National Grid

Electricity Transmission Owner Stakeholder Consultation

Future role of Transmission

July/August 2017

Purpose and content of this consultation

- As the England and Wales Electricity Transmission Owner, we recently held a series of workshops to continue discussions with our stakeholders around some of the key topics that are important to both them and us
- These workshops were the first of their kind for our Electricity Transmission Owner business, with the intended aim that we listen to our stakeholders, establish their priorities, shape the topics of our future engagement, and start the process of incorporating stakeholder views into our business plans. Topics covered were:
  - Reliability of the Transmission network
  - Future role of Transmission
  - Connections to our network
  - The environment and our work with communities
- We are not consulting on the topic of Safety because we consider this to be non-negotiable

Purpose and content (continued)

- The following slides focus on the topic of the Future role of Transmission
- Specifically, we would like to hear your views on what you need from the Transmission network given the changing nature of the industry, and how this might develop over time
- This consultation pack is structured as follows:
  - Slides 4-6: general background information on National Grid
  - Slides 7-25: a look at different technologies and their possible impact
  - Slide 26: potential questions to consider
  - Slides 27-28: link to consultation survey and next steps

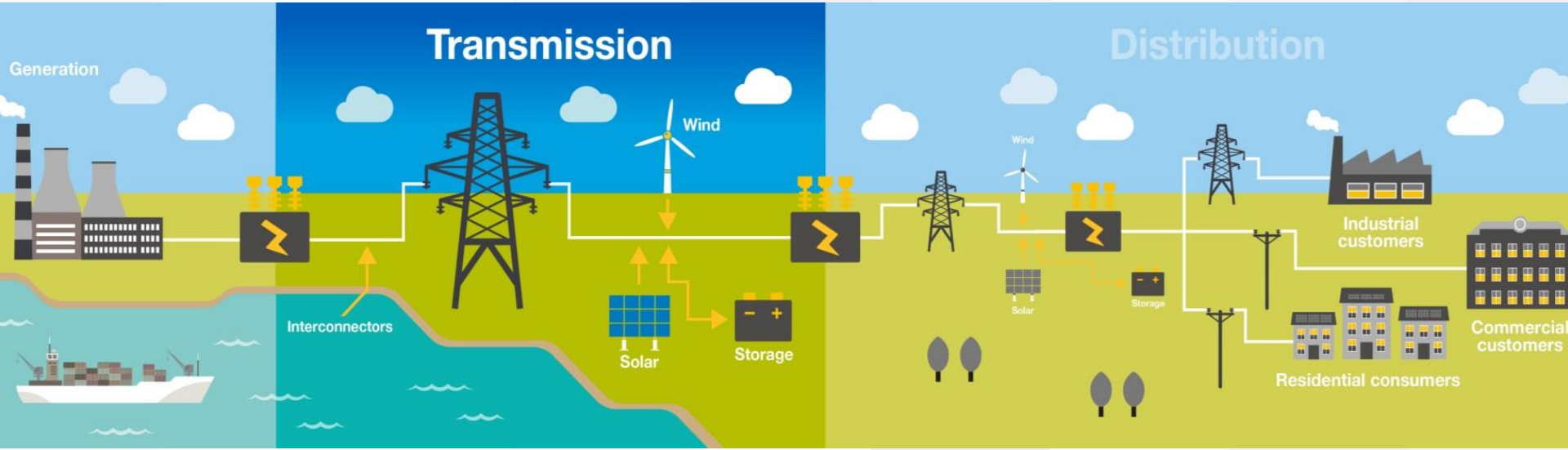
Introduction to National Grid

National Grid: what we do

- We are the England & Wales Electricity Transmission Owner (TO)
  - We own, build and maintain the network
- We are also the GB Electricity System Operator (SO)
  - We balance the system and ensure that voltage and frequency are kept within acceptable limits
- We are currently working with Ofgem to make our Electricity System Operator independent from the rest of our business (to take effect from 2019)
- For Gas, we are the GB TO & SO
- We also have US interests in New York, Massachusetts, Rhode Island, New Hampshire and Vermont
- We hold a minority stake in four UK Gas Distribution networks (now known as Cadent)
- We own other non-regulated businesses

