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Briefing Paper

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Renewable Energy – Grid Connection

1 Introduction

The following paper provides background information on connecting renewable generation to the electricity grid with reference to connection procedures in the UK, the Republic of Ireland, Denmark and Germany.

2 The Grid

Figure 1, on the following page, outlines the workings of a modern electricity grid. As is evident from the diagram, renewable energy may fit into the system at two separate points – the transmission system and the distribution system.

The transmission system, or network, transmits electricity from power stations over high-voltage lines. The operations of the transmission network are overseen by the Transmission System Operator (TSO). As such, it is generally large-scale generators who connect to the transmission network.[i] The TSOs in the UK and the Republic of Ireland are as follows:

- Northern Ireland – NIE;
- England and Wales – National Grid Electricity Transmission;

- Southern Scotland – Scottish Power;
- Northern Scotland – Scottish and Southern; and
- Republic of Ireland – Eirgrid.[ii]

The distribution network delivers lower voltage electricity from ‘grid supply points’ to the customer. The distribution network facilitates ‘distributed power’, where small to medium scale generators (often utilising renewable sources) feed power directly into the distribution network.[iii]

Across Great Britain there are a wide variety of Distribution Network Operators (DNOs) in operation. In Northern Ireland and the Republic of Ireland DNO functions are carried out by NIE and ESB Networks respectively. Please see Figure 2 for more details.

Figure 1: The modern power system[iv]

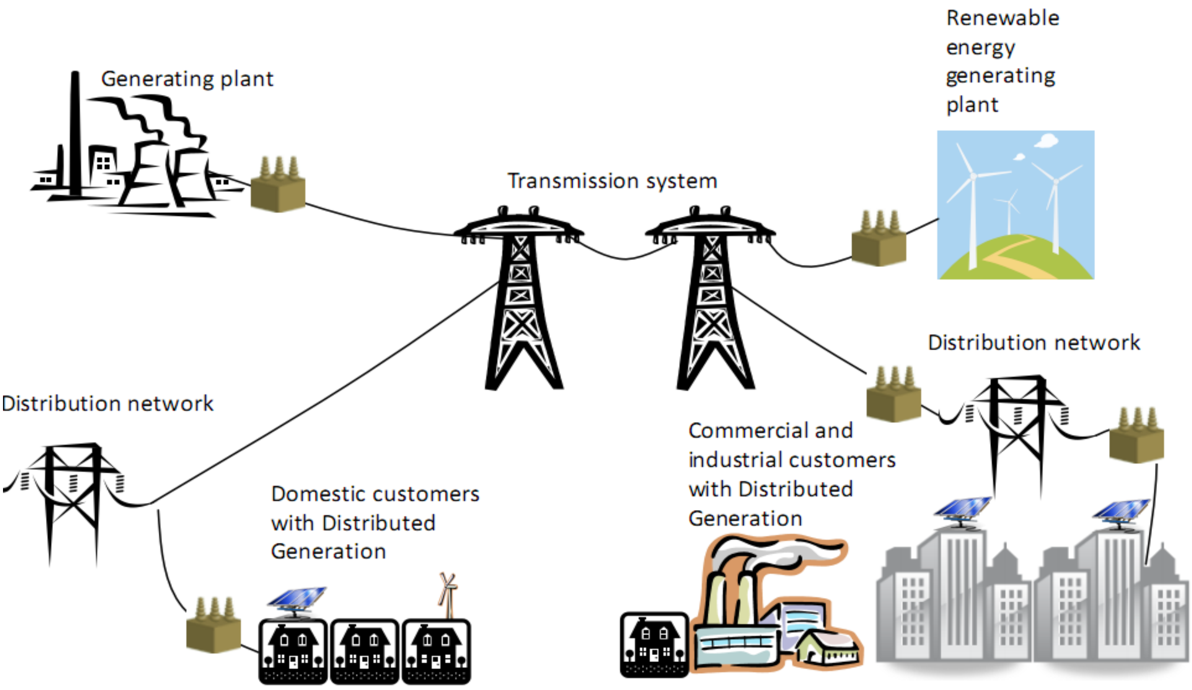
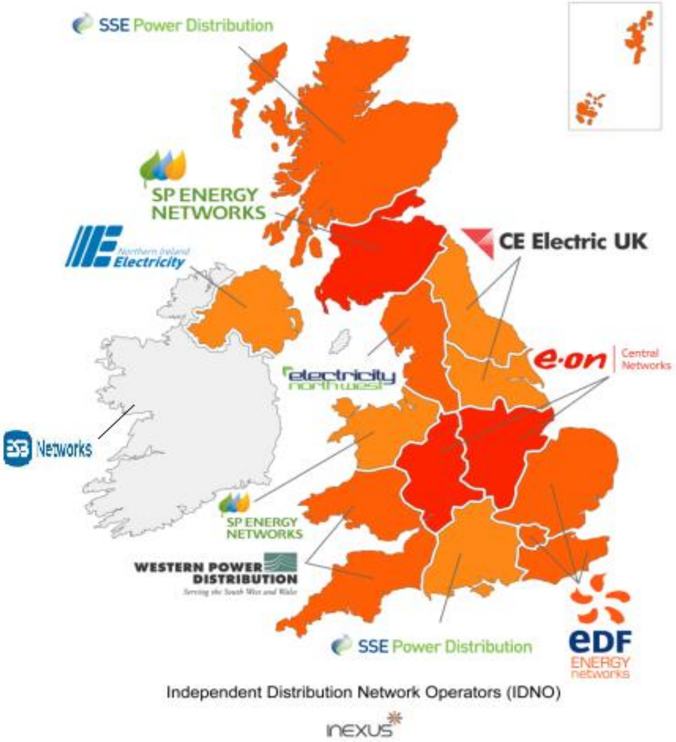


