Nemo Link®

Development of an Interconnector between the United Kingdom and Belgium

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Need Case

1 Introduction

1.1 A 1000MW subsea electricity interconnector is being jointly developed by National Grid Nemo Link Limited ("NGNLL")[2] and the Belgian transmission company Elia (together referred to as the Nemo Consortium). The project, known as the Nemo Link, will connect the UK and Belgian electricity transmission systems by means of subsea cables between Richborough, Kent and West Zeebrugge in Belgium. It is proposed that the Nemo Link will become operational in 2018.

1.3 This report explains the need for an electricity interconnector linking the UK with Belgium and describes the role that interconnectors can play in the efficient operation of electricity markets and in supporting renewable energy and security of supply.

1.4 This document and other information regarding the Nemo Link can be found on the project website

http://www.nemo-link.com

2 Background

The Electricity Market in Great Britain

2.1 A single electricity market serves the whole of Great Britain. The market comprises competing generators and suppliers. Generators produce electricity from a variety of fuel sources, including coal, gas, nuclear and wind, and sell into the electricity wholesale market.

2.2 Supply companies purchase electricity in the wholesale market and supply to end customers. Transmission and distribution companies, which are licensed monopolies in their respective areas, carry bulk supplies of electricity from power stations, and distribute supplies to end customers. National Grid

[2] National Grid Nemo Link Limited is a subsidiary company of National Grid plc for the development of the Nemo Link. More information about the Nemo Consortium companies is provided in Appendix 1.

Electricity Transmission plc ("NGET") is the operator of the high-voltage transmission system for the whole of Great Britain and the owner of the high voltage transmission network in England & Wales[3].

2.3 Annual electricity demand in Great Britain is around 310 Terra Watt hours. This value represents the total amount of electrical energy used in one year and is equivalent to 310m heaters rated at 1000 Watts all operating for 1 hour. The peak electricity demand occurs in winter and is over 60 GW. The minimum demand occurs in summer and is approximately 40% of peak (~24GW).

2.4 The combined capacity of all the generators is greater than peak demand. The excess of generation capacity over maximum demand, known as the "Plant Margin", is needed to ensure that maximum demand can be met, allowing for fluctuations in the levels of maximum demand and available generating capacity.

2.5 The electricity industry in Great Britain is undergoing unprecedented change. In the next few years, 12GW of coal-fired power stations will close, as they cannot meet the new requirements of European emissions legislation. At the same time, around 7.5GW of nuclear capacity will come to the end of its operating life. This reduction in existing generating capacity, and consequent reduction in Plant Margin, means a huge investment in new generating capacity is needed including investment in new interconnection between the UK and Europe and Scandinavia. Furthermore, the need to tackle climate change requires a major investment in generation from low-carbon sources, such as wind, nuclear and efficient gas-fired plant.

Climate Change Targets

2.6 The UK has two key environmental targets relating to renewable energy and greenhouse gas emissions. The first of these targets is part of the European Union's (EU) integrated energy/climate change proposal. This proposal sets a target of 20% of European Energy (including electricity, heat & transport) to come from renewable sources by 2020 (known as the EU 20/20/20 vision)[4]. The Renewable Energy Strategy[5] (published in July 2009) identified that, for

[3] The transmission network in Scotland is owned by Scottish Power Transmission Limited in southern and central Scotland and by Scottish Hydro-Electric Transmission Limited in the north of Scotland.

[4] http://www.energy.eu/directives/com2008_0030en01.pdf

[5] **http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx**

the UK to meet its share of the EU target (UK's share is 15% of energy sources including electricity, heat and transport), 30% of the UK's electricity would have to come from renewable sources.

2.7 The second target is incorporated in the Climate Change Act 2008 [6]. This goes further than the EU 20/20/20 vision, and sets a target of 80% reduction in UK greenhouse gas emissions from 1990 levels by 2050. This equates to a 34% reduction in greenhouse gas emissions by 2020 as specified by the Climate Change Committee[7].

