Issues at the transmission-distribution interface

ICMS
Management of Energy Networks

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17 January 2018

Introduction to Baringa

Baringa Partners is a market-leading consulting company with a focus on the challenges of tomorrow, operating in the Utilities, Energy, Financial Services, Telco and Consumer Retail sectors.

We help clients using our deep industry insights to:

- Run more effective businesses
- Launch new products & businesses and reach new markets
- Understand and navigate industry shifts

We have worked with energy companies across:

- Strategy & Regulation
- Market design
- Enterprise Architecture
- Programme delivery and assurance
- We deliver these services across the whole energy value chain

Our clients include:

SCOTTISHPOWER, BT, EDF, SEVERN TRENT WATER, nationalgrid, Thames Water, e.on, npower, United Utilities – helping life flow smoothly, Southern Water, electricity northwest, nationalgrid, BRISTOL WATER, anglianwater, UK Power Networks, British Gas, ofgem, Department for Business, Energy & Industrial Strategy, Data Communications Company, energy technologies, ena energynetworks association

We all roll up our sleeves to deliver.

We bring deep industry experience to client projects.

Collaboration runs through everything we do.

Our independence means we provide impartial advice.

Our award-winning culture attracts the brightest people.

We don't want to be the biggest... Baringa was founded in 2000 and now has:

550 employees

55 partners

5 Offices worldwide (UK, Germany, Ireland, UAE and USA).

Our reputation is hard won and we're determined to keep it growing.

GREAT PLACE TO WORK® 2017 Best Workplaces™

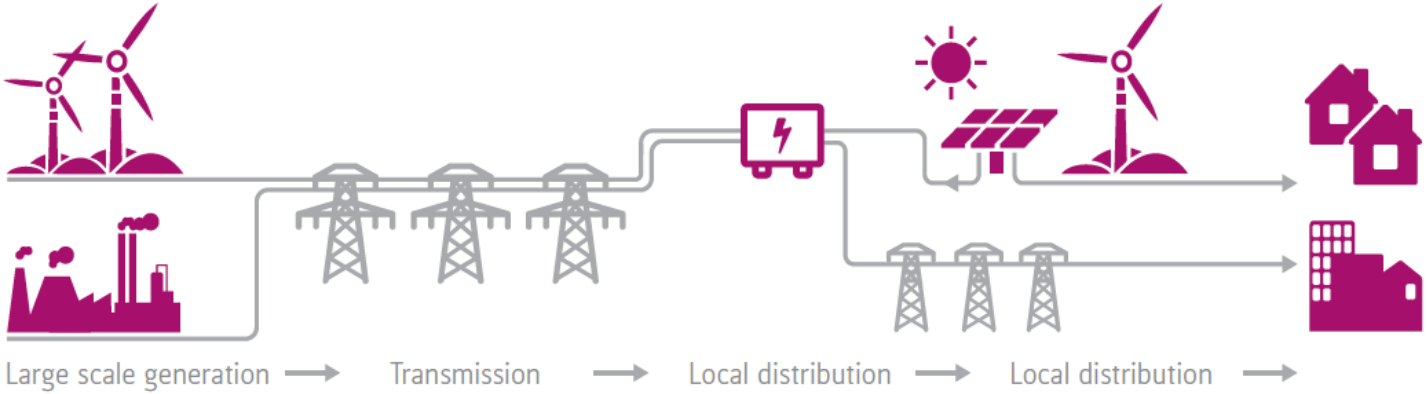
Best Workplaces Master 2007-2016 United Kingdom

EnergyRisk AWARDS WINNER 2015 Regulatory Advisory House of the Year

Commodity Business Awards Baringa Partners WINNER 2014 Market Policy & Advisory

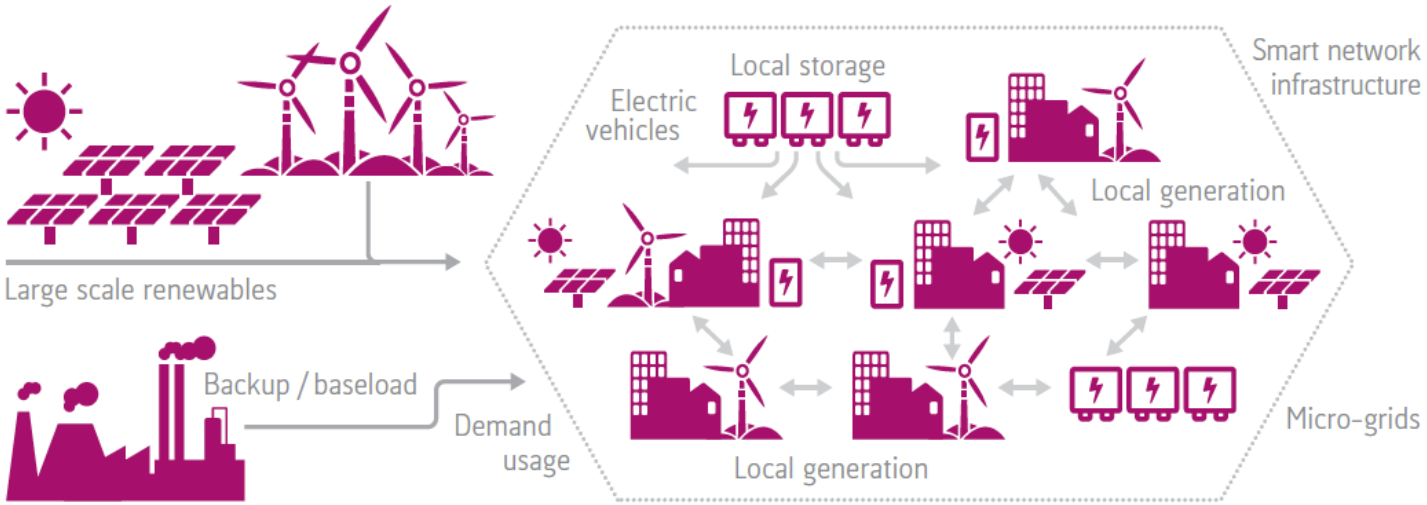
The Electricity System Revolution

The growth of new forms of Distributed Energy Resources is driving a broader energy transition



Old World

- Electricity provision by major utilities
- 95 per cent large-scale generation and transmission
- Niche DG
- No Smart Grids / Homes



New World

- De-centralised generation
- Smart Grid and Smart Homes
- Battery storage and EV deployment
- Emerging markets may not require large generation

Drivers of active DSO development

Internationally, there is a common set of drivers for the need to develop active distribution networks and integrate Distributed Energy Resources (DERs)

