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Models of Power Market Design and Network Regulation to Promote Flexibility and Smart Grids

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Designing Power Markets to Promote Flexibility

The market for electricity relies on effective regulation to deliver efficient outcomes

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Supply/ demand fluctuate in real time and the commodity cannot be stored

⇒ Effective competition requires regulation to define a tradable product that reflects physical supply/demand conditions on the system reasonably closely

Source: https://www.elliswhittam.com

Source: http://buildipedia.com

Transport is only economic via natural monopoly networks, preventing competition

=> Regulation is required to constrain the pricing of grid companies and set access terms

Electricity has some “public good” characteristics, and is often highly politicised

=> Regulation is often used to protect vulnerable consumers

Source: http://www.telegraph.co.uk

Key Challenge: Ensuring the regulation required to create effective markets keeps track with changing technology

In theory, traditional "energy-only" power markets can remunerate investment in generation through price spikes

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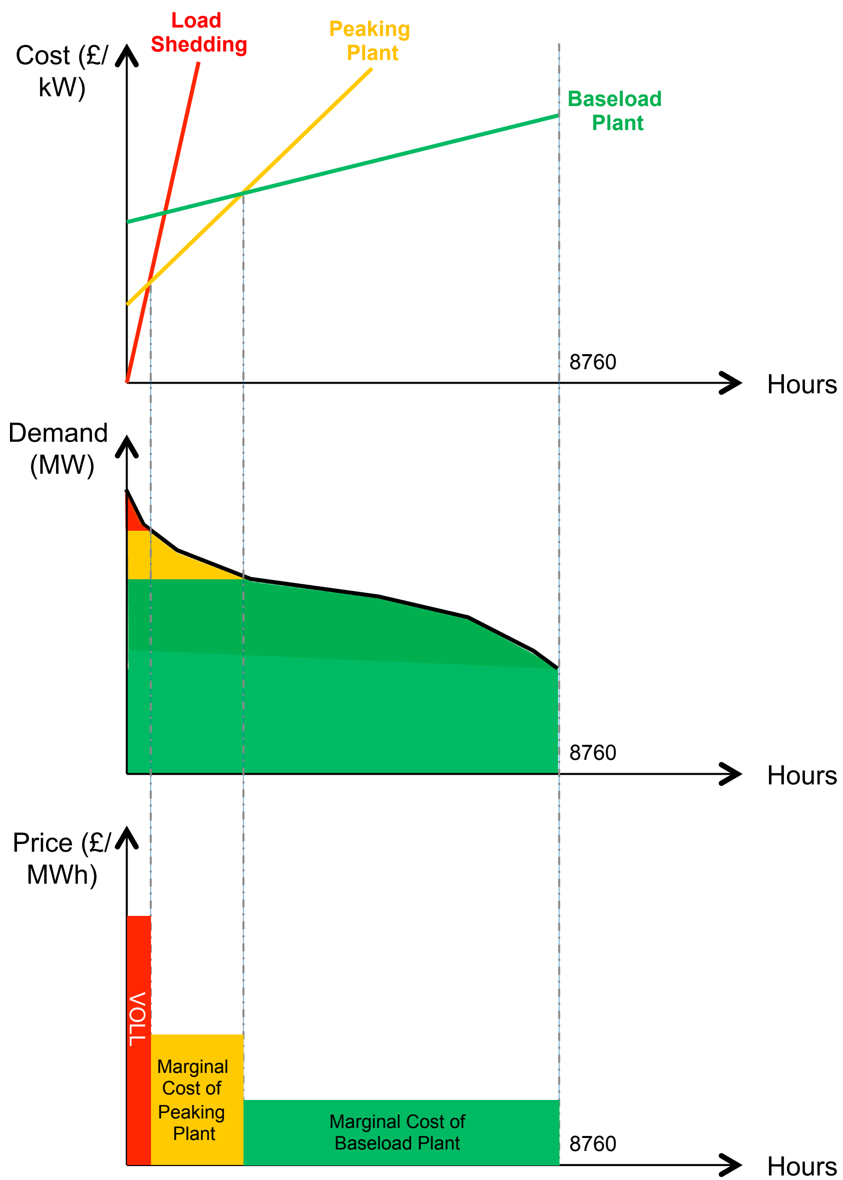

- Traditionally, the challenge of planning an electricity system required an optimal mix of technologies to meet demand
- Then, the prices to emerge in a competitive power market (= system marginal cost) would remunerate efficient investment
- Essentially, generation capacity is remunerated through "spikes" in the price of energy

Example: Growing supply of low carbon generation can still be supported (in theory) through an energy only market structure

