SMART GRID MARKET ANALYSIS: UK

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1 Executive summary

The future of the electricity market in the United Kingdom is driven by a number of trends that include a transition from Distribution Network Operator (DNO) to Distribution System Operator (DSO), the rapid take up of Low Carbon Technologies (LCTs) and increasing competition. The UK market is currently dominated by a low number of private actors within distribution and transmission, but with a more fragmented generation and supply market. Demand-side response, electric vehicle charging and energy storage are some of the growing trends in the smart grid market. Generation from renewable sources is another growing trend, which now represents 25% of the country's total electricity production. With growing instability of the electricity grid, interconnectors, energy storage and demand-side response are seen as future stabilisers. In an effort to support an informed reform, the UK has issued a countrywide rollout of smart meters, which will help define a more data-driven approach, as well as include consumers in the smart grid sector.

The vision for smart grid in UK is:

"*A smart electricity grid that develops to support an efficient, timely transition to a low carbon economy to help the UK meet its carbon reduction targets, ensure energy security and wider energy goals while minimising costs to consumers. In modernising our energy system, the smart grid will underpin flexible, efficient networks and create jobs, innovation and growth to 2020 and beyond. It will empower and incentivise consumers to manage their demand, adopt new technologies and minimise costs to their benefit and that of the electricity system as a whole*." [1]

The main drivers for smart grid in the UK include:

- Increasing security of supply and integration of low carbon technologies through enhanced monitoring and control of the network, and managing local supply and demand more efficiently;

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf

- Reducing consumer electricity bills by reducing network costs – optimising the use of existing network assets and giving consumers greater control of their energy use;
- Support economic growth and jobs through faster and cheaper network connections, potential exports and job creation associated with smart grid technologies

For Swedish companies hoping to capitalise on these trends and upcoming reforms, they would benefit from a unified Swedish approach. Sweden is well-regarded in the UK and has a strong history in providing smart solutions through an environmentally conscious approach, which would support Swedish initiatives within the smart grid market in the UK. The next steps for Swedish companies looking to the UK should be to properly prepare for internationalisation and account for differences in business settings.

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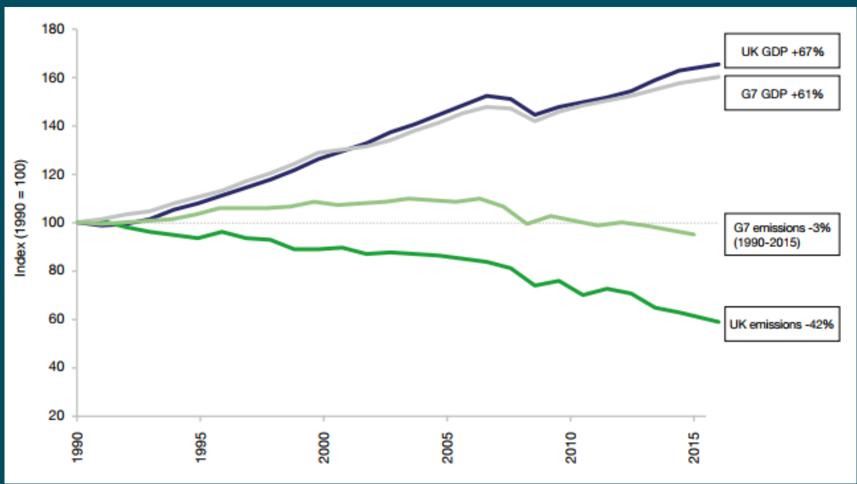
2 Introduction

The United Kingdom of Great Britain and Northern Ireland (UK) has long been committed to developing its capabilities within green and clean energy, and has to-date managed to reduce its carbon emissions more than any other developed country in the world. The UK took the *Climate Change Act of 2008* to heart, and committed to reduce its carbon emissions by 80% from 1990 to 2050. Since 1990, the UK has reduced its emissions by 42%, while also growing its economy by two-thirds (see Figure 1). On October 12th, 2017, the Department for Business, Energy & Industrial Strategy (BEIS), published the UK's new *Strategy for Clean Growth*, further outlining its ambitious targets to grow the economy while continuing to ensure affordable energy supply to businesses and consumers. Following the years of the *Climate Change Act of 2008*, coal-fired electricity has lost market share to gas-fired electricity, renewables and nuclear. As of 2016, 47% of the UK's electricity came from low carbon intensive fuel sources, including the largest offshore wind capacity in the world.

UK and G7 economic growth and emissions reductions



Source: Clean Growth Strategy, (UNFCCC; World Bank, BEIS)

Figure 1 UK and G7 economic growth and emission reduction from 1990

Like Sweden, the UK government sees a smart energy grid as key to achieving a low-carbon, efficient, and reliable way of providing electricity. There are several government initiatives to support the development and integration of smart grid innovations into the electricity market through legislation and both stick and carrot policy-making. The developments in the

UK electricity market create numerous business opportunities for Swedish companies. The aim of this report is to outline the state of the UK smart grid market, identify growth areas and key market stakeholders, and identify and evaluate business opportunities for Swedish companies. A joint Swedish promotion plan is presented based on the smart grid technology areas with the most potential for Swedish companies.

3 Electricity market

The UK electricity market is heavily shaped by the industry privatisation that followed the introduction of the *Electricity Act of 1989*. Today, the market is completely privatised. The current political and regulatory driving force for the market relies on three main goals: decarbonising the electricity grid, securing the electricity supply, and lowering energy costs for end consumers. While historically a market powered by coal, the UK now has a significant share of gas (45%), renewables (25%) and nuclear (22%) in its electricity generation portfolio. The market is structured along the electricity value chain of generation, transmission, distribution and supply, with a few large companies active in each part of the value chain. While there are thirteen key companies operating a majority of the electricity value chain, only two of these thirteen are vertically integrated across the entire chain (see Table 1). Due to the privatisation of the market, foreign-owned companies hold a large part of the electricity market.

Table 1: Key companies' role across the electricity value chain

Key companies in the electricity industry in the UK and their role in the value chain				
Customer name	Generation	Transmission	Distribution	Supply
ScottishPower/SP Energy Networks	X	X	X	X
SSE/SSEN	X	X	X	X
National Grid		X		
Northern Ireland Electricity		X	X	
Centrica	X			X
Drax	X			X
EDF Energy	X			X
North West Electricity Networks			X	
Northern Powergrid			X	
RWE Npower	X			X
UK Power Networks			X	
E.ON UK	X			X
Uniper	X			
Western Power Distribution			X	
Number of companies	7	4	7	7

The breakdown of a household electricity bill is shown in Figure 2. It can be seen that whilst the wholesale electricity cost makes up the largest portion of the energy bill, network costs are also a high percentage, with supplier operating costs and environmental costs also being significant.

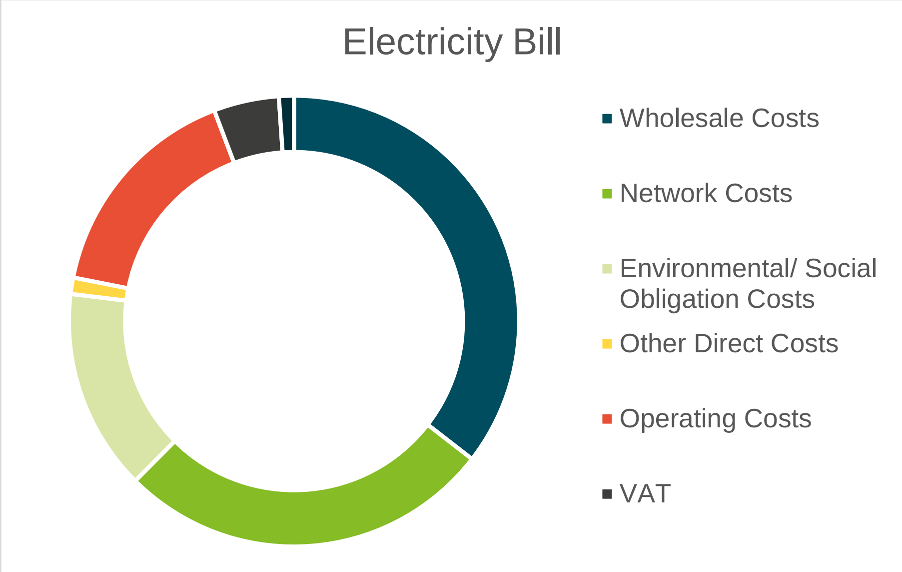


Figure 2: Breakdown of household electricity bill based on realised costs as reported by the six larger energy companies for 2016 (Ofgem)

The price of electricity in the UK is currently 14.4p per kWh, with some variation by UK region. Prices are broadly comparable to those of the UK, with Sweden slightly higher.

The average variable unit cost for standard electricity in 2018 for UK domestic customers was £0.158/kWh. The average cost for Economy 7 electricity, in other words electricity from base load generation, in 2018 for UK domestic customers was £0.19/kWh for day units and £0.09/kWh for night units.[2]

The average unit cost for electricity in the second quarter of 2018 for UK non-domestic customers was £0.1107/kWh excluding the climate change levy and £0.1144/kWh including the climate change levy.[3]

Domestic consumers can shop around for the cheapest electricity supplier. Switching suppliers has been made much easier in recent years, and there are sever website offering price-comparison services so that consumers can find the optimal supply tariff. Non-domestic consumers may negotiate the cost of electricity with their supplier. Thus, large consumers tend to pay less per unit than smaller consumers. For example, in the second quarter of 2018, very small non-domestic consumers paid an average of £0.1497/kWh (excluding climate change levy) and extra-large non-domestic consumers paid an average of £0.0935/kWh (excluding climate change levy).

2 https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics
3 https://www.gov.uk/government/statistical-data-sets/gas-and-electricity-prices-in-the-non-domestic-sector

3.1 UK electricity generation

In 2017, the electricity generation market was estimated at GBP 17.5 billion, powered by three main energy sources: natural gas (45%), renewables (25%) and nuclear power (22%). Over the course of the last five years, the UK has replaced almost its entire coal generation capacity, which today represents only about 4.5% of total electricity generation. The fate of coal-fired electricity in the UK is sealed and related main investments are currently in the transformation of coal plants to either gas or biomass, but generation from gas and renewable sources has become increasingly important (see Figure 3).

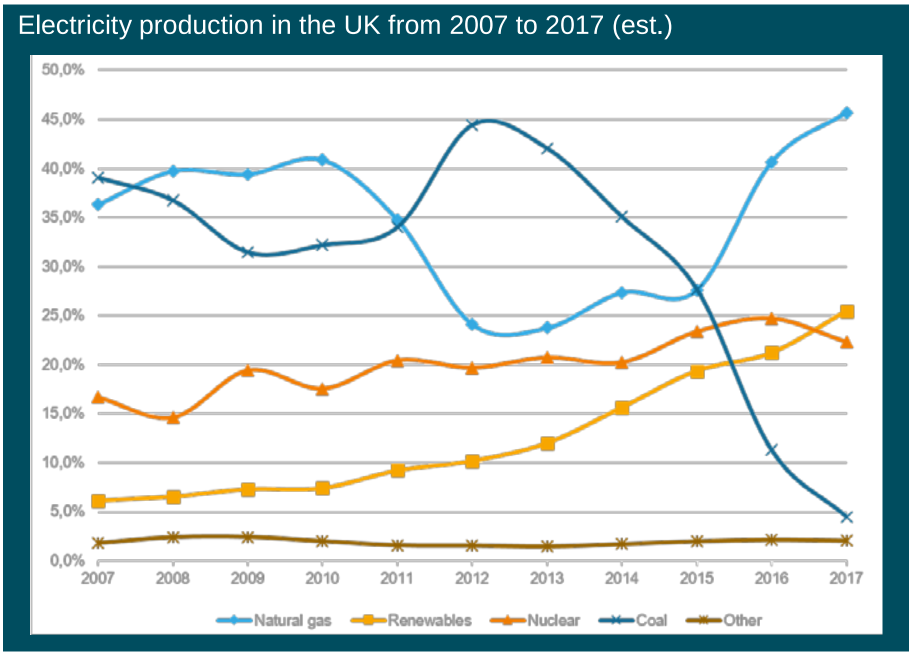


Figure 3: Estimated electricity generation in the UK by energy source 2007-2017

Seven companies dominate electricity generation in the UK, holding approximately 80% of the market (see Figure 4). Four of those companies are foreign-owned: EDF Energy held by its French parent company with the same name; RWE Generation held by its German parent company RWE AG; ScottishPower held by the Spanish energy group Iberdrola; and Uniper (part of E.ON SE) owned by its German parent with the same name. Together these four companies hold approximately 47% of the electricity generation market in the UK. Despite the domination of large corporates, smaller actors have started to enter the market, notably within renewable electricity generation. Since the privatisation of the market, the number of Major Power Producers (MPPs), signifying companies with a primary purpose of generating power, has risen to 57 in 2016. Since 2007, many renewable generators also count as MPPs, which has contributed to an additional increase. However, as can be seen in Figure 4, there are still only six actors that individually generate more than 5% of the UK's electricity.

