



Iceland-UK Interconnector: Strategy for Macroeconomic and Legal Feasibility

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1 ABSTRACT

The UK must undertake drastic changes in their energy system if they are to achieve energy policy goals of competitive electricity prices, ensuring security of supply, and decarbonization of generation. Interconnection with Iceland, which is dominated by renewable energy, could offer an enticing, cost-competitive alternative to building new low-carbon generation in the UK and carries the potential for positive economic and technical benefits for both countries. However, the structure of EU and UK electricity systems and legislation places some blockades in this project attaining legal and macroeconomic feasibility. While there is some regulatory uncertainty associated with it, there is a potential that the status quo merchant interconnection investment model could be applied to the Iceland-UK in order to attain the aforementioned feasibility - especially if there is a potential for the application of the emerging legal precedent and business model framework in the Imera/ElecLink merchant interconnection exemption request. The macroeconomic feasibility of this framework could potentially be strengthened if there is a possibility to apply the UK's new Feed-in-Tariffs with Contract-for-Difference (FiT CfD) to generators in Iceland. The Imera/ElecLink framework adequately covers investor concerns over stable, long term returns while satisfactorily addressing regulator concerns over competition and third-party access rules for transmission assets. When combined with the FiT CfD program, there is a strong potential that this project can attain macroeconomic feasibility while still being feasible under EU energy legislation. However, due to the ElecLink exemption not being due till spring 2014 and there being no clear precedent concerning the application of the UK's FiT CfD program to non-UK generators, this potential still requires more in-depth investigation.

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2 CONTENTS

| | |
|---|-------------------------------------|
| Acknowledgments..... | 5 |
| 2 Abstract..... | Error! Bookmark not defined. |
| 3 Introduction to Iceland-UK Case | 9 |
| 4 Motivations for HVDC interconnection | 16 |
| 4.1 Increased Competition | 16 |
| 4.2 Reduction in Ancillary Service Costs | 17 |
| 4.3 Integration with Variable Renewables..... | 18 |
| 4.3.1 Hydro Power Storage..... | 19 |
| 4.3.2 Distributed Generation | 20 |
| 4.4 Iceland-UK HVDC Interconnection Fits UK Energy Policy Goals..... | 22 |
| 4.4.1 Competitive Energy Prices | 22 |
| 4.4.2 Energy Security | 23 |
| 4.4.3 UK's Low Carbon Transition | 25 |
| 4.5 Iceland Specific Potential Benefits | 29 |
| 4.6 Summary of Potential Benefits for Iceland-UK HVDC Interconnection | 31 |
| 5 The Nature of Electricity as a Commodity and the Emergence of Liberalized Electricity Markets | 32 |

| | | |
|-------|---|----|
| 5.1 | Nature of Electricity | 32 |
| 5.1.1 | Inability to Store Product | 33 |
| 5.1.2 | Lack of Substitutes | 33 |
| 5.1.3 | Standardized Product..... | 33 |
| 5.1.4 | Capital Intensive..... | 34 |
| 5.1.5 | Natural Monopolies in Transmission and Distribution Systems..... | 34 |
| 5.1.6 | Environmental Impacts | 34 |
| 5.2 | Energy System Structures in the UK..... | 35 |
| 5.2.1 | Electricity Generation, Transmission, Distribution and Supply Systems | 35 |
| 5.2.2 | Implications for HVDC Interconnectors | 37 |
| 6 | Models for Iceland-UK Interconnection | 38 |
| 6.1 | Regulated, TSO-Owned Model..... | 40 |
| 6.2 | Legal Framework for Merchant Model | 41 |
| 6.3 | Merchant Interconnector Exemptions in Practice | 45 |
| 6.3.1 | Estonia-Finland Estlink HVDC Submarine Cable | 45 |
| 6.3.2 | Imera East-West Interconnectors..... | 46 |
| 6.3.3 | ElecLink Channel Tunnel HVDC..... | 48 |
| 6.3.4 | UK-Netherlands BritNed HVDC Submarine Cable..... | 49 |

| | | |
|-----|---|----|
| 6.4 | Cap-and-floor and the NEMO Interconnector | 51 |
| 6.5 | Offshore Generator | 55 |
| 7 | Which model should be applied for Iceland-UK cable? | 58 |
| 7.1 | What recommendations can be made for stakeholders? | 61 |
| 8 | Conclusions | 64 |
| 9 | References | 67 |
| 10 | Appendix | 74 |
| | | 75 |

3 INTRODUCTION TO ICELAND-UK CASE

Iceland generates nearly 100% of its electricity from renewable sources, primarily geothermal and hydropower[1]. With a population of approximately 320,000 people, Iceland's renewable energy resources vastly outweigh household energy consumption. The traditional method for capturing this significant resource rent has been foreign investment in energy-intensive industries, namely aluminum production. As of 2011, energy-intensive industry accounted for 80% of generated electricity consumption [1]. Total generation in Iceland amounted to approximately 17 TWh/year in 2011[2] and estimates of economically viable, untapped energy resources have been estimated to be 50 TWh/year [3][4].