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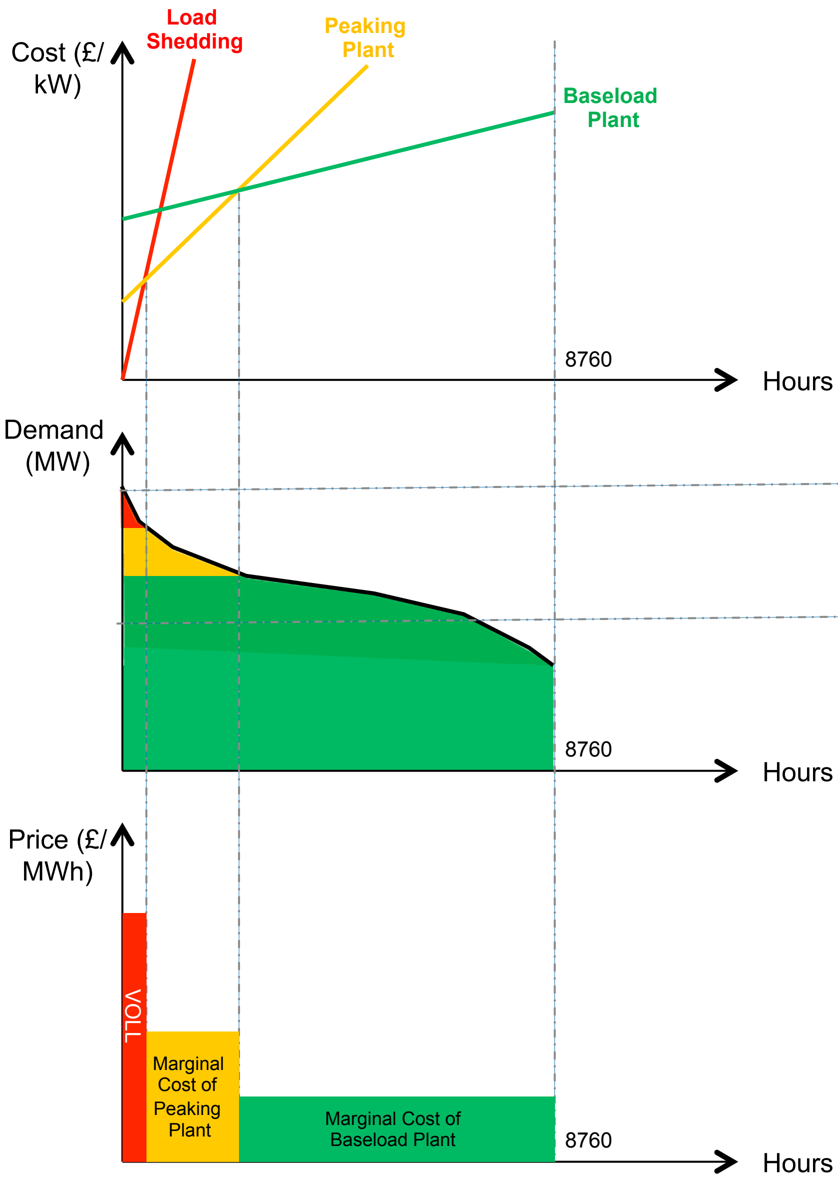
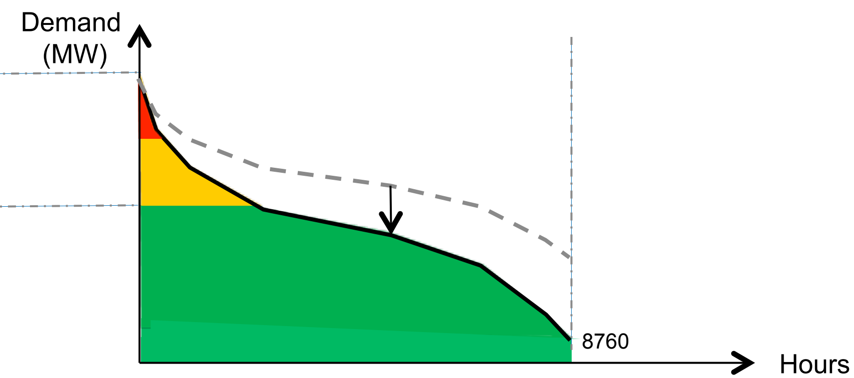


- Growth in low carbon technologies reduces the net demand to be served by other technologies



- The efficient balance between peaking and baseload technologies changes as a result

Capacity payments can be used to reduce the need to rely on price spikes, mitigating the risk of government intervention

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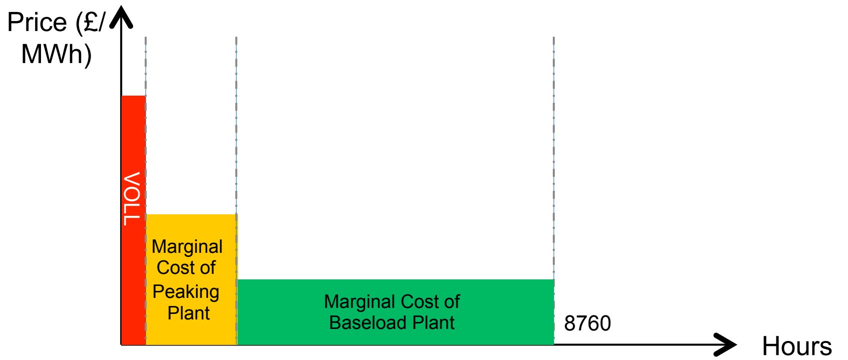

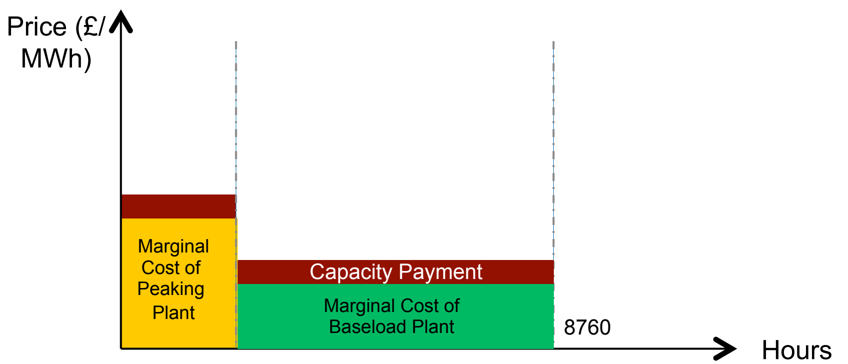

- Capacity markets substitute for spikes in energy prices as a means of remunerating investment
  - However, capacity "markets" are highly regulated mechanisms
- They smooth out volatility, and act as a hedge against government intervening to constrain peak prices

In reality, capacity payments are also seen as a means of offsetting reductions in energy margins

