Decentralisation and digitalisation of the energy system

It doesn't need to cost the earth to save the world

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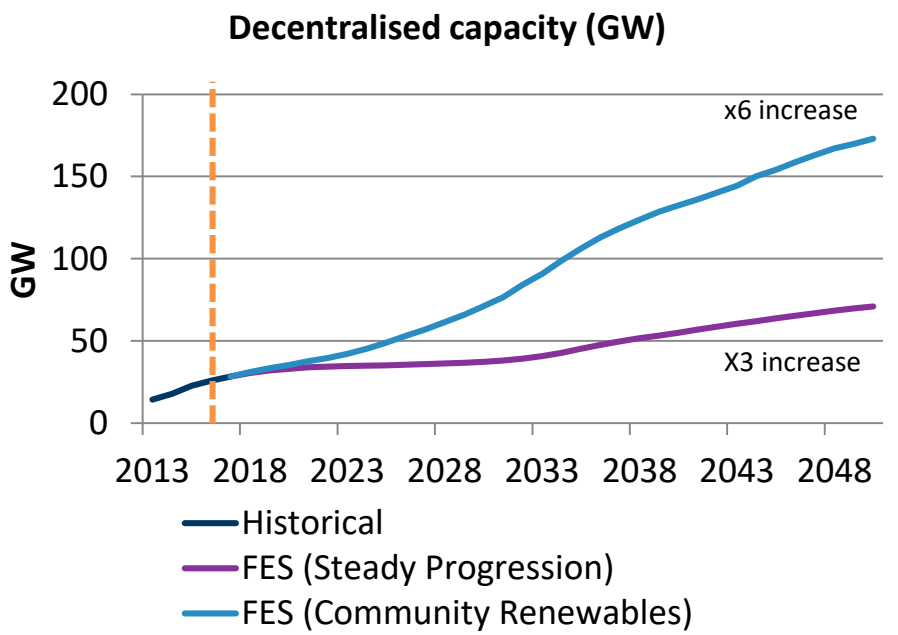
10 May 2019

Well understood that energy decentralisation increasing rapidly, changing fundamentally the nature and role of distribution networks