The Legislative and Licensing Framework

2.8 Generation, Supply and Transmission of electricity are all licensable activities in Great Britain under the Electricity Act 1989 (as amended) ("the Electricity Act"). The development and operation of an Interconnector is a separate licensable activity under the Electricity Act.

2.9 The Electricity Act requires that the holder of an Interconnector Licence (or its subsidiaries) cannot also hold a Generation, Supply or Transmission Licence. As National Grid Electricity Transmission plc ("NGET") holds a Transmission Licence in respect of its operation of the transmission system in Great Britain, the Nemo Link is being developed (with Elia) by a separate National Grid company, National Grid Nemo Link Limited ("NGNLL"). NGNLL has applied for an Interconnector Licence for the Nemo Link.

3 The Role of Interconnectors

Concept

3.1 Interconnectors connect a transmission system in one country with another. Where a border is land based the interconnector will typically take the form of an overhead line or cable and will appear no different to that of the domestic transmission system. The transmission systems in Great Britain and mainland Europe operate at a frequency of 50Hz and, where two transmission systems are linked, they both have to operate at the same frequency.

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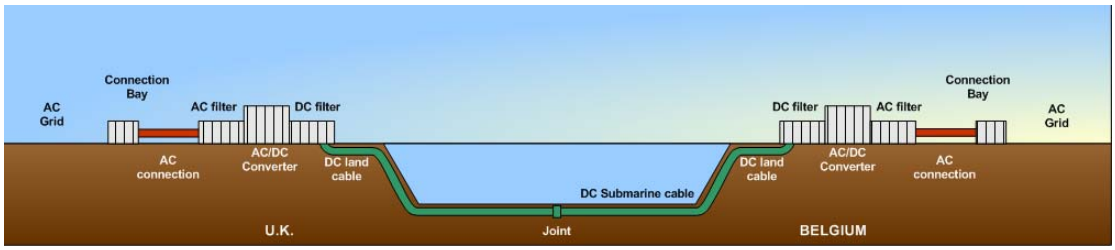
http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/Renewable%20Energy%20Strategy/1_20090717120647_e_@@_TheUKRenewableEnergyStrategy2009.pdf

[6] http://www.opsi.gov.uk/acts/acts2008/ukpga_20080027_en_1

[7] http://www.theccc.org.uk/

3.2 Where national electricity transmission systems are separated by sea it is only possible to use sub-sea cables to connect the two systems. If the distance across the sea is greater than ~50km then High Voltage Direct Current (HVDC) technology is more cost effective than AC undersea cable. The shortest distance between the UK and Belgium is over 100km, and therefore an HVDC interconnector between the two countries is preferred. The use of HVDC also avoids the necessity to synchronise the two interconnected AC networks. A typical HVDC interconnector configuration is shown in the illustration below.



A typical HVDC interconnector configuration

3.3 The configuration consists of two converter stations (one in each country connected to its respective high voltage transmission systems) connected through HVDC subsea cables. The link operates by taking AC power from one system and converting it from AC to DC. The electricity, in DC form, is then transported via the subsea cables to the receiving converter station where it is then converted back from DC to AC for use on the receiving system.

3.5 Interconnectors can therefore provide power to or from a transmission system, thereby acting as either a source of generation or demand within the system.

Interconnectors and Electricity Prices

3.6 The direction of flow on an interconnector is largely determined by any price differential between the two systems. Power will be bought in the lower priced country and sold in the higher priced country. The price differential between the two countries is referred to as the arbitrage. Where the arbitrage is large, it is likely that the interconnector will flow to its maximum capacity. For example, where wholesale electricity prices in the UK are higher than in Europe, the interconnector would allow power to be bought in Europe and sold in the UK wholesale market. Conversely, where power prices were higher in Europe than in UK, power would be bought in the UK and sold into the European markets. Physical power flows on the interconnector reflect the direction of trade.

3.7 Belgium is heavily interconnected with central Europe, so a UK-Belgium link provides further opportunities to trade power between the wider Continental European power markets and the UK, thereby further contributing to downward pressure on wholesale prices.