- This consultation is about the Electricity TO…

National Grid
Electricity Transmission Owner



- Our network operates at 400,000, 275,000 and 132,000 volts
- 45 power stations, 12 Distribution networks and 3 interconnectors are connected to our network, along with a few, large directly connected customers

- What we don't do:
  - Generate electricity in the UK
  - Own or operate UK electricity Distribution networks
  - Sell electricity to end consumers in the UK

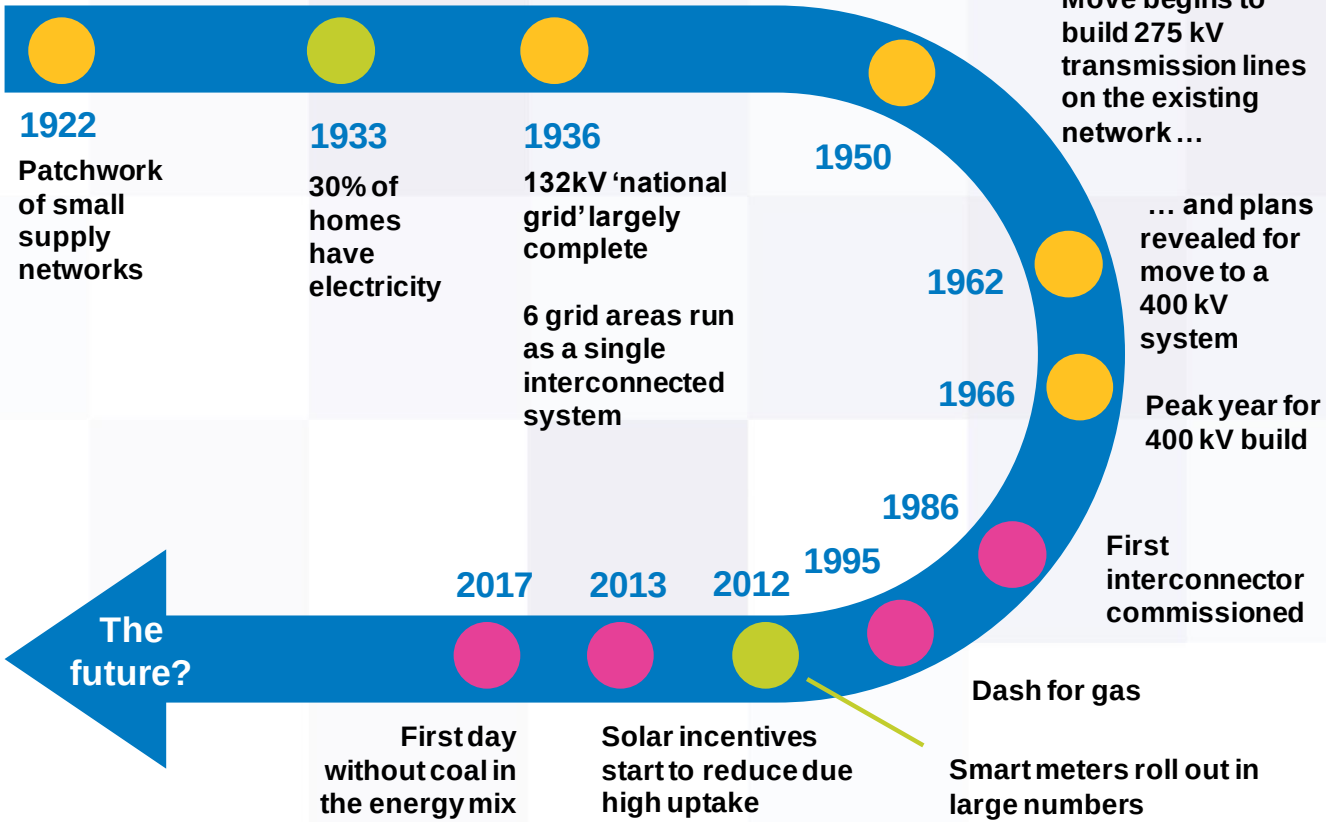
Future role of Transmission

Future role of Transmission

- We would like your views on the future role of the Transmission network, considering:
  - energy networks in general
  - changes in generation technologies
  - changes in how we consume electricity