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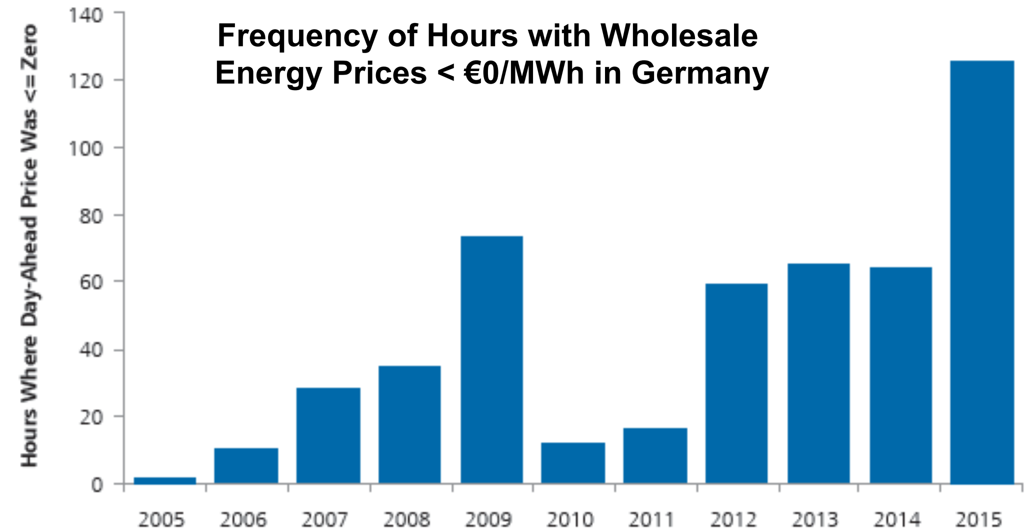
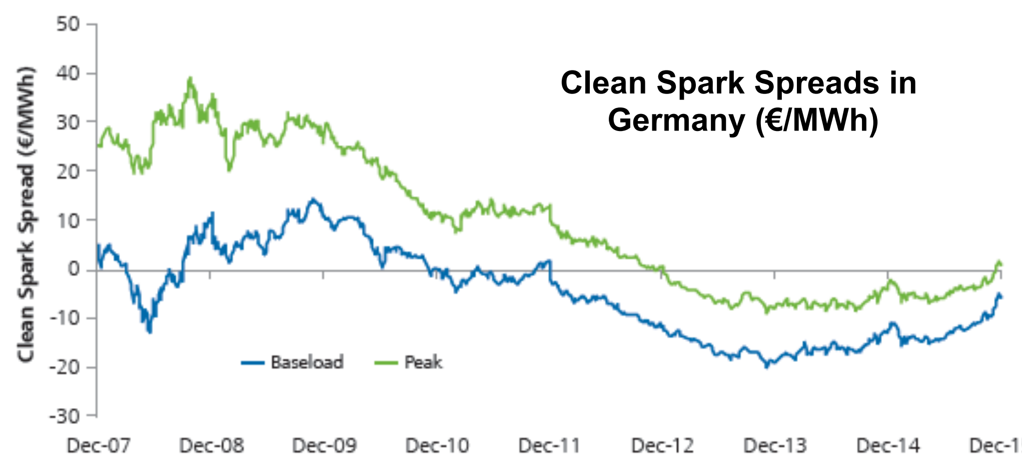
- Lately, capacity markets have also been used in Europe to provide investors with long-term contracts that provide a hedge against government interventions to adjust the generation mix, eg. due to low carbon policies

- They have also provided some compensation to investors in traditional plant, which have seen diminishing earnings from the energy market due to large volumes of low carbon generation being forced onto the system





Source: (Top Panel) European Power Exchange via Platt's PowerVision. (Bottom Panel) OTC via Platt's PowerVision and NERA Analysis[6]

Demand for flexibility will also increase as the generation mix changes

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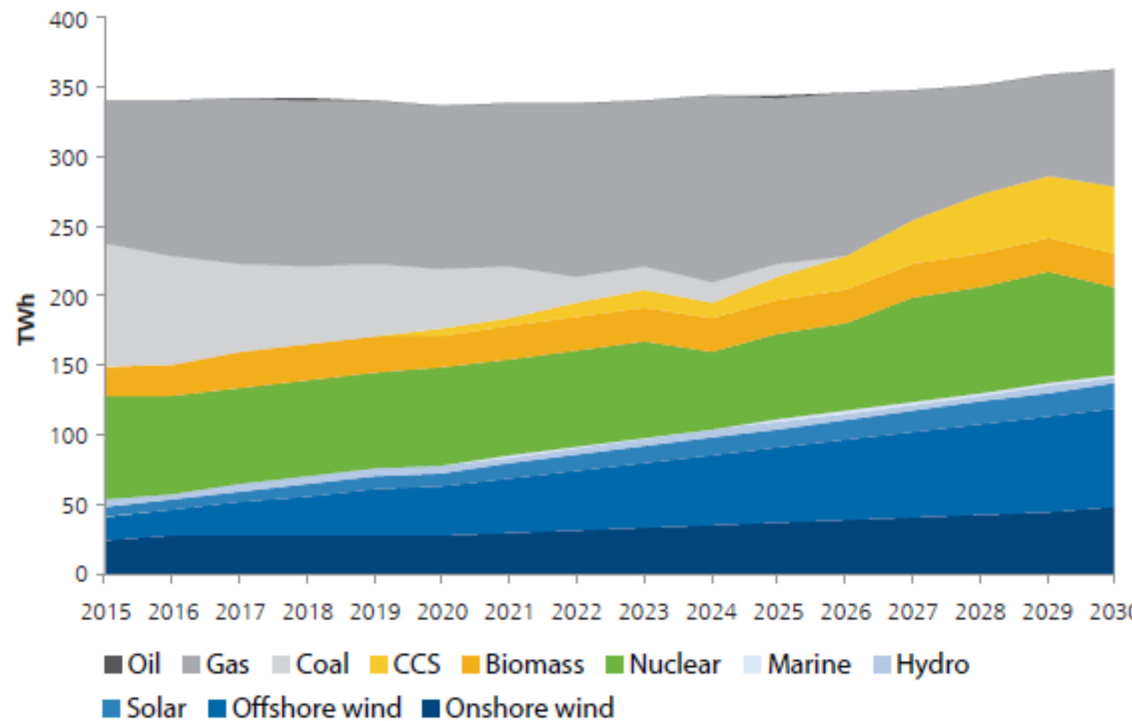
- A range of trends are eroding the market for energy and increasing the market for
  - Declining output from traditional generation means less “inertia” on the system.
  - A more volatile supply mix, with more wind and solar
  - New large nuclear units also increase reserve requirements
- **Result: more demand for “flexibility” services that are not reflected in the products most widely traded in competitive electricity markets**



