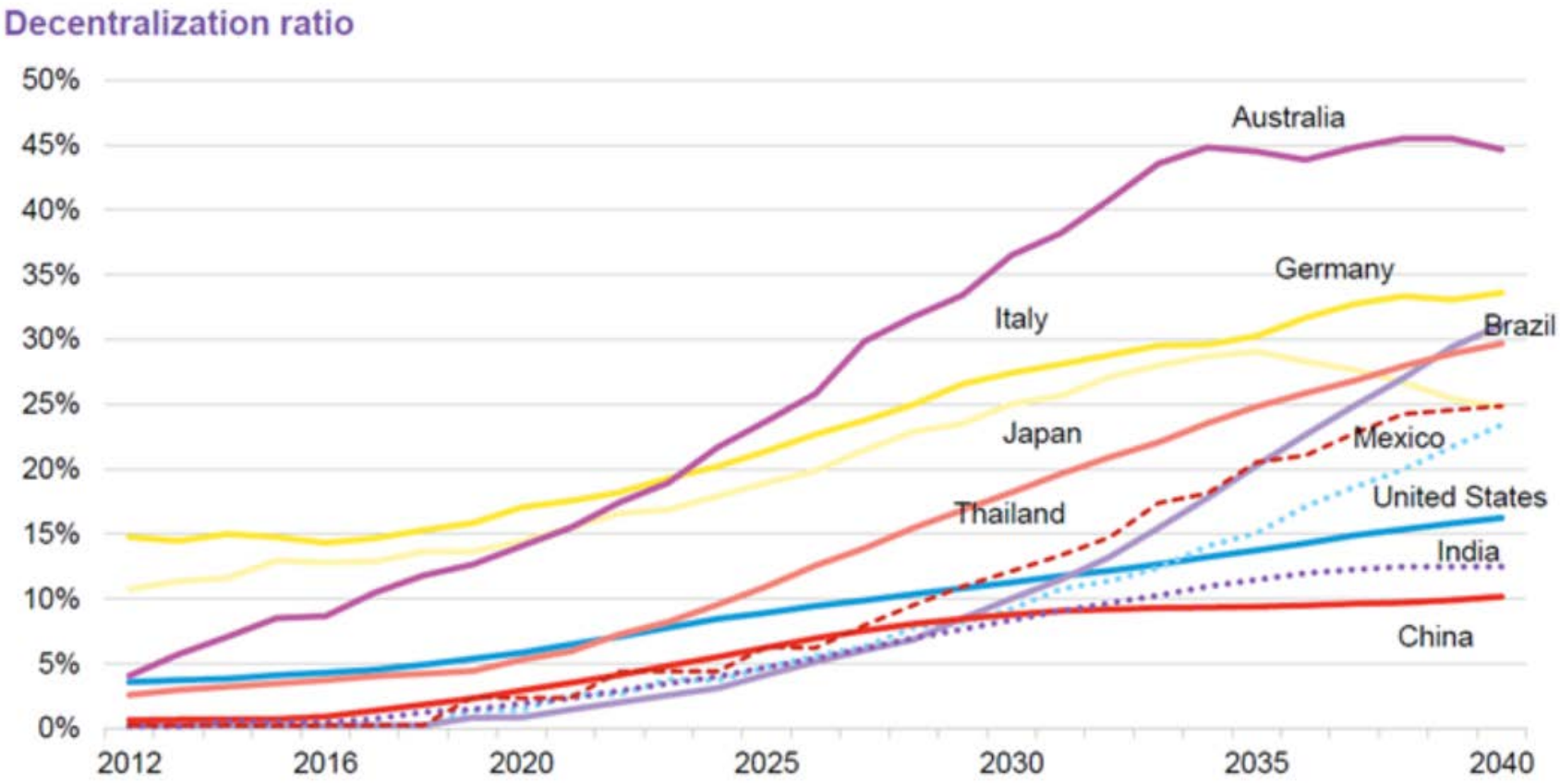
- Ability to shift demand= ability to reduce or avoid costs (Global demand response programmes can provide 185 GW of flexibility and avoid USD 270 billion of investment in new electricity infrastructure.)