Approximately 1000km away, the UK has seen a vastly different development in its energy sector. Electricity supply in the UK has historically been dominated by fossil fuel sources. As of 2012, fossil fuels represent 87.3% of total primary energy supply [5, p. 11] Historically, the UK has enjoyed strong security of supply with fossil fuel sources due to substantial domestic coal reserves and productive North Sea oil and gas reserves, but this situation has declined rapidly in the past decade[5, p. 16].

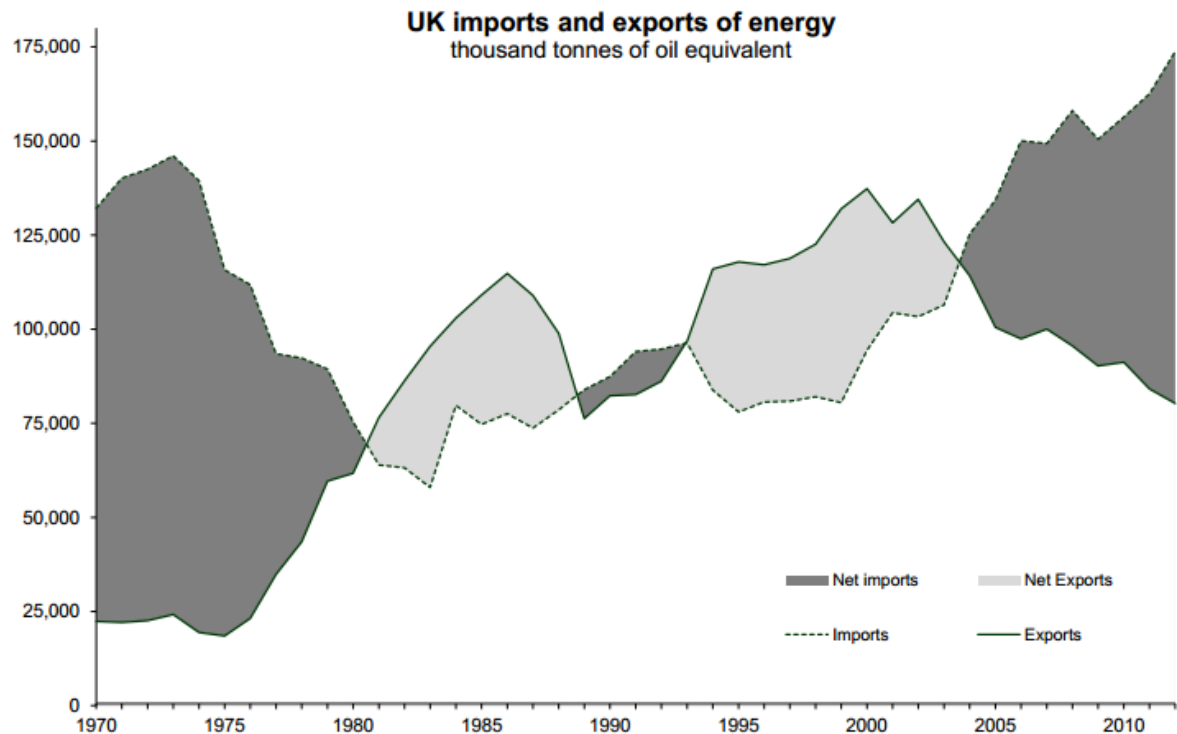
Declining North Sea oil production has increased the import deficiency rapidly from a historic trend of fossil fuel self-sufficiency to nearly 50% of fuels needing import. Table 1 illustrates this rapidly declining situation.

Table 1: Net import dependency 2010 to 2012 in thousand tonnes of oil equivalent[5, p. 16]

| | 2010 | 2011 | 2012 |
|------------------------------------|---------|---------|---------|
| Net Imports | 65,158 | 78,398 | 93,511 |
| Primary Energy Supply + Bunkers | 229,458 | 214,306 | 217,257 |
| Net Import Deficiency | 28.4% | 36.6% | 43.0% |

This short term trend illustrated above is further reinforced by an analysis of long term trends. Figure 1 below demonstrates this worsening trade deficit in net energy imports between 1970 and 2013.

Figure 1: UK Net Energy Imports 1970-2013[6, p. 4]



Coupled with this decline in fossil fuel production, the UK has demonstrated continued interest in developing renewable energy for electricity production. The UK has set unilaterally binding targets for greenhouse gas emission reductions of 50% by 2027 and 60% by 2050 over 1990 levels[7]. The pressure for decarbonization of energy supply systems in the UK has placed additional pressure on policy makers to develop innovative measures to continue to meet their goals of security of supply, competitive prices, and sustainability.

Investment in renewable energy in the UK has largely been in variable energy sources such as wind and solar. Variable renewables suffer from uncertainty of supply due to the intermittent nature of the resource. This makes matching supply and demand increasingly difficult as renewables begin to make up a larger percentage of energy supply. Moreover, in many cases renewable energy sources such as wind and solar have required market intervention in order to be commercially competitive.