Source: CCC, Fifth Carbon Budget Dataset, Central Scenario

As demand and supply conditions become more variable, the definition of traded products may need to change to support effective competition

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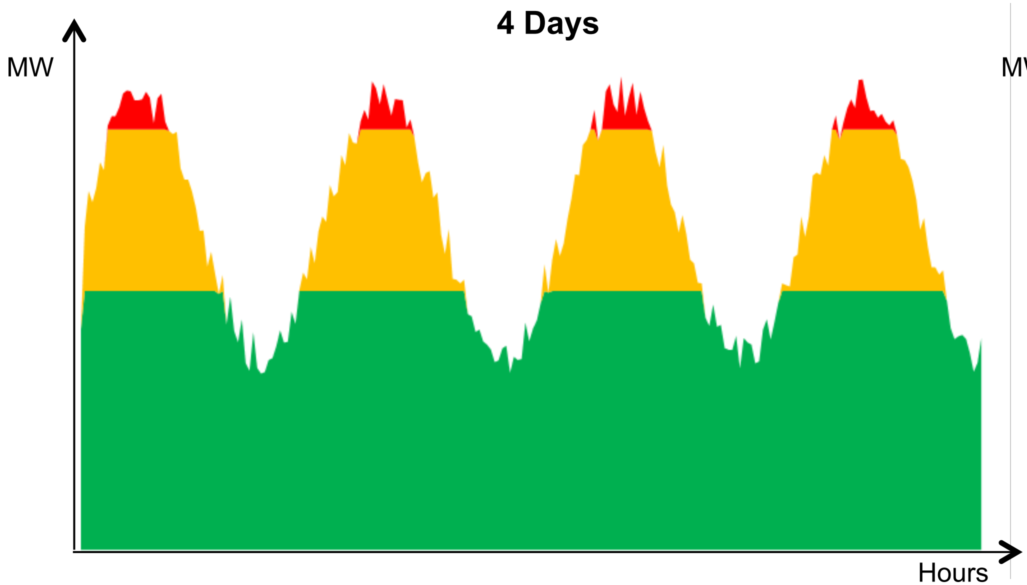
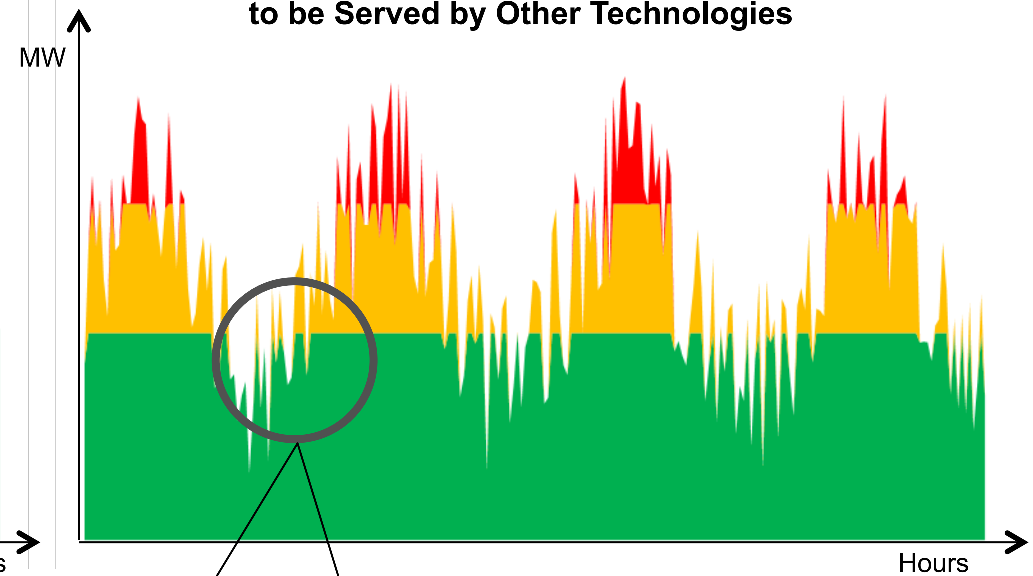
Illustrative Profile of Production Over 4 Days



…Less the Impact of Volatile Wind on Demand to be Served by Other Technologies



Fluctuations in supply in real time, which increase due to intermittency, will not necessarily change the value of the traded energy product (hence prices), which usually reflects average conditions over circa 30 minutes, across a wide geographic area

Electricity market design should evolve to recognise the value of flexibility – they are an ever less “ancillary” service