Source: IEA (2017)

The future is distributed

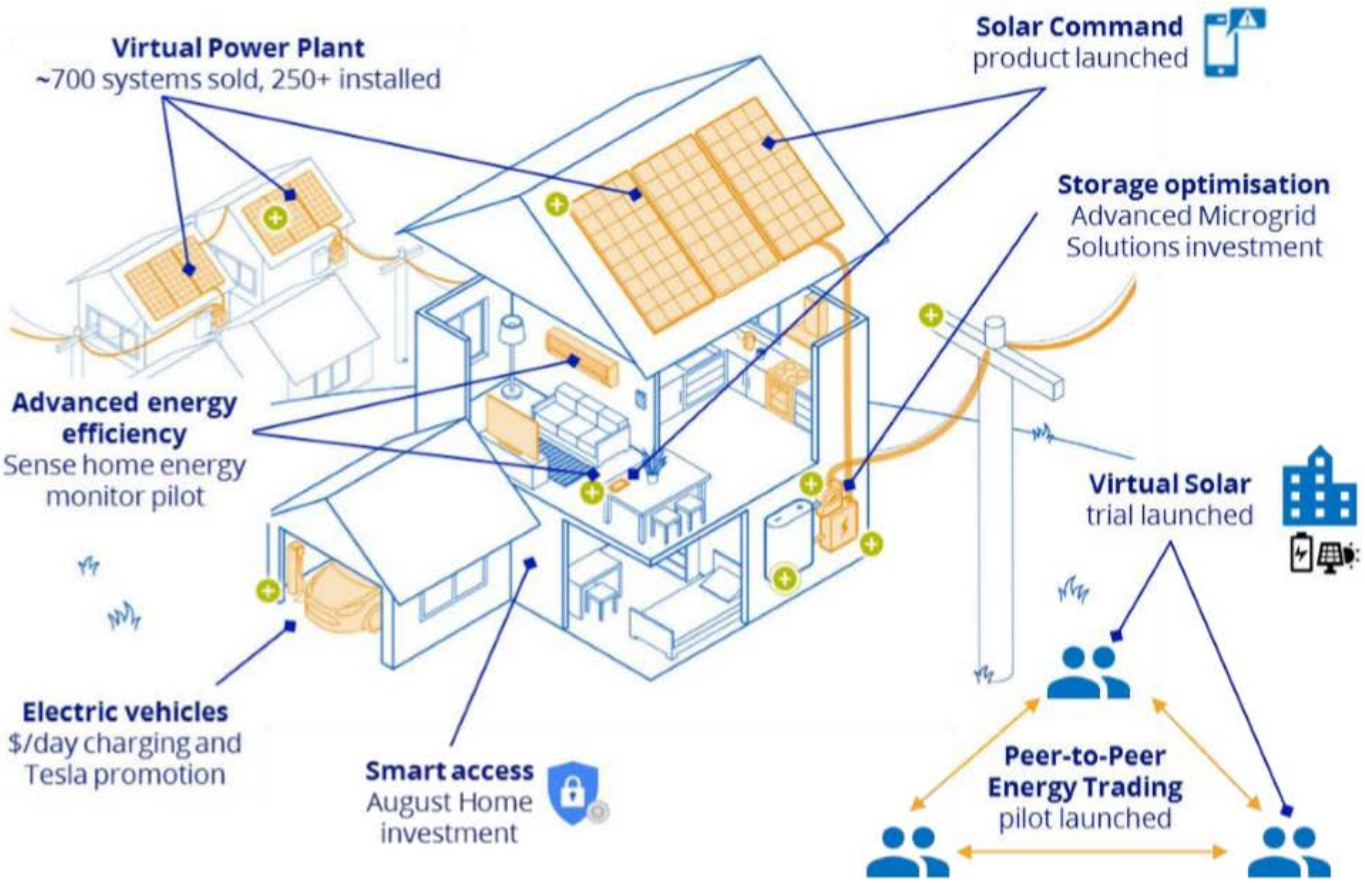
- Forget grids?



Decentralization ratio = ratio of non-grid-scale capacity to total installed capacity
Source: Bloomberg New Energy Finance

What the future could look like?