3.8 Interconnectors also tend to reduce the frequency and severity of high price spikes in both interconnected markets.

Supporting Renewable Energy and Security of Supply

3.9 The UK's current generation portfolio comprises of mainly thermal plants such as nuclear, coal and gas fired power stations where each fuel source contributes to around one third of the total used to generate electricity. Coal is regarded as a heavily polluting fossil fuel. Gas is used for both power generation and domestic and industrial heating. Whilst the UK has enjoyed an abundance of natural gas from the North Sea Continental Shelf (NSCS), these supplies are reducing and the UK is increasing its reliance for gas from overseas either piped directly to the UK or shipped in the form of Liquefied Natural Gas to an importation terminal. As a result of securing gas from non-indigenous sources, its availability is increasingly subject to international supply and demand pressures including geopolitical issues.

3.10 As a consequence of the Large Combustion Plant Directive, 12GW of coal fired generation plant is due to be decommissioned by 2016. Additionally, 7.5GW of aged nuclear reactors are due to be decommissioned by 2020 as they reach the end of their service lives. The anticipation is that it will take around 15 years to plan and build new nuclear generation facilities. Personal energy consumption is increasing as a result of changing lifestyles and a growing population. There is therefore, an increasing need to satisfy demand whilst the UK moves to new forms of generation.

3.11 The UK Government's vision to ensure safe, secure and affordable supplies for the future involves the construction of a new fleet of nuclear generation, rapid expansion of renewable energy (mainly through offshore wind), and the development of interconnector projects. Specifically, the UK is committed to the European Commission's 3rd energy package which states that 15% of the UK's demand for energy needs to be generated from renewable sources by 2020. To meet this target, the UK will need an energy portfolio of 34% wind generating capacity by 2020, rapidly building on 4% wind capacity of today. The vast majority of this wind capacity is expected to be obtained from the

Crown Estate's licensed Round 3 Development Zones which has the aim to install 25 GW of offshore wind capacity by 2020. This huge investment into the UK Renewables sector is part of an aspiration to develop a large-scale green industry to boost the UK economy and create jobs.

3.12 By its nature, wind generation is intermittent. It is therefore necessary to have plant and equipment that can respond to rapid changes in generating output. Interconnectors, such as the one proposed between the UK and Belgium, provide an effective way to manage these fluctuations in supply and demand.

4 Policy Support for Interconnectors

European Context

4.1 European strategy recognises the urgent need to upgrade Europe's energy infrastructure and to interconnect networks across borders to meet the EU's core energy policy objectives of competitiveness, sustainability and security of supply[8].

4.2 These objectives are supported by European policy which facilitates the urgent upgrading and extension of electricity networks, including interconnectors, to maintain existing levels of security of supply and, in particular, to transport and balance electricity from renewable sources, which is expected to more than double in the period 2007 to 2020.

4.3 Interconnectors enable power to flow between member state transmission networks and are vital for ensuring a competitive and well-functioning integrated market for energy. Despite the existence of common rules for the internal market in electricity, the European Commission has recognised that the internal market remains fragmented due to insufficient interconnections between national energy networks.

4.4 In 2002 the EU Council set a target for all Member States to have electricity interconnections equivalent to at least 10% of their installed production capacity by 2005. The UK is still failing to meet this target. Total UK interconnection capacity amounts to 3.5GW which represents just over 4% of the 85 GW of installed generation capacity.

[8] "Europe 2020" EC Communication (2010) 2020.

4.5 In December 2009 the UK and Belgium both became signatories to the North Seas Countries Offshore Grid Initiative (NSCOGI) with the objective to coordinate offshore wind and infrastructure developments in the North Sea. Interconnection between countries is a prerequisite to achieving this ambition.

4.6 This initiative was endorsed by the European Commission in its Communication dated 17th November 2010 titled "Energy infrastructure priorities for 2020 and beyond - A Blueprint for an integrated European energy network". That document called for a new EU energy infrastructure policy to co-ordinate and optimise network development at a European level. As part of the implementation of this policy, the Commission has identified a limited number of trans-European priority corridors for which EU action is most warranted. The list of priority corridors in the electricity sectors includes the offshore grid in the North Sea[9].