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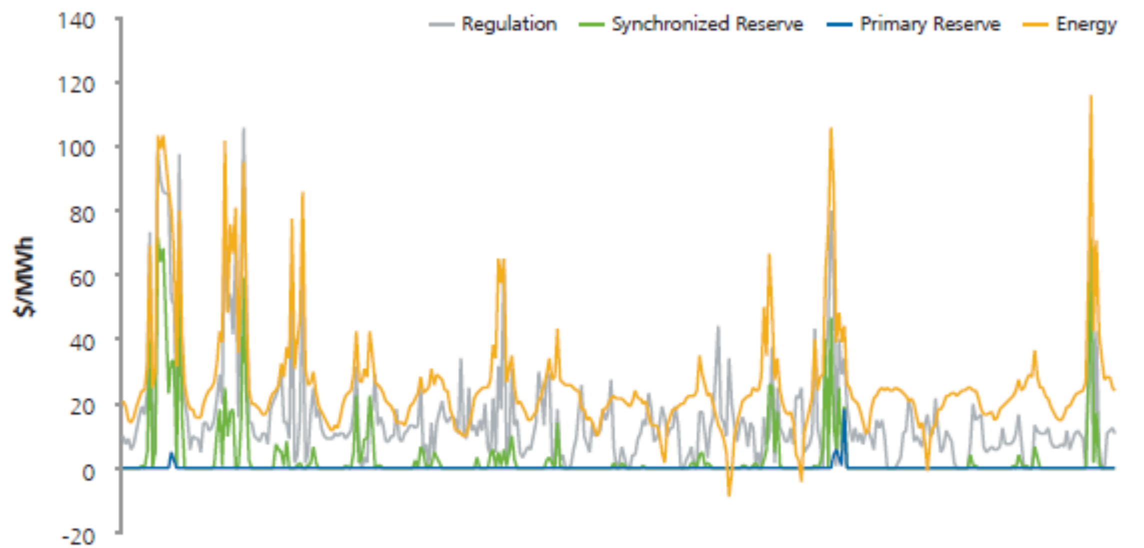
- Market reforms are focusing on subsidising low carbon generation, and insulating investors from the resulting regulatory risks through long-term contracting
  - New capacity remuneration mechanisms, etc.
- However, making competition work in evolving electricity markets may require changes in the “product definition”:
  - **Energy traded over shorter time intervals**
  - **More granular locational signals**
  - **More emphasis on (no longer) “ancillary” service markets**



Source: Energy prices are real-time LMPs for the RTO downloaded from SNL Energy; Ancillary Services prices are from PJM's website.[24]

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Models of Network Regulation to Promote Smart Grid Investments

When is it efficient to use "smart grid" measures?

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- "Smart" technologies reduce or defer traditional network investments, which may reduce total cost:
  - "Distributed Energy Resources" (DERs) like storage, demand response and active network control, can substitute for conventional asset-solutions
  - Requires flexible and sometimes innovative planning practices

Efficient Investment Decisions Require a Trade-off Between Traditional and Innovative Solutions

Traditional, high capex solution

vs.

Economising on capex using other operating measures

When is it efficient to use "smart grid" measures?

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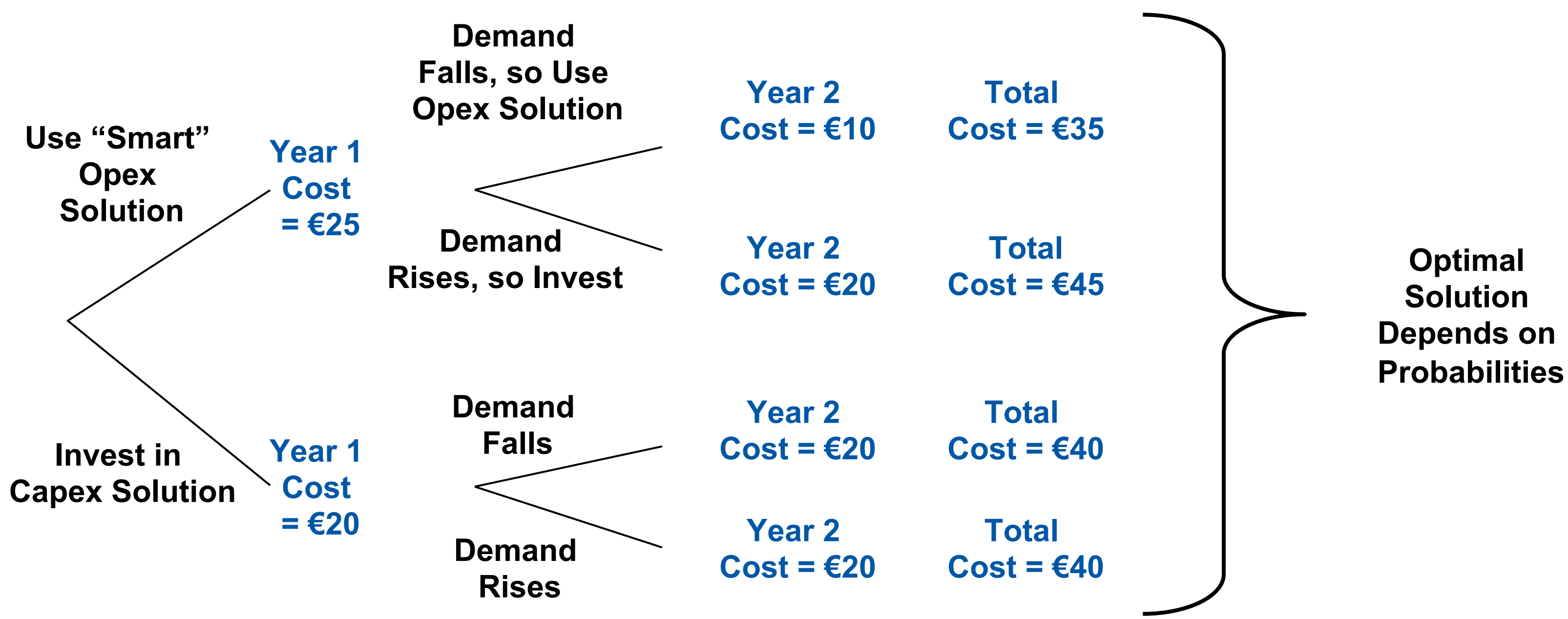
From the perspective of the distributor **"smart" technologies reduce or defer traditional network investments, which reduces total cost in some situations**

- Reducing risk of stranded assets through the **option value** of "smart" measures
  - Using a relatively expensive operating solution today can still be preferable to a capex solution if it provides a value from waiting for uncertainty about the future to resolve



From a DSO's perspective, what is needed to deliver smart measures efficiently and how can regulation help?