The evolution of Transmission

The ‘national grid’ was originally built to join up local networks across the country and allow more efficient, bulk transfer of electricity from sources of generation to sources of demand



Why electricity Transmission?

Transmission provides access to a market which lowers costs to consumers – there is a mismatch between the location of supply and demand

It provides security of supply to homes and industry by providing greater interconnection and diversity of supply

It does this economically – higher voltages are more efficient over longer distances and provide economies of scale

And it supports the transition to a low carbon economy

Generation and demand are not located equally across the country

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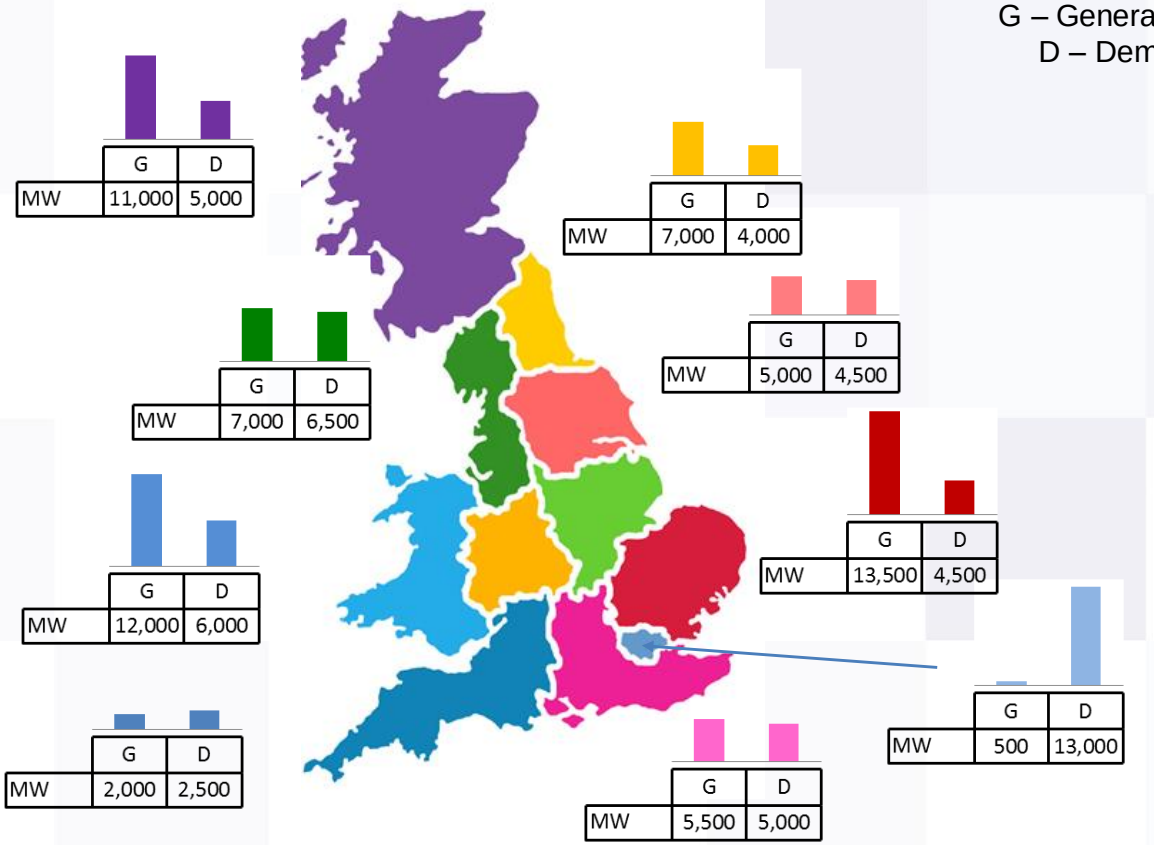