Electricity production company market shares, 100%=GBP 17,5 billion

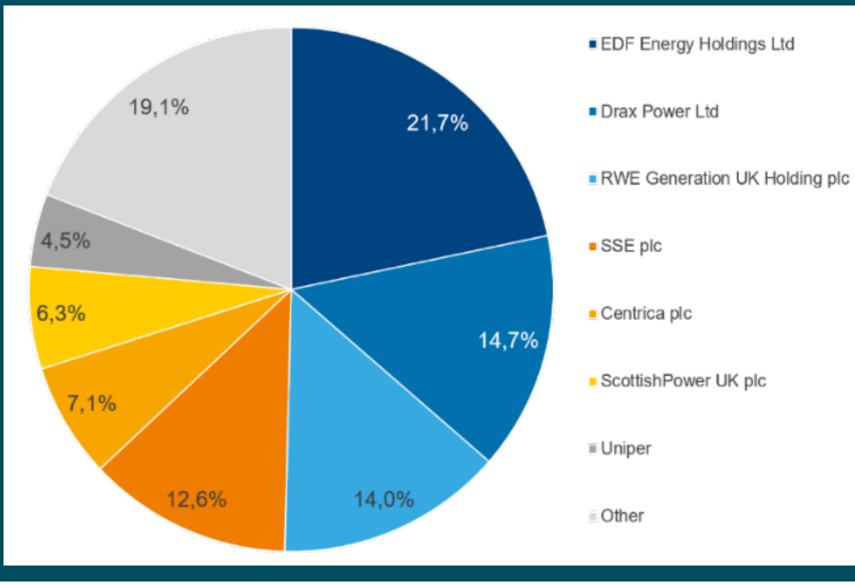


Figure 4: Electricity generation company market shares

Regionality of electricity generation

During 2016, the UK generated approximately 340 TWh of electricity, with England having the majority of the generation, accounting for 71.3% of the total. England is also the largest consumer, accounting for 81.5% of the UK's total electricity consumption (see Figure 5). In total, the UK is a net importer of electricity with 5% of its total consumption imported. Imports come primarily from three countries: the Netherlands, France and the Republic of Ireland.

The four countries that make up the UK (i.e. England, Scotland, Wales and Northern Ireland) have slightly different shares of sourced fuel types in relation to the UK's total electricity generation of 340 TWh (see Figure 6). Scotland and England are the only countries in the UK with nuclear electricity generation. Nuclear electricity generation accounted for as much as 42.8% of Scotland's total generation in 2016.[4] Gas is the dominant fuel source in England, Wales and Northern Ireland accounting for 45%, 62.9%

4 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/669719/Regional_Electricity_Generation_and_Supply.pdf

and 50% respectively. Northern Ireland and Wales also had notable shares of electricity sourced from coal, with 23.3% and 17.2% respectively.

Countries' electricity production and consumption shares in the UK

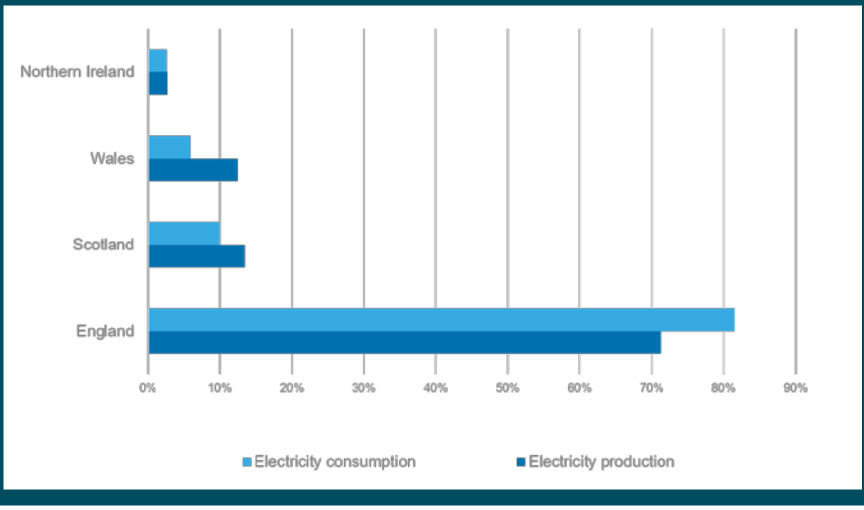


Figure 5: UK countries' share of total electricity generation and final consumption in 2016

Electricity production source shares per fuel type

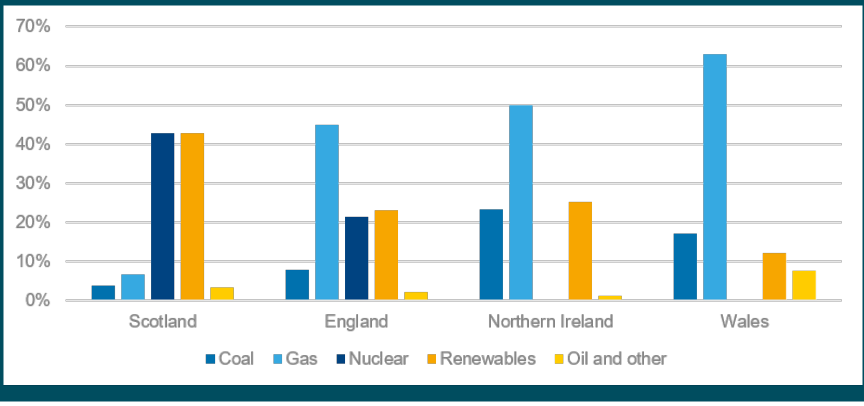


Figure 6: Electricity generation in the four countries of the UK in 2016, by fuel type

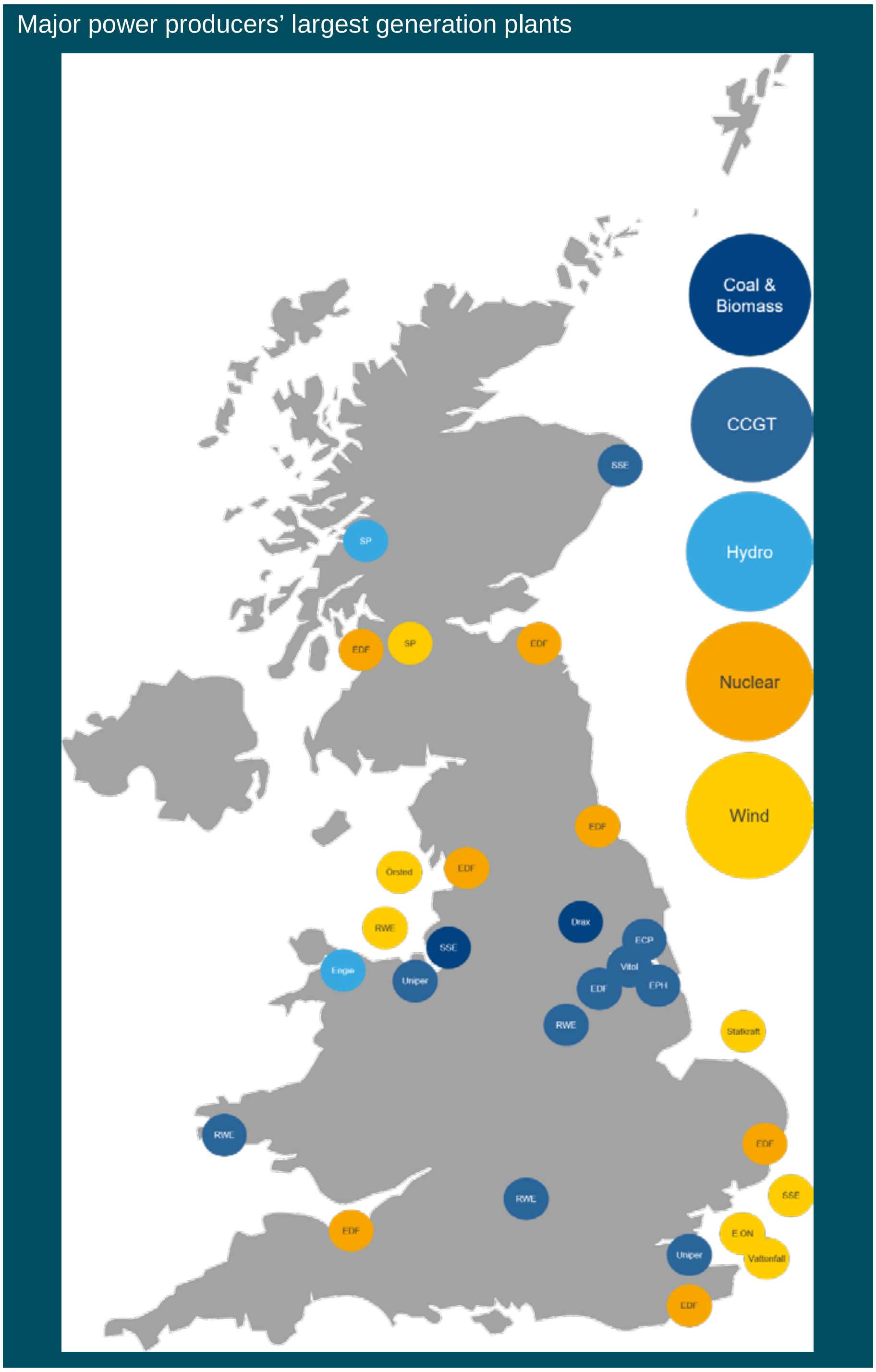


Figure 7: The major power producers' largest generation plants in the UK in 2017 within sourcing categories based on capacity levels, excluding solely coal-fired generation

Gas-fired electricity generation

Gas-fired electricity generation has increased significantly over the past five years, due largely to low gas prices and the reduction in coal-fired generation. To date, gas represents 45% of the UK's total electricity generation. There are ten gas or combined cycle gas turbine (CCGT) plants with capacity of over 1 GW in the UK. These are owned by RWE Generation, Uniper (E.ON), EDF Energy, EPH, Vitol, ECP and SSE. The plants are located mainly in Eastern England, but there are also two plants in Wales and one in Scotland (see Figure 6).

Renewable electricity generation

The UK has a large share of renewables, with 25% of electricity coming from renewable sources, and wind power and bioenergy being the main contributors (see Figure 7). The expansion of renewable electricity generation is driven partly by new technology advancements allowing cheaper generation coupled with government incentive programmes. The first large governmental initiative came in 2002, when the Renewables Obligation (RO) was introduced. It required electricity suppliers to source an increasing share of their electricity from renewables, which spurred the development of renewables in the years that followed. The RO was closed in 2017 for new generation capacity and to some extent replaced by a Contracts for Difference (CfD) scheme. The CfD balances market price volatility for renewables to incentivise more investment into renewables, providing a top-up payment between a market-based reference price and a pre-defined strike price. CfD is part of the more comprehensive Electricity Market Reform (EMR), which aims to secure supply, decarbonise the grid and lower energy costs for consumers. Mainly driven by the Feed-in Tariff (FiT) scheme, which allows generators to sell back excess electricity to the grid, solar photovoltaics (PV) deployment in the UK has experienced a significant increase, reaching a capacity of 12.7 GW in February of 2018, where large scale installations of over 5MW account for 45% of the total PV capacity (see Figure 8).