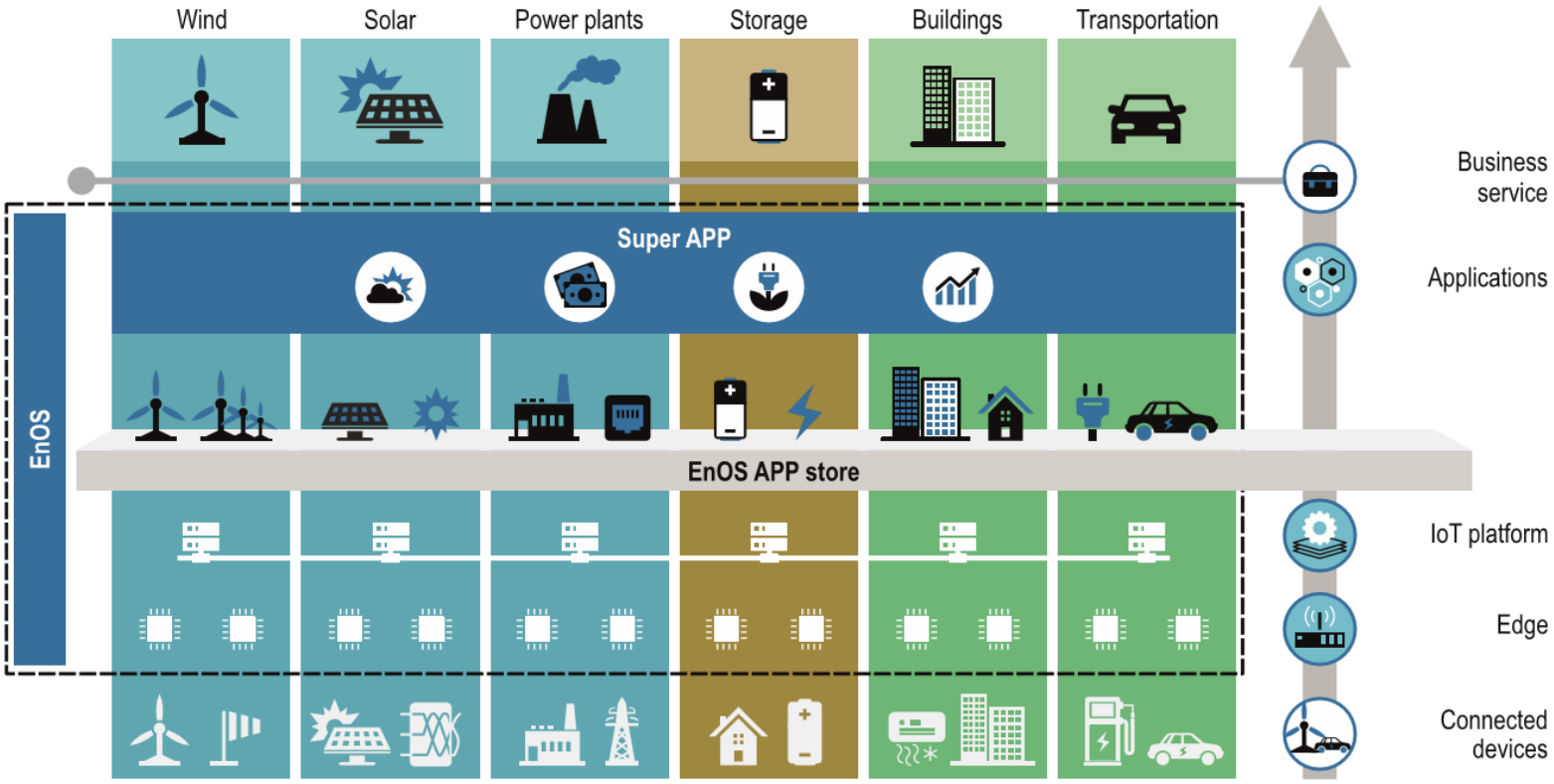
- A virtual power plant connects and aggregates distributed energy resources



Source: AGL

What the future could look like?

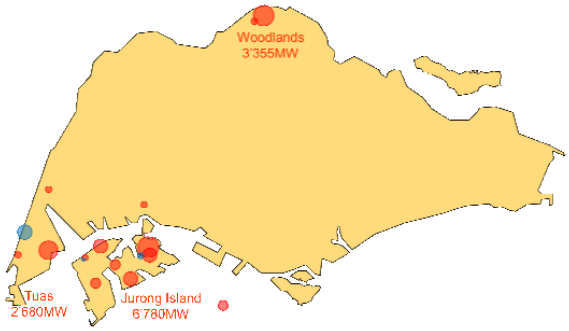
- A platform for Internet of things connects and manages a wide range of both generation and end-use technologies in order to enable collaboration at the level of households, communities and cities.



Source: EnOSTM platform for Internet of Things (Envision, 2017)

Legacy grids anticipate distributed generation

- Singapore's energy transition
  - In 2014, intermittent generation sources integrated with energy storage are not deemed as intermittent if they are dispatchable.
  - In 2015, energy storage is allowed to participate in the regulation reserve market.
  - In 2016, the regulator launched an energy storage test-bed to study grid-level storage applications.
  - In 2018, full retail contestability in the electricity market

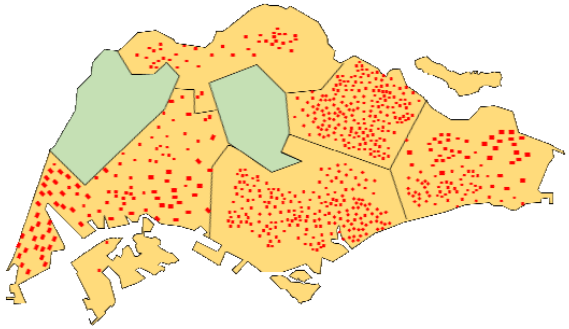


Conventional on-demand power from centralised plant clusters

In 2017, 97% of electricity from a handful of CCGT/co-gen/tri-gen plants

Fossil fuel generating capacity (03/17)