Figure 2: DNOs in UK and Republic of Ireland[v]



3 Connection Cost

The cost of integrating renewable energy supplied electricity (RES-E) into the grid is comprised of three factors;

- Grid connection costs;
- Grid reinforcement costs; and
- Investment costs into regulating power plants caused by RES-E.[vi]

Looking at each cost centre in more detail:

- **Grid connection costs:** comprise of the installation of the underground or over ground cabling required to connect to the local transmission or distribution grid. Other costs include the modification of the existing transformer and busbar[vii]. Upon connection it is essential that EU defined requirements concerning power quality and short circuit levels are met. The grid operator may also have specific requirements. In general, the cost of grid connection can be further divided into the cost of connection to the local electrical installation (or internal grid) and the cost of connection to the power grid. The latter cost is generally variable, dependent upon:
  - The distance between RES-E plant and point of connection with the grid;

- The voltage levels of the connection line and the connected grid; and
- The opportunity, or lack thereof, to utilise standardised equipment.

- **Grid reinforcement costs:** the integration of large-scale RES-E can require additional transmission and distribution network capabilities. For example, in Germany the majority of wind generation is located in the North of the country, whereas the majority of consumption is to be found in more central areas. The country's grid, as originally designed, was not appropriately constructed to transmit large amounts of electricity from North to South and from East to West. As such grid reinforcements were necessary to ensure the increased 'traffic' could be accommodated. Further reinforcements may be necessary to manage the intermittent nature of RES-E. Again, the cost is variable and dependent upon:
  - The RES-E power capacity connected to and structure of the grid;
  - Changes to the typical load flow pattern caused by the integration of (intermittent) RES-E power capacity; and
  - The need to ensure that increased RES-E connection does not lead to a decrease in power quality and system stability.
- **Investment costs into regulating power plants caused by RES-E:** The irregular nature of RES-E has the potential to result in power fluctuations and forecast errors. The need to ensure supply security may necessitate investment in new sources of flexible power generation (e.g. gas turbines) and storage facilities (e.g. pumped hydro or compressed air storage).

Across the EU, jurisdictions tend to operate within one of three variations of grid cost allocation – a Deep cost allocation, Shallow cost allocation or hybrid cost allocation.

A **Deep cost allocation** places a requirement on the renewable energy producer to cover the cost of grid connection and any necessary reinforcements to the grid.[viii]

Examples of regions operating a deep cost allocation method include Italy and Portugal.[ix] The major advantage of such an approach is that the renewable generator is often not liable to pay use of system charges for ongoing grid connection. Conversely, the major disadvantages are:

- Upfront connection cost can be prohibitively high;
- Network reinforcement costs are often uncertain; and
- A single generator can end up paying for reinforcements caused by other generators.[x]

A **Shallow cost allocation** requires the renewable energy producer to pay for the cost of connection only. In such models it is often the Transmission Systems Operator (TSO) or Distribution System Operator (DSO) who is required to pay any grid reinforcements.[xi] The costs of grid reinforcement in a shallow allocation model are often socialised, that is they are passed onto the consumer in their electricity bill.[xii]

Examples of regions operating a shallow cost allocation method include Denmark and Germany.[xiii] The major advantages of such an approach are:

- It is the lowest cost approach for renewable generators;
- Cost transparency & consistency regardless of connection point; and
- Reinforcement costs can be passed through the tariff system.