4.7 Development of an interconnector of 1000MW between the UK and Belgium will contribute towards achieving the UK's interconnection capacity target set by the European Council whilst establishing infrastructure identified as a pre-requisite to the development of the NSCOGI.

United Kingdom Context

4.8 Currently, the UK has three interconnectors providing a total of up to 3,500MW of power transfer capability:

- UK – France: Known as IFA (Interconnexion France Angleterre), this is a 2000MW HVDC connection commissioned in 1986. It is jointly owned and operated by National Grid Interconnectors Limited and Reseau de Transport d'Electricite.

- UK – Netherlands: Known as BritNed, this is a 1000MW HVDC connection commissioned in 2011. It is owned and operated by BritNed Development Limited which is a joint venture of Dutch Transmission System Operator TenneT and National Grid Holdings One Plc, a subsidiary of National Grid Plc.

- Scotland – Northern Ireland: Known as the Moyle interconnector, this is a 500MW connection between Scotland and Northern Ireland. It was

[9] See Proposal for a Regulation of the European Parliament and Council on guidelines for trans-European energy infrastructure and repealing Decision No. 1364/2006/EC (2011/0300 (COD))

commissioned in 2001 and is operated by SONI (System Operator Northern Ireland) on behalf of Northern Ireland Energy Holdings.

4.9 The 7th Report of the Energy and Climate Change Parliamentary Committee which looks at the case for a European Supergrid refers to the role of interconnectors in realising such a prospect. With the increasing deployment of intermittent renewable generation the Committee noted in its report that intermittency poses two problems:

- it will increase price volatility; and
- it will damage grid stability, increasing the challenge of system balancing and system reliability.

4.10 The report also noted that renewable energy has prompted additional demand for reserve and response operations in order to balance out unpredictable peaks and troughs in supply. This will be expensive and present challenges in terms of achieving adequate supply when it is needed. This trend will get worse as EU member states increase the deployment of wind power and other intermittent renewable energy sources to deliver the 20% renewable target formulated in the European Renewables Directive of 2009.

4.11 Importantly, the report acknowledged that increased interconnection with European and Scandinavian transmission systems could offer scope for flexibility.

Regulatory Context

4.12 In January 2010, the energy regulator Ofgem (Office of Gas and Electricity Markets) published a consultation on Electricity Interconnector Policy. The target audience was electricity traders, transmission companies, interconnector developers, generators and suppliers, customer representatives and other interested parties across the UK and Europe.

4.13 It was acknowledged in this consultation that:

"The GB electricity market currently has limited interconnection with other markets but this is expected to increase significantly in the decade ahead. In part, this reflects the expectation that increased interconnection will help

accommodate the expected huge increase in intermittent wind generation and will contribute to security of supply".

4.14 To date in Great Britain, interconnectors have been developed as stand-alone projects outside the price-controlled transmission business. By contrast, in other European Member States, it is more common for interconnection to be developed by national transmission companies with revenues underwritten by consumers. Amongst other matters, the Ofgem consultation proposed and sought views on the regulatory treatment of interconnector investment.

4.15 Responses to the consultation were received from 21 organisations and interested parties. As part of the next steps from this consultation, Ofgem demonstrated its support for the proposed UK – Belgium Interconnector in proposing to develop a regulatory investment model for the project by working with its regulatory counterpart in Belgium, CREG (Commission de Régulation de l'Électricité et du Gaz) and the Nemo consortium which could be used as an alternative model for this and future interconnector investment.

4.16 Details of the consultations can be found at

http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=2&refer=Europe

http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=67&refer=Europe

4.17 An industry consultation carried out by National Grid Interconnectors Ltd, Elia and RTE in [2008] concluded that there was significant demand for new interconnection between Great Britain and Continental Europe.

4.18 Respondents considered interconnection to be an important means to:

- respond to intermittency of wind generation, which varies according to the strength of the wind;
- respond to periods of excess power, specifically when wind generation is greater than electricity demand;
- help meet the challenge of retiring fossil fuel and nuclear plants in UK; and

- support neighbouring wholesale and supply markets and, in the case of DC interconnectors, the provision of balancing and ancillary services.