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Innovative thinking from the company + Some enabling investments, like IT infrastructure + Corporate processes for trading-off the pros/cons of Opex and Capex solutions + Commercial mechanisms for buying "smart" services from network users = Efficient use of "smart" measures

Innovative thinking from the company	Some enabling investments, like IT infrastructure	Corporate processes for trading-off the pros/cons of Opex and Capex solutions	Commercial mechanisms for buying "smart" services from network users
A regulatory regime that rewards innovation and economically efficient behaviour will encourage this	*Prudence criteria (where applied) need to recognise the potential value of anticipatory investments*	*Incentives to efficiently trade off short-term Opex and long-term Capex*	*Cost-reflective network pricing, procurement mechanisms for non-network technologies, smart metering*

Requires anticipated rates of returns commensurate with the risks of particular investments (applies to the second and third items)

The incentives imposed on DSOs through tariff regulation determines whether these conditions for the efficient use smart grid technologies are satisfied

A notional framework for setting tariffs using a *cost of service* approach

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$$\text{Revenue}_t = \text{Actual or Budgeted Operating Costs}_t + \text{Depreciation of RAB}_t + \text{Estimated WACC} \times \text{RAB}_t$$

$$\text{Regulatory Asset Base (RAB)}_t = \text{RAB}_{t-1} + \text{Actual Capex}_t - \text{Depreciation}_t$$

- Revenues are closely linked to costs, so companies may see short-term benefits from reductions in Opex, but generally do not benefit from longer-term operational cost savings or Capex reduction
- Some jurisdictions use an approval process for capex projects on a case-by-case basis, sometimes linked to defined prudence rules

Will this framework deliver an efficient use of smart grid measures?

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Aspects that are supportive of smart measures

- ✓ Low risk environment may be necessary for attracting capital, particularly in emerging markets, which is important for both "smart" and traditional investments
- ✓ Some models may convey modest incentives to beating the regulator's annual Opex forecasts

Aspects that may prevent the efficient uptake of smart measures

- X Weak incentives to minimise cost leads to low incentive to innovate or adopt new working practices
  - X Planning standards and prudency criteria are somewhat mechanical and often outdated
- X Potentially strong Capex biases:
  - X Little incentive to make efficient trade-offs between Opex and Capex, especially where Capex allowances are set using cost-plus mechanisms and opex allowances are fixed for short periods
  - X Sometimes allowed returns exceed market cost of capital

European regulatory models do not tend to encourage smart grid deployment

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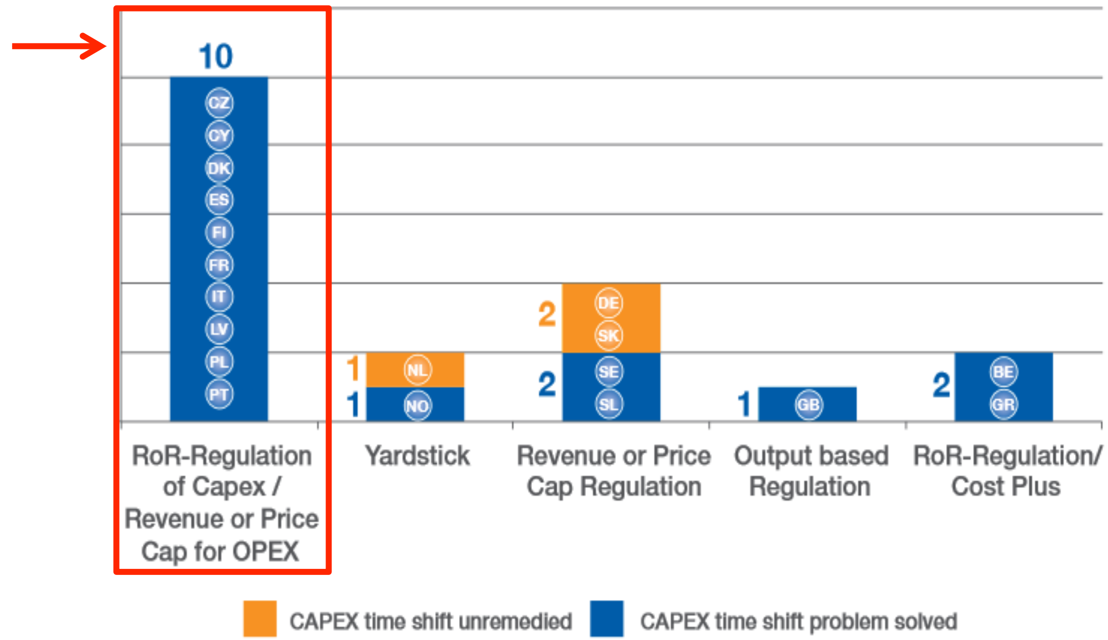
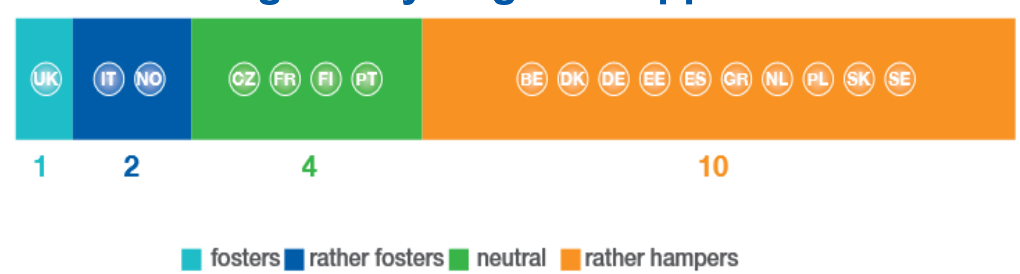
- Most EU Member States set electricity network companies' revenues to cover operating and capital costs, such that:
  - Revenue to cover "allowed opex" is set ***based on a forecast*** for several (e.g., 3-5) years, so companies have an incentive to reduce costs
  - Revenue to remunerate historical capex ("allowed depreciation and return") is set ***based on actual costs***, as long as companies comply with planning standards
- *Problems:*
  - *Limited incentive for innovation that reduces long-term costs*
  - *Distorted incentives when making trade-offs between opex and capex*

Types of Regulatory Regimes Used Across 19 EU Member States



Does the Regulatory Regime Support Innovation?