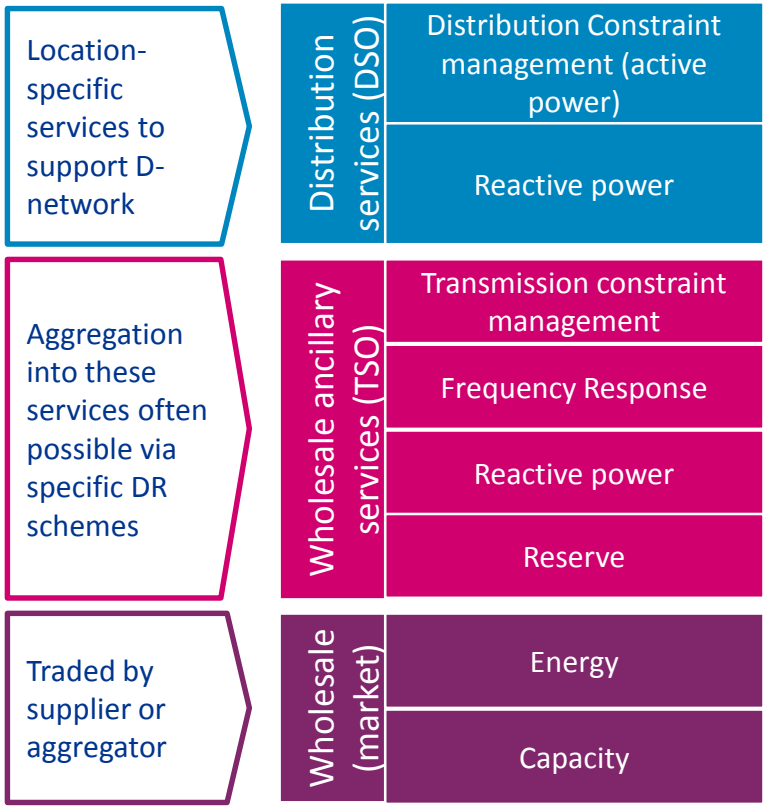
- **Deployment of small scale renewables (wind and solar PV)**
- **Decarbonisation (electrification) of heating and transport**
- **New technologies for electricity storage: batteries, CAES, etc**
- **Requirement for greater flexibility and new ancillary services to manage intermittent generation and new sources of demand**
- **Development of new business models – aggregators and platforms**
- **Deployment of smart metering**
- **More active consumer engagement**
- **Regulatory incentives to deliver more energy with less network capacity**

Designing markets to enable participation

Baringa

How can markets and services be adapted to enable Distributed Energy Resources to provide services and maximise the value it can provide?

Potential short term service provision by Distributed Energy Resources (examples)



Focus above is on markets and service provision. Locational or temporal value can also be signalled by time of use charges / tariffs

Potential route to market

Route to market	Description	Pros	Cons
Multiple	DERs or their aggregators contract directly with TSO, DSO and in wholesale market	• Allows for competition to develop • Limited market changes required	• Aggregator must mange conflicting usage, penalties etc. • Risk of conflicting requirements not being coordinated or managed
TSO led	TSO coordinates participation of DER	• TSOs experienced in procuring and coordinating services	• Risk of double payment for same service • More limited role for aggregator
DSO led	Active DSO coordinates participation of DER	• Locational aspects of DER considered (e.g. if DER is behind a constraint)	• Step out for DSOs More limited role for aggregator
Third party platform	Third party platforms developed for DER, which interface with markets	• Platform could account for conflicting usage, penalties etc • May compete with aggregators	• Risk of double payment for same services • How to integrate with wider market

Case studies: GB, New York State, and I-SEM

Jurisdictions with ambitious targets but different starting points and backgrounds

Role	New York	Great Britain	I-SEM
Size of market (population)	19 million	64 million	6.6 million
Peak load	31 GW (2015)	61 GW (2016)	6.5 GW (2016)
System operator(s)	NY ISO	National Grid (NG)	EirGrid & SONI
Transmission owner(s)	Joint Utilities (4 companies)	>132kV 3 TOs including NG	ESB Networks NIE Networks
Distribution owner(s)	Joint Utilities (4 companies)	<132kV 6 DNOs	ESB Networks NIE Networks
Distribution system operator(s)	Joint Utilities (4 companies)		
Generators	38 GW	81 GW Competitive wholesale market	14 GW
Wholesale Suppliers	JU, NYPA/LIPA, and ESCOs	Competitive – 6 main suppliers	Competitive
Aggregators	Active but small role	Active but small role	Active role in wholesale market
Regulator(s)	PSC, FERC	Ofgem	CRU and NIAUR
DER connected	>500 MW (DG PV, 2016)	Circa. 30GW	~400 MW of DSU

Key drivers of change

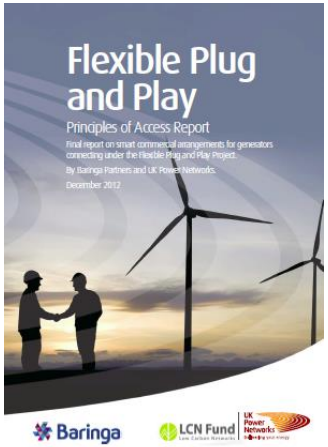
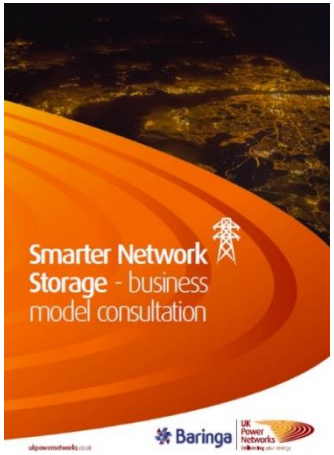
The same change drivers can be seen across multiple regions, but under some scenarios GB might be particularly affected

Challenge Areas	Ireland	Germany	United States			GB
			New York	Texas	California	(*Gone Green* Scenario)
Distributed generation	✓	✓✓✓	✓	✓	✓✓✓	✓✓✓
Heat pumps	✓	✓	✓	✗	✗	✓✓✓
Electric transportation (BEVs & PHEVs)	✓✓	✓	✓	✓✓	✓✓✓	✓✓
Microgrids and community energy systems*	✗	✓	✓✓	✓	✓✓	✓✓
Interconnections	✓✓✓	✓✓	✓	✗	✗	✓✓✓
Large scale renewables and inertia challenges	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓

SOURCE: Future Power System Architecture Project (2016) *International Study*

Example innovation projects in GB (1)

Several of the innovation projects we have worked on have trialled new commercial and business models for delivering flexibility on to the system.