Decentralisation increasing, but future trajectory highly uncertain

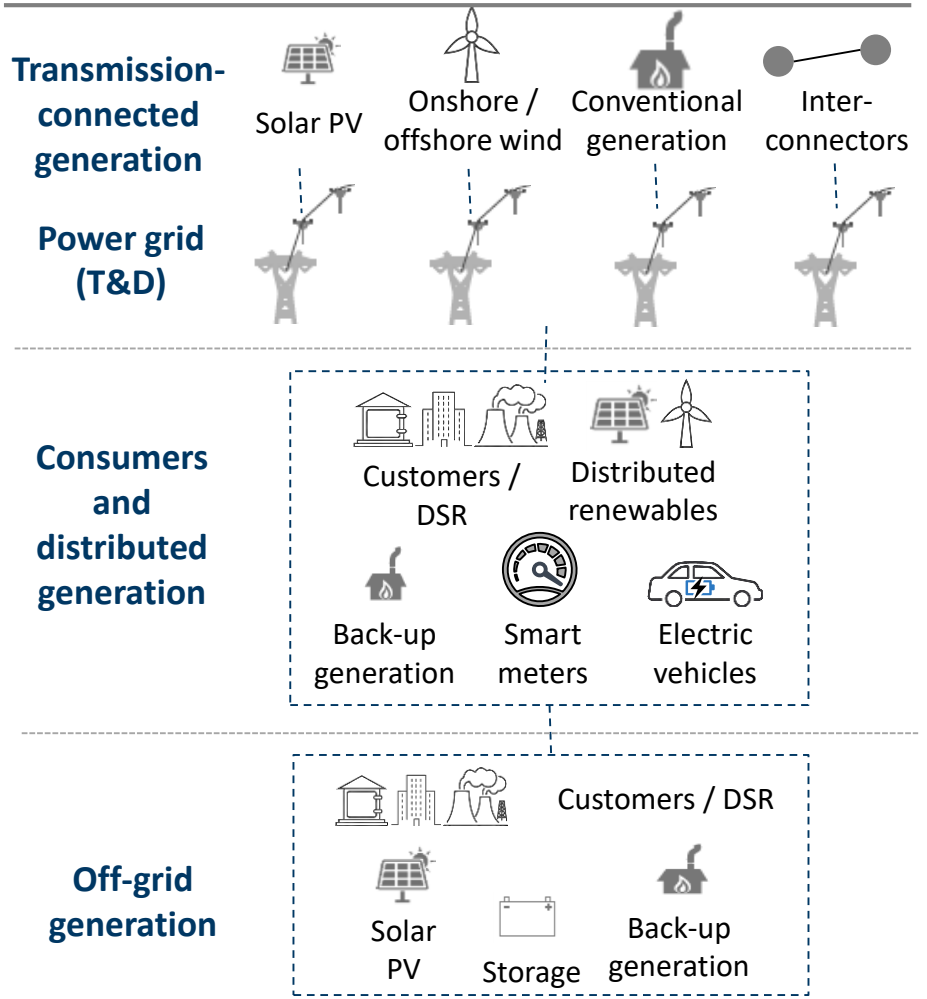


Source: 2018 Future Energy Scenarios

Key drivers of uncertainty.:

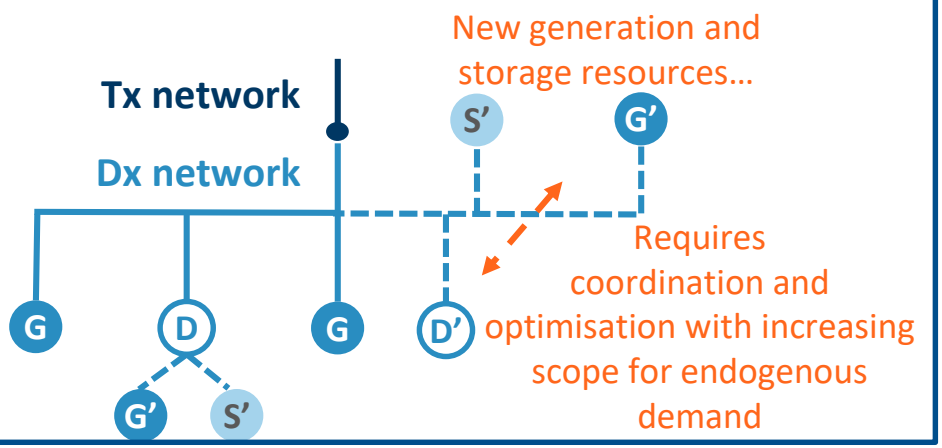
- Electrification of heat / heat policy
- Electrification of transport
- Emerging technologies (battery storage, DSR etc)

As well as greater volumes, type of decentralisation increasingly diverse

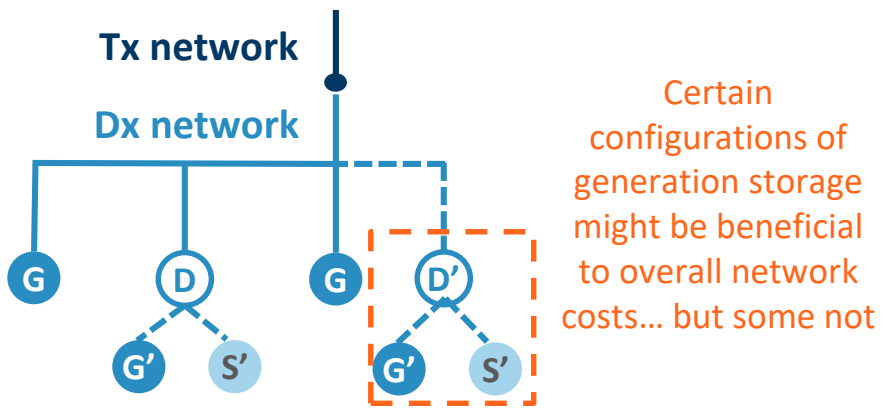


Greater **decentralisation** offers potential for huge benefits – but could be exceptionally costly unless managed properly