Renewables production market in the UK, 100%=GBP 4,46 billion

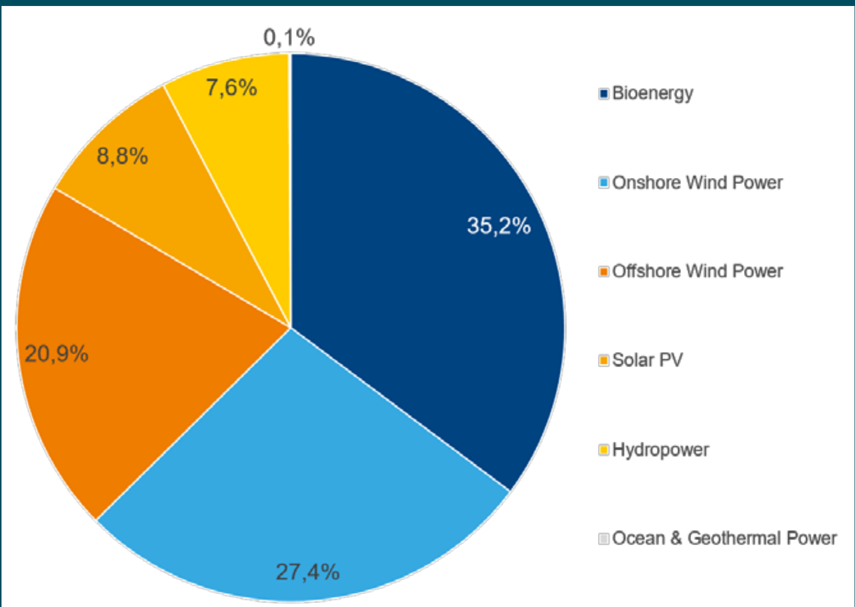
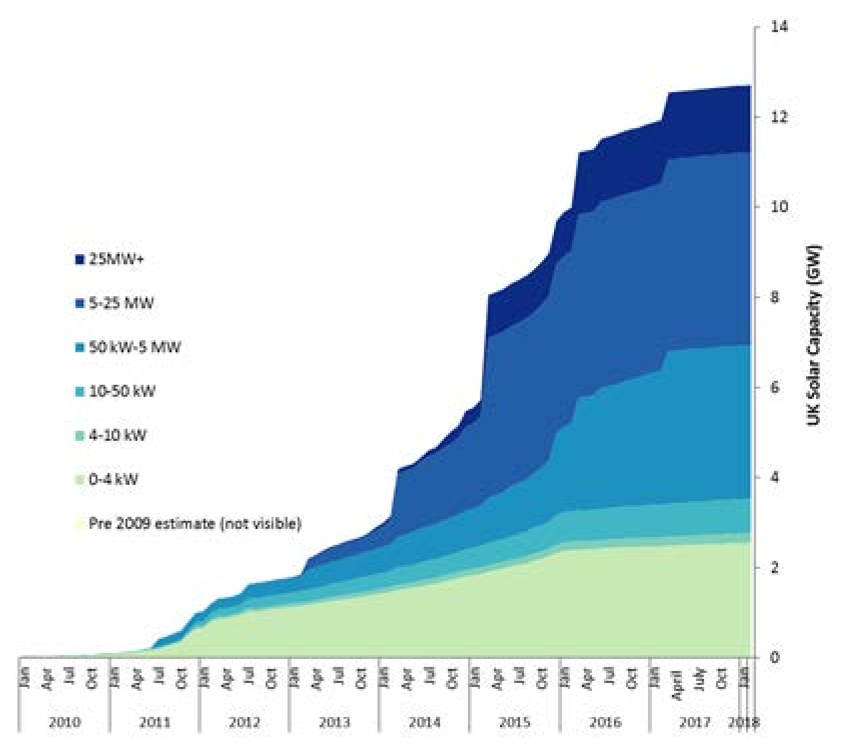


Figure 8: Renewables generation market in the UK

Approximately 47% of the UK's renewable electricity comes from wind. The UK has both large onshore and offshore windfarms, with the largest amount of onshore wind generation being in Scotland (see Figure 6). The largest offshore wind farms are located in the North Sea off the east coast of England, with a few exceptions, such as the Gwynt y Mor windfarm (RWE Innogy) in the Irish Sea off the north coast of Wales, and Örsted's (formerly DONG Energy) windfarms in the Irish Sea off the north west coast of England (see ibid.). The owners of the ten largest on- and offshore wind farms are E.ON, RWE Innogy, SSE, Örsted, ScottishPower, Statkraft Wind (Norwegian) and Vattenfall Wind Power (Swedish). Most of the larger biomass plants are found in eastern England, with a small number also located in Scotland. Scotland and Wales, hosts all of the larger hydropower plants. Among the ten power stations with the most renewable energy capacity, there is a varied mix of fuel types being sourced. Biomass, pumped storage, hydro, and wind are represented among the main renewable power plants. These plants, which are spread out across Great Britain, are owned by Drax Power, SSE, Engie, E.ON, RWE Innogy, ScottishPower and Örsted. It is worth noting that the Drax Power biomass unit and Engie's pumped storage plant significantly exceed the other renewable plants in terms of capacity. While gas is still a large source of energy, the government has indicated that the long-term strategy is to decrease the dependence on gas.

UK Solar Deployment: By Capacity (updated monthly)



Source: BEIS

Figure 9: UK solar deployment by capacity (GW) 2010 to February 2018

The UK's electricity generation from renewable sources is dominated by five companies holding 47.7% of the total renewable electricity market, with SSE, ScottishPower and E.ON UK being the three largest (see Figure 10). However, a growing number of smaller companies are entering the market, in particular in small scale solar and wind generation. The increasing number of smaller local generation sites allows generation to occur anywhere along the value chain, which in turn increases the complexity of the grid.

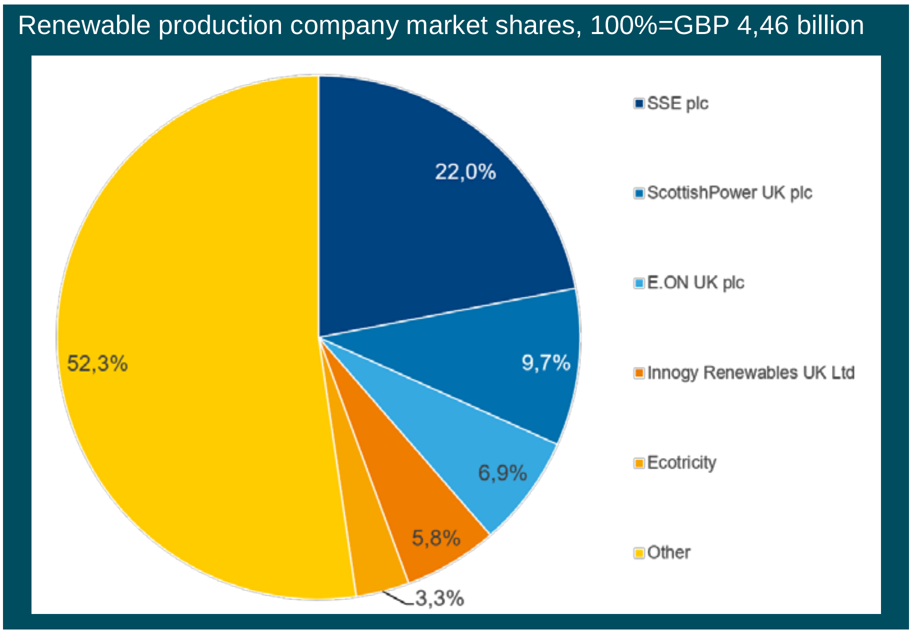


Figure 10: Renewable generation market shares in the UK market

Nuclear electricity generation

Nuclear power reactors generate about 22% of the UK's electricity. EDF Energy owns and operates all of the UK's nuclear power reactors, with four located in Scotland and eleven in England (see Figure 7)[5]. While the current nuclear power stations are planned to shut down between 2023-2035, the government re-established the Nuclear Industry Council in 2017, which is meant to support the efforts in nuclear new build. By the end of 2017, there was one approved new build of nuclear, Hinkley Point C (HPC), which comprises two new reactors, of which one is expected to be operational around 2026. Again, EDF Energy will be in charge of building HPC with a partial ownership from Chinese General Nuclear Corporation (CGN) of 33.5% (see Table 2). There are more new build proposals up for consideration by the UK government, notably two additional reactors by EDF Energy, four by Horizon (a subsidiary of Hitachi) and three by NuGen (a joint venture between Engie and Toshiba).

5 Centrica currently owns a 20% stake in EDF's existing nuclear power plants

Table 2: Existing and planned nuclear power reactors in the UK

Existing and planned nuclear power reactors in the UK				
Plant	Company	Capacity (MWe net)	First power	Exp. shutdown
Dungeness B 1&2	EDF Energy	2 x 520	1983	2028
Hartlepool 1&2	EDF Energy	595, 585	1983	2024
Heysham I 1&2	EDF Energy	580, 575	1983	2024
Heysham II 1&2	EDF Energy	2 x 610	1988	2030
Hinkley Point B 1&2	EDF Energy	475, 470	1976	2023
Hunterston B 1&2	EDF Energy	475, 485	1976	2023
Torness 1&2	EDF Energy	590, 595	1988	2030
Sizewell B	EDF Energy	1198	1995	2035
Hinkley Point C 1&2	EDF Energy (66.5%) & CGN (33.5%)	n/a	2026 (exp.)	n/a

3.2 Electricity transmission in the UK

The UK's electricity transmission network transmits high-voltage electricity from the point where it is generated to where it is needed throughout the country through a high-voltage grid. The transmission grid is operated by the system operator (SO) National Grid, responsible for ensuring stability and security. The grid is owned by three licenced transmission owners (TOs): National Grid Electricity Transmission, Scottish Hydro Electric Transmission (related to SSE) and SP Transmission (related to ScottishPower). The TOs are responsible for developing, operating and maintaining the high-voltage systems in their respective geographic areas. National Grid owns the electricity transmission system in England and Wales, which consists of approximately 7,200 km of overhead line, 1,500 underground cables and 342 substations. In South Scotland, SP Transmission controls about 4,320 km of overhead and underground cable, and 132 substations for the transmission grid, while Scottish Hydro Electric Transmission operates approximately 5,000 km of cable in Northern Scotland. Northern Ireland Electricity (NIE) owns the 2,200 km transmission networks in Northern Ireland. However, it is operated by the System Operator Northern Ireland (SONI), which in turn is owned by the Irish company EirGrid.

Electricity transmission company market shares, 100%=GBP 5,2 billion

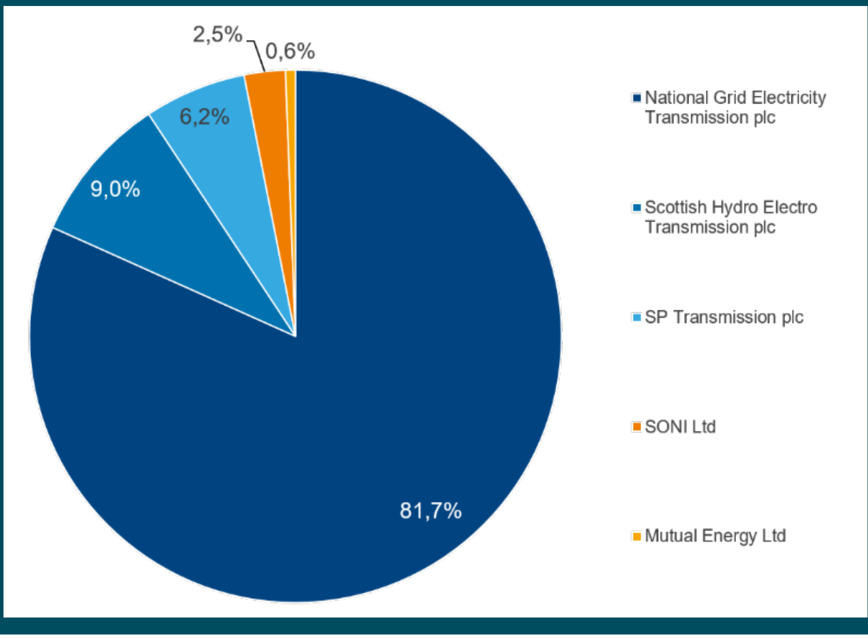


Figure 11: Electricity Transmission company market shares

While currently operating as a natural monopoly (see Figure 11), the market regulator Ofgem seeks to foster more competition in the transmission market. In 2009, offshore transmission was opened to competition through a competitive tender process for obtaining offshore transmission licences. Furthermore, in 2017, Ofgem planned the introduction of the Competitively Appointed Transmission Owner (CATO), a regime to foster competition in onshore transmission. However, the new regulation is delayed due to parliament's busy schedule and a result of uncertainty related to the UK's exit of the European Union. Ofgem has also pursued other possibilities to increase competition. The Hinkley-Seabank project, which is proposed to connect the new Hinkley Point C (HPC) nuclear power station to the British electricity grid, has been redesigned and Ofgem has confirmed that it meets the criteria for opening up to competition. However, this will use the Competition Proxy model rather than the CATO model.

Another way of opening up the market is to increase the number of interconnectors and allow new market entrants. There are currently four existing interconnectors to the UK market and an additional seven are in development or planning stages according to Ofgem (see Table 3). The existing interconnectors have a total capacity of 4 GW, but the Moyle connector has been operating at half of its full 500 MW capacity since 2012. During 2016, the UK's total net electricity imports amounted to 17.5 TWh, contributing to 5% of the country's supply. National Grid has stated that with the planned interconnectors' capacity, approximately 35% of the UK's peak electricity demand could be met. Mutual Energy operates the Moyle interconnector and earns revenues from selling transmission services, while EirGrid operates the other connection to the Republic of Ireland and National Grid operates the UK side of the remaining two to continental Europe. Currently there are only five companies operating in the naturally monopolised transmission industry. However, more companies are expected to enter the market with the new interconnectors that are planned in the coming years.