Source: Eurelectric

Source: Electricity Distribution Investments: What Regulatory Framework Do We Need?, Eurelectric, 2014.

Options for developing regulatory frameworks to encourage economically efficient use of smart technologies

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Broader use of incentive-based regulation

- Fixed term price controls to strengthen efficiency incentives, with allowed tariffs linked to forecasts of, not actual, expenditure
- Incentive mechanisms linked to quality of service targets

Encourages cost reduction, including potentially through smart measures

- But, many models of incentive regulation have Capex biases
- There tends to be a strong focus on opex reduction, and little incentive to innovate
- Solutions (e.g., UK, Italy): adopt Totex mechanisms to equalise Opex and Capex incentives

Institutional challenges for Implementation in South East Europe

- Prevalence of state ownership mutes incentives for efficiency
- Requires strong, independent regulatory institutions to protect DSO investor returns

Options for developing regulatory frameworks to encourage economically efficient use of smart technologies

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Prudence (Capex approval) criteria that oblige companies to consider smart alternatives

- Some EU jurisdictions use cost-plus regulation for capex, which could be easily supplemented with enhanced criteria for investment approval

Obliges companies to consider the alternatives to conventional solutions

- This could work, for instance, by obliging DSOs to tender for non-network alternatives to proposed network reinforcements (above a certain threshold)
- Australia's Regulatory Investment Test for Distribution is an example of this mechanism
- This could be combined with reform of planning standards to define processes for assessing the value of smart alternatives, and possibly defining what smart measures should be used in what circumstances

Potential savings have to be offset against extra administrative costs

- Tenders for non-network solutions might be administratively complex
- New obligations to use cost benefit analysis to select smart investments might impose cost on DSOs

Options for developing regulatory frameworks to encourage economically efficient use of smart technologies

Explicit incentive payments for adopting smart measures

Simple, targeted measure to promote smart grids

Blunt instrument; may distort other incentives

- For instance, some jurisdictions offer WACC premia for investments in smart grid measures. (Some US states offer premia on the Cost of Equity)

- Gives companies a defined objective to achieve increased deployment of smart technologies
- Can be used to offset the capex biases that would tend to lead companies to use more conventional alternatives

- A big downside is that this is a crude instrument, which requires calibration based on the assumed benefit of smart grid measures
- These benefits are hard for regulators to observe and even harder to codify, as they are highly variable

Options for developing regulatory frameworks to encourage economically efficient use of smart technologies

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Funding for innovation programmes

- One barrier to smart measures is the lack of innovation in network technologies
- Most regulatory models provide no incentive to undertake R&D funding

Simple, targeted measure to promote smart grids

- Can accelerate deployment of smart measures, as well as enhance knowledge and understanding

Funding constraints may be prohibitive

- Funding constraints may be prohibitive in some developing jurisdictions
- Such jurisdictions may prefer to adopt a “fast follower” model, drawing on research conducted in other jurisdictions (see major research programmes in UK and Germany, for instance)

Options for developing regulatory frameworks to encourage economically efficient use of smart technologies

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More efficient pricing of energy and network access

- Move to more cost reflective network charges to better signal the cost that users impose on (benefit users create for) the DSO
- Introduce differentiation by location and maybe customer type
- Nodal, real time tariffs is the desirable (though potentially infeasible) target

Encourages efficient behaviour by potential providers of smart solutions

- More efficient tariff structures support the efficient deployment (location and amount) of embedded generation, storage and demand response by third parties
- Important for getting the most out of smart meters

Some more "advanced" time of use tariffs may be complex and require smart meters

- Some enhancements to tariff design are relatively straightforward (more cost-reflective balance between per kW/kWh charges)
- Whilst efficient, some tariff models raise concerns over equity (consumer protection, etc) for smaller customers

Conclusions on the regulation required to achieve efficient smart grid measures

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- In jurisdictions with cost-plus regulatory arrangements, new investment approval processes may be needed to:
  - Recognise anticipatory investments, possibly combined with higher rates of return, commensurate with the risks associated with these assets; and
  - Incorporate non-network solutions to encourage or oblige DSOs to trade-off “smart” and traditional solutions.
- In jurisdictions with incentive regulation arrangements, an equal treatment of Opex and Capex to remove Capex biases may support efficient investment
- Innovation is also important in promoting smart grids:
  - Most European regulatory regimes provide weak incentives for innovation, so some are providing significant R&D funding
- Cost-reflective network pricing and procurement mechanisms for non-network technologies will all help third parties to provide network services

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Tariff structures that fail to reflect network companies' cost structures may promote "grid bypass", eroding their revenues

- A large proportion of power system costs are invariant to consumption
- If tariffs designed to recover fixed costs are linked to consumption, consumers may avoid paying for fixed costs by using emerging self-supply options