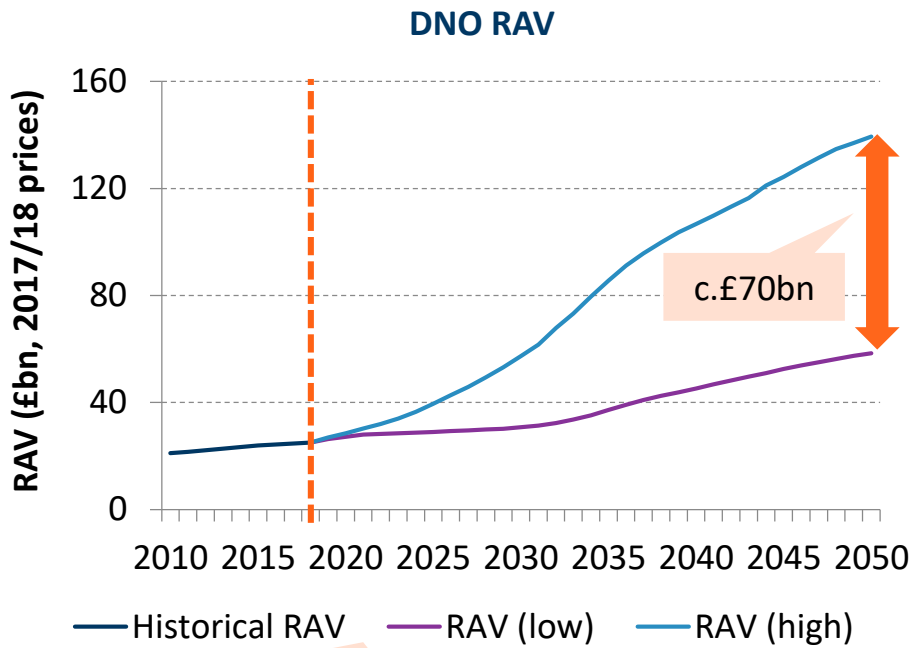
Distribution network no longer passive one way flow system



So long as it is well located, generation and storage can offset need for distribution network…



…but badly located and managed could necessitate a huge expansion in network costs



In one scenario, the CCC estimates that there are potentially £8bn/year of savings through better use of existing assets (i.e. through the value of flexibility)

**illustrative RAV growth based on the same % increase in decentralised capacity in slide 2*

Improved market design offers opportunity of running a system without need for excessive network capacity

Fortunately, GB policy makers have 30 years experience in trying to achieve investment and operational efficiency at transmission level

…and have used a range of market and policy tools at the transmission level…

Wholesale market	Incentivise operational efficiency (and investment)	**Regulation of system operation**	Incentivise better congestion management, procurement of reserves and balancing
Network use of system / connection charging	Incentivise efficient siting decisions	**Capacity market**	Incentivise investments through longer-term price signals
Regulation of networks	Encouraging efficient investments in expansion	**Market coupling**	Enables efficient trading across interconnectors

…variants of which could be deployed at distribution level.

However managing transmission is relatively easy…

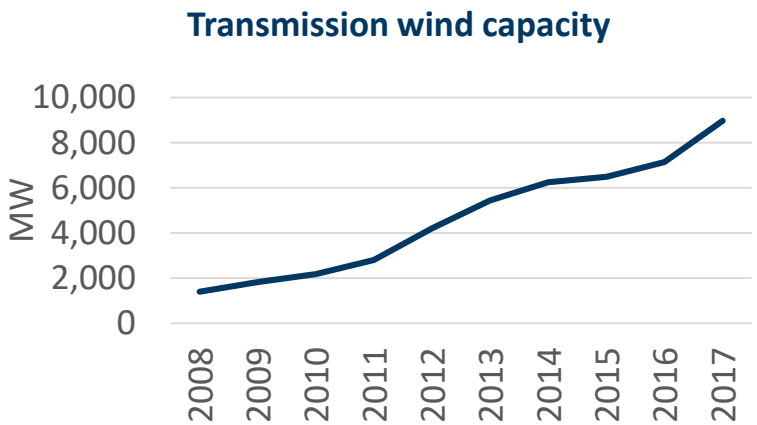
- Hundreds of assets to manage
- Few discrete investments annually
- Network expansion regulated carefully
- Meshed network
- Congestion resolved through operational measures
- Losses relatively low