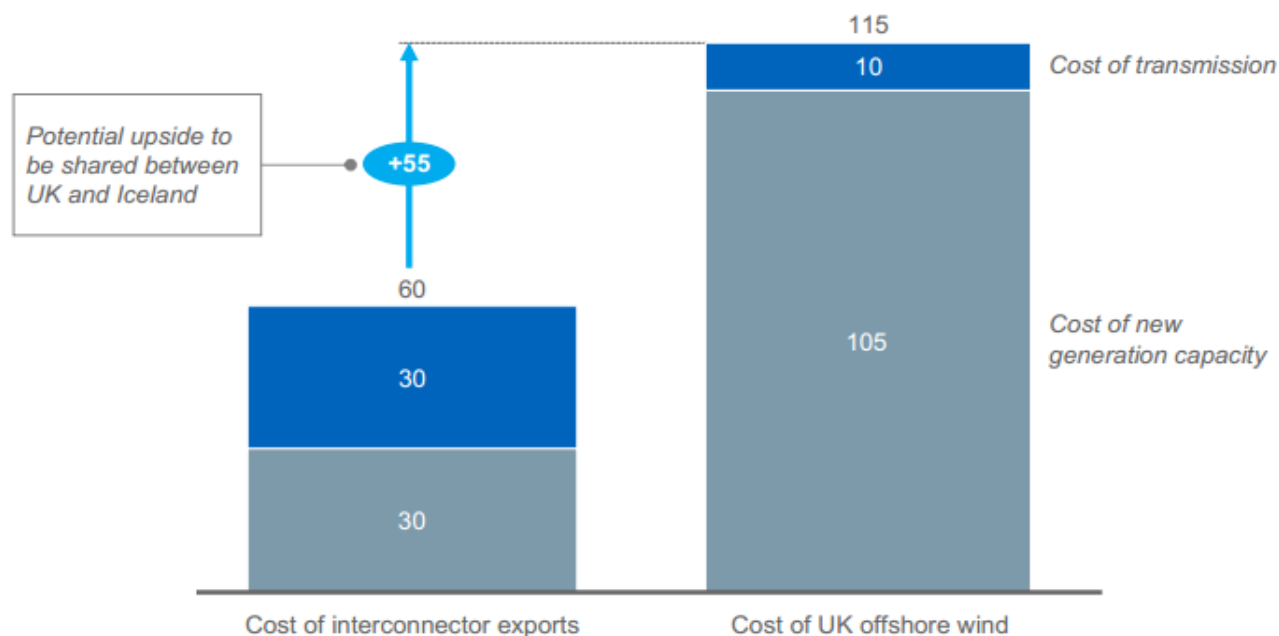
The realities of declining security of supply and increased development of renewable energy sources has resulted in the UK government undertaking multiple measures in order to ensure a stable, competitive, and decarbonized electricity system. One of these measures is the development of electricity interconnectors. Interconnectors provide multiple benefits which specifically can help ensure these policy goals of a stable, competitive and decarbonized electricity system are met. Iceland's location 1000km north-west of the UK and extensive and underutilized renewable energy resources could potentially be a viable solution to the UK's ongoing energy crisis.

Discussions regarding the feasibility of an Iceland-UK cable began in the late 1980s. A 1989 feasibility study on the technical and financial feasibility study of the proposed project found that there should be no technical issues in the manufacture or laying of the submarine cables. The report found that cost of the cable and a build out of generation in Iceland for export would at least be equal to the cost and availability of building new coal, gas, or nuclear generation in the UK[8]. These findings are reinforced in later studies by the same author[8]–[10] including a 2010 update of the 1989 paper[11]. A 2010 presentation given by Edvard G. Guðnason, Director of

Sales and Marketing at Landsvirkjun (National Power Company of Iceland), argued the technical feasibility of the proposed cable; however, implied that commercial profitability is still something that needs deeper examination[12]. These comments are reinforced in a presentation by Hörður Arnason, CEO of Landsvirkjun, at the Iceland Energy Summit of 2013 being held by Bloomberg in London. Hörður argues that there is substantial potential for the proposed Iceland-UK interconnector but that more in-depth study needs to be undertaken before the project is undertaken [13]. As the commercial profitability of the proposed cable is largely dependent on the price of electricity but also on the capacity of the cable and the arrangements for capacity allocation, there can be large variations on commercial profitability depending on the particular business model being analyzed. A 2010 McKinsey macroeconomic analysis on charting an economic growth path for Iceland mentions an interconnector as a potentially attractive compliment to the energy-intensive industry dominated electricity market structure. When the cost of the cable and cost of generation in Iceland is compared to the expected cost of new generation in off-shore wind in the UK, significant cost savings can be seen.

Figure 2 below illustrates this gap visually:

Figure 2: cost comparison of Icelandic exports via HVDC cable VS Build out of offshore wind for year 2020; Price in real 2011 EUR/MWh McKinsey & Company,[14] Exhibit 38, 2010



This cost savings of approximately EUR 55/MWh could be shared between Iceland and the UK. The McKinsey report states that current resource rents for domestic energy in Iceland are approximately 1% of GDP. Depending on favorability for Iceland in negotiations for the cable, the McKinsey report finds that with an interconnector, the recoverable resource rent could exceed 5%. This is very close to the 6% value for resource rents from petroleum operations in Norway[14, p. 74]. The McKinsey report also notes that emphasis should be placed on negotiations with potential partners in Europe. Moreover, Iceland should develop a regulatory regime that helps distribute resource rents fairly across the country in order to develop a broad social and political consensus that is required for seeing the project through.