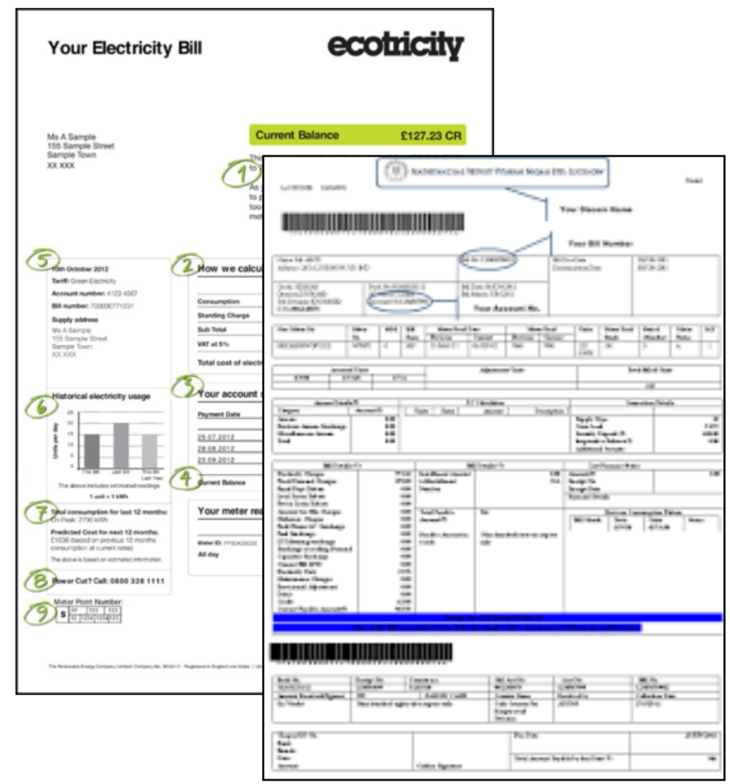
Costs of Self-Supply

vs.

Costs of Serving End-Users

vs.

Retail Price



Even more sophisticated tariff structures may need to become more "dynamic"

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Example:
From the UKPN Charging Statement for East Anglia

RED: Mon-Fri (16:00-19:00)
AMBER: Mon-Fri (07:00-16:00, 19:00-23:00)
GREEN: Mon-Fri (23:00-07:00) and All Day Sat-Sun
TURQUOISE: 24hrs x 365 days

Tariff name	Unit charge 1 (NHH) or red/black charge (HH) p/kWh	Unit charge 2 (NHH) or amber/yellow charge (HH) p/kWh	Green charge(HH) p/kWh	Fixed charge p/MPAN/day	Capacity charge p/kVA/day	Reactive power charge p/kVArh	Exceeded capacity charge p/kVA/day
Domestic Unrestricted	2.005			4.59			
LV HH Metered	10.976	0.078	0.014	14.26	3.14	0.330	3.14
LV Generation Intermittent	-0.885			0.00		0.282	
LV Generation Non-Intermittent	-9.428	-0.088	-0.015	0.00		0.282	

Source: UK Power Networks

New tariffs are emerging that allow flexible demand to avoid paying for fixed network costs

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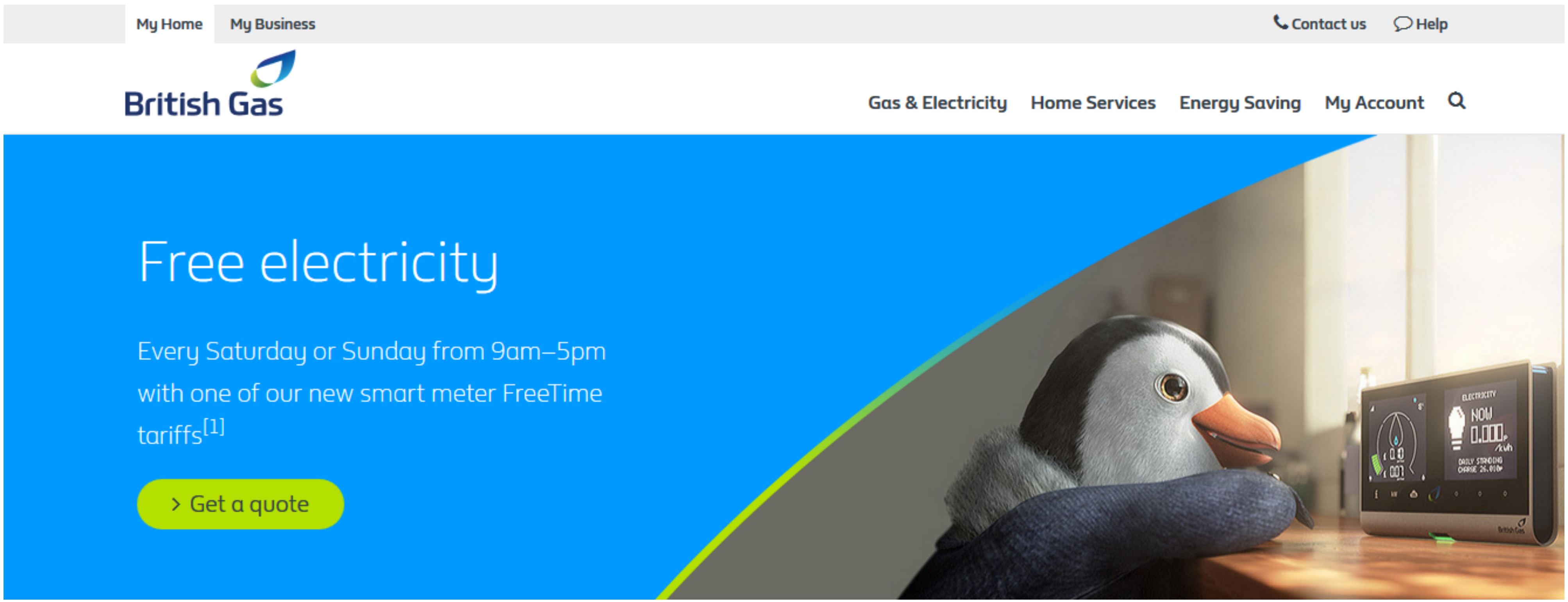

Source: British Gas Website