Licensed:	13'348MW



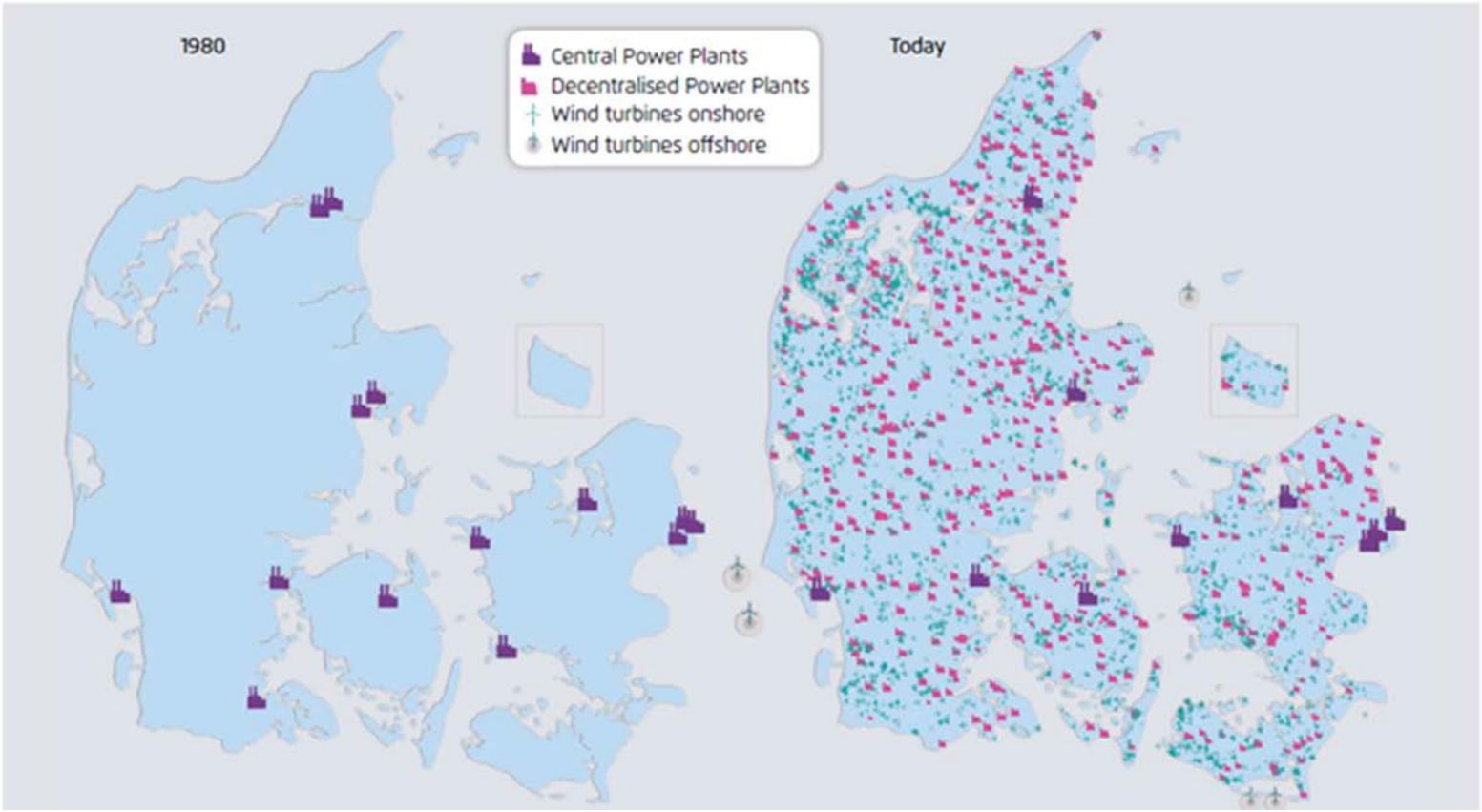
Weather-driven power from dispersed small-scale PV plants (~2'000 sites)

Installed PV:	136MWp
Backlog PV:	>100MWp
Central:	442
East:	379
NE:	491
North:	239
West:	405
Total sites (30/06/17):	1'956

Source: EMA (www.ema.gov.sg)