In many areas of the country, generation and demand are very different

- In and around London, demand is far greater than generation
- In areas such as Scotland, Wales and the East of England, the opposite is true

Generation types and their scale

Domestic Solar	Onshore Wind	Open Cycle Gas Turbine	Combined Cycle Gas Turbine	Inter-connector	Offshore Wind	Nuclear Power
Typically connected to Distribution			*Typically connected to Transmission*			
<1 home	20,000 homes	300,000 homes	1 million homes	1 million homes	2 million homes	6 million homes

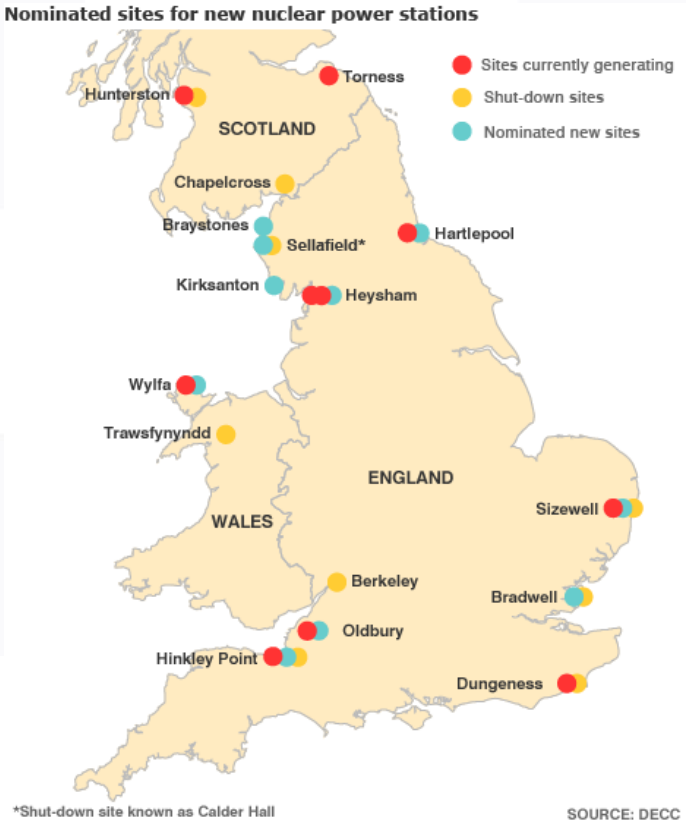
- The diagram above shows approximately how many homes one ‘unit’ of each type of generation can typically supply
- Today’s total energy demand is equivalent to around 90 million homes
- So one technology type is unlikely to meet all needs, all the time
- There are therefore benefits in encouraging diversity in energy sources

Technologies and their potential impact

- The next few slides look at some of the main technologies which are likely to influence the future role of Great Britain's electricity networks

- For each technology, we describe alternative ways in which it may have an impact on the Transmission network

Nuclear power



- Nuclear currently provides c.20% of all UK generation
- Typically provided ‘base load’ generation i.e. the level of generation that is needed most of the time
- The largest individual source of power connected at any location (3 gigawatts)
- Existing and proposed nuclear connections tend to be at coastal locations
- At some point in the future, smaller nuclear reactors – like those in submarines – could become viable