…distribution promises to be much more difficult

- Thousands / millions of assets to manage
- Many small investments continually annually
- Difficult to regulate network expansion (due to scale)
- Meshed and radial networks
- Very limited experience of congestion management
- Line losses, voltage limits and reverse flow issues more prominent on the distribution level

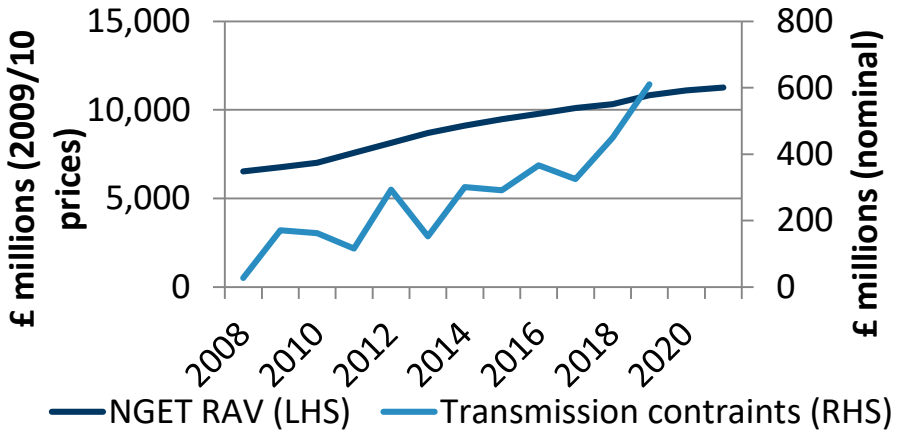
Unfortunately, GB policy makers current market design might not have achieved optimal investment or operational efficiency…

Intermittent renewables generation on transmission network expected to increase to c.12-13x since 2008 by 2021…



Source: DUKES

…has been a factor in a 20-fold increase in congestion costs and a doubling of the RAB…



Source: National Grid MBSS, Ofgem's RIIO-T1 annual report, PCFM

Note: In addition, asset utilisation is estimated to be relatively low, at below 50% (however driven by the N-2 requirements)

…and a doubling of the transmission asset base

…not solved by perennial reviews of transmission network charging

- **Transmission access and losses under NETA (2001)**
- **Transmission access review (2008)**
- **Significant Code Review (2018)**
- **Multiple working groups (e.g. Access Reform Options Development Group from 2006)**

…suggests policy makers need to be very wary about extrapolating current GB market approach to distribution network issues

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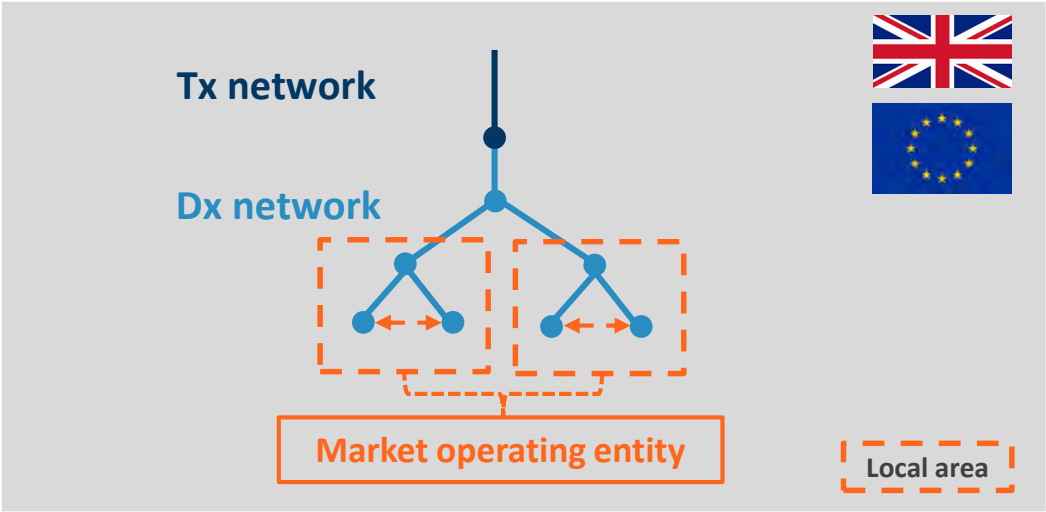
Therefore should draw on learnings from existing policies, but adapt these to meet growing challenges. We see two broad options:

Zonal pricing

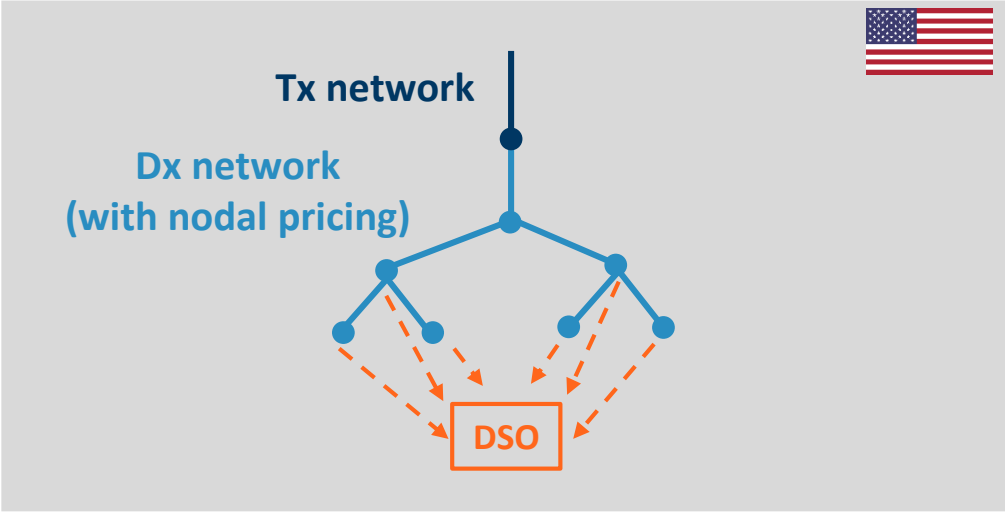
Transposition of the EU Target Model on the distribution level



- Akin to EU target model, the distribution network could be broken down into zones reflecting constraint boundaries
- Resources can trade with each other within zone on a bilateral basis (or through aggregator)
- Price per zone
- Trading between zones via centralised market (cf market coupling)
- Network operator can also contract for services to manage network issues (as per NG now)
- Could have locational network charges within zone…
- …could complement with a locational capacity mechanism
- Congestion within zone either compensated or curtailed