In a report concerning a comprehensive strategy for energy in Iceland, the objective of examining a submarine interconnector is put forward[15, p. 5]. In April 2012, the Icelandic Ministry of Industry and Commerce announced the appointment of an advisory group to analyze the macroeconomic feasibility of the submarine cable. The report, which was submitted to the Ministry of Industry and Commerce in May of 2013, concluded that there was significant uncertainty in assessing the macroeconomic viability of the project but that project could prove to be macro-economically viable if certain conditions were met. These conditions consisted of (but not limited to) the outcome of negotiations, the business model selected, favorability of energy prices, and the securing of long term contracts[16].

This paper sets out to analyze a potential strategy for meeting these conditions by looking at experiences with existing regulatory models and the potential for emerging regimes when applied to the proposed Iceland-UK interconnector. As there is very limited research on the application of available regulatory models for interconnectors to the proposed Iceland-UK interconnector, this paper will set out to analyze which of these models are available now in order to provide a strategy for interested stakeholders in this proposed interconnector. Section 4 will examine potential economic, technical, and policy benefits behind the Iceland-UK interconnection project. Section 5 will discuss the nature of electricity as a commodity and the structures of liberalized electricity systems in the UK. This will provide insight into some of the implications these systems have on the development of interconnectors. Section 6 will examine potential regimes for the Iceland-UK interconnector by discussing experiences with existing regulatory models and emerging regulatory models in the UK. Section 6 will apply the findings of these models to the Iceland-UK case in order to provide clarity into which strategy should be

undertaken in order to meet the conditions for macroeconomic feasibility discussed above. The findings of this paper seek to provide insight into what conditions should be applied in future, more detailed analyses on commercial and macroeconomic feasibility.

4 MOTIVATIONS FOR HVDC INTERCONNECTION

The Iceland-UK interconnector has the potential to offer multiple technical and economic benefits for the two countries. While it is important to note that positive economic welfare benefits are not automatically generated by every project - as the costs are high and the benefits are somewhat uncertain - the following section will discuss potential benefits that could arise from an Iceland-UK interconnector. This will lead into a discussion in Section 4.4 on how this project fits energy policy goals and new developments in UK energy policy that could be applied to the Iceland-UK interconnector project.

4.1 INCREASED COMPETITION

One potential economic benefit is increased competition in one or more of the connected markets. Interconnectors when operated as a market connector can reduce the market power of dominant generators in the importing market [17]. Under certain interconnection models (which will be discussed further in section 6), more market players can be expected to attempt to enter the wholesale electricity market between the interconnected countries leading to decreased influence from dominant incumbents. This likely will result in a decreased wholesale electricity price, especially during peak hours. Due to this competition, the price of the product can be

assumed to converge closer to the lowest cost of production across both markets. This benefit will be passed onto consumers through lower electricity price volatility. In addition, there is a potential that increased competition could result in better dispatch and allocative efficiency from generators [18].

In a liberalized electricity market, suppliers always have the option to buy electricity from the cheapest source during peak demand. In an Iceland-U.K. cable, this could potentially be inexpensive wind energy exported northward from the U.K. or inexpensive Icelandic geothermal and hydro power sent southward. This increased competition in either market could possibly erode market share of dominant generators. This is of particular interest in Iceland where the electricity market is dominated by a single generator, Landsvirkjun, with a market share of nearly 75% [19]. While the price difference between the two markets means the majority of flows would be imported from the UK, a 2008 study determined that price differences between the UK and Iceland could result in Iceland importing electricity 30% of the time [20].

4.2 REDUCTION IN ANCILLARY SERVICE COSTS

Closed or isolated markets, such as Iceland, and markets with limited interconnection, such as the UK, require increased installed generation capacity in order to meet periods of peak demand or supply shortages. This reserve capacity forms part of a set of services referred to as *ancillary services*. The U.S. Federal Energy Regulatory Commission (FERC) defines ancillary services as “those services necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system” [21]. Ancillary services

like frequency control and spinning reserve are especially important and costly in an isolated market in order to meet security of supply demands[22].

In the case of an Iceland-UK HVDC interconnector, Icelandic hydro reserve storage can be reduced and peak generation investment in the UK can be lowered as the interconnector can be used to meet peak demand. The efficiency of unused capacity required to meet energy security in the system can be assumed to increase and related ancillary services can be assumed to decrease in cost. This has largely been the experience of the Norway-Netherlands HVDC interconnector (NorNed) [22].

4.3 INTEGRATION WITH VARIABLE RENEWABLES

Renewable energy has become increasingly pivotal for a variety of reasons, including security of supply, increasingly competitive pricing with traditional sources and increased concern of anthropogenic climate change. However, renewables like solar and wind by nature are subject to the day-to-day variation of weather patterns. As will be further discussed in section 5.1.1, electricity as a product is unique in that it has to be produced and consumed simultaneously and cannot be stored as the final product. In scenarios with large scale penetration of variable renewables, this presents significant issues for transmission and distribution operators.

In the UK, wind energy has seen some of the largest market share gains of any of these emerging renewables largely due to it being cost competitive with many traditional fossil fuel fired plants [23]. As of November 2013, there were over 5,100 wind turbines installed in the UK. This includes over 6,900 MW of onshore turbines and over 3,500 MW of offshore installations and is expected

to increase substantially over the next decades in order to meet renewable energy penetration goals [24][25]. The installed capacity of wind turbines is coupled with over 2,400 MW of solar photovoltaic installations which combines for over 15.5% of total installed capacity [25][26]. This presents the UK with a particularly difficult energy security issue – the variable nature of these renewable sources. A 2003 study on wind variability found that when the installed capacity of wind reaches 15-20% of installed capacity, substantially costly mitigation measures need to be undertaken taken in order to maintain required system flexibility [27].