Nordic experience from central to distributed generation

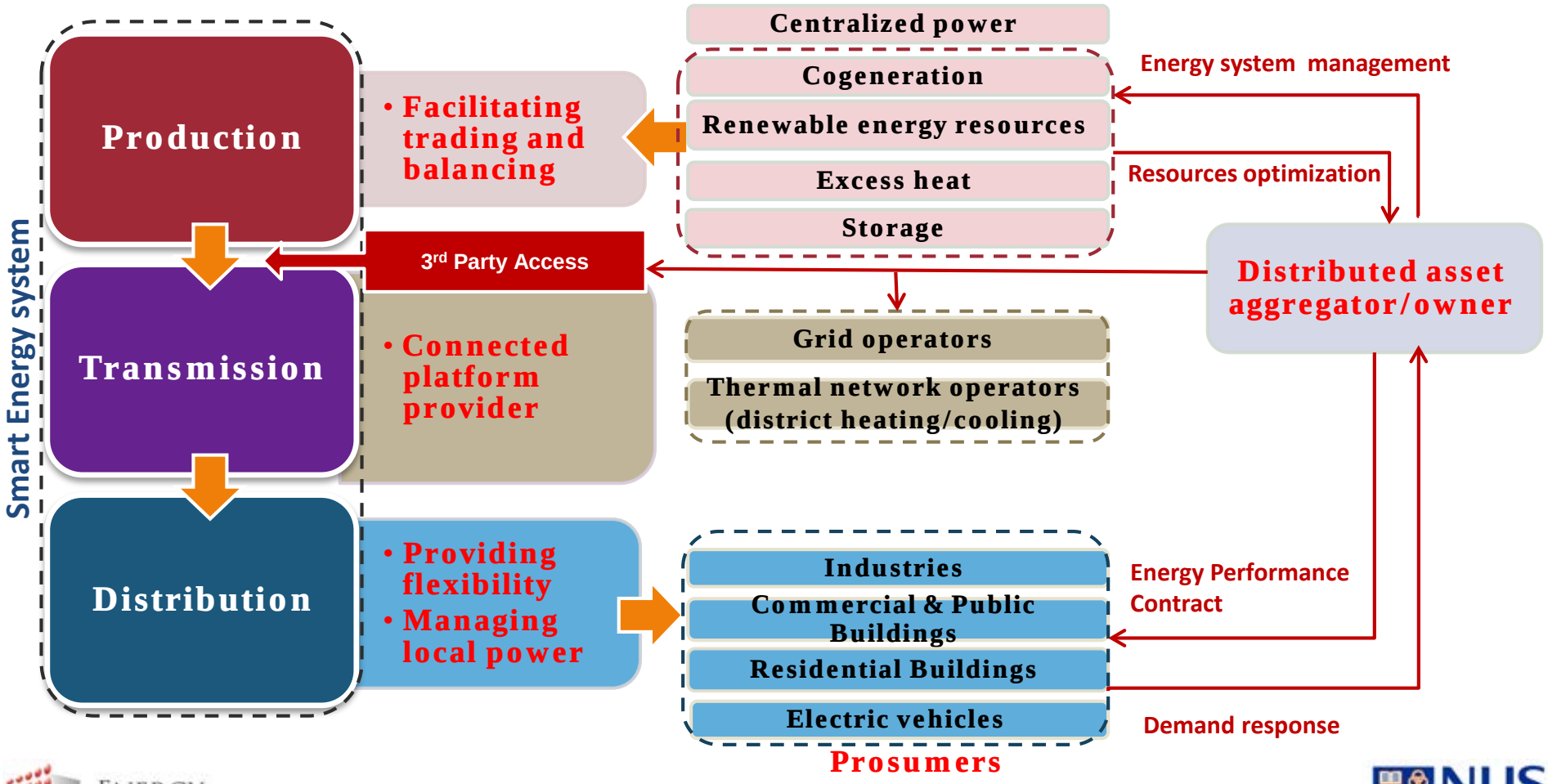
- Denmark's energy transition: CHP heat/power + decentralised solutions



Source: Energinet

New roles for market participants

- Provide energy services beyond electricity as a commodity



Source: own elaboration

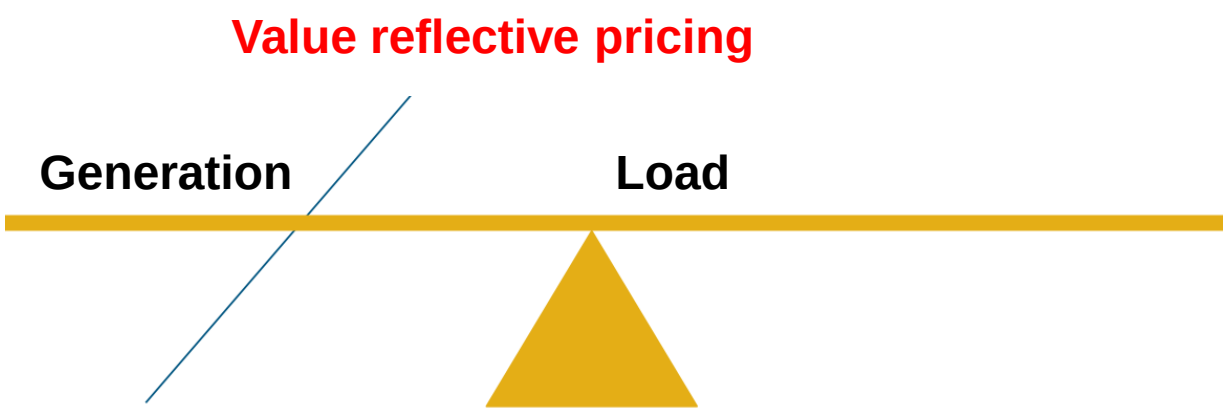
Why is this market new?