Nodal pricing

Extension of the US-style nodal pricing on the distribution level

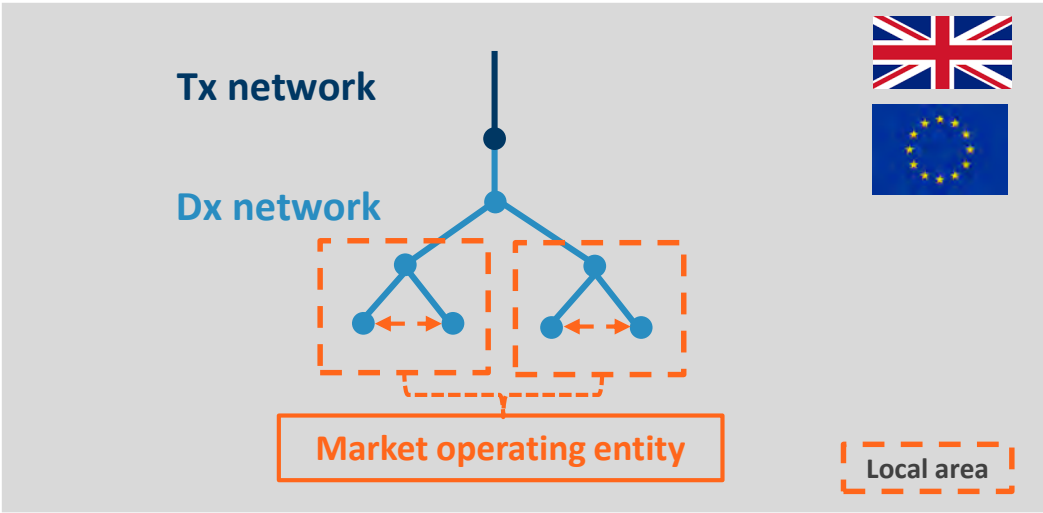


- Akin to US model, the DSO co-optimises reserve and energy, albeit for local area only
- Participant bids / costs either submitted or assumed (standing bids)
- Nodal prices could provide price signals at very granular level (at cost of computational complexity)
- Ex ante scheduling time needs to take account of trade off between forecast uncertainty and computational time…
- …and need slick “intra day” updating processes
- No “physical” trading between peers other than via the distribution system operator…
- …but financial peer-to-peer trading might be possible.
- Postage stamp network charge to recover residual d costs

If it can be made to work (computationally), the nodal pricing approach might have greater advantages…

Zonal pricing

Transposition of the EU Target Model on the distribution level



- ✓ Peer-to-peer trading within zone – however requires a "copper plate" to be effective
- ✓ Self scheduling within zone
- ✗ Counter-trading or uncompensated curtailment if network conditions not suitable given intended operation
- ✗ Locational network charges only second best – and will become problematic if zones large…
- ✗ …or need lots of distribution investment
- ✗ Difficult to regulate large zone network investment

Nodal pricing

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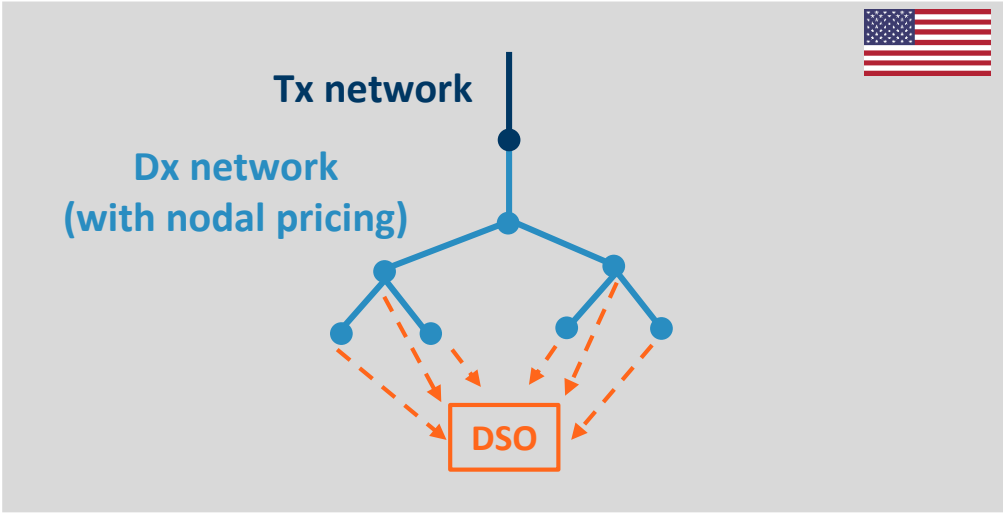

- ✓ Granular price signals reflecting (potentially only near) real time marginal cost at each location
- ✓ Resolves network congestion management
- ✓ No need for inaccurate complex network charging
- ✓ Improves coordination between resources and investments
- ✓ Network expansion more straight forward to regulate
- ✗ Nodal pricing (especially DLMPs) highly complex – particular given likely non-linearity and non-convexity of costs
- ✗ Incorporating storage into real-time marginal cost pricing and optimisation not yet solved
- ? Peer-to-peer trading via local DSO only