Fortunately, there are significant benefits for the UK to interconnect to a market like Iceland that has the flexibility to overcome many of these challenges. The following subsections will look at these potential synergies.

4.3.1 Hydro Power Storage

Over 75% of the current energy production in Iceland is supplied through its extensive hydropower resources [28]. Around the world, hydro power storage whether in the form of pumped storage or hydro power reservoirs have served as instrumental in grid balancing systems due to their relatively fast dispatch times, large-scale storage above 1000 MW, high efficiency, and comparably low operation costs[29]. Competing storage systems such as compressed air storage, flywheel systems, conventional batteries, and hydrogen fuel cells have yet to offer the scale, efficiency, or cost competitiveness required in order to supplement variable wind resources [29]. For these reasons, hydro storage has stood as the only technology commercially viable for large scale electricity storage.

Wind energy, when available, can be cost competitive with other sources. Germany's experience with wind energy integration have shown a rise in periods of negative energy prices. During these periods, low demand couples with high wind energy in-feed thus resulting in generators bidding prices below their variable costs in an effort to avoid ramping down base-load power plants [30]. While this isn't an intrinsically negative situation by nature, it implies structural issues with the electricity market. A 2010 study on German power system flexibility with extensive wind integration found that demand side flexibility and storage options were of particular issue with respect to market design with increased variable renewable penetration [30]. The study highlighted that interconnection presented an ideal solution to demand flexibility issues.

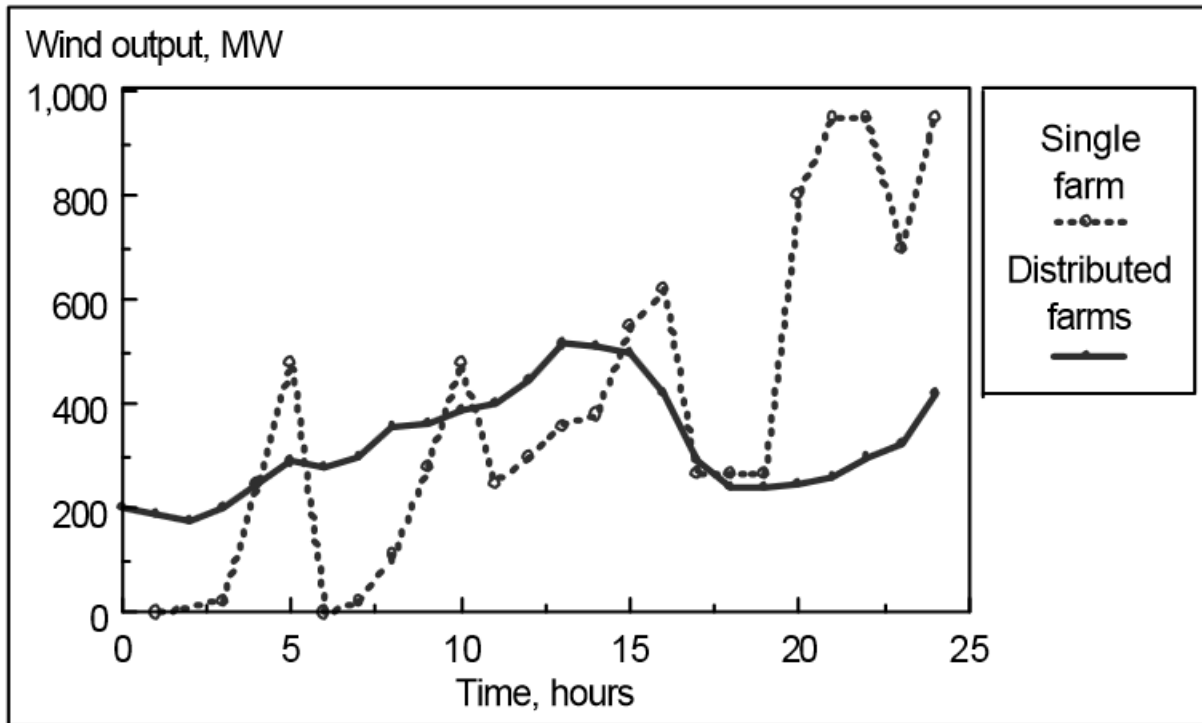
In the case of an Iceland-UK cable, interconnection can provide an ideal solution to both storage and demand flexibility. When there is a surplus of wind energy and low demand in the UK, there is the potential for this energy to be exported north to Iceland and used for pumped hydro storage or offsetting the need to tap hydropower reservoirs. This symbiotic relationship of wind energy and hydropower can be exploited to create a scenario of more efficient extraction of both resources in each country.

4.3.2 Distributed Generation

While from a single location, wind output is subject to substantial variability, distributed wind farms over a large geographical area do much to smooth the wind output curve.

Figure 3 below demonstrates how a 1000MW wind farm in one location can have its output volatility reduced by having the same 1000MW dispersed across a wide area.