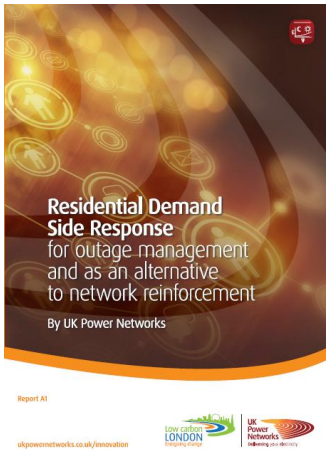
		Innovation project	Next steps
Flexible connections (Flexible Plug and Play)		• Using Active Network Management (ANM) to offer flexible connections – cheaper and faster connections in exchange for a degree or curtailment (uncompensated) where distribution network export capacity is constrained. • Principles of access based on Last in First Offer (LIFO) or pro-rata basis	• WPD committed to rolling out ANM across its whole region by 2021, and UKPN across 2 of the 3 of its licence areas • UKPN exploring more market based mechanisms for allocating curtailment and/or trading capacity
Distribution level storage (Smarter Network Storage)		• Demonstrating different business models for connecting electricity storage to distribution networks, and providing peak shaving services to the network operator • 6 MW/10 MWh battery commissioned in 2014 at Leighton Buzzard, East of England	• 201 MW of battery capacity procured by National Grid in the 2016 Enhanced Frequency Response auction • Connection and charging arrangements being changed to facilitate battery storage • Connections queues for storage development in a number of areas

Example innovation projects in GB (2)

We are now working with UK Power Networks and National Grid on a trial exploring the TSO-DSO interface using a common platform for procuring Balancing Services from DERs

		Innovation project	Next steps

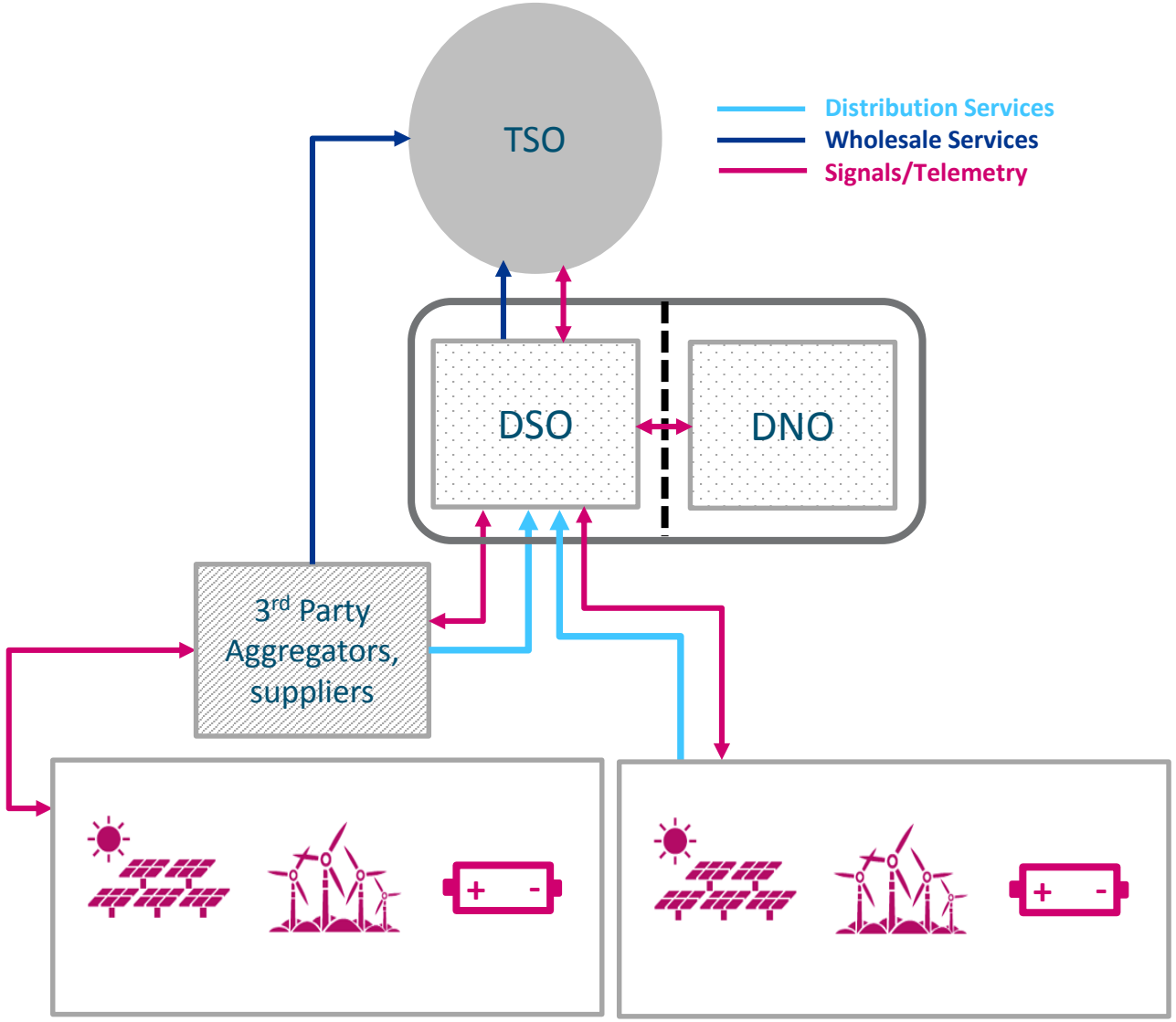
TSO/DSO coordination (Power Potential)		• Accessing balancing services from DERs, notably reactive power, in a constrained part of the network.
		• Demonstrating a coordinated approach to balancing services procurement across the TSO and DSO.
		• UK Power Networks and National Grid believe Power Potential can deliver over 3.7 GW of additional generation capacity in the area by 2050 and reduce the need to build additional electricity infrastructure.
			• Move to joint regional planning with common assumptions and scenarios
			  • Enhanced network data and models
			  • Regional strategies – CBAs, local scheme designs, T/D joint planning, network options analysis redesign to consider operability/service solutions
			  • Enhanced operability schemes – Improved visibility and control of D-DER,

Demand side response (Low Carbon London)		• Assessing the impact of a range of distributed energy resources on urban distribution networks including distributed generation, demand side response and electric vehicles. • Procurement of DSR from I&C customers in constrained parts of the network, and trialling of dynamic time of use tariffs for residential customers	• DNOs looking to procure demand side response as an alternative to network reinforcement as part of business as usual • An example being UK Power Networks' upcoming flexibility services tenders

An emerging model for DSO in GB

Active DSO as part of the Distribution Network Operator (DNO), procuring distribution services from DERs

- The DSO role is likely to develop as part of the DNO. The DSO function would procure and deploy services from DERs to manage Distribution system reliability, defer reinforcement and manage connection queues
- The DSO may also provide access to TSO ancillary services (e.g. when D constraints restrict use of DER)
- However likely that there will be routes direct to TSO (e.g. via third party aggregators or platforms)
- Wholesale energy will continue to be traded separately



Structure of New York state energy market

Different market structures throughout jurisdictions

Role	New York	Great Britain
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Aggregators	Active but small role	Active but small role
Regulator(s)	PSC, FERC	Ofgem
DER connected	>500 MW (DG PV, 2016)	Circa. 30GW

Key similarities to GB:

- Ambitious decarbonisation targets
- Emerging aggregator market to facilitate access to TSO markets for DER
- Drive from state regulator to roll out DSO enabling capabilities
- Shallowish connection boundary

Key differences to GB:

- Bundled retail, distribution and transmission (the Utility)
- Independent System Operator (NYISO)
- Far less DG connected to date but ambitious plans
- Two regulators: Federal (FERC) and State (Public Services Commission)

New York's Reforming the Energy Vision (REV)

A policy framework for developing markets for DERs

Timeline

2014

- The New York State Energy Plan sets out a roadmap for a clean, resilient and affordable energy system. This includes:
  - 40% reduction in greenhouse gas emissions from 1990 levels;
  - 50% electricity from renewable energy resources; and
  - 600 trillion Btu increase in state-wide efficiency