4.19 The proposed interconnector between the UK and Belgium is one of a small number of interconnector projects currently under development/construction. Other projects include:

- Republic of Ireland – UK, 500MW interconnector, known as the East – West Interconnector, linking the Republic of Ireland (RoI) with Deeside, North Wales. This project is currently under construction and is being developed by Eirgrid, the Transmission System Operator for the RoI.

- UK – Norway: Approx 1400MW interconnector linking the north east of England with Norway. This project is jointly being developed by National Grid International and Statnett, the Transmission System Operator for Norway.

4.20 Taking into account these other projects, the UK – Belgium interconnector provides further diversity to the UK's interconnection portfolio and will contribute 15% of total interconnection capacity of 6.4GW which in turn represents 7.5% of installed generation capacity.

5 Need for the Nemo Link

Energy market and policy drivers

5.1 This report has explained the challenges facing the UK's electricity sector over the next few years and the essential role that interconnectors play in meeting those challenges.

- The closure of 12 GW of coal-fired generating plant by 2016, combined with the closure of up to 7.5 GW of nuclear power stations by 2020, means that investment in new interconnectors is essential for the ongoing provision of a secure electricity supply.

- Interconnectors are needed to manage fluctuations in supply and demand brought about by the increased deployment of intermittent renewable power generation. They also contribute to the functioning of an effective electricity market.

- Significant levels of additional interconnector capacity are needed for the UK to meet the EU Council's target for member states to have interconnectors equivalent to at least 10% of their installed production capacity.

5.2 A number of new interconnector projects are underway in the UK to help meet this need, including connections to Norway and the Republic of Ireland. National Grid Nemo Link Ltd considers that additional connections to mainland Europe are needed to enhance the diversity of supply and ensure the UK is not overly dependent on the limited number of existing interconnectors.

Project location

5.3 A UK-Belgium interconnector is regarded as the best way to meet this need. Belgium is particularly suitable for a new interconnector not only because of its geographical proximity to the UK, but also because its electricity transmission system is highly connected to Central Europe. A UK-Belgium interconnector will therefore provide enhanced opportunities for the UK to trade with wider European power markets. There is no existing connection between the UK and Belgian transmission systems, so the construction of a new connection is required to achieve these objectives. The proposal to build an interconnector to Belgium is based on:

- risk mitigation: it is prudent to interconnect the UK to different parts of the European Continent. Building all interconnection to a single point reduces security of supply in case of grid problems at that single point.

- cost: a subsea cable route to Belgium is the obvious next best choice after France to minimize the cable route length. France is however already interconnected through the Channel and therefore less suitable from a risk perspective, as explained above.

5.4 The construction of a UK–Belgium interconnector is also needed to achieve the objectives agreed by the two countries as signatories to the 2009 North Sea Countries Offshore Grid Initiative.

5.7 A separate document "Development of an Interconnector between the UK and Belgium: Review of Options" explains the process by which the preferred location for the UK converter station has been determined.

Project specification

5.8 The 1000MW capacity of the Nemo Link has been carefully determined having regard to the technical requirements of the UK and Belgian transmission systems and to make optimum use of available marine cable and converter technology. A higher capacity could lead to power system stability issues in the existing AC transmission systems which must be able to withstand the sudden failure of the link. To date the GB transmission system has been designed and operated to accommodate a maximum interconnector loss of 1000 MW[10] A lower capacity, however, would drive up the cost per MW and therefore make the investment less favourable from an economic point of view. A capacity of 1000 MW therefore strikes the right balance between system stability and cost per MW.

5.9 The UK's current interconnection capacity only amounts to around 4% of total installed generation capacity; well short of the 10% target set by the EU Council in 2002. A new 1000MW interconnector with Belgium, combined with the other new interconnectors being developed, will increase UK interconnection capacity to approximately 7.5% of the UK's installed generation.