Figure 3: The smoothing effects of geographical dispersion of a single wind farm[27]



Landsvirkjun (The National Power Company of Iceland) has recently invested in two 0.9MW research and development turbines in the Búrfell area of Iceland. The investment in these two turbines is to examine the feasibility of larger wind turbines in Iceland. Landsvirkjun has stated in their 2012 Annual Report that wind energy is expected to play an increasing role in the Icelandic energy mix [31]—this statement is supported by the findings of a March 2013 study examining the wind energy potential of Iceland. Using Weather Research and Forecasting (WRF) model simulations, the researchers determined wind resources in Iceland are among the highest in Europe. In particular the study noted that considering the substantial and potentially permanent

environmental impact of further exploitation of hydro resources, investment in wind power should stand as a “serious option for renewable energy production [32].”

Therefore it can be argued that with further development of wind energy in Iceland, aggregation of wind turbines connected via an interconnector could do much to alleviate volatility in either area while lessening potential environmental effects of further hydropower exploitation. Moreover, the expansion of wind energy in Iceland fits well with the balancing properties of existing hydropower capacity in Iceland and could potential increase the value of flexible, hydro reservoirs.

4.4 ICELAND-UK HVDC INTERCONNECTION FITS UK ENERGY POLICY GOALS

Discussing the current goals of UK energy policy is valuable in order to better understand the value of an Iceland-UK interconnector. The economic and technical benefits of interconnection discussed in previous sections are largely intertwined with the policy goals of the UK. The previous sections serve as a valuable starting point for understanding some of the current state-level motivations for increasing investment in interconnectors. The following sections will briefly discuss some of these motivations and apply them to the Iceland-UK HVDC interconnector case.

4.4.1 Competitive Energy Prices

As will be detailed later in this paper, electricity market reform has largely centered on the unbundling of generation and supply activities from the natural monopolies of transmission and distribution activities in order to spur better competition in energy markets and consequently

competitive and lower energy prices for consumers. This same logic is one of the main drivers for why competition has dominated energy policy making over the last few decades.

Since the early 1990's, UK energy policy has continued to emphasize the development of liberalized electricity markets in order to spur competitive electricity prices [33]. The 2011 UK *White Paper on Energy* outlines the continued interest of the UK government in facilitating competitive electricity markets [34]. The paper emphasizes that non-generation techniques such as interconnection will play an increasing role in reducing market power of incumbent generators by introducing greater market access for more market participants. This mirrors many of the economic arguments for interconnectors and their effects on increased competition outlined in section 4.1.

4.4.2 Energy Security

Historically speaking, the UK has had traditionally strong energy security due to a mixture of extensive North Sea oil and gas resources, strong regulatory frameworks and liberalized markets for electricity [35]. However, due to steep declines in North Sea oil and gas production, industrial action and tough climate change abatement policy, the UK faces an unprecedented challenge in ensuring continued energy security through the next few decades [35]–[37].

In response to this imposing pressure, the UK government implemented an obligation in the 2011 Energy Bill for the Office of Gas and Electricity Markets (Ofgem) to present an annual report to the UK Secretary of State detailing the risk to energy security under different future scenarios. The first report was delivered to the Secretary of State in October 2012 and is planned to be

updated annually. The 2012 report found that decommissioning of coal and oil power plants and reduced investments in new generation facilities would significantly, negatively impact energy security. The updated 2013 report from Ofgem found a worsening situation. The outlook for electricity supply had deteriorated beyond their original calculated scenarios.

The Ofgem annual energy security report uses a parameter to analyze this risk referred to as “loss of load expectation” which represents the hours per year where demand is expected to outstrip supply without intervention from the system operator, National Grid. Using different scenarios that varied levels of supply, demand, conventional generation, and interconnector flows, the report expects an increase of loss of load expectation in their reference scenario from one hour per year in 2012/2013 to three hours per year in 2015/2016. While three hours per year is still within the maximum risk allowed by many European states [37], some of the higher demand scenarios saw increases well beyond this into the nine hours per year range. To put the findings of the reference scenario in perspective, the possibility of a controlled blackout for some customers goes from 1 in 47 years in 2012/2013 to 1 in 12 years for 2015/2016. If demand isn’t significantly curtailed, this rate could be as high as 1 in 4 years.

Regarding the impact of interconnector flows on this energy security issue, Ofgem states that by nature interconnectors are integral for securing energy supplies. In particular it is noted that their uses in ancillary services such as reserves balancing, frequency response and ‘black starts’ are important for energy security in the UK.

In a sensitivity analysis of expected interconnector flows, Ofgem states that due to similar structural environments and market environments of their interconnected markets in Europe,

the findings are not conclusive on direction of flows for future interconnectors in times of tight reserve capacity. However, the analysis shows that during periods of reserve capacity margins below 30%, interconnectors have generally provided positive benefits for energy security.

From these findings, an argument can be made that in the case of the development of an Iceland-UK interconnector further improvements can be made for energy security in the UK by increasing the percentage of interconnection to total capacity. Currently, there is only 4GW of interconnection to the UK compared to over 15,000GW of capacity [38]. Ofgem and the DECC note that increasing interconnector capacity is vital for securing energy supply in the coming decades. Interconnection with an ‘energy island’ like Iceland could provide significant benefits for energy security in the UK.