Table 3: Current and planned interconnectors in Great Britain

Current and planned interconnectors in Great Britain				
Project Name	Developers	Connecting Country	Capacity	Delivery Date (est.)
IFA	NGIH and RTE	France	2000MW	1986
Moyle	Mutual Energy	Ireland	500MW	2002
BritNed	NGIH and TenneT	Netherlands	1000MW	2011
EWIC	EirGrid	Ireland	500MW	2012
ElecLink	STAR Capital and Groupe Eurotunnel	France	1000MW	2019
NEMO	NGIH and Elia	Belgium	1000MW	2019
NSN	NGIH and Statnett	Norway	1400MW	2020
FAB Link	Transmission Investment and RTE	France	1400MW	2022
IFA2	NGIH and RTE	France	1000MW	2020
Viking	NGIH and Energinet.dk	Denmark	1400MW	2022
Greenlink	Element Power	Ireland	500MW	2021

3.3 Electricity distribution in the UK

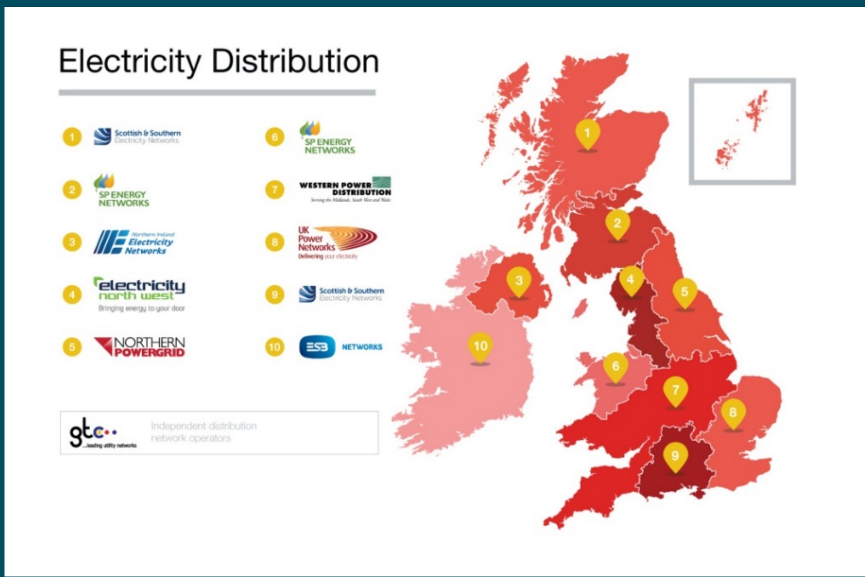
Electricity distribution networks carry electricity from the high voltage transmission grid to industrial, commercial and domestic users. By the end of 2017, there were fourteen Distribution Network Operators (DNOs) and fourteen Independent Distribution Network Operators (IDNOs) in the UK. A DNO is licenced to service a certain geographic area (as indicated by Figure 11), while IDNOs usually serve new developments through extensions to the DNOs. One of the newest IDNOs was the Swedish company Vattenfall, which received its licence as an IDNO on the 1st of November 2017, after previously only being active as a generator and supplier.

A major change to electricity distribution in the UK in coming years is the transition of distribution network operators (DNOs) to distribution system operators (DSOs), which is envisaged to take place over the period to 2030.

This transition is a major event in the UK electricity market and it is not possible to give a detailed description here of all of the system and regulatory changes that will occur, as these are not yet known. However, as a broad outline, traditionally, DNOs control and maintain distribution networks to get electricity from the transmission grid to end-users, with uni-directional power flows. However, with the increase in distributed generation, renewable sources, energy storage, and microgrids, the distribution network is now much more complex than in the past. Thus, under the new DSO models, distribution system operators will take a much more active role in balancing local generation and demand. The DSOs will securely operate and develop an active distribution system comprising networks, demand, generation, and other flexible distributed energy resources. The aim of this transition is to enable competitive access to markets and the optimal use of distributed resources on distribution networks in the support of whole system optimisation.

The transition will bring about significant regulatory changes and likely increase the market for system services, such as regional load-balancing. This in turn opens up new opportunities to manufacturers smart grid equipment and control technologies.

Electricity distribution



Source: ENA

Figure 12: Electricity distribution networks categorised by operators' regions

Only six companies own the fourteen DNOs in Great Britain: UK Power Networks, Western Power Distribution, SSE, ScottishPower, Northern Powergrid and Electricity North West. The two largest actors on the market, UK Power Networks and Western Distribution, own almost half of the UK distribution market (see Figure 13) and both operate in southern England.

Ofgem regulates the DNOs, while Northern Ireland Electricity, which operates in Northern Ireland, is regulated by NIAUR, which is the equivalent in Northern Ireland. Regulators measure DNOs on two main indicators: customer interruptions (CI) and customer minutes lost (CML). Depending on the performance of the network with regard to the set targets, the DNO will either be rewarded or penalised. The UK grid is one of the more reliable electricity grids in Europe and provided a 99.992% availability in 2016. However, about 7.7% of transmitted electricity is estimated to be lost in the process due to inefficient networks or fraudulent behaviour (i.e. technical and non-technical losses).

It should be noted that the subject of losses has recently become a strategic priority for Ofgem, and hence the DNOs. For example, Ofgem's Losses Discretionary Reward (LDR) aims to encourage and incentivise DNOs to undertake additional actions to better understand and manage electricity losses on their networks. This is run in three tranches, with LDR Tranche One having a maximum reward value of £8 million across all applications. The Electricity Networks Association (ENA) has just commissioned a piece of work which will define a losses incentive mechanism for technical losses.

Manufacturers of smart grid technologies could capitalise on this efficiency drive by offering inherently more efficient equipment – such as low loss transformers – and communication, monitoring, and control technologies that can facilitate efficient operation of the distribution network.

The distribution networks will see large investments in the coming years to connect new homes, replace old assets and increase network efficiency and security as a way to meet carbon reduction targets. For example, the ongoing rollout of smart meters is expected to support the DNOs in tackling inefficient networks and distribution through access to better data and smart controls.

Electricity distribution company market shares

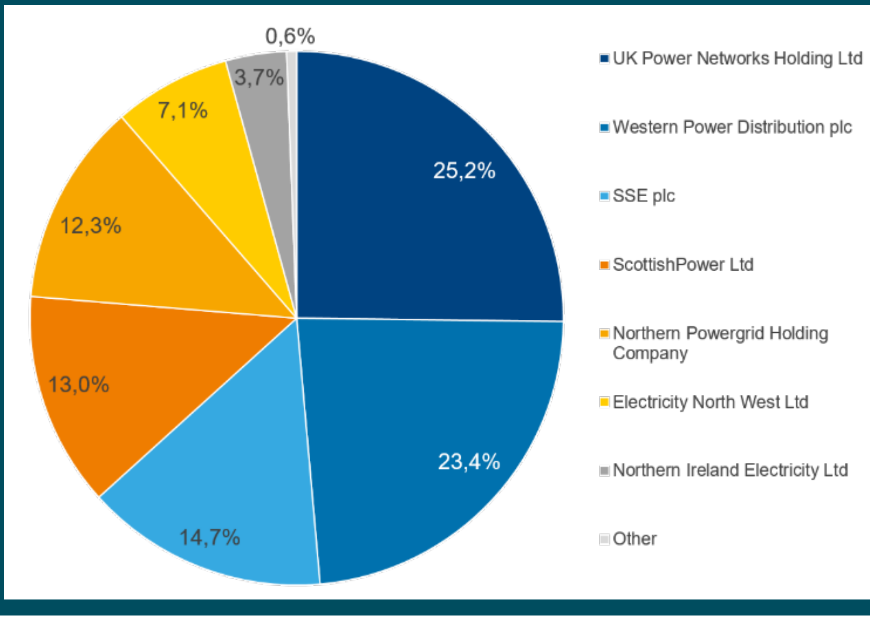


Figure 13: Electricity distribution company market shares

3.4 Electricity supply in the UK

The electricity supply industry entails the supply of electricity to the final consumers in the retail market. The generators and suppliers participate in the wholesale market to trade electricity. Electricity consumption has steadily gone down between 2007 and 2016 due to a decrease in industrial manufacturing activity and the development of more efficient domestic energy usage. The final electricity consumption in the UK in 2016 was 304 TWh, showing a decline of 11.2% during the ten-year period (see Figure 14). Demand is primarily driven by the domestic market with 37.5% of the consumption (114 TWh), while the manufacturing industries represent 29% (86 TWh) and the commercial premises 25% (76 TWh). Other consumers (e.g. public administration establishments or transport industries) consume around 8.7% of the UK's electricity (26 TWh). Even though the consumption has decreased over the last decade, this is not a clear indication of the future. The anticipated increase in electrified heat and transport is only one factor expected to drive up the demand in the coming decades.

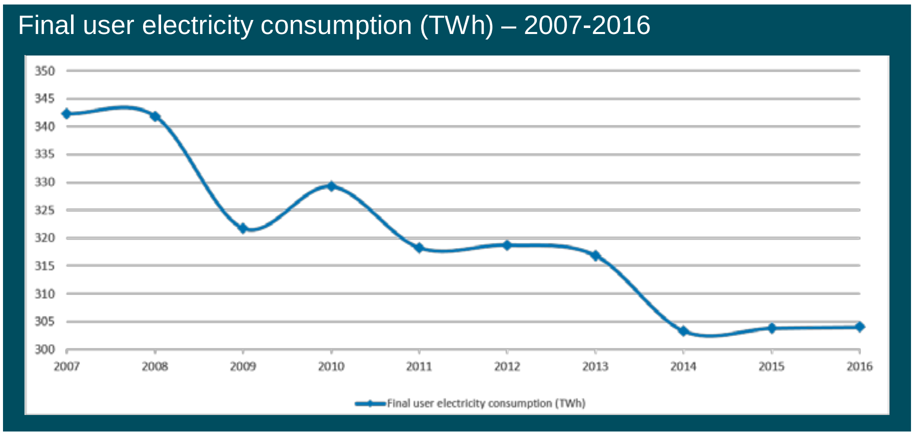


Figure 14: Final electricity consumption in the UK 2007-2016

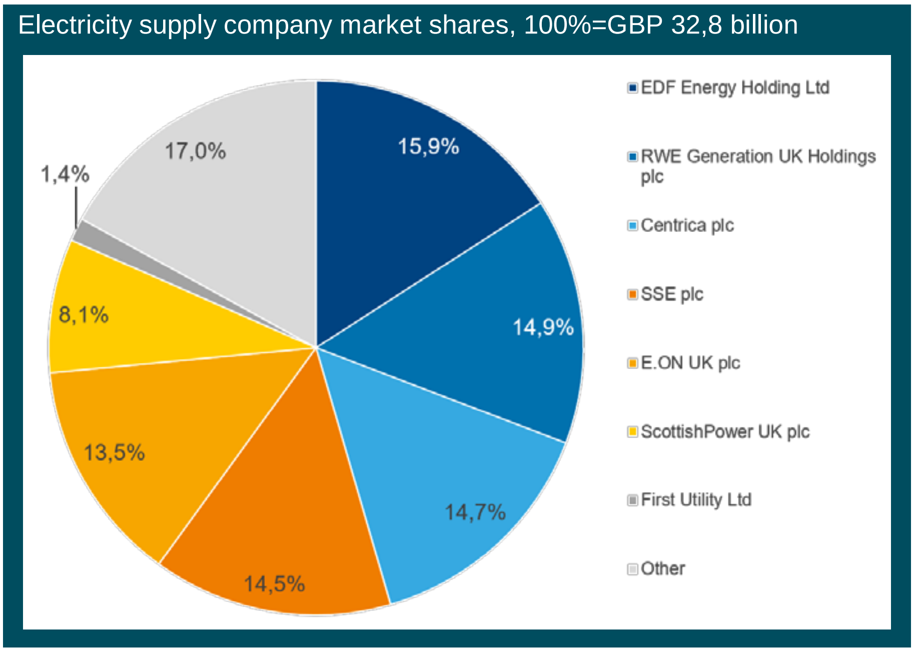


Figure 15: Electricity supply company market shares

Six large companies, referred to as the ‘Big 6’, dominate the supplier industry: EDF Energy, Npower (RWE), British Gas (Centrica), SSE, E.ON and ScottishPower, which together hold approximately 82% of the market (see Figure 15). However, the market is changing and the incumbents are challenged by new market entrants who are increasing their market share. In June 2017, there were as many as 53 active electricity suppliers in the UK market, of which 49 provided both electricity and gas, and four provided solely electricity to consumers. In 2016, there were 20 electricity suppliers to the domestic sector, 26 to the commercial sector and 26 to the industrial sector.

Electricity Charging

Users of the electricity transmission system are subject to connection charges, TUoS (Transmission Network Use of System) charges and BSUoS (Balancing Services Use of System) charges.

Connection charges are the costs to connect the asset to the transmission system which would not be normally used by another connected party, such as a new dedicated overhead line or cable.