Disadvantages include:

- DSO/TSO reinforcements may be needed before connection, adding to project delays; and
- Generators are likely to be subject to ongoing Use of System charges.[xiv]

A third option, known as the **hybrid model,** offers different cost allocation for connecting to the transmission network compared to the distribution network.[xv]

Examples of regions operating a hybrid cost allocation method include the UK and the Republic of Ireland[xvi]. In both regions deep connection charges apply when connecting to the distribution network and a shallow allocation applies when connecting to transmission network. The advantages and disadvantages of a hybrid system are similar to those outlined above depending on whether the generator is connecting to the distribution network (under a deep model) or the transmission network (under a shallow model).[xvii]

Prior to connecting to the grid the developer is often subject to an administration fee. In Northern Ireland, for example, the project developer is liable to pay for a network connection and capacity study to determine the final cost of connection, the capacity available at point of connection and the details of work required to provide the connection for specific capacity and technology. The cost associated with the connection and capacity study depends on the capacity of the project seeking connection as follows:

- 20kW or less – £587.50;
- 21kW-151kW – £1,762.50; and
- 151kW-2000kW - £5,875.[xviii]

NIE note that the cost of the connection and capacity study '*will be deducted from the final connection charge, provided the project is completed within three years from the initial date of application'*.[xix]

Connection to the grid may require the developer (or TSO/DSO in a region that employs a shallow connection) to pay the cost of a range of equipment types, including:

- An electrical substation;
- Transformer;
- Metering unit; and

- Cabling.

Civil works may also be required, further driving up the cost of connection. Other factors influencing the final connection charge include:

- Statutory and other standards governing the system;
- The length of cable or overhead line required to connect to the system;
- Whether the project requires overhead lines or underground cabling;
- The type of ground requiring excavation;
- The need for river, railway, telecommunication, other electric circuit or road crossings;
- The availability of wayleaves[xx] or easements for cables or lines, including any planning consents; and
- The connection programme.[xxi]

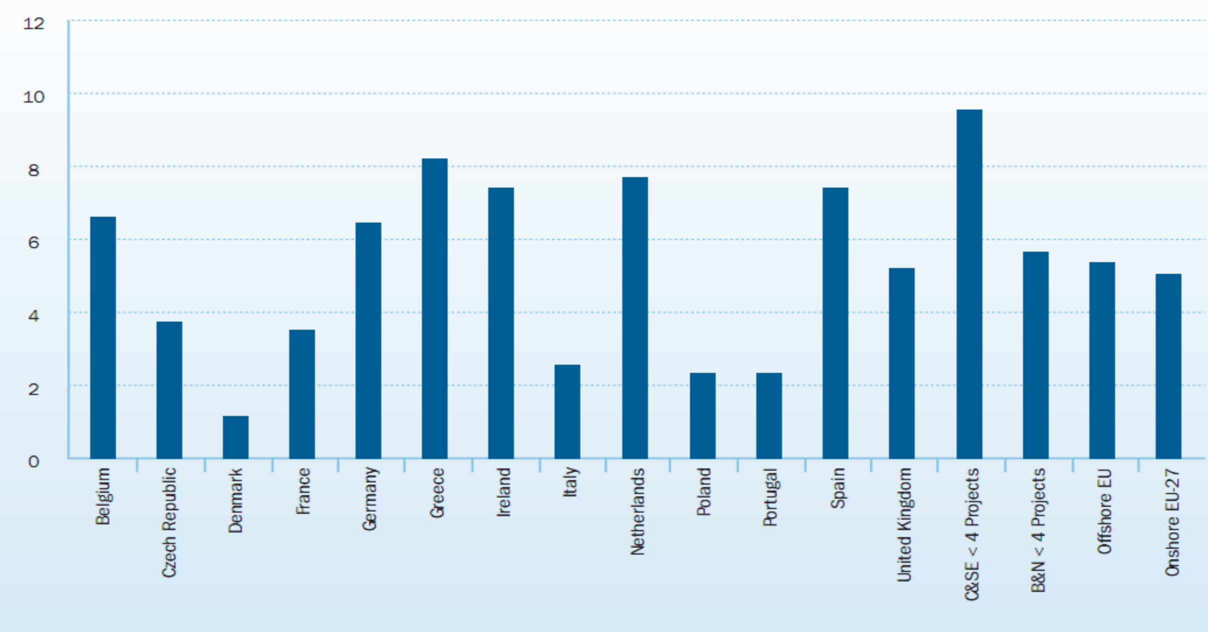
Average grid connection costs (in this context grid connection cost is taken to mean the cost for grid extensions, staff costs and all related paper work) in the EU represent approximately 5.13% of the total cost of an onshore wind project and 5.43% in the case of offshore wind. In six countries, Italy, Sweden, Denmark, Poland, Portugal and Finland, the costs are considerably lower representing 2.5% of total project cost (or just over 2.5% in the case of Italy). These results are sourced from a European Wind Energy Association study, *'Wind Barriers',* published July 2010. The study caveats the above stating:

> *…the low sample size for Sweden and Finland does not allow definite conclusions to be drawn.*[xxii]

Portugal's inclusion in this list demonstrates that a deep cost allocation method need not necessarily result in a high connection costs.