5.10 The choice of converter technology for the Nemo Link has been carefully considered by the Nemo Consortium.

5.11 There are two types of converter technology currently deployed in modern HVDC interconnector applications. These are line-commutated current source converters (CSC), and the more recently-developed voltage source converters (VSC).

5.12 Initially, the Nemo Consortium submitted a Connection Application to NGET for a CSC-based interconnector. By 2010, however, the Nemo Consortium had satisfied itself that the VSC technology had evolved sufficiently that it could be reliably used with a subsea interconnector of 1000MW capacity by the time the project places supply and installation contracts.

5.13 VSC offers greater operational flexibility than its CSC counterpart and requires fewer consequential reinforcements to the transmission system compared to CSC-based converters.

[10] Although the IFA (Interconnexion France Angleterre), is a 2000MW HVDC connection it is a bipole configuration of 2 x 1000 MW. The GB transmission system must be secure for loss of one bipole i.e. 1000 MW.

Project timing

5.14 The urgency of the need for the Nemo Link is driven partly by the energy market and policy drivers described above, and partly by factors which are specific to the project.

5.15 The imminent changes to the UK energy market and the targets established by climate change legislation, require new interconnection capacity to be established as a matter of urgency. Much of the UK's coal-fired and nuclear generating capacity will go offline by 2020, to be partly replaced by intermittent renewable sources. It is important that increased interconnection capacity is in place by this date to manage fluctuations in supply and demand and to provide the UK with access to additional sources of power generation.

5.16 In addition to these factors, the Nemo Consortium consider that the benefits of the Nemo Link can only be realised if the interconnector is commissioned by 2018. 2018 is the earliest date by which NGET could offer a connection to the high voltage transmission system.

Regulatory support

5.17 The energy regulator, Ofgem, is supportive of the Nemo Link and is working with its counterparts in Belgium to seek a regulatory investment model that will shape how future regulation will apply to new interconnector projects.

Glossary of Terms

AC	Alternating current
CSC	Current source converter
DC	Direct current
GW	Gigawatt (1000 million Watts)
HVDC	High voltage direct current
kV	Kilovolt (1000 Volts)
km	Kilometre
MW	Megawatt (1 Million Watts)
NGET	National Grid Electricity Transmission plc
NSCOGI	North Sea Countries Offshore Grid Initiative
NGNLL	National Grid Nemo Link Limited
Ofgem	Office of the Gas and Electricity Markets
TWh	Terawatt Hour (1 billion Kilowatt Hours)
VSC	Voltage source converter

Appendix 1

Nemo Consortium

Company Information

National Grid Group

National Grid Nemo Link Limited is a subsidiary of National Grid plc, and has been established specifically for the development of the Nemo Link.

National Grid plc, is one of the largest investor-owned utilities in the world. It is a low-risk international electricity and gas company with 95% of its activities in regulated businesses. It is the largest utility in the UK and the second largest utility in the US.

A separate subsidiary, National Grid Electricity Transmission plc (NGET) owns the high-voltage electricity transmission system in England and Wales and operates the system across Great Britain.

National Grid plc also has a number of businesses operating in related areas such as liquefied natural gas importation, land remediation and metering.

Elia Group

Elia System Operator SA is Belgium's transmission system operator and is responsible for the transmission of electricity in that country. Electricity is transmitted over the high-voltage grid from electricity generators to the distribution system operators and large industrial consumers. As system operator, Elia System Operator organises transparent, objective and non-discriminatory access to the grid.

Elia Asset SA is a subsidiary of Elia System Operator SA and owner of most of the Belgian grid. Elia Asset's principal mission is to develop, modernise and maintain the Belgian high-voltage grid and be responsible for the operational management of the system, under exclusive instruction of Elia System Operator.

Together, Elia System Operator and Elia Asset operate under the brand name "Elia", carrying out the regulated activities described in the Belgian Federal and Regional

Electricity Acts. The relationship between both companies is also established in these Acts.

Elia has recently expanded its activities on a broader European level and, following its acquisition of German TSO 50Hertz and in cooperation with Industry Funds Management (IFM), is now one of the top five transmission system operators in Europe.