4.4.3 UK’s Low Carbon Transition

In light of increasing interest in climate change abatement, decarbonization of electricity generation has become an issue of foremost importance in UK energy policy. In the 2011 White Paper on Energy, the Department of Energy and Climate Change (DECC) stated that “climate change is one of the gravest threats” facing the future of the UK [34]. The report outlined the importance of urgent decarbonization of electricity generation in order to meet the legally binding 20% reduction over 1990 levels by 2020, and 80% reductions in CO₂ emissions over 1990 levels by 2050. These ambitious reductions are being motivated by EU wide legally binding targets of CO₂ emission reductions of 20% by 2020 [39]. The challenges for achieving these goals are significant and will require at least £110 billion in investment in generation and transmission systems by 2020, which is more than double the amount invested between 2000 and 2010 [34].

As discussed in the introduction to this paper, Iceland generates nearly 100% of its electricity from renewable sources. The technical and economic synergy between the Icelandic energy resource and variable renewables in the UK make an Iceland-UK interconnector ideal for meeting this decarbonization goal. The DECC notes the importance of interconnection in meeting these goals in the 2011 White Paper discussed above [34] and in their updated *UK Renewable Energy Roadmap* which was published in 2013 [26].

4.4.3.1 *Electricity Market Reform (EMR)*

In order to meet decarbonization goals while continuing to ensure secure, cost competitive electricity, the UK government has responded to this challenge with new policy mechanisms. The DECC's White Paper on Energy [34], discussed in the previous section, outlines the UK government's four pronged policy proposals for meeting these challenges. The DECC estimates these policies will ensure investment in secure, decarbonized generation while saving the UK economy £9 billion between 2010 and 2030 [34, p. 6]. These four proposals consist of two market mechanisms and two support mechanisms to ensure the success of the goals of the Energy Market Reform (EMR). The UK System Operator, National Grid, will administer two market mechanisms:

- Feed-in-Tariffs with Contracts-for-Difference (FiT CfD) – introduced to spur new investment in low-carbon electricity generation technologies and to provide these generators protection from electricity market price volatility
- Capacity agreements – whereby a central body can allocate separate payments for generation capacity outside of the electricity market in order to ensure security of supply.

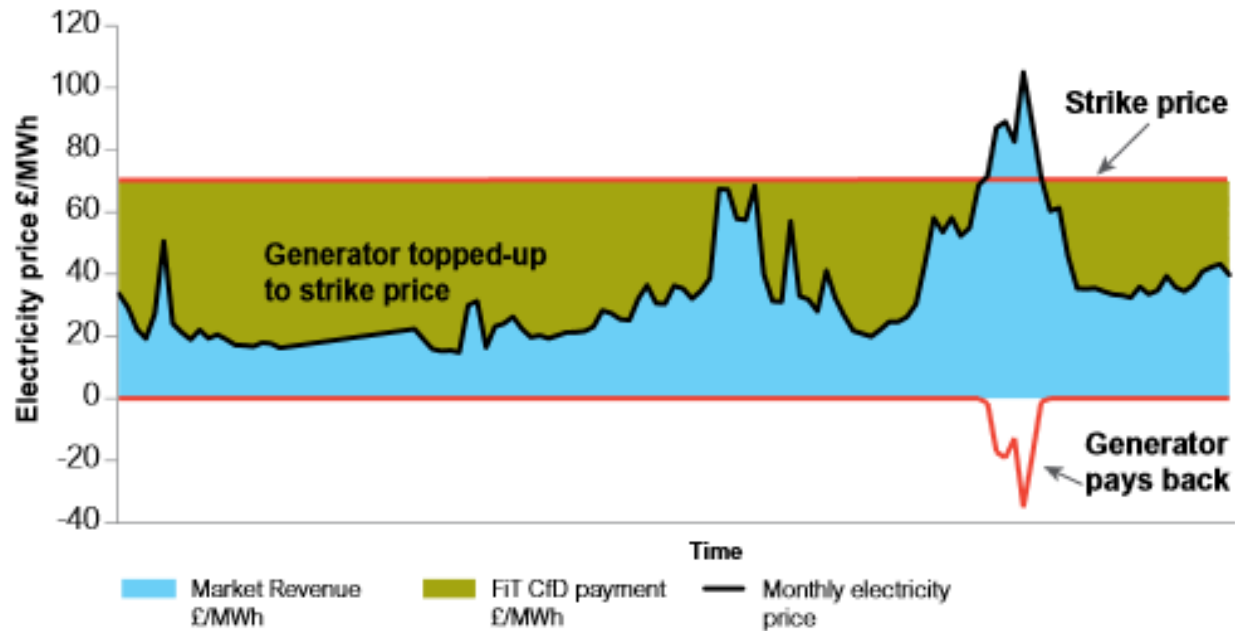
These two market mechanisms will be supported by:

- Carbon Price Floor – a tax administered in order to provide a firm price for the price of carbon in order to provide a clearer long term signal for investors in new low-carbon generation
- Emission Performance Standard (EPS) – an annual limit on CO₂ emissions placed at 450g CO₂/KWh in order to limit the construction of new fossil fuel power plants without Carbon Capture and Sequestration (CCS)

The FiT CfD looks to give a support to generators in low-carbon technologies a stable, contractual return on new investments while protecting consumers from potential windfall benefits. The FiT provides generators a payment for the difference between the wholesale price of electricity and a predetermined “strike price”. The strike price is a pre-agreed price which is set administratively based on the type of generation technology. If the price of electricity exceeds this pre-agreed strike price, the generator pays back the difference above the strike price to the TSO, National Grid.