- So far …

SUPPLY = DEMAND

While, with smart grid solutions…

SUPPLY ≠ DEMAND

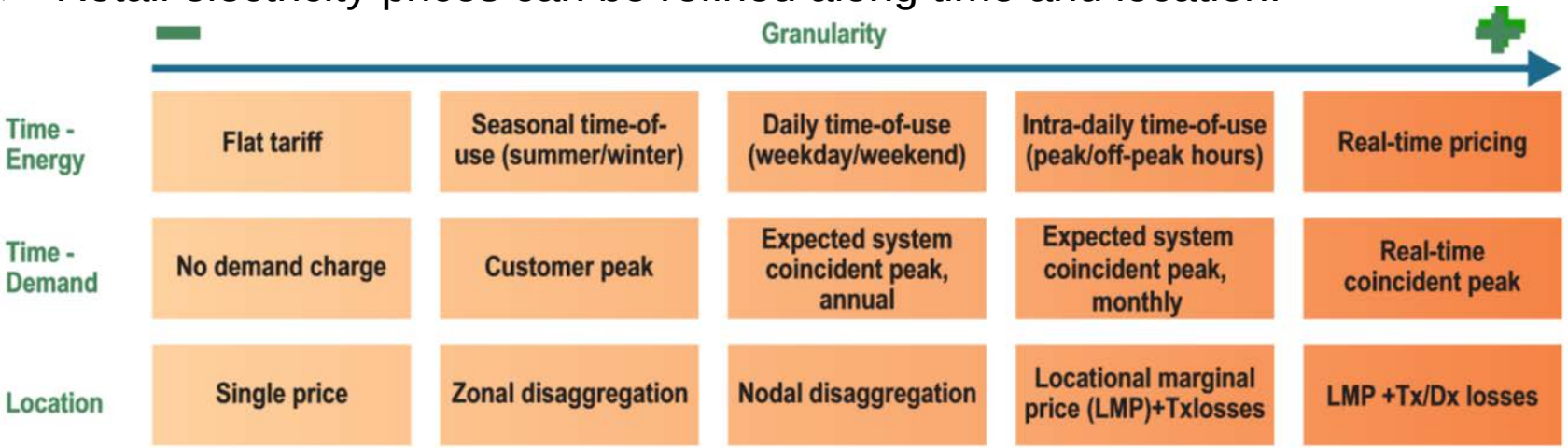


Focus on the broader, overall system value or customer value?

- Rewarding distributed energy resources requires a detailed analysis of the various value components.

Energy services	Avoided capacity	Grid Support	Financial	Additional benefits
■ Energy ■ Tranmission and distribution losses	■ Generation ■ Transmission and distribution	■ Reactive power ■ Voltage control ■ Frequency support ■ Operating reserves	■ Fuel price hedge ■ Market price	■ Grid security ■ Environmental/ carbon emissions ■ Socio-economic development

- Retail electricity prices can be refined along time and location.