2015

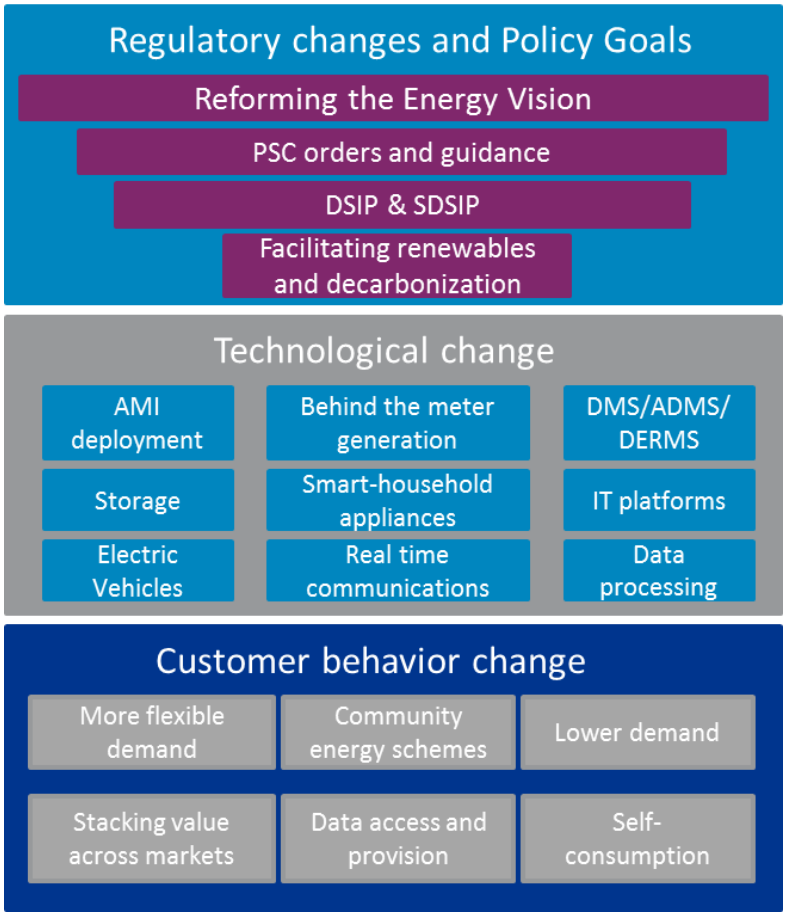
REV Track 1 order

- The New York State regulator – the Public Services Commission (PSC) issues an order around Reforming the Energy Vision (REV)
- This outlines a new role for the New York Electric Utilities as the Distribution Services Platform – DSP

2016

DSIP & SDSIP

- Utilities submit detailed plans on how they will start to transition into the DSP



Definition: "*The DSP is an* ***intelligent network platform*** *that will provide safe, reliable and efficient electric services by integrating diverse resources to meet customers' and society's evolving needs. The DSP* ***fosters broad market activity*** *that monetizes system and social values, by enabling active customer and third party engagement that is aligned with the wholesale market and bulk power system*". p34 REV Track 1 order

Innovation in New York

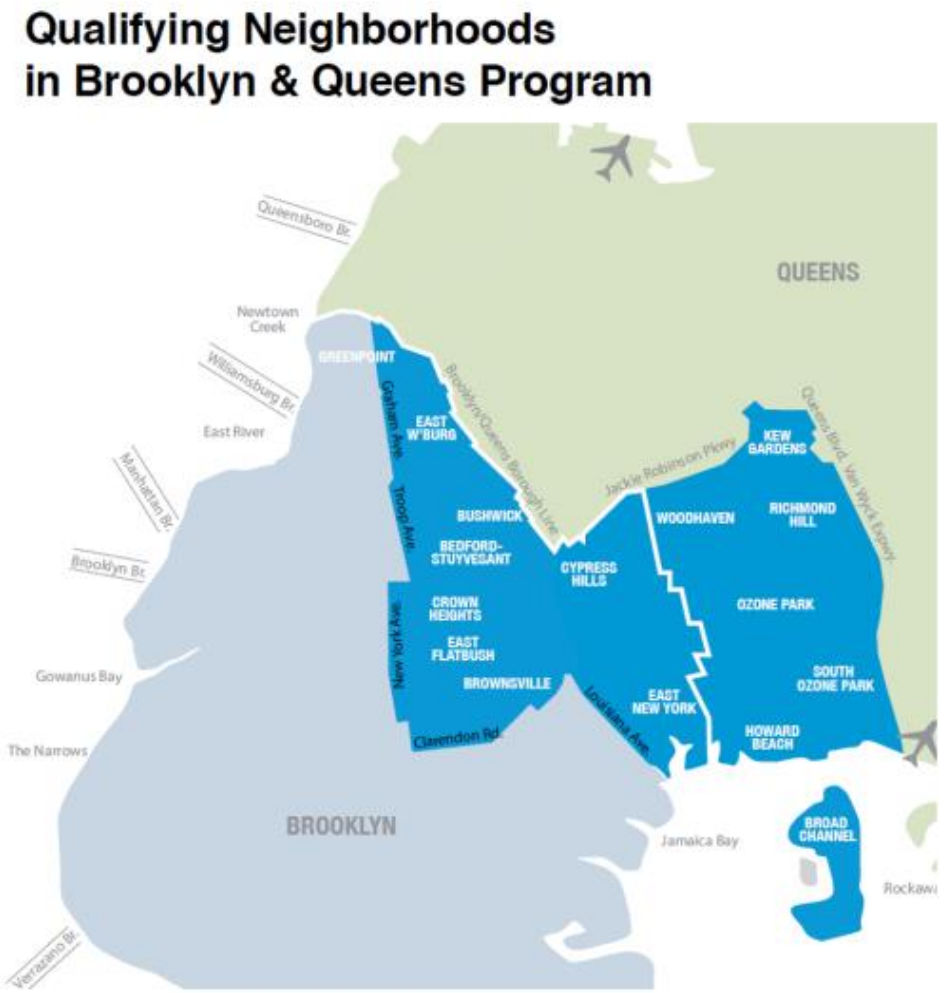
REV demonstration projects include Non-wires Alternatives and flexible connections for renewables

Example 1: Brooklyn Queens Demand Management

- Reduce demand via competitive procurement of Demand Response, to defer Distribution Reinforcement
- Further NWA procurements have now occurred
- Future NWAs will be open to storage.
- Rules for receiving additional value by participating in wholesale markets are still to be determined