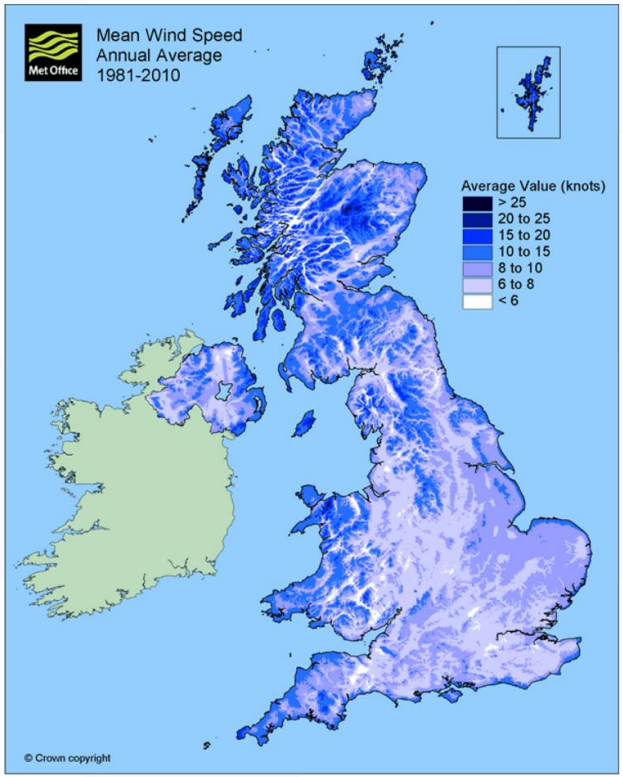
Nuclear power: network role

- Possible future options…

Option 1: Nuclear power stations continue to be large scale but relatively small in number	Nuclear power stations continue to connect to Transmission due to their scale and 'safety case' requirements. Transmission allows the power to be used across Great Britain.
Option 2: Smaller scale nuclear becomes a viable option (~300MW)	Smaller nuclear power stations could connect to Distribution networks. Larger nuclear sites would continue to connect to Transmission (see Option 1 above).
Option 3: Nuclear is no longer a viable / acceptable technology and is removed from the mix	Power plants are decommissioned and some parts of the Transmission network are no longer required by the mid to late 2030s (provided there is no future need)

Wind farms: offshore and onshore

Where it's windiest…



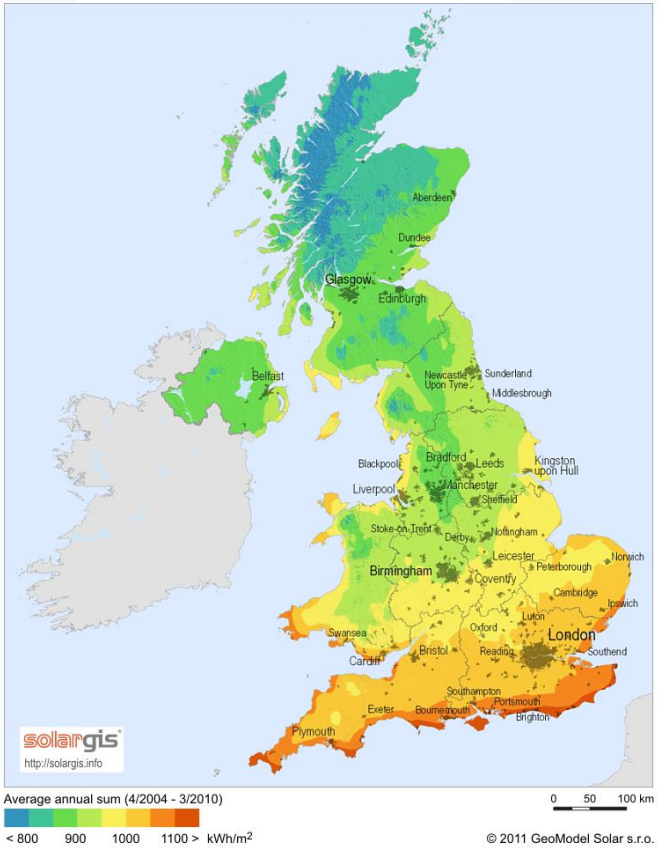
- Wind can connect onshore or offshore:
  - Onshore, the greatest potential is in Scotland but also in areas of Wales and the South West
  - Offshore wind tends to be concentrated on the East Coast
- It is likely that the amount of offshore wind power will grow as costs drop around the world
- Typically, one offshore wind farm is equivalent to more than 60 onshore farms and will power more than 2 million homes for a year