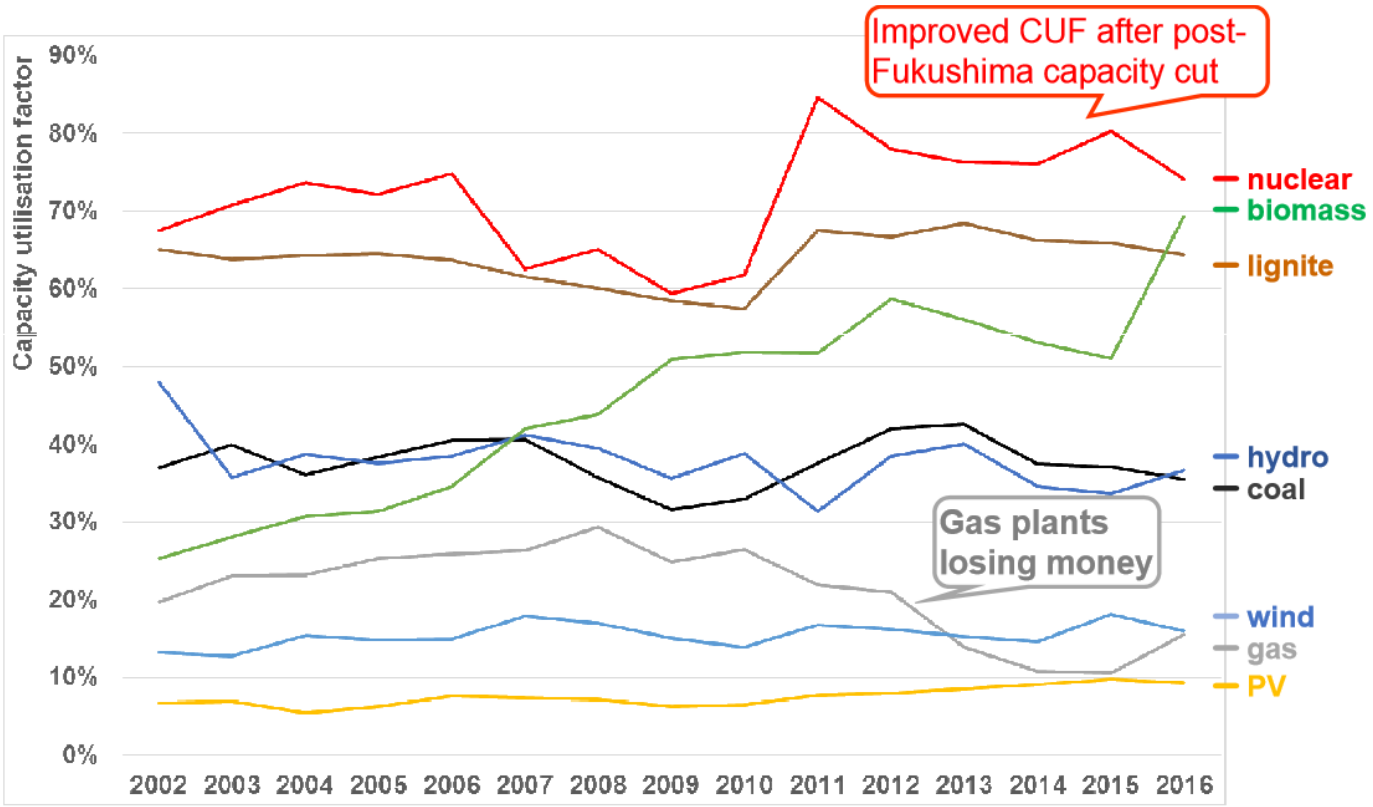


Notes: Tx = transmission; Dx = distribution; LMP = locational marginal price.

Source: IEA, 2017

Germany's cautionary tale

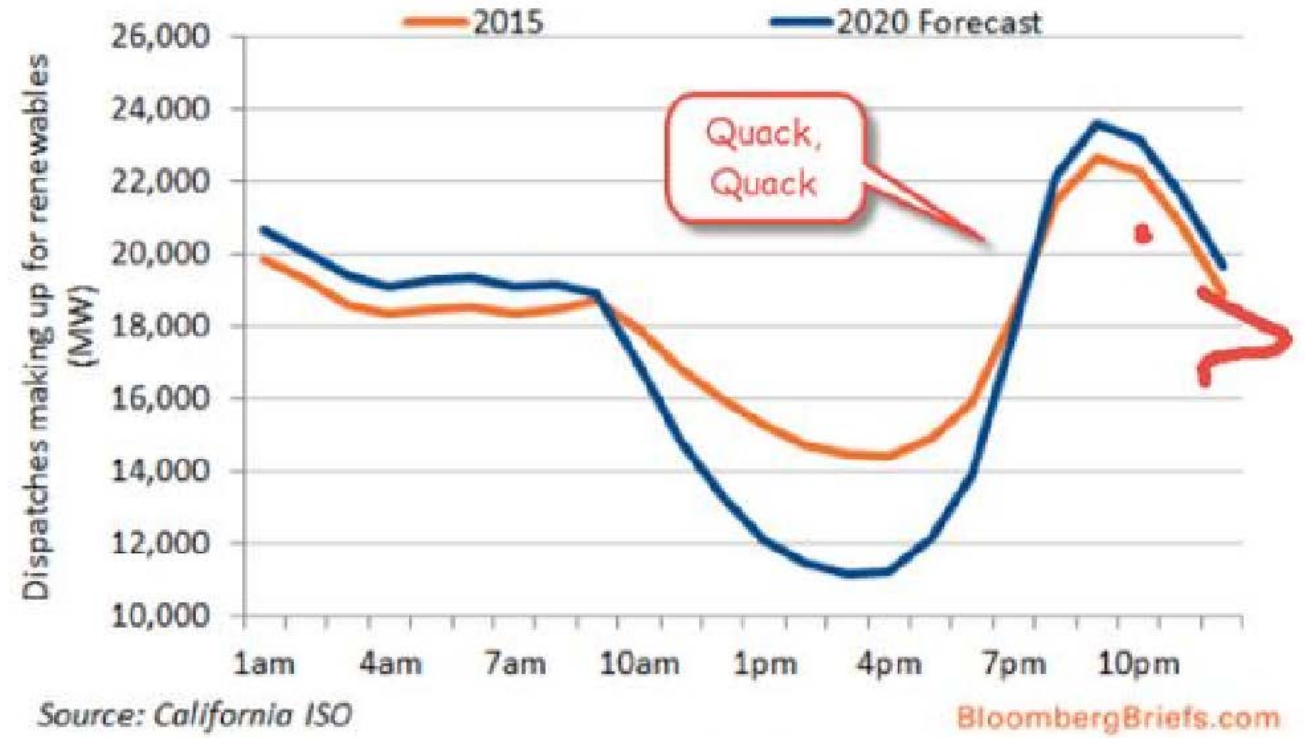
- Renewables push down the electricity market prices and make higher price conventional plants lose viability