TNUoS charges recover the cost of providing and maintaining shared transmission assets. They are split into wider TNUoS (this covers that Main Interconnected Transmission System – MITS) and local TNUoS (shared connections up to the MITS).

BSUoS charges are the costs for day to day operation of the transmission system, which primarily included costs for balancing the electricity system and constraining generation.

The wider TNUoS charge forms a large part of the total transmission charge, and is zonal in nature. Figure 16 shows the generation TNUoS zones for the UK. The tariffs range from approximately £25.6/kW in Zone 1 (North Scotland) to -£12.5/kW in Zone 23 (Central London) for conventional low carbon generation. This shows that in areas of the UK further from demand (e.g. Northern Scotland) the generator must pay a significant fee in order to connect generation, but in areas closer to demand the generator may receive a rebate to connect (e.g. Central London). The idea is that the tariffs are cost reflective, i.e. reflect the transmission cost of connecting at different locations.

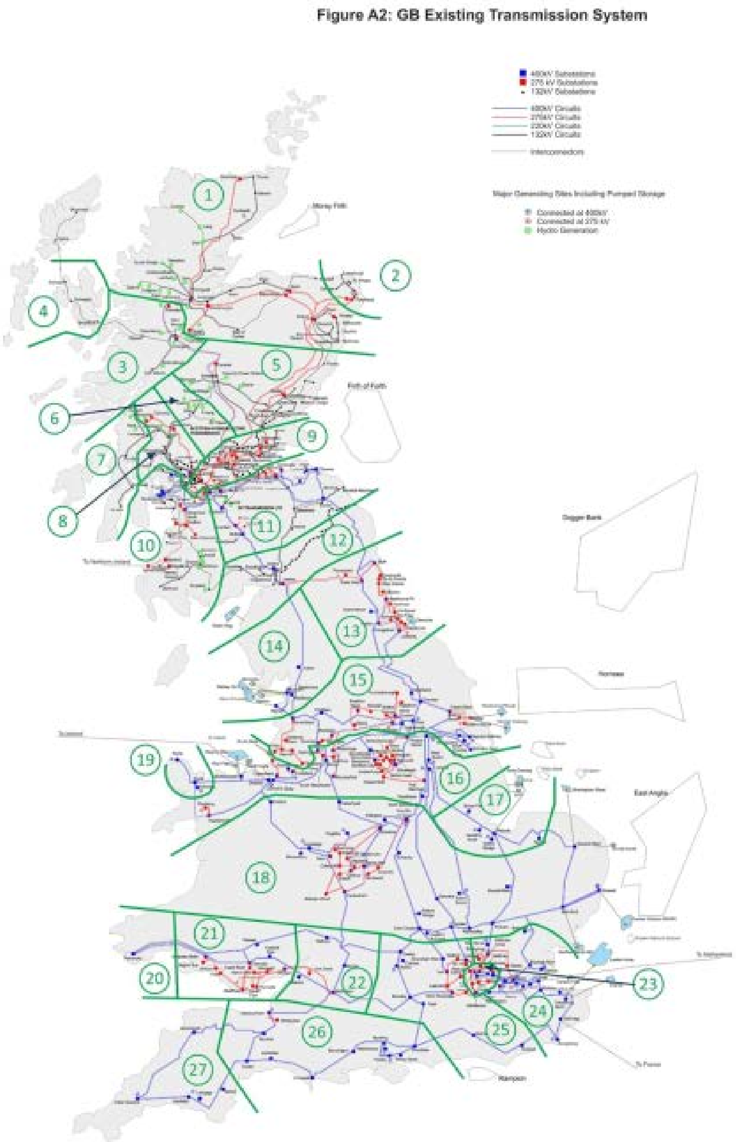


Figure 16: Generation TNUoS Zones in the UK[6]

Smart Meters

Traditionally across Europe, the DNOs have owned the electricity meters installed in homes, but the UK government has assigned the suppliers to lead the smart meter rollout which commenced in 2012 with an original target completion date of 2020.

6https://www.nationalgrid.com/sites/default/files/documents/Final%20TNUoS%20Tariffs%20for%202018-19%20-%20Report.pdf

The smart meter system design in the UK is built around three parties: the consumers, the Data & Communications Company Limited (DCC) and the DCC Service Users. DCC is a wholly-owned subsidiary of Capita plc, and is a monopoly provider regulated by Ofgem. The electricity data is sent from the consumer through the Communication Service Provider, which is part of DCC. Arqiva is the communication service provider in the north and Telefonica in the central and southern regions. The data is processed by CGI, which is the Data Service Provider, and the data service provider sends the appropriate messages to the DCC Service Users. The service users are the energy suppliers, the DNOs, and any other authorised third party.

The suppliers either own or rent the meters that are installed and have the responsibility to complete a national rollout of some 52m meters (electricity and gas). The suppliers however cannot force their customers to have smart meters installed in their homes, but all customers need to be offered the installation of a smart meter in their home by 2020.

By the end of 2017, there were only approximately 5.5 million electricity smart meters installed in the UK. Of these almost all are based upon an interim specification SMETS 1 (Smart Metering Equipment Technical Standard) which has limited functionality and does not allow for customers to switch supplier without changing the meter. The SMETS 2 specification with full interoperability has been plagued with problems and delays which means that the national rollout is considerably behind schedule and is already significantly over budget.

In December 2018 the Brattle Group published a report suggesting that the UK Government had only two options available in order to achieve a positive outcome from the smart meter rollout.

Firstly, remove a large proportion of the customer base from requiring a Smart Meter. This "Refocused Rollout" path would concentrate the rollout on the most cost-effective customer segments, in order to focus upon a deployment that is driven by customer demand. It would therefore maintain the programme's original foundation of voluntary meter adoption

Alternatively, the report suggests a "Default Deployment" model as employed in most international jurisdictions, where smart meters are treated as essential energy infrastructure. As a result, the meters are rolled out on the basis of a mandatory deployment.

The smart meter rollout could offer opportunities in several areas to Swedish companies, the most obvious being smart meter manufacturers. However, there are also significant opportunities in communications and data storage technology – data from the smart meters must be transmitted, stored, and analysed. Mobile telephone apps are increasingly popular for controlling heating and lighting for domestic users; developers may be able to come up with an app that will receive data from a smart meter and then be used to control electricity use accordingly.

Electric Heating

Electric heating is commonplace in the UK, particularly in modern buildings in cities where sold fuel heating cannot be used and mains gas is not available. The 'Economy 7' tariff is specifically designed for domestic electricity consumers with electric heating. The 7 refers to the 7 hours of the day when electricity demand is lowest (generally from 11pm – 6am, or 12am – 7am, depending upon the supplier). This tariff is designed to encourage people to charge storage heaters over night when demand is lowest, with the cost per kWh for night units being significantly cheaper than for day units. However, the cost of day units on an economy 7 tariff can be more expensive than for standard units. This means that some consumers would prefer to find more efficient and more controllable means of heating than the old storage heaters.

Another technology becoming more popular in the UK is Heat Pumps. This technology works in a similar fashion to a refrigerator, taking heat from the outside air of the ground and using it to heat water and underfloor heaters and radiators. Heat pumps require an electricity supply to work, but, as they are generally more efficient than conventional heaters and can help to reduce electric bills, it is anticipated that their use will increase further in the future as more people become aware of their benefits.

Heat Networks

Heat networks (or district heating) are networks of insulated pipes that deliver hot water or steam from a point of generation to end users. They enable heat energy that is often wasted to be captured and used. There are over 14,000 heat networks in the UK and nearly 492,0000 heat connection in total. [7]

The opportunities associated with heat networks are increasing as more parties, such as local councils, housing associations, universities etc see the benefits. In addition, the combination of heat networks with private wire electricity connections as a strategic solution is gaining increased interest. There are opportunities for helping these organisations to design and develop the optimal solution for their needs.

Swedish companies with experience in providing advice on both local heat and electricity networks may find that there are opportunities in this sector, particularly if new, relevant experience and track record from Sweden can be applied in the UK.

7 https://www.theade.co.uk/resources/what-is-district-heating

4 Regulation

The incentives in the electricity market and for smart grids derive from numerous regulations and policies. The government's EU renewables targets binds the country to a target of 15% of final energy consumption coming from renewable sources by 2020. In order to reach the target, the lead scenario is that approximately 30% of electricity, 12% of heat and 10% of transport will come from renewable sources by 2020 (see Table 4). Even if the decarbonisation of electricity appears to be on track, the de-carbonisation of heat and transport is broadly considered to be behind schedule, and more support from the government can be expected before the end of the decade. The electrification of heat and transport is identified as a possible way forward, which has been followed by governmental support for both electrified heat, such as heat pumps, and low emission vehicles, both of which will put a heavier strain on the electricity grid.

The goals for the electricity sector are underpinned by the three objectives outlined in the Electricity Market Reform, which in turn included the introduction of Contracts for Difference and Capacity Market (see Table 5). The objective of the Capacity Market is to ensure the security of electricity supply to the market by supporting generation and non-generation capacity providers (including storage and demand-side response) that are part of the Capacity Market, a predictable revenue stream if they provide reliable capacity and by penalising them if they fail to do so. The Capacity Market auctions, determined by expected future demand, are run by the National Grid Electricity Market Reform Delivery Body, which in turn is overseen by Ofgem.

Table 4: UK's renewable energy achievements and targets

	2010	2016	2020 (f.)
Electricity	7.4%	24.6%	31%
Heat & Cooling	2.8%	6.2%	12%
Transport	3.3%	4.5%	10.3%
Overall	3.8%	8.9%	15%

Table 5: The three objectives of the Electricity Market Reform

The three objectives of the Electric Market Reform
"**Ensuring a secure electricity supply** by providing a diverse range of energy sources, including renewables, nuclear, CCS equipped plant, unabated gas and demand side approaches; and ensuring we have sufficient reliable capacity to minimise the risk of supply shortages."
"**Ensuring sufficient investments in sustainable low-carbon technologies** to put us on a path consistent with our EU 2020 renewables targets and our longer-term target to reduce carbon emissions by at least 80% of 1990 levels by 2050."
"**Maximising benefits and minimising costs** to the economy as a whole and to taxpayers and consumers - maintaining affordable electricity bills while delivering the investment needed. EMR minimises costs compared to the current policies because it seeks to use the power of the markets and competition and reduce Ministerial intervention and support over time."

In 2017, the UK government published the Clean Growth Strategy, entailing a set of policies, proposals, and government spending with the aim to lower emissions and sustain economic growth.

A key regulation that supports the smart grid development is the RIIO (Revenue=Incentives+Innovation+Outputs) regime that was implemented in 2013. RIIO is a price control framework primarily designed to promote smarter gas and electricity networks. The price controls incentivise innovation in the network operators' organisations that can generate tangible customer benefits by controlling the onshore operators' investments. There are three price controls: one for gas and electricity transmission (RIIO-T1), one for gas distribution (RIIO-GD1) and one for electricity distribution (RIIO-ED1). The framework also requires the network companies to publish eight-year business plans including investment plans, expected customer outcomes and innovation plans. The first round of price controls, RIIO-1, runs until 2021 for transmission and 2023 for electricity distribution. The new price controls, RIIO-2, will be introduced once the previous price controls end but are already under development.

The framework opens up the network operators to working with third parties on innovation projects and developments, but without subsidies. This provides various opportunities for manufacturers and developers of smart grid technologies and systems to participate in large projects with the network operators as the operators are encouraged to find innovative solutions to optimise the operation and control of their networks.

This is a slightly different system to that in Sweden where the Swedish Energy Agency (Energimyndigheten) directly finances research for new and renewable energy technologies, smart grids, and vehicles and transport fuels of the future.

4.1 Key policy making and regulatory bodies

The Department of Business, Energy and Industrial Strategy, BEIS, is the public body that supports the Secretary of State of Energy when developing policy and legislation proposals for the energy sector. BEIS works closely with parliament, the regulatory bodies and industry to develop effective policies for the energy market.

Great Britain (England, Wales, and Scotland) and Northern Ireland have separate regulatory bodies for their electricity markets. Whereas the Office for Gas and Electricity Markets (Ofgem) regulates the GB market, the Northern Irish market is regulated by Northern Ireland Authority for Utility Regulation (NIAUR). Both Ofgem and NIAUR are non-ministerial National Regulatory Authorities that are recognised by EU directives. They regulate prices within the natural monopolies of the transmission and distribution grids as well as forming rules in the generation and supply markets to develop healthy competition.

5 Commercial and political development

The smart grid development in the UK is driven by commercial interests with much support from the government and regulatory bodies. There are many financial incentives offered by the government, such as funds with special purposes, and regulatory regimes, such as aforementioned RIIO (Revenue=Incentives+Innovation+Outputs) or CfD (Contracts for Difference).