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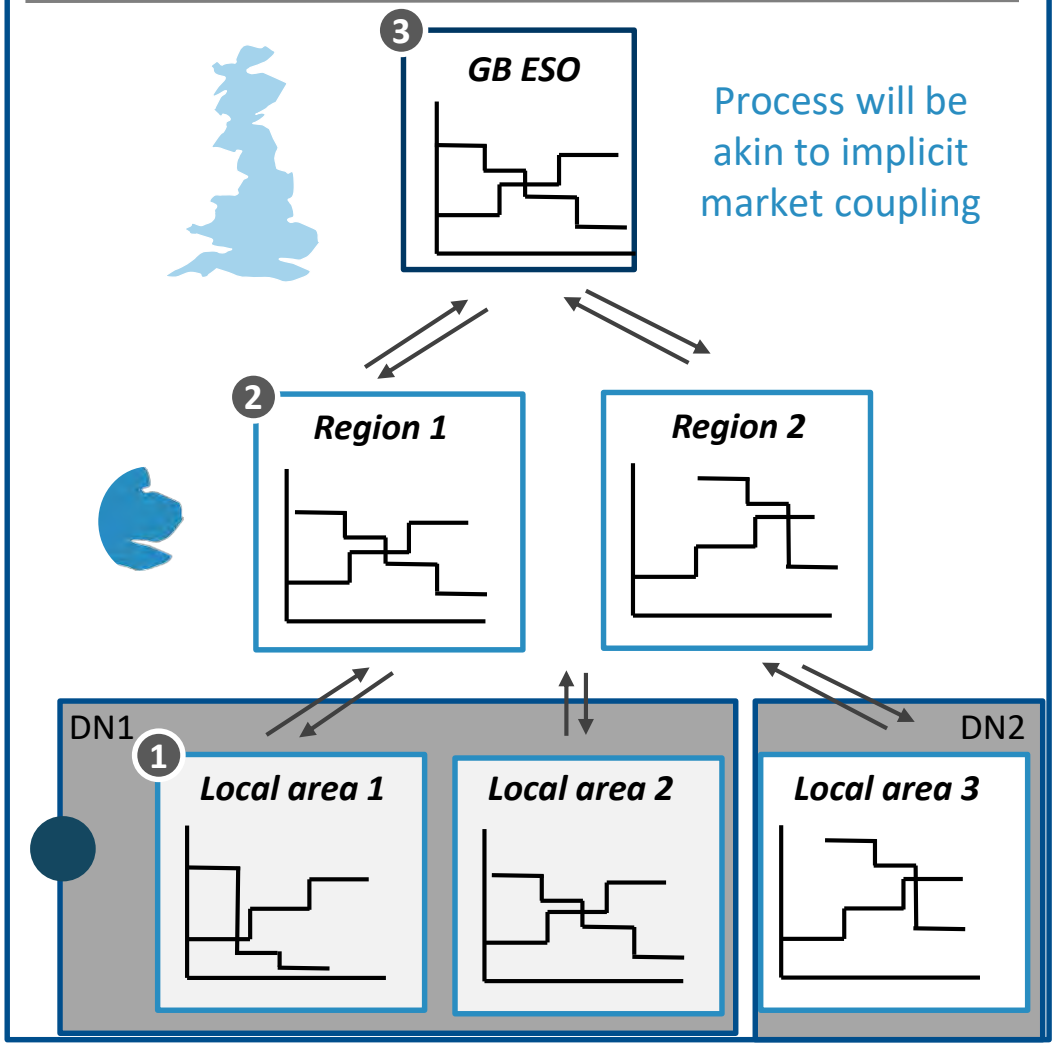
Once resolved local market can then use principles of market coupling to cascade markets upwards to settle at transmission level

Example of a potential model of "co-optimised" local energy markets



Example of the mechanics of the model

Ex-ante co-optimisation process (day-ahead / intraday)