Wind farms: network role

- Possible future options…

Option 1: The amount of **offshore** wind generation increases	New offshore wind farms could connect to Transmission, or alternatively the Distribution networks might be reinforced, but this would require significantly more circuits to carry the same energy. Transmission allows offshore wind to sell its energy across Great Britain and to balance the system when more offshore wind power is supplied than is needed.
Option 2: The amount of **onshore** wind generation increases	Onshore wind likely to connect to Distribution networks and serve local communities. Local storage would enable energy to be stored for later use when it's windiest.

Solar: domestic and solar farms



- Solar energy is most abundant in the southern regions but also makes a contribution elsewhere if economically viable
- It requires adequate roof space or land, facing the right direction, to install solar panels
- Most of the current and future solar energy is likely to be Distribution connected because of its scale and the ability for households to participate
- Solar is likely to be coupled with storage to allow excess energy to be stored until it's needed e.g. at night

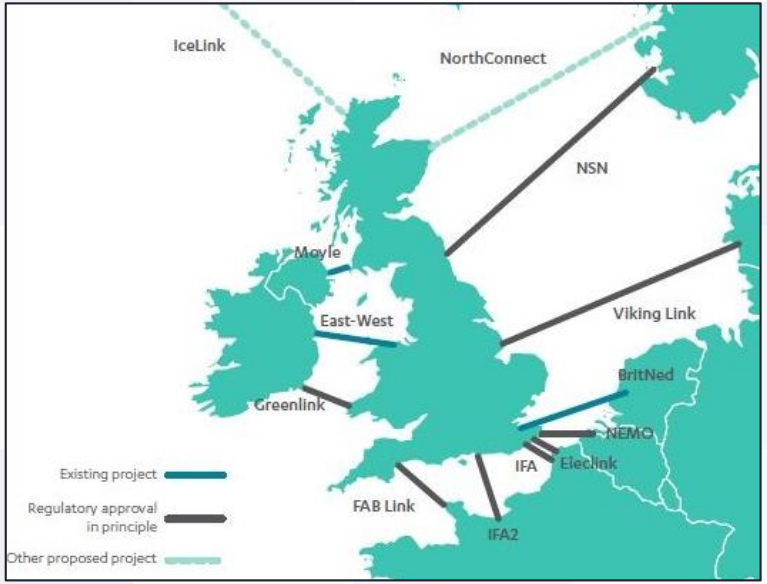
Solar: network role

- A couple of alternatives…

Option 1: Solar is managed by the Distribution networks and local storage (batteries)	Solar remains relatively small-scale so can all connect to Distribution. The development of battery technologies helps to manage gaps in supply and demand. The Distribution networks connect schemes together to manage local variability in supply, demand and storage.
Option 2: Batteries and local management are not sufficient to manage gaps every day across the entire year	Balancing between Distribution networks is provided by Transmission, as well as access to more conventional generation from other regions to provide acceptable levels of security of supply.

Interconnectors between countries

- Great Britain currently has 3 interconnectors, totalling about 5% of the existing generation capacity
- They provide capacity for electricity to flow between two countries with power flowing to the market that has higher prices
- Benefits of using interconnectors to access non-GB sources of supply:
  - lower electricity supply prices
  - lower cost of delivering security of supply
  - access to low carbon energy from countries that might have an excess
  - option to export power to other markets



- They do present challenges however, as they are sources of both supply and demand
  - currently all interconnection reacts to the same triggers
  - direction of power flows can change very rapidly

Interconnectors: network role

- There are two high level future options…

Option 1: Interconnectors remain an important part of the GB energy system	Transmission is required to connect sources of interconnection, potentially with expansion and/or reinforcement if the number of interconnectors grows
Option 2: The role of interconnectors decreases (or they are smaller) as other sources of generation are established	Transmission plays a smaller role in line with the lower usage of interconnectors. Subject to no future need, small sections of the Transmission network can be down-rated or even decommissioned.