Example 2: Flexible Interconnect Capacity Solution

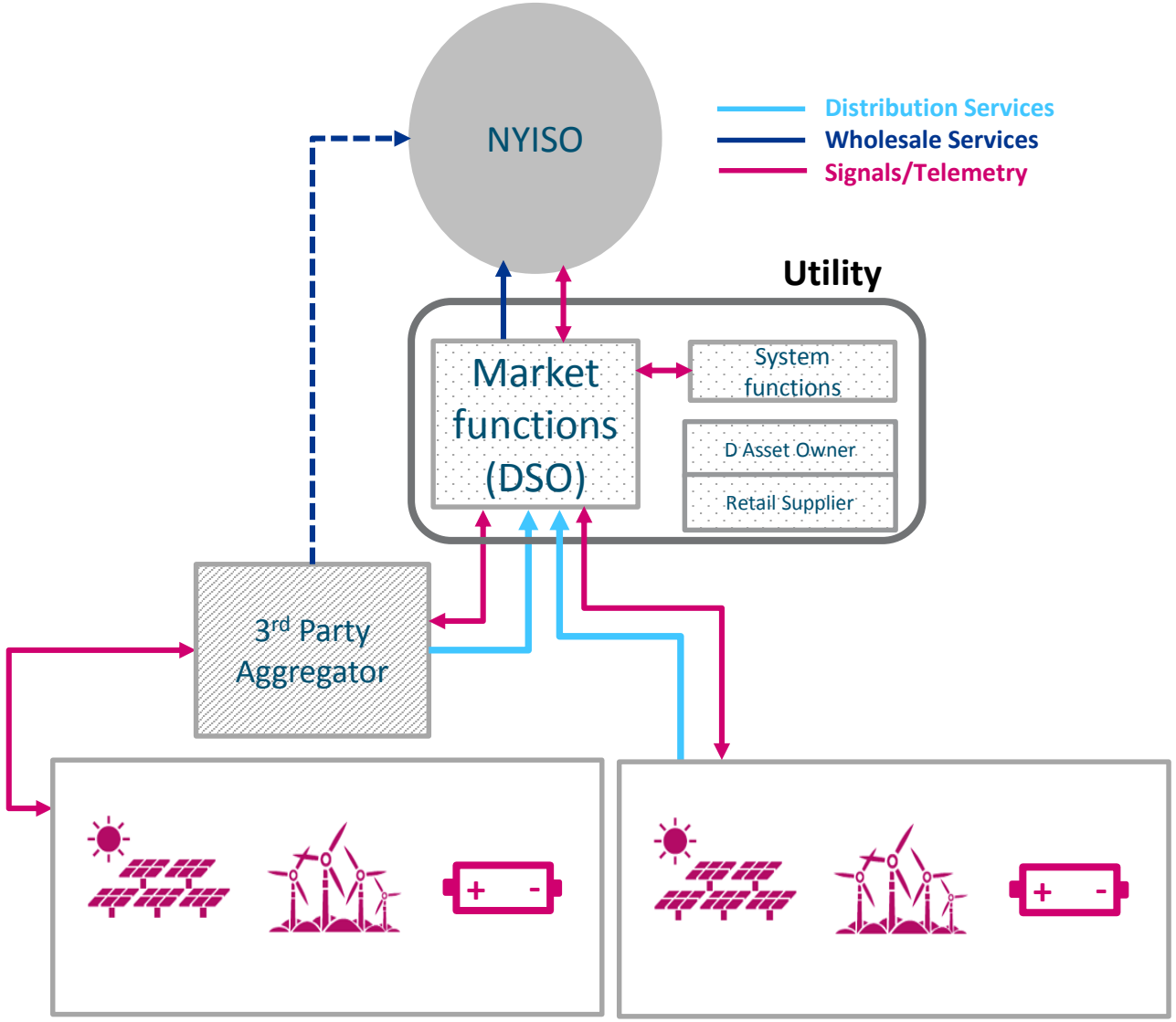
- A trial of flexible connections, similar to GB trials of ANM such as Flexible Plug and Play.
- For connection of solar PV in upstate New York



An emerging model for the “DSP” (DSO) in New York

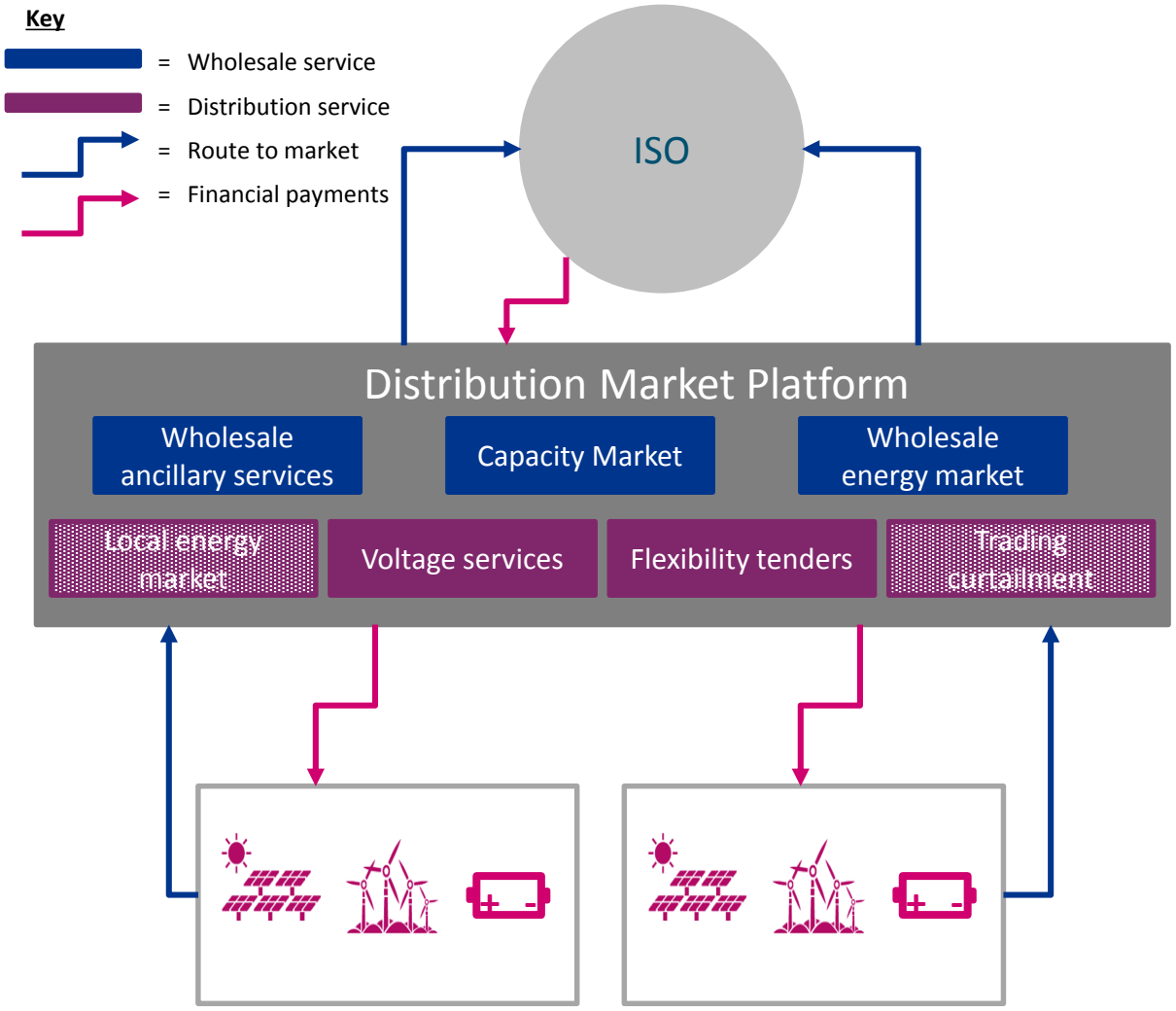
Utilities may run a Distribution Market Platform