1. Participants / aggregators submit day-ahead / intraday offers (which could be standing or assumed)
2. DSO optimises local schedules both within, and across each local area
   - DSOs submit (network constraint) compliant increment and decrement bids to the ESO
3. TSO optimises these schedules at day-ahead / intraday (and may direct each DSO on adjustments needed to optimises through zonal price signals?)…
   - …in concert with transmission connected units (e.g offshore wind, interconnectors etc)
   - Calculates nodal prices at transmission level
4. Will need to update frequently as real time approaches given RES and Demand uncertainty

Emerging technology offers potential for consumers to engage nearly effortlessly – aka "democratisation"

Users simply set preferences through devices - no need for "super-engaged" consumer

- Set expected time at home / away at home
- Set preferred time to charge / use EV
- Battery storage to optimise time-of-use
- Device informs (or locks-in) expected costs of the different options
- Or in-built machine-learning algorithm to optimise preferences

Instead, supported by suppliers, aggregators or other third parties, the "Internet of Things" will engage on consumers behalf

Millions of separate payment flows will be facilitated through a decentralised platform

- ✓ Potential role for blockchain technology as a distributed, secure "ledger" - holds millions of transaction records (in each time period) securely
- ✓ Records actions privately and independently of a centralised operator
- ✓ Platform could then be used to make or aggregate any forecasts of unscheduled demand / resources
- ✗ Blockchain technology still in nascent stages (e.g. potentially requires lots of energy to process)
- ? Unclear to what degree consumers will (or should) be exposed to price fluctuations/imbalances (but perhaps choose)

Cornwall local energy market

- 3 year trial (led by Centrica) on a virtual marketplace
- Developing a platform to **automatically optimise** the sale of flexible energy capacity to the local grid and wholesale energy market

Drivers of institutional change at transmission level that led to formation of ESO may well apply at distribution level too…

Current trajectory

- Single DNO and DSO
- Responsible for network planning, scheduling

✓ Each local DNO would be familiar with its own local network configurations

✗ Potential conflicts of interest between the DO and SO esp. on network planning

✗ Requires a new function / expertise

Independent DSO

- Independent DSO – responsible for network planning and scheduling
- DNO is network owner and asset provider

✓ Independent DSO functions as the aggregator of local resources

✓ Retains local knowledge of system but not conflicted.

✗ Risk of not knowing system well enough and therefore increasing congestion costs (esp. if big zones)

Market operator

- Market operator and network planner for all distribution networks

✓ Independent market operator to establish rules and direction for DSOs

✓ "Centre of excellence" in terms of local market design and operation

✓ Easier for national optimisation

✗ Complexity of a new entity and new interactions required

"All-seeing" SO

- Integrated ESO and DSO
- Separate DNOs

✓ Single decision-maker – avoids need to co-optimise twice (see slide above)

✓ Easier for national optimisation

✗ Lacks local knowledge (and potentially legitimacy – could hamper planning and consenting)

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Policy-makers will need to make some difficult decisions sooner rather than later. Some suggestions to policy makers…

Recognise that the market design will need to be complex	• Prices will be volatile and vary markedly by location. These need to be reflected onto participants if we are to avoid large network build • This tends towards either small price zones or (preferably) DLMPs
Be wary of unfettered peer-to-peer trading..	• Empowering consumers sounds very attractive, but actually is unduly simplistic • Unfettered trading creates risk of big costs, either through network reinforcement, congestion resolution, or inefficient curtailment
..and recognise SO need to be involved in local markets	• The interactions between system issues and energy issues are much greater than transmission… • …the residual balancing role of the ESO is not likely to be suitable in distribution
Locational network charges don't work that well	• Be wary of relying on "future policy initiatives" in network charging … • …really is a recipe for policy procrastination ("kicking the can down the road")
Institutional changes might well be necessary	• Given history, economic incentives and regulatory limitations, it will be very difficult for DNOs to move away from an "asset heavy approach" for network planning • While linked to market design, might need to think about changing arrangements
Don't wait	• Once established, we know changing market design is difficult as creates vested interests and, in turn, winners and losers (c.f. transmission charging) • Hence a "let's see how it goes" approach might risk embedding the wrong approach that is difficult to move away from and/or potentially very costly to build through

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