Figure 3 (overleaf) outlines mean grid access cost, as a percentage of overall wind project costs (onshore and offshore) across the EU-27 (Sweden and Finland are excluded from the Figure due to the sampling issues mentioned above). In the UK grid connection represents between 4% and 6% of total project cost. In the Republic of Ireland it is just below 8%.[xxiii]

Figure 3: Relative cost for connecting wind parks across the EU-27: mean grid access costs (% of overall project costs)[xxiv]



[i] Parliament Office of Science and Technology, *Postnote: Electricity in the UK* (February 2007) http://www.parliament.uk/documents/post/postpn280.pdf (accessed 09/11/10)
[ii] Energy Networks Association *Distributed Generation Connection Guide* (October 2010) http://2010.energynetworks.org/storage/DGCG%20G83%20S2%20Oct%202010%20-%20Red.pdf (accessed 09/11/10)
[iii] Parliament Office of Science and Technology, *Postnote: Electricity in the UK* (February 2007) http://www.parliament.uk/documents/post/postpn280.pdf (accessed 09/11/10)
[iv] Energy Networks Association *Distributed Generation Connection Guide* (October 2010) http://2010.energynetworks.org/storage/DGCG%20G83%20S2%20Oct%202010%20-%20Red.pdf (accessed 09/11/10)
[v] *Ibid*
[vi] GreenNet-EU27 *Guiding a least cost grid integration of RES-electricity in an extended Europe* (November 2006) http://www.ecn.nl/docs/library/report/2007/b07002.pdf
[vii] Busbar refers to an electrical conductor that makes a common connection between several circuits
[viii] GreenNet-EU27 *Guiding a least cost grid integration of RES-electricity in an extended Europe* (November 2006) http://www.ecn.nl/docs/library/report/2007/b07002.pdf
[ix] Dalton *et al Non-technical barriers to wave energy development, comparing progress in Ireland and Europe* (2009)
http://www.see.ed.ac.uk/~shs/Wave%20Energy/EWTEC%202009/EWTEC%202009%20(D)/papers/270.pdf (accessed 15/11/10)
[x] ELEP – *European Local Electricity Production Deliverable 2.1, Issue 1 distributed generation connection charging within the*
European Union - review of current practices, future options and european policy recommendations (September 2005)
[xi] GreenNet-EU27 *Guiding a least cost grid integration of RES-electricity in an extended Europe* (November 2006) http://www.ecn.nl/docs/library/report/2007/b07002.pdf
[xii] ELEP – *European Local Electricity Production Deliverable 2.1, Issue 1 distributed generation connection charging within the*
European Union - review of current practices, future options and european policy recommendations (September 2005)
[xiii] Dalton *et al Non-technical barriers to wave energy development, comparing progress in Ireland and Europe* (2009)

http://www.see.ed.ac.uk/~shs/Wave%20Energy/EWTEC%202009/EWTEC%202009%20(D)/papers/270.pdf (accessed 15/11/10)

[xiv] ELEP – *European Local Electricity Production Deliverable 2.1, Issue 1 distributed generation connection charging within the European Union - review of current practices, future options and european policy recommendations* (September 2005)

[xv] GreenNet-EU27 *Guiding a least cost grid integration of RES-electricity in an extended Europe* (November 2006) http://www.ecn.nl/docs/library/report/2007/b07002.pdf

[xvi] [xvi] Dalton *et al Non-technical barriers to wave energy development, comparing progress in Ireland and Europe* (2009) http://www.see.ed.ac.uk/~shs/Wave%20Energy/EWTEC%202009/EWTEC%202009%20(D)/papers/270.pdf (accessed 15/11/10)

[xvii] ELEP – *European Local Electricity Production Deliverable 2.1, Issue 1 distributed generation connection charging within the European Union - review of current practices, future options and european policy recommendations* (September 2005)

[xviii] *Ibid*

[xix] *Ibid*

[xx] On wayleaves, NIE states If NIE needs to install equipment on any third party landowner(s) property to facilitate your work then legal consent in the form of a wayleave agreement is required from the relevant landowner(s). Please note that the timescale to obtain landowner approval will depend on the landowner's willingness to sign the wayleave agreement. Work cannot commence on site until these voluntary consents have been obtained.

[xxi] Northern Ireland Electricity *Statement of Charges for connection to the Northern Ireland Distribution system* June 2008

[xxii] EWEA *WindBarriers Administrative and grid access barriers to wind power* (July 2010) http://www.windbarriers.eu/fileadmin/WB_docs/documents/WindBarriers_report.pdf

[xxiii] *Ibid*

[xxiv] *Ibid*