- Utilities have integrated distribution and supply functions, and are tasked with offering value to DERs
- The DSP would procure and deploy services from DERs to manage Distribution system reliability, defer reinforcement and manage connection queues
- DSP also likely to become main (but not exclusive) route to market for DER to sell **energy and ancillary services**



Key function: Distribution Market Platform

The Distribution Market Platform provides access to active transaction based markets



Key aspects of Distribution Market Platform

- The Distribution Market Platform (DMP) is a key function and drives the evolution to DSO
- DER can sign up to different products on the DMP
- The DMP is likely to start as a route to Distribution services and then gradually become a vehicle to stack value in wholesale markets, while providing distribution value
- The nature of the DSO's role may be different for each product:
  - For trading curtailment or enabling local energy markets, the DSO may simply provide the platform for DER to trade between themselves
  - For ancillary services, the DSO may need to be more active. For example actively bid DER (which it does not require for distribution services) into the ISO ancillary markets
  - For energy the DSO will likely aggregate DER to the ISO (filtering for distribution reliability)
- The information gained through the DMP will help the DSP make operational and planning decisions
- The existence of the platform means that the ISO can access services from DER without having to deal with each DER individually
- In reality there might be a series of local platforms, co-ordinated through the DSO

Structure of all island I-SEM energy market

I-SEM is a smaller market with more direct control by the System Operator

Role	Great Britain	I-SEM
Size of market (population)	64 million	6.6 million
Peak load	61 GW (2016)	6.5 GW (2016)
System operator(s)	National Grid (NG)	EirGrid & SONI
Transmission owner(s)	>132kV 3 TOs including NG	ESB Networks NIE Networks
Distribution owner(s)	<132kV 6 DNOs	ESB Networks NIE Networks
Distribution system operator(s)		
Generators	81 GW Competitive wholesale market	14 GW
Wholesale Suppliers	Competitive – 6 main suppliers	Competitive
Aggregators	Active but small role	Active role in wholesale market
Regulator(s)	Ofgem	CRU and NIAUR
DER connected	Circa. 30GW	~400 MW of DSR

Key similarities to GB:

- Ambitious decarbonisation targets
- Somewhat islanded market
- Similar wholesale market and capacity market (from 23 May 2018 with introduction of I-SEM)

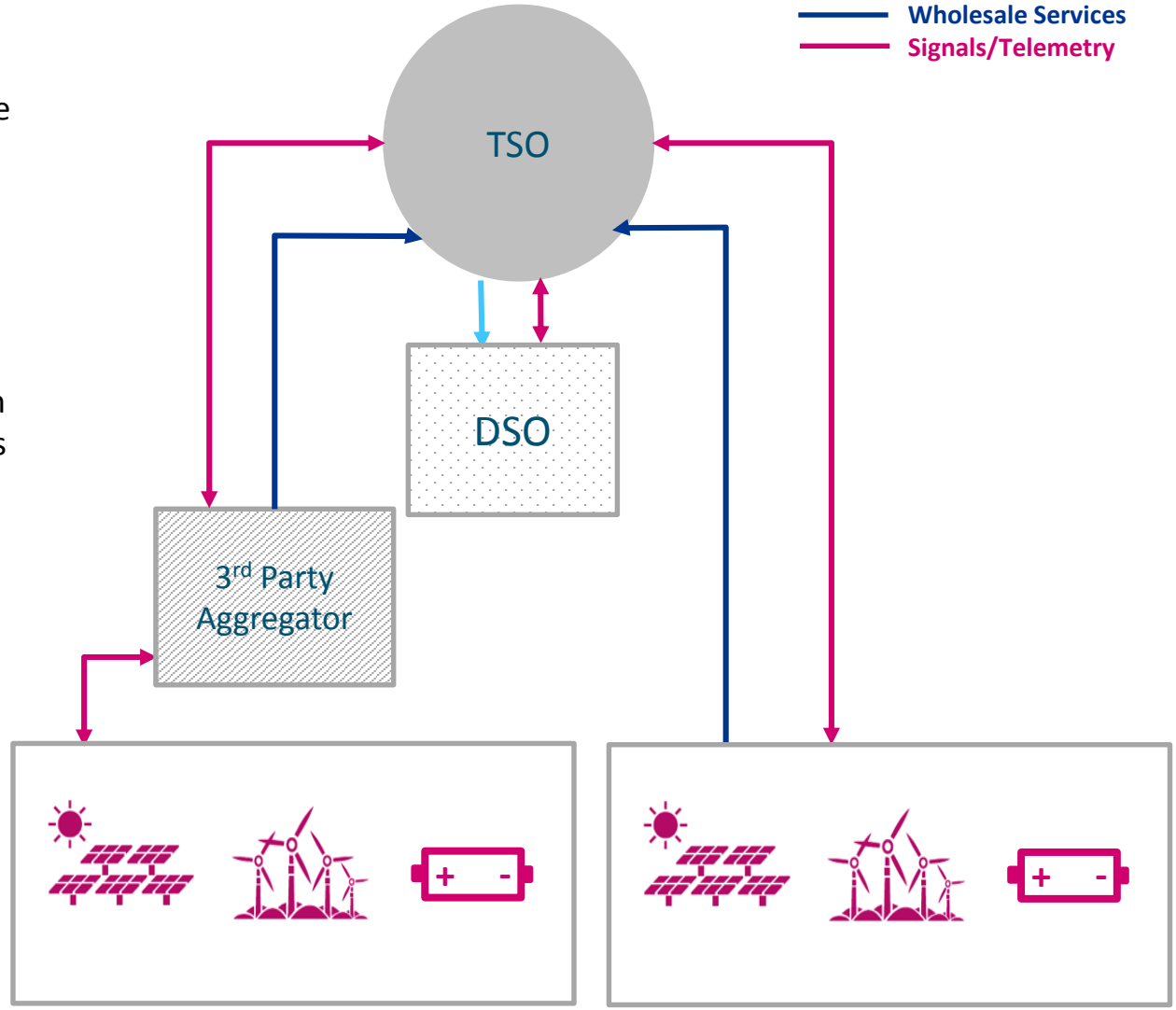
Key differences to GB:

- Much smaller market (with high demand growth)
- Current overcapacity in generation
- Very high levels of wind generation, limited solar uptake (in RoI)
- More direct control of DG (wind) by System Operator
- Mandated Time of Use tariffs
- Two regulators: CRU and NIAUR

An alternative: TSO led

TSO assumes role of coordinating and managing DER

- TSO manages and coordinates DER participation in wholesale markets where the DSO does not bilaterally procure any DERs
- TSO takes data from the DSO and dispatches DER in the same way it does for large generators
- TSO maintains distribution reliability through coordination of DER (i.e. some DSO functions are in the TSO).
- In TSO led model DER could serve transmission network needs first, remaining resources would then be used on the distribution network