The implementation of smart grid solutions is mainly driven by the DNOs and the SO, as well as the suppliers, with support from the government and through incentives by the regulatory body Ofgem. One driving force is the requirement of network operators to publish their eight-year business plans, which indicate the strategic aim for the DNOs and TOs. Other bodies rolling out and funding projects include Innovate UK, Energy Systems Catapult, the Industrial Strategy Challenge Fund, the Carbon Trust, Scottish Enterprise and the Engineering and Physical Sciences Research Council (EPSRC).

5.1 Financial incentivising programmes and funding

The main funding mechanisms for smart grid innovation in the UK are the governmental competitions and funds, and the European Regional Development Fund (ERDF). The key examples of incentivising schemes, excluding the CfD and Capacity Market mechanisms, are outlined in Table 6.

Table 6: Examples of active financial incentivising programmes and funding

Examples of active financial incentivising programmes and funding	
Programme or funding mechanism	Description
NIA and NIC	The Network Innovation Allowance (NIA) is a set allowance within the RIIO price control mechanism, which supports the network operators in smaller scale projects. This could feed into cooperation with Swedish companies being able to deliver improving solutions to be tried on a smaller scale. The NIA will run until 2023 for DNOs and until 2021 for TOs. Within the scope of RIIO, and running during the same time period as NIA, is the Network Innovation Competition, which spurs network operators to compete for a funding of GBP 81 million per year for innovation projects. Third party companies (non-network companies) cannot directly bid for NIC projects, but can do so together with a network company. Under the NIA, 75% of the funding must be spent with third party companies.
HNDU and HNIP	BEIS set up the Heat Networks Delivery Unit in 2013, with the purpose of supporting local authorities and spur development of low carbon heat networks in the UK. The Heat Networks Investment Project was set up as a capital investment programme to support the local authorities in developing their heat networks, with a total of GBP 320

	million in funding. The first round went in 2017 and will be followed up by a second round in 2018.
FiT scheme	The Feed-in Tariffs (FiT) scheme was introduced in 2010 by the government in order to promote small-scale renewable electricity generation technologies. The FiT scheme requires FiT licensees (compliant energy suppliers) to pay generators a fixed fee for renewable electricity.
RHI	The Renewable Heat Incentive (RHI) is a governmental incentive for energy users to source renewable heat. It grants periodic payments to the green users, depending on their use of renewable energy for heating.
WHD	The Warm Home Discount (WHD) is a scheme tackling fuel poverty in the UK, through requirements placed on the larger energy suppliers to support the people suffering from fuel poverty or that are at a risk of it.
ECO	The Energy Company Obligation (ECO) is a governmental scheme to tackle fuel poverty and energy efficiency, in accordance with heating of homes. There are two main obligations under the scheme: 1. Carbon Emissions Reduction Obligation (CERO) 2. Home Heating Cost Reduction Obligation
Faraday Challenge	The Faraday Challenge is a GBP 246 million commitment by the government, through the Industrial Strategy Challenge Fund, to the innovation and development of batteries for electric vehicles.
Plug-in grant	Car dealerships and manufacturers can be eligible to receive grants to reduce prices for certain new electric and hybrid vehicles.
Capital allowance on energy efficient items	Businesses can claim capital allowance on their tax return for energy efficient, low or zero carbon technology.

In addition to the incentivising schemes, there are many investment budgets allocated with direction in the government's Clean Growth Strategy, with most funds planned to be allocated at least before 2025. Additional planned funding for projects was stated in the Automotive Sector Deal, published in 2018, such as GBP 400 million for electric vehicle (EV) infrastructure development and GBP 100 million in grants for the uptake of EVs (plug-in car grant). In combination with these governmental and regulatory funding and incentive schemes, the private market is itself funding projects.

A large share of the Clean Growth Strategy focuses on investment into renewable electricity generation and the electricity grid, creating many opportunities for Swedish smart grid companies within these categories. In the strategy, the government commits, among other things, to invest in the uptake of EVs (see Table 7).

Table 7: Examples of potential future governmental investments from the Clean Growth Strategy

Examples of smart grid related opportunities outlined in the Clean Growth Strategy		
Category	Funding	Description
Overarching	GBP 2.5 billion	Invest over GBP 2.5 billion in low carbon innovation between 2015-2021
Overarching	**n/a**	Offer all households to have a smart meter by 2020
Transport / EV / DSR	**n/a**	End the sale of new conventional petrol and diesel cars and vans by 2040
Transport / EV / DSR	GBP 1 billion	Support the uptake of ultra-low emission vehicles (ULEVs) with GBP 1 billion
Transport / EV / DSR	GBP 95 million	Invest an additional GBP 95 million supporting electric vehicle-charging infrastructure
Transport / EV / DSR	GBP 150 million	Invest GBP 50 million supporting dedicated electric taxi charging points and GBP 100 million supporting retrofit and new low emission buses
Transport / EV / DSR	GBP 500 million	Support innovation in connected and autonomous vehicle technologies with a GBP 250 million investment, matched by industry
Transport / EV / DSR	GBP 841 million	Invest GBP 841 million in low carbon transport technology and fuels
Transport / EV / DSR	GBP 265 million	Invest GBP 265 million in smart systems to reduce the cost of electricity storage, advance innovative demand-side response technologies and develop new ways of balancing the grid
Electricity generation	n/a	Phase out unabated coal for electricity generation by 2025
Electricity generation	n/a	Progress talks and efforts on nuclear new build
Electricity generation	GBP 557 million	Support route to market for renewable technologies with up to GBP 557 million for Pot 2 Contracts for Difference auctions (next one planned in Spring 2019)
Electricity generation	GBP 460 million	Invest GBP 460 million in nuclear to support work in areas including future nuclear fuels, new nuclear manufacturing techniques, recycling and reprocessing, and advanced reactor design
Electricity generation	GBP 177 million	Invest GBP 177 million to further reduce the cost of renewables, including innovation in offshore wind turbine blade technology and foundations
Heating	GBP 4.5 billion	Invest in low carbon heating by reforming the Renewable Heat Incentive, spending GBP 4.5 billion to support innovative low carbon heat technologies in homes and businesses between 2016 and 2021

5.2 Political goals for the smart grid

In 2014, the British Smart Grid Forum published a report on the vision for UK's future smart grid. The Smart Grid Forum was set up by the government and Ofgem to bring relevant actors in the energy market together, in order to examine and develop strategies for UK's smart grid. The vision for the smart grid is to:

1. Decarbonise the electricity grid
2. Ensure energy security
3. Minimise energy costs for consumers

The vision also states that moving towards a smart grid will allow for flexible and efficient networks, while creating jobs, stimulating innovation and incentivising consumers to manage their own demand.

The "Smart Systems and Flexibility Plan" and the "Open Networks Report" from 2017, outlined many of the aims for the coming six years and the needs for regulatory and commercial developments. The most significant changes are those related to the transition of DNOs to become distribution system operators (DSOs).

6 Smart grid developments

The electricity market in the UK is currently undergoing a large reform striving to become up-to-date and to meet the country's technical, social and environmental goals. In a study conducted for the UK government, it was found that a transition to a smart energy system could provide benefits of GBP 17-40 billion to 2050. The benefits would derive from avoiding network reinforcements and new generation build, and through better operation of the system. The Electricity Networks Association (ENA), which is the member organisation for the electricity and gas network operators, has an online website called Smarter Networks Portal, where its member companies have their ongoing and completed smart grid projects[8]. There are over 470 completed projects and more than 1,200 that are live at this moment, and that in total are valued approximately GBP 52.6 million. Since the market is privatised, so are also most of the tenders. The online Network Innovation Collaboration Portal[9] is a platform connecting third-party companies with upcoming smart grid-related projects. Companies can propose projects to network operators and express their interest for announced projects.

Within the nine identified smart grid areas by the IEA, the emphasis in the UK is put on renewable and distributed generation integration, transmission enhancement, distribution grid management, advanced meter infrastructure, EV infrastructure, customer-side systems, and cyber security.

8 The Smarter Networks Portal can be found at www.smarternetworks.org
9 The Network Innovation Collaboration Portal can be found at www.nicollaborationportal.org

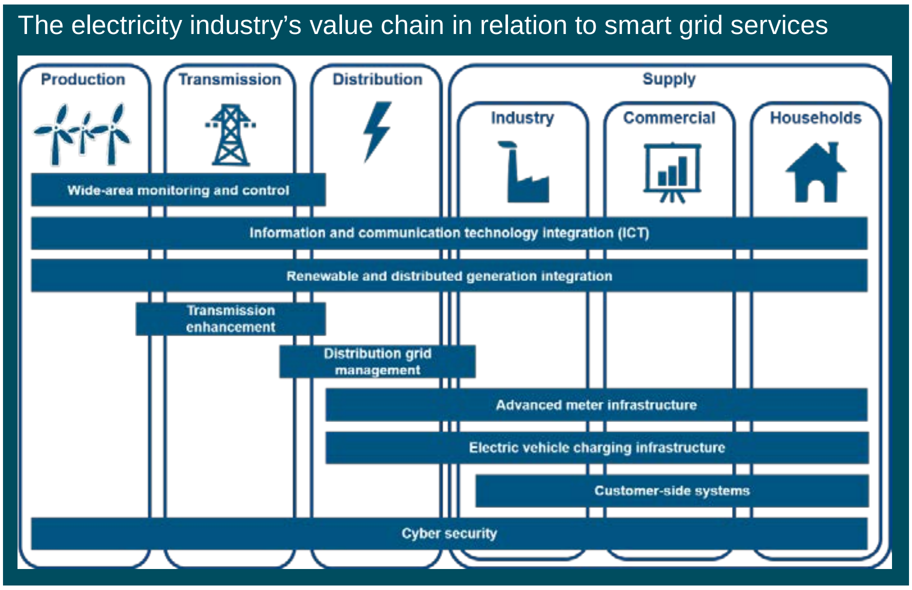


Figure 17: The electricity industry's value chain in relation to smart grid services (simplistic)

Distribution System Operator

Adoption and availability of distributed energy sources, including EV charging, solar panels or storage solutions are variable, difficult to predict and therefore raise new challenges in connection, management, and operation of electricity distribution networks.

In 2017 the UK Government and Ofgem mandated that DNOs would not be allowed to own or operate storage solutions, in a move that was the first indication that the role and function of the DSO and the DNO would be legally separate functions. This was further confirmed by the subsequent ruling that National Grid would also be made to operate the Transmission Grid and the Energy Systems Operator as two distinct businesses.

As a result, each DNO has been engaging the market to explore how to develop a DSO business that would potentially deliver 'flexibility' services and likely regional or local balancing operations.

Flexibility measures are intended to negate potentially expensive network reinforcement options regarding the integration of fast-acting supply, demand response and energy storage solutions. The majority of such Flexibility services therefore require implementation of 'smart' management and control to support complex and 'multi-agent 'systems across the distribution networks.

Advanced communication and data exchanges between different parts of the power network will make central management and operation more and more challenging. DSOs will therefore develop local distributed control and management systems in order to optimise adoption of distributed energy and demand side platforms, in consideration of specific local topology and network constraints.

The DSO transition is leading to a number of opportunities, including in participation in innovation project (for example Ofgem NIC and NIA projects), provision of communications equipment, development of services and data processing. One particular trend is that the ability to understand and operate in various different areas, such as IT, communications, finance and electrical networks, is becoming more important. There are opportunities for players that can bring expertise from different sectors and apply this knowledge to the electricity networks.

Ofgem review of Network Access charges

Smart Grids and the developing role for the future DSOs are intended to facilitate the effective and economic integration of sustainable distributed energy solutions. In order to incentivise the adoption of these technologies however, a transparent mechanism regarding how relevant capital and operational costs will be recovered and balanced against the resulting benefits must be developed.

In a 2016 study carried out for Ofgem, potential savings of up to £4-15bn cumulatively to 2050 were suggested, from reducing capital expenditure on electricity network reinforcement, if flexible technologies can be used to help address network constraints.

In December 2018 Ofgem therefore launched the Electricity Network Access and Forward-looking Charging SCR (also referred to as the Electricity Network Access Project), The objective is to ensure that electricity networks are used efficiently and flexibly, reflecting users' needs. In particular Ofgem want to allow consumers to benefit from new technologies and services while avoiding unnecessary costs on energy bills in general.

Industry commentators seem to agree that the net result of the review will be a reduction in the network companies previously allowed levels of capital returns. This will likely also include a cost mechanism / structure for Flexibility and interconnection services that will be aimed at driving increased adoption and interconnection of distributed energy solutions

The transition from network to system operators is already facilitating new entrants to the market through more transparency and openness to innovative solutions, which otherwise can be cumbersome for those new to a market. There is also an increasing opportunity to interact with the government, Ofgem, SO and DNOs to influence the future standards.

Asset Management

The UK is facing challenges in the electricity grid, and the grid is becoming more complicated. The electricity grid infrastructure, for both transmission and distribution, is aging and offers opportunities for innovative solutions to drive down the costs of the vast transmission and distribution refurbishment that would be needed. There are opportunities here for companies with innovative asset management techniques. The ability to collect and process data more easily is driving forward improvements in these techniques.