Source: www.energy-charts.de; Energetix

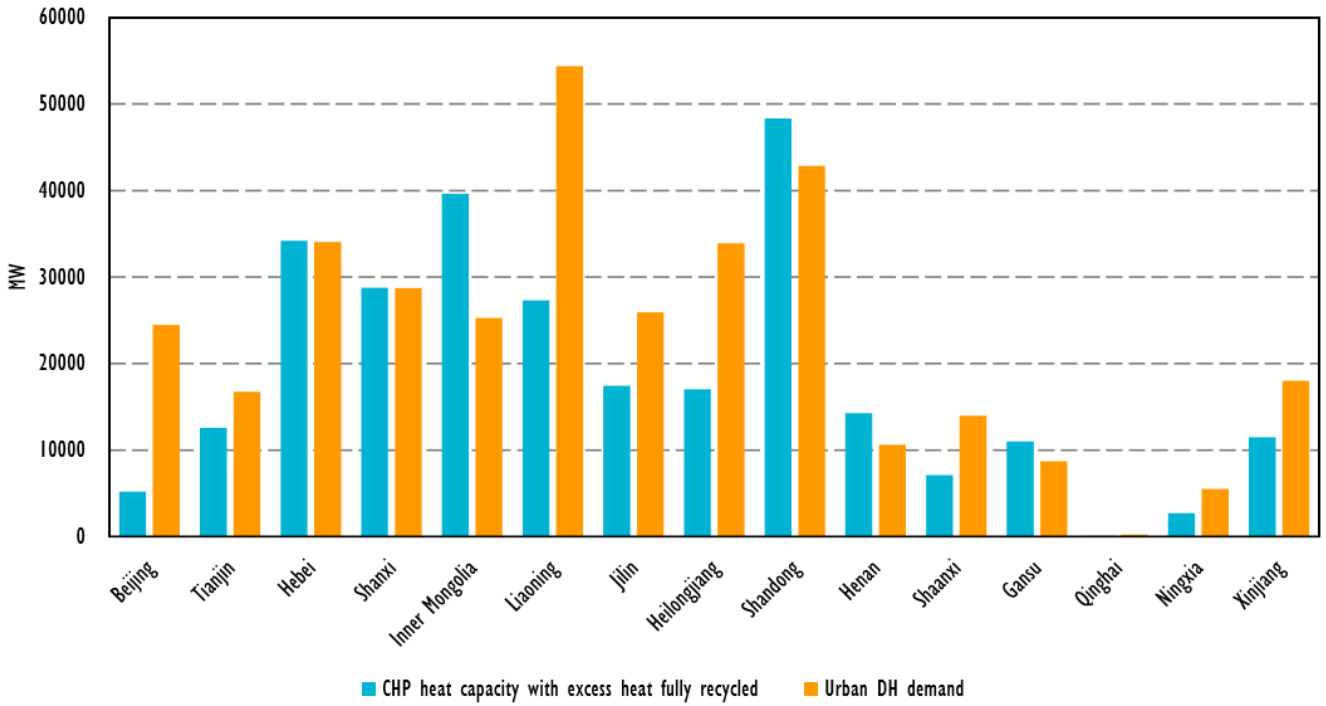
California's duck curve

- Baseload generators displaced during peak demand hours, then rapid ramp up in late afternoon and ramp down in the morning- need to ensure sufficient reserves, esp. the fast response regulation reserves.



China's energy efficiency plan - Coupling power and heat

- The central government plans to exploit low-grade waste heat through district heating to replace more than 50 million tons of coal consumption associated with heating area of more than 2 billion m^2 by 2020.
- Heat capacity from co-generation excess heat is equivalent to around 80% of the 2015 heat demand in northern district energy networks.



Issues we need to address an intelligent market design

- While the context may vary, some questions are universal:

- How to guarantee **a fair access** to the market ?
- How to integrate **prosumers** in existing market ?
- How to limit the **market power** of existing entities ?
- How to encourage **investments** in cleaner technologies ?
- How to bill the customers involved in **Demand Response** programs ?
- How to bill the ancillary services provided by **storage assets** ?

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Thank you!

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