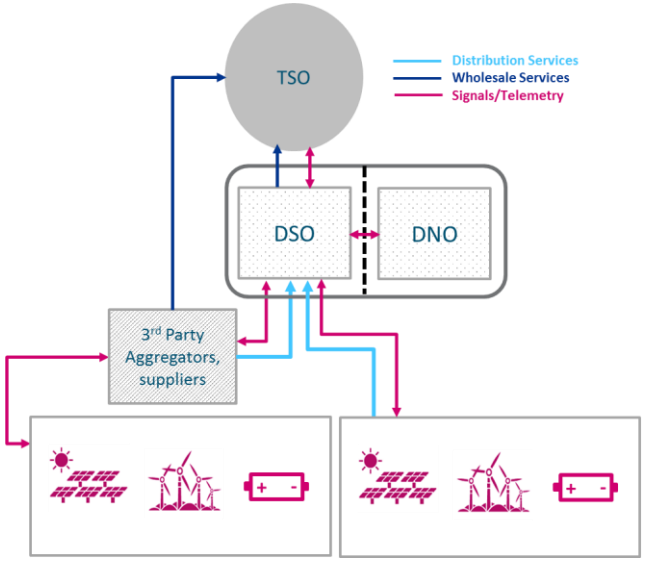
Key Differences from Other Models:

- DSO function is run by the TSO
- The DSO accesses all markets via the TSO

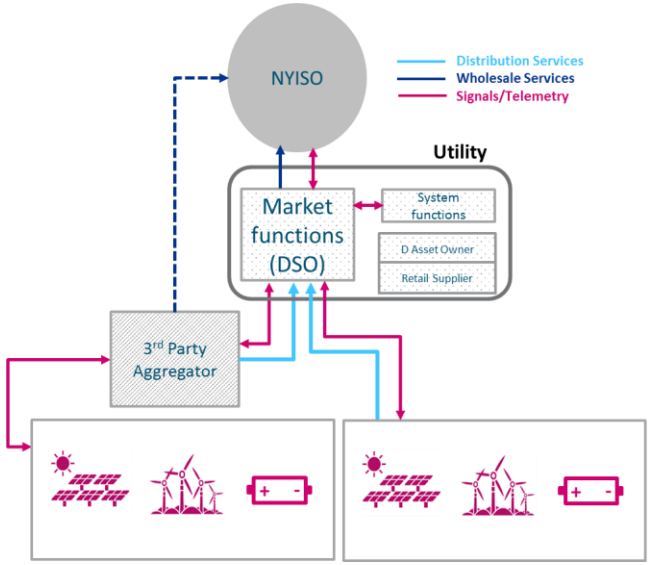
Which option is right for Ireland?

The emerging models for DSO in GB and New York involve an active DSO with market functions and relationships to DER. Does I-SEM have unique features which suggest an alternative model?

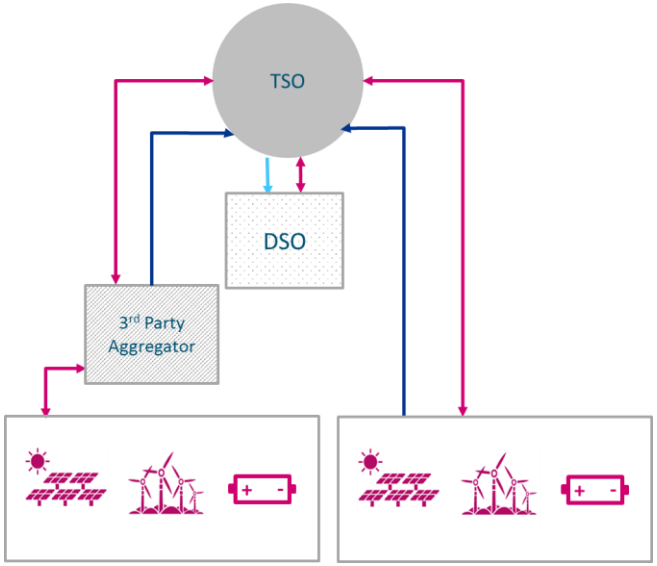
Emerging model - GB



Emerging model - New York



TSO led



- The DSO role is most extensive in the New York model, and least in the TSO led model
- In the emerging NY model, the role for aggregators is potentially reduced

Is there a case for a TSO led model in I-SEM?

- As in SEM, I-SEM will continue to be centrally dispatched by the TSOs (including for example small wind)
- I-SEM is a small system with challenging operational constraints

EnergyPath Networks tool for ESC / ETI

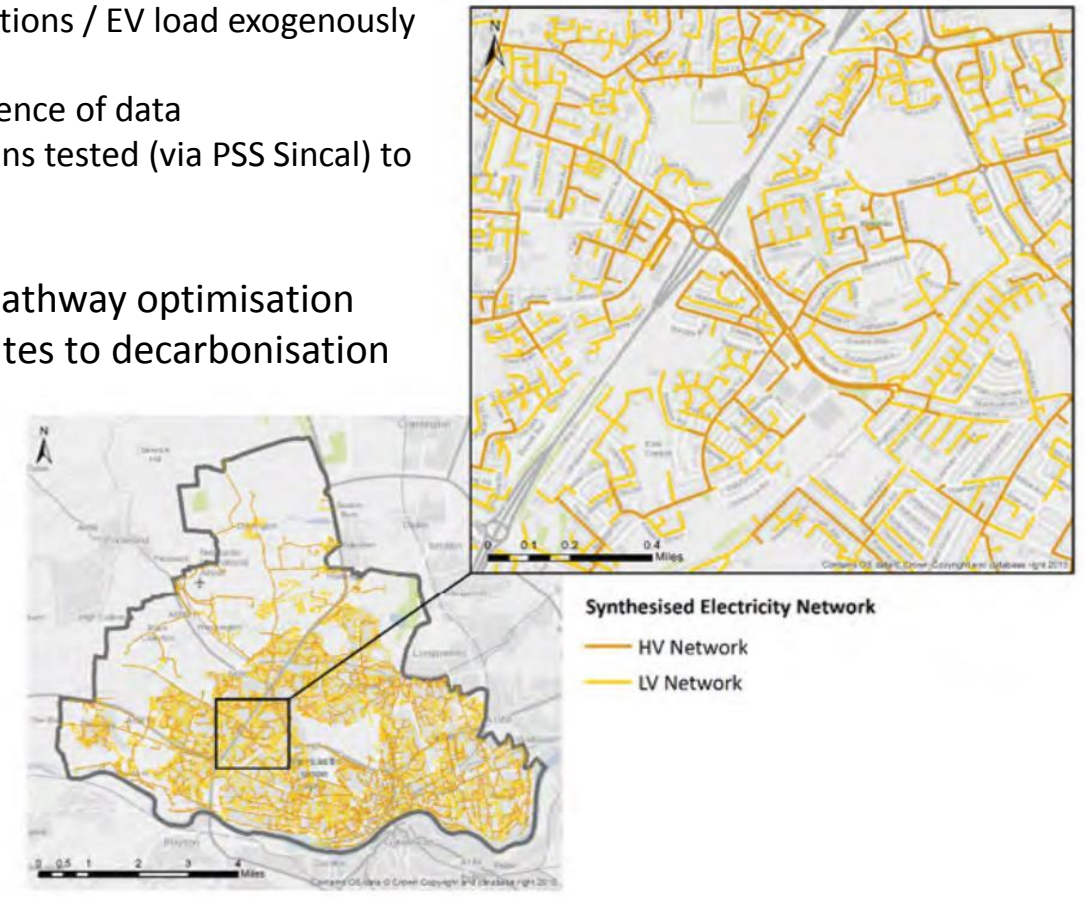
Development and application of a strategic planning tool for local area energy systems to 2050