Many advanced and smarter asset management strategy have been developed and practiced in other industries (Condition Based Maintenance, Reliability Centred Maintenance, mainly in Oil and Gas, Nuclear Power, Defence, Marine and Aircraft.) To date, these strategies were not practiced in power networks as the required data was not accessible in electricity network or it was very costly to access. Now with the growing trend of using smart monitoring along with cheap data transfer and storage devices, DNOs may review their ongoing asset management strategy and use other industry experiences to develop a smart, cost effective strategy which provides the actual requirements of their network. There are therefore opportunities to provide advice on these asset management techniques, or supply systems to improve DNO asset management.

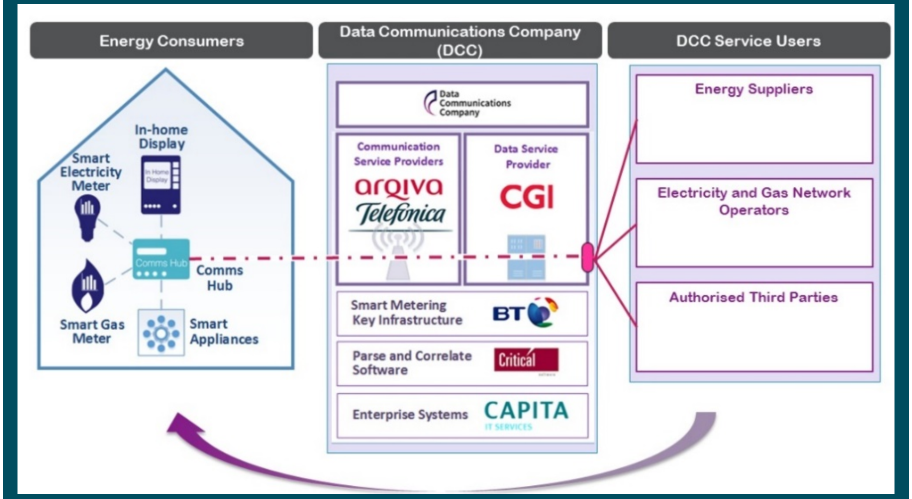
Interconnectors

One of the UK's challenges is the expected closing of two-thirds of the country's existing electricity capacity by 2030. In order to secure the future energy supply, which is one of the country's main goals, connecting to other countries' power grids is vital for the UK. The current interconnections provide a capacity of 4 GW (5% of supply), but with the planned developments the interconnectors' capacity will increase to approximately 12-18 GW by 2022. This offers major opportunities for Swedish companies that deliver components and services in relation to interconnectors. The Swedish company ABB, which is one of the leading suppliers worldwide of HVDC converters, is expected to act on the arising opportunities.

Smart meter rollout

The supplier-led rollout of smart meters in the UK began in 2012 and due to be completed by 2020, which means that all consumers would have smart meters installed by that time, or at least have been offered by their supplier. However, the smart mater rollout is currently somewhat behind schedule. By the end of 2017, more than 5.5 million electricity smart meters and 4.1 million gas meters had been installed. Consumers do not have to bear the upfront cost of smart meter installation. The deployment of all the estimated 53 million smart meters in the UK is expected to cost GBP 11 billion and deliver benefits of GBP 17 billion by 2030.

High-level system design of the Smart Metering System



Source: DCC

Figure 18: High-level system design of the Smart Metering System

Smart meters will allow the network operators to gain a better understanding of the electricity grid and its utilisation. Today, the network operators use generic profiles when evaluating new connections and network reinforcement requirements. Introducing electric heat pumps and EV infrastructure will change the demand profile significantly and the data from smart meters will prove useful in better assessing the future potential load on the distribution grid, hence the need for new connections and reinforcement. Smart meters will also provide an opportunity in outage management. Demand-side response is an evident follow-up on the smart meter installations, offering pricing mechanisms to consumers; this may in turn offer opportunities in further interface and software deployment. Furthermore, the interaction between consumers and their energy suppliers may offer a route into the market for Swedish companies with competencies in customer-side systems.

Renewable and distributed generation integration

Distributed generation is generation that is connected to the distribution network instead of the transmission network. Transmission losses are in that way reduced, but distribution losses can rise if local demand is insufficient and the surplus electricity needs to be transmitted over the distribution network. There are increasingly many requests for renewable generation connections to the distribution grid, e.g. solar and onshore wind, and the previous forecasts have been far outmatched. For instance, there are close to one million homes in the UK that have solar panels on their roofs. Combined heat and power (CHP) generation is also predicted to increase, which will lead to higher fault levels on the distribution networks in larger cities. The increasing number of low carbon technologies, such as heat pumps and EVs, that will tap into the low-voltage network are expected to significantly increase demand on the network. During network reinforcement, the planned outage of parts of the network can cause bottlenecks and other issues. To address these issues, the distribution network operators are developing and implementing innovative solutions, such as Active Network Management (ANM), that provide more flexible connections to stabilise the grid.

Active Network Management (ANM) schemes improve the utilisation of the existing network infrastructure by instructing generators to control their output in real-time to match available network capacity. One example of such a scheme is the ANM system on the Orkney Isles, which was switched on in 2009. The technology is based on a centralised controller collecting data from “pinch points” geographically distributed around the network, and illustrated in Figure 19 below.

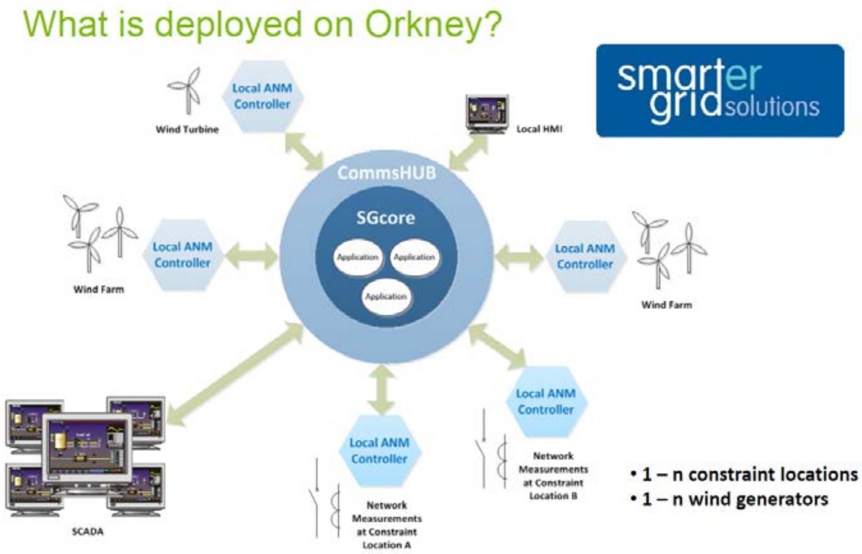


Figure 19: Active Network Management on Orkney

The Orkney scheme was the first smart grid to be deployed in the UK. It was developed by a spin-off from the collaboration between Scottish and Southern Energy Power Distribution (SSEPD) and the University of Strathclyde, which is now called Smarter Grid Solutions. SSEPD states that the total cost of delivering the Orkney Smart Grid was £500,000 compared with a cost of £30 million that would have been required to reinforce the network and accommodate this generation. The scheme has facilitated the connection of nearly 20MW of additional renewable generation.

ANM schemes are now quite common on DNO networks, with generators now being offered these schemes in many parts of the UK. However, ANM systems are still being developed, and there are potentially opportunities to get involved in developing new types of ANM systems.

There are numerous opportunities within the renewable and distributed generation sector due to ongoing developments, offering openings for innovative solutions. There are opportunities for renewable generation to be connected to the distribution network, where feed-in tariffs are one incentive. Balancing distributed generation with the local demands using smart grid technologies, especially in urban areas, is a major opportunity.

Electric vehicle charging infrastructure

In 2016, one in five operational battery electric cars in Europe were manufactured in the UK and exports of low emission vehicles were approximately GBP 2.5 billion in 2015.

The electrification of heat and transport is a major undertaking for the UK, which is integral in meeting the 2030 and 2050 low carbon targets. Electric vehicle (EV) infrastructure is viewed as an important consideration in the future of smart grids in the UK. The potential of EV energy storage is being explored and large investments from the government and industry are planned to develop the infrastructure and uptake of EVs; it is also a very active area of research in academia. The government has earlier announced a policy stating that new petrol and diesel cars will be banned in the UK from 2040.

Vehicle-to-grid (V2G) technology could potentially be one of the most important distributed energy sources and a number of system trials are being undertaken in the UK. In 2018 Innovate UK announced a series of large-scale V2G demonstrator projects. UK Power Networks is part of consortia that won a total of £11 million for five different projects.

The development of bi-directional chargers and the related system management solutions represents a nascent market however the UK government's commitment to V2G demonstrator projects shows there is political will and strong interest from across the industry.

In December 2018 the Government confirmed their commitment to drive adoption of V2G solutions by announcing that from July 2019 all government-funded charge points (the UK Government provides a £500 grant to each home installing an EV charging point) installed at people's homes must use innovative 'smart' technology in order to help reduce the strain of electric-car charging on the grid. These new chargers must be remotely accessible with the ability to receive, interpret and react to a signal as well as changing their behaviour to suit the demands on the grid.

The Department of Transport said that all chargers installed from that deadline must be able to be remotely accessed, and capable of receiving, interpreting and reacting to a signal, as outlined in the Government's Road to Zero Strategy published earlier in 2018.

In 2016, GBP 40 million was awarded to Nottingham, Bristol, London and Milton Keynes for promoting the uptake of EVs in selected urban areas and to develop large-scale EV infrastructure. In the Automotive Sector Deal, which was released in early 2018, the government committed to GBP 200 million in investments in EV infrastructure, a sum to be matched by the industry. Electric Nation, which is a trial project aiming to investigate the

UK's capacity for EV charging during peak times, is the world's largest EV smart charging trial, with 500-700 participants. The trial is being conducted in a number of networks operated by the DNO Western Power Distribution. The development of EV rollout and infrastructure is in its infancy and is expected to increase in the coming years.

Energy storage

The large increase in renewable generation, albeit in line with national goals, puts a progressively large strain on the electricity grid. Energy storage technologies have been identified as one way of stabilising the grid and supporting renewable generation. By using energy storage, consumers can for instance purchase energy when prices are down and use the energy when prices have gone up. The three pillars of the smart grid vision in the UK are all addressed with energy storage technologies. However, even if energy storage is seen as an important factor for the development of smarter grids, the current main focus from the UK government lie on innovation, research, and regulatory change, with the aim of putting the UK in the forefront of smart storage technology. There are projects announced, for example by Northern Powergrid, intending to include energy storage in their larger smart grid implementations.

The National Infrastructure Commission stressed in their report in 2016 that subsidies are not necessary for energy storage technologies and that businesses are already lining up to invest. However, the regulations for the electricity market will need to be updated since the providers of energy storage are charged double, once for charging the store and once for again exporting the electricity. The government is aware of the issue and has recently stated that this will be amended. The current barriers are hindering the full-out deployment of the technology, which otherwise could support the balancing of the grid, the cut of consumer costs and the security of supply.

National Grid predicts the installed capacity of electricity storage to increase in each of their four Future Energy Scenarios (FES)[10]. This is due to higher flexibility requirements due to increasing penetration of renewable generation. The assumptions include storage costs continuing to fall, and residential batteries becoming more widely available. Another assumption is that co-location of storage with renewable technologies and thermal plants increases. Figure 20 shows the predicted increase in installed storage capacity for each of the four FES scenarios.

10 http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf

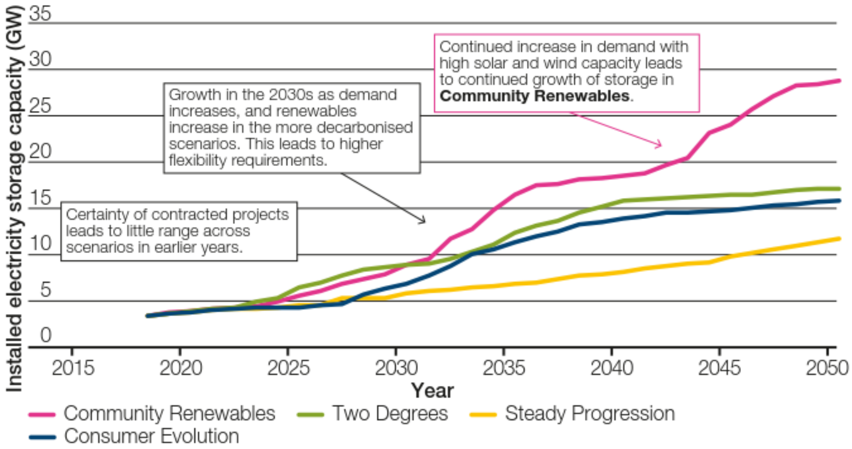


Figure 20: High-level system design of the Smart Metering System

Data / Communications solutions

In many European utilities deployment of advanced metering infrastructure (AMI) and smart metering systems has involved implementation of requisite regional and national data communications systems. A large proportion of these have employed PowerLine Communications (PLC) technology to employ existing utility infrastructure where possible and thereby significantly minimise the considerable potential costs of ubiquitous data communications networks. These systems have also provided a communications platform for implementation of initial 'Smart Grid' applications providing network / substation monitoring and control

In the UK the Smart Meter data communications was contracted to independent network operators, O2 and Arqiva. In addition, the meter rollout itself was made the responsibility of the Energy suppliers, with the result that there was no opportunity for the DNOs to leverage the data communications infrastructure for implementation of Smart Grid applications to facilitate distribution automation and integration of distributed generation.