Energy storage

- Storage comes in various forms and sizes: e.g. hydro and batteries
- It allows short / long term changes in supply to be balanced with demand
- Particularly useful when there is more intermittent generation on the system
- On a grid scale, the technology is advanced but the markets are not (yet)
- Locally, batteries can fill the gaps between rooftop solar or small-scale wind generation and when we need power
- But the cost is currently an issue:
  - a Powerwall is ~£6k each and 4-5 are needed to store energy for 1 day
  - you would need 100+ to store energy to use between seasons

Energy storage: network role

- Looking first at **small-scale storage** and assuming that costs reduce to an affordable level…

Option 1	Transmission acts as the 'landline' for households and businesses without (a) enough generation or (b) enough batteries to meet their demand
Option 2	Local distribution networks are able to sufficiently balance supply and demand within their own areas of the country

- And if market conditions change to allow **large-scale storage** to become more widespread…

Option 1	Storage connects to **Transmission** and not much changes with the Transmission network
Option 2	Storage connects mainly to **Distribution** networks and therefore the need for Transmission potentially reduces

Electrification of transport

Range per full charge	150 miles
Average miles driven /year	10,000 miles
Energy to charge battery	30 kWh
Typical domestic energy / year	3300 kWh
Increase due to EV charging	60%

- Currently there are approximately 100,000 electric vehicles on Britain's roads, including plug-in cars, lorries and buses – this is approximately 0.3% of all road vehicles
- Around 40% of the rail network is electrified
- There are currently around 13,000 charging points across 4,500 locations. The majority are slow sub-11kW chargers.
- Electric vehicles could be 20% of fleet by 2030
- Large amounts of electricity will be required to cover journeys (~10% more than today's total demand)
- The existing infrastructure in our homes and streets would be unable to support fast charging and provide a 'filling station' speed of service

Electrification of transport: network role

- High level future options…

Option 1: Significant growth in the electrification of transport, with Transmission playing a key role	Transmission remains an integral part of the connection of electricity generation to demand to: ▪ balance energy requirements across GB ▪ provide access to larger sources of generation to meet the significant increase in demand
Option 2: Significant growth in the electrification of transport, managed by Distribution and storage	Consumers charge their cars on renewable energy generated locally. Charging will be available at certain times of day to coincide with supply. This will require large amounts of local generation and storage connected to Distribution networks.
Option 3: No significant increase in the electrification of transport	No incremental change to network requirements

Questions for consideration

That's the end of the consultation material, now we'd love to hear your views. Some potential questions to consider are below, and you can provide your thoughts via the link on the next slide.

1. Based on the consultation material and your own additional knowledge, what do you think is most likely to happen in the industry as a whole?
2. What is the your view of the timing or sequencing of the impact of each new technology?
3. What are your views on the role of Transmission under each possibility?
4. If you see this role changing over time, what timescales do you think are most likely?
5. Is there anything we've not considered?

Consultation survey

- Our consultation on the Future role of Transmission is now open and we invite you to provide your views via the link below:
  - Please click here to provide your feedback
- The consultation will be open until Friday 25th August 2017
- You'll also find consultations on the Reliability of the Transmission network, the Connections process, and the Environment and Communities using the same link

Next steps

- Our commitment
  - After the consultation closes, we'll collate what you've told us and combine it with feedback from our stakeholder workshops
  - We'll share this with you and explain how we propose to take it forward (planned for early September)
  - We'll work with you in more detail on your priorities
  - We'll change our plans as a result
  - We'll make this our business-as-usual

Thank you

Any questions? Please email:
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