- Complex model designed and developed by Baringa from 2014-2016 + ongoing support
  - Helps create objective evidence base for developing a real-world local area energy decarbonisation strategy
- "*Aims to support building of consensus across the multiple parties involved in local area energy infrastructure, aiding political and commercial decision making and securing private investment*"
  - Local Authorities)
  - DNOs (electricity, gas)
  - Heat network developers
  - Distributed generation / storage developers
  - Housing associations
- Tool used by ESC (with support from Baringa) in:
  - Newcastle (complete)
  - Bridgend (final stages)
  - Manchester (Bury) (initial stages)
- Tool integrates, evaluates, and prioritises interventions across:
  - Building fabric insulation
  - Heat conversion/storage at network/building level
  - Gas, electricity, heat networks
  - Install, upgrade, decommission, repurpose to H2
  - Reflect implications of other exogenously specified loads (e.g. EVs)
- Detailed representation of current local area and potential upgrade options
  - Representation then simplified such that choices and trade-offs can be resolved via cost optimization process over pathway to 2050

Example of representing real world area

Electricity LDNs

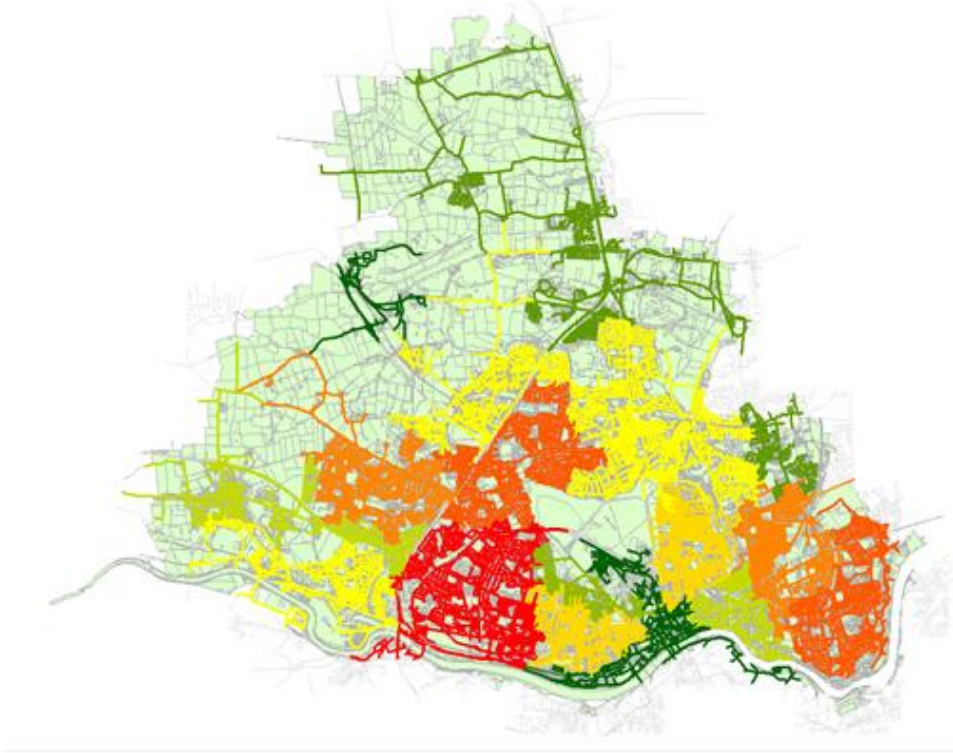
- Location of HV / LV substations and mapping of feeders to building loads (domestic / NDBs) from DNO data
  - Ability for user to define new build housing locations / EV load exogenously (*i.e. not chosen by model*)
  - Network synthesis process (using ArcGIS) in absence of data
  - 1000s of alternative network / load configurations tested (via PSS Sincal) to understand potential reinforcement costs
- Parameterised into cost functions for use in pathway optimisation e.g. trade-off electrification vs alternative routes to decarbonisation



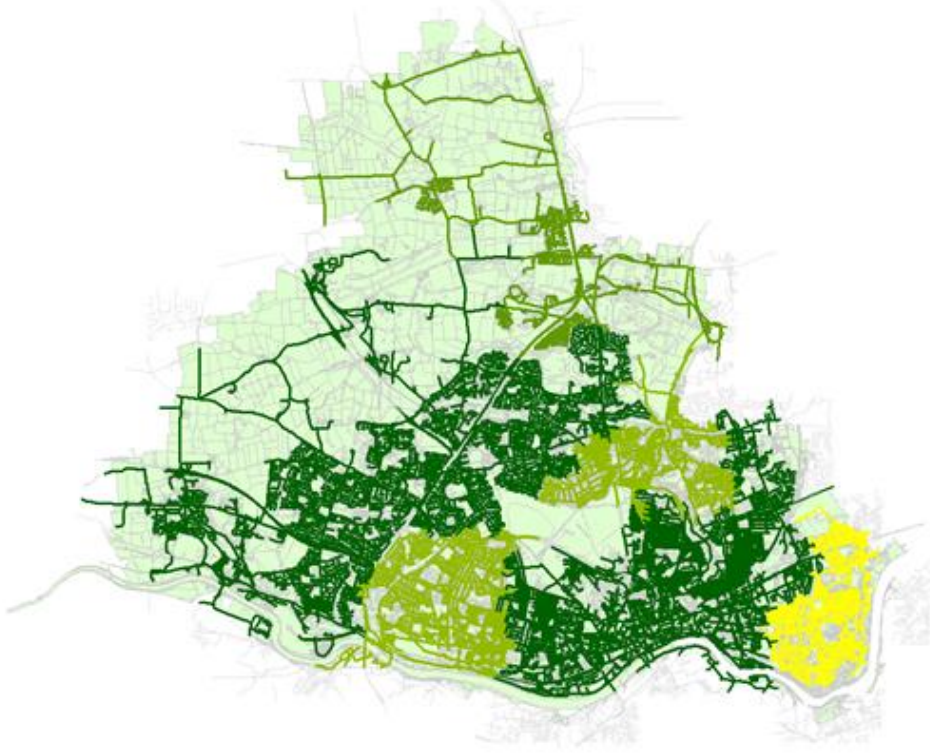
Illustrative output 1: Newcastle

Peak electricity demand by HV substation in 2050

- **Base test case (significant ASHP uptake)**



- **Low cost district heat network sensitivity**



Illustrative output 2: Newcastle

Evolution of district heat networks

- **2020: modest extension of existing networks**
- **2050: significant expansion via core energy centre**

Questions?

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