As a result, the UK Government and the DNOs are presently evaluating available technology and service options that can support high penetration levels of monitoring and control functionality across their MV and LV networks. This is likely to represent a considerable market when one considers that the cost of building out a national data network capability for the smart meter rollout was budgeted in the region of £7 bn. The functionality and QoS required to support DNO / DSO 'Flexibility Services' is far more complex than the smart meter communications specification and is therefore likely to cost significantly more.

Cyber security

The expansion of intelligent networked devices throughout the energy distribution system, together with the supporting integrated communications networks, creates an urgent requirement for a co-ordinated energy cyber security strategy. The range of potential attacks (or 'threat vectors') is multiplied, both by the growing sophistication of cyber attackers and by the increasing number of accessible targets within the smart energy ecosystem.

The smart energy transition across the UK and EU incorporates key characteristics which directly impact development of effective cyber security policy. Even if Brexit proceeds, a smart and decarbonised UK wide energy system will likely expand upon the existing interconnection and interdependency of the UK networks with EU Member States: As a result, orchestrated cyber-attacks could have a domino effect across multiple national energy systems. Secondly, the current status of smart energy system development is not at all consistent across the EU and this could pose specific challenges in harmonising an effective EU cyber security strategy for the energy sector

Therefore, the UK's cyber security strategy has never been as crucial. In the UK, cyber security is identified as a critical development area, particularly for the energy and other critical infrastructure. In fact, energy is one of the networks under most penetration attempts in the UK by states and state-sponsored actors. There are UK government initiatives to further develop the skills and knowledge within energy cyber security in the country. The government intends to support cyber security start-ups with investments, but the main focus will be on home-grown capabilities. Although, the government has stated that it is open to fund specific interventions in order to close immediate skills gaps. The government further intends to be less risk averse in testing and implementing new solutions, in order to drive innovation.

The UK Smart Grid transition incorporates key characteristics which directly impact development of effective cyber security policy. Firstly, a smart and decarbonised EU energy system will likely expand upon the existing interconnection and interdependency of the networks across Member States: as a result, orchestrated cyber-attacks could have a domino effect across multiple Member States. Secondly, the current status of smart energy system development is not at all consistent across the EU and this could pose specific challenges in harmonising an EU cyber security strategy for the energy sector.

Critically, there appears to be insufficient information sharing and co-ordination of action in the UK energy sector. A number of steps are being taken to implement cross-sector strategies and platforms which will address some of these issues. However, these measures are not commensurate with the nature, diversity, scale and direction of recent and future challenges.

Research, development and innovation in cyber security is undoubtedly occurring in the energy sector, however this appears to be mostly ad hoc and not the product of specific coordinated and focussed objectives.

This situation is broadly mirrored in terms of relevant policy activity within the EU. Numerous activities are ongoing to address cyber security in general and applying the NIS Directive in particular. This includes three 'pillars' to 1) assess minimum standards, 2) ensure the development of capabilities through audits and sanctions, and 3) encourage cross-border information sharing.

Blockchain, Piclo and Flexibility

Blockchain is an emerging database technology that offers the potential to optimise grid management electricity at a device level. Blockchain is also a distribute ledger system, with block chains that can be used like a ledger being shared by anyone with appropriate permissions. In 2016 $1.4bn was invested in developing use cases for blockchain. The World Economic Forum estimates that by 2025 10% of global GDP will be managed on the blockchain and in 2016 in Davos they launched a Global Blockchain Council. Blockchain has huge potential – but investment is needed to understand and develop applications.

Blockchain examples include the following:

- DENA (German Energy Agency) found that 48% of German energy executives were exploring blockchain. GE, Siemens and DENA are currently collaborating on a blockchain study looking at B2B, B2C and P2P markets.
- RWE (Germany) – RWE / Innogy have launched an e-mobility business to explore the increasing link between EVs and energy consumption. Blockchain is the secure transaction layer that allows an EV to charge seamlessly or pay for services.
- Transactive Grid (LO3 Energy / Siemens – US) / Powerledger (Australia) – these projects are exploring how energy can be sold from a prosumer to a neighbour within a micro-grid, rather than create and sell a REC (Renewable Energy Credit).

Whilst there is significant discussion on the potential for blockchain in the UK, there have so far been few real projects. Conversely, a company in the UK known as Piclo has developed a marketplace for flexibility services called "Piclo Flex" that can be used for buying and selling smart grid flexibility services[11]. All 6 GB DNOs have now signed up for DSO trials. They have also signed up over 120 flexibility providers and the Piclo flex platform has been used to publish 60 local flexibility opportunities. Three DNOs were actively using the Picoflex platform in January 2019 as part of their tender process for local flexibility services. This is a different (simpler) approach compared with Blockchain, but appears to be gaining traction more quickly.

Smart Grids Procurement

There are various ways to get involved in smart grids in the UK. These include:

- Monitoring tender portals such as Achilles and Tenders Direct: Achilles requires registration, but many large tenders (including local authority requests for support on local energy projects) are let out through this portal. A wide range of consultancy projects are let out under Tenders Direct.
- Monitoring relevant websites such as Carbon Trust and Energy Systems Catapult: These organisations do not have frameworks, but they will notify those organisations with which they have relationships of tenders directly via email. They will also post these tenders on their websites.
- Tracking frameworks and bidding frameworks when they arise (such as ENA): To track frameworks it is generally necessary to have direct contact with the procurement division of the organisation, which will inform the company of upcoming frameworks or frameworks to be renewed.
- Proposing innovation ideas directly to DNOs, TOs and ENA when they have calls for innovative project ideas: Ofgem has funding available under NIC and this funding is released if ideas that are suggested pass Ofgem's assessment. A bid first needs to be submitted to Ofgem and DNOs sometimes have funding available for consultancy support to write the bid.

11 https://piclo.energy/flex

7 Challenges

While there are many opportunities for Swedish companies in the UK electricity market, there are also challenges. There are external challenges connected to the market and industry, such as the uncertainty related to Brexit, a complex and burdensome regulatory system, and the fact that the UK electricity industry is characterised by a few very large corporations. Swedish companies highlighted, in a survey of Swedish smart grid companies and their export efforts, differing regulatory frameworks, the uncertainty of Brexit and a lack of resources as some of the main barriers of market entry.

There are also challenges related to Swedish companies' internal capabilities to grow internationally and on the UK market e.g. lack of market knowledge, resources, and that they lack a local network.

The below table outlines the external and internal challenges facing many Swedish companies when establishing and growing their business in the UK market.

Table 8: External and internal challenges for Swedish companies looking to the UK market

External challenges	
Uncertainty related to Brexit	*The uncertainty related to the UK leaving the European Union may deter some Swedish companies to consider the UK as a potential market. If the UK leaves the European Union, it may deter even more companies to consider the UK but also have direct consequences for companies already active in the UK. Depending on what deal the UK and the European Union agrees upon, it may have implications in terms of new tariffs, volatile exchange rates, Swedish companies UK employed workforce, taxes, supply chain and regulation e.g. intellectual property, GDPR, competition law.*
Heavy regulation	*The UK electricity market is heavily regulated, which on the one hand makes it transparent, on the other hand makes it burdensome for Swedish companies that wish to enter the UK market to understand the regulation and its implications for the company's business model, solution fit, distribution set-up and pricing strategy etc.*
Outdated regulation	*The existing regulatory framework for the electricity market is not designed to take into account the number of new technologies entering the market. The current regulation may in some cases disproportionately disadvantage or mitigate the benefit of new smart grid technologies. For example, power storage is not included in the Electricity Act 1989, which has resulted in network costs being disproportionately distributed to new energy storage providers, to*

	mention one implication. Ofgem is working closely with the industry to address the identified challenges with the regulatory framework for TOs and DNOs to develop and integrate new technologies in the networks.
Complex and large customers	*The UK electricity market is relatively consolidated with a few large players. The key stakeholders, i.e. the TOs, DNOs and electricity supply companies, are large organisations with a generally slow update of new technologies and timely decision-making processes. A new technology is not integrated until after undertaken a series of pilots, which can make sales cycles long and often costly.*

Internal challenges	
Lack of market knowledge	*Swedish SME has limited knowledge about the business opportunities outside of Sweden, including in the UK smart grid market. It often results in companies choosing export markets based on irrational or no underlying analysis.*
Limited experience of internationalisation	*SMEs lack the competences and experience internally to grow their business internationally. It often results in companies underestimating the preparation, resources and time required to successfully enter a much larger market such as the UK.*
Limited financial resources to grow	*SMEs, in particular the smallest companies, lack financial and resources to grow their business outside their home market. It is a challenge in many aspects, both in terms of preparing a market entry, recruiting dedicated sales and service staff, but also being able to endure long sales processes.*
Product adoption needs	*A company's offering is often developed to fit only the Swedish market. Many businesses do not take into account the product or solution adoption needs required to fit a new market before initiating market entry and sales processes. They also do not consider necessary industry certificates and standards required to sell the product on a new market.*
Lack of local network	*SMEs lack a local network in the UK market required to build long-term business. A strong network within the electricity industry is important to get access to stakeholders and key decision makers, to stay updated on the latest market updates and opportunities, and ultimately to build a company brand.*
No physical presence	*To be successful in the UK smart grid market, companies need to be in the UK. Companies without physical presence on the UK market will have big challenges to win business within the smart grid industry. Companies are taken more seriously if they have a UK*

	address and a local sales and customer service team.
No brand recognition	*SMEs generally lack brand recognition in the UK, making it difficult to win traction among potential partners and customers i.e. TOs, DNOs and electricity supply companies.*
Relevant references	*While Swedish SMEs may have a strong list of references in Sweden, in the UK it is important to have references from customers known in the UK.*

8 Opportunities for collaboration and key stakeholders

8.1 Swedish presence and footprint in the UK

Swedish brands are generally highly regarded in the UK, and in certain sectors there is even something called “Scandimania”, referring to the popularity of Scandinavian television programmes and gastronomy.

There are approximately 1,000 Swedish companies established in the UK and most of the largest Swedish actors have a UK presence, such as Securitas or IKEA (see Table 6). Swedish companies are spread across the UK and employ more than 100,000 people. There are also around 90,000 Swedes living in the UK.

There are past and existing promotion activities for Swedish companies within the energy segment in the UK. Among the current energy-focused initiatives, there are mainly two on which Swedish smart grid companies could leverage: Heat Networks – Sustainability by Sweden, and Cleantech Hubs. There are numerous Swedish companies within the energy segment present in the UK, one of the largest being Vattenfall. Other large Swedish actors include Ericsson, Volvo AB, Sweco, ABB and Electrolux to name but a few. In total, there are at least 45 identified Swedish smart grid companies with activity in the UK market.

Table 9: Examples of large Swedish companies with presence in the UK

Examples of large Swedish companies with presence in the UK	
Swedish company	Employees in the UK
Securitas	15,500
IKEA	8,500
H&M Group	7,100
Skanska	5,400
Ericsson	4,000
Volvo AB	3,500
Stena Line	3,500
Handelsbanken	2,100
SCA	1,800
Scania	1,600
Sandvik	1,300
SKF	1,000

9 Conclusions

9.1 Conclusions from the state of the Smart Grid market

The smart grid market in the UK is still in its infancy, although the electricity market is mature. The market has undergone privatisation and liberalisation, and is now facing its next challenge – how to develop operational excellence through digitalisation and modernisation. The identified drivers in the smart grid development are demand-side response, EV uptake, energy storage and the smart meter rollout. These drivers will open up opportunities for Swedish companies working within the areas of:

- renewable and distributed generation integration (including storage)
- Distribution grid management and control solutions
- Data Communications networks and services,
- EV-charging infrastructure and customer-side systems.
- Energy trading platforms incorporating P2P and Blockchain solutions

Swedish companies will face internal as well as external challenges when entering the UK electricity market, but as the smart grid developments are in a relatively nascent stage, the Swedish companies can leverage on a united Swedish approach and competence to reach the relatively few key stakeholders on the market.