The result of this arrangement protects both investors in low-carbon generation from either benefiting or suffering from price volatility. This point is illustrated in Figure 4 below:

Figure 4: The operation of an intermittent Feed-in Tariff with Contract for Difference [34, p. 38]



The DECC's intention is to begin offering FiT CfD contracts as early as 2014 [40]. UK legislation has stipulated FiT CfDs could be applied to non-UK generators [41, p. 24]. This implications this could have on the proposed Iceland-UK interconnector will be expanded upon in further sections of this paper.

Coupled with the FiT CfD program is a new capacity market whereby all providers of capacity, from generators to energy storage operators, the opportunity to purchase contracts outside of the electricity marketplace from the TSO, National Grid, to a supply electricity on a future date in order to ensure security of supply. The auction will be undertaken by a central authority, National

Grid, and the total amount of electricity required for the capacity market will be estimated by forecast of future peak demand.

The two support mechanisms of a carbon price floor and the EPS will provide support to the FiT CfD and capacity market by increasing the cost of investing in new carbon intensive generation such as coal by placing a minimum cost on carbon emissions and placing a cap on emissions for new fossil fuel power plants. These methods will increase the cost of building new fossil fuel plants in order to make investment in low-carbon technologies (including CCS technologies) more attractive to investors [42].

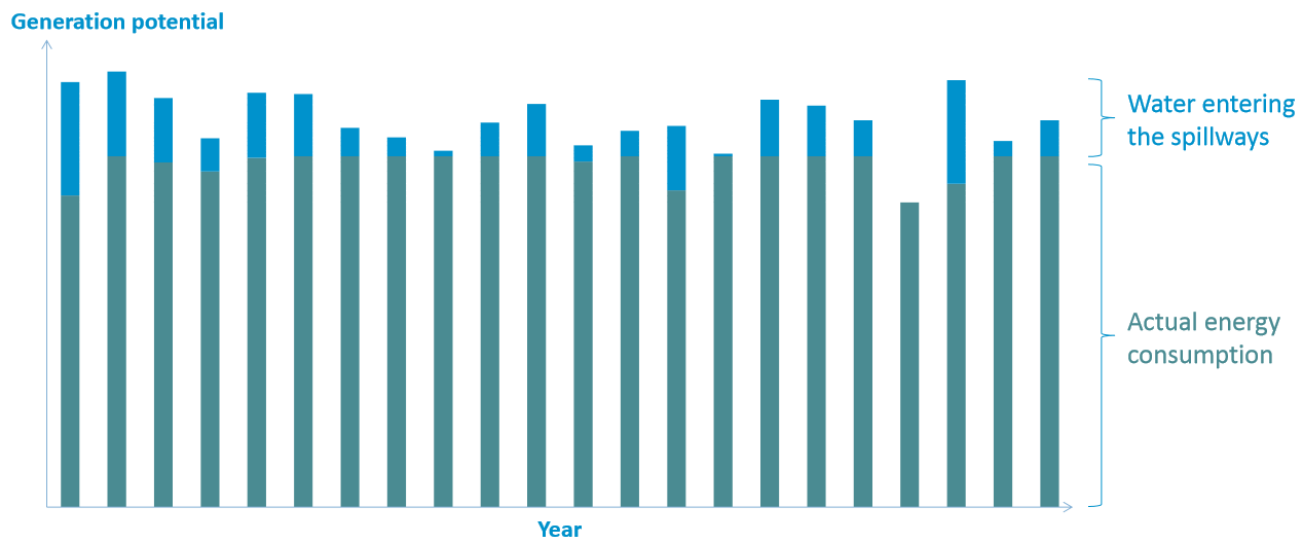
These market mechanisms and renewable energy support mechanisms can be seen having potential positive benefits in support of the proposed Iceland-UK interconnector as generation in Iceland is completely dominated by renewable energy. The FiT CfD program is particularly interesting if there is the possibility that the FiT CfD could be contracted out to generators in Iceland. These points will be further examined in later sections of this paper.

4.5 ICELAND SPECIFIC POTENTIAL BENEFITS

In addition to these broader interconnection benefits to the public in either country, there are a series of additional benefits for stakeholders in Iceland. In particular, stakeholders in Iceland would have access to a market with higher electricity prices. In 2012, energy prices for households were approximately 45% lower than other countries in the EU [43], [44]. Iceland currently produces much lower gross value per TWh than other similar markets such as Norway [14, p. 71]. An interconnector could give stakeholders in Iceland an opportunity to maximize the

value of the energy resources, especially if there is a potential to take advantage of the UK government's new FiT CfD program in the EMR described in the previous section. In addition to access to higher prices, generators in Iceland could have the opportunity to more efficiently use energy resources, especially in the case of hydro power. As discussed above in the section on ancillary services, isolated markets such as Iceland require significant reserve capacity in order to meet potential peak demand or potential supply shortage. Hydro power reservoirs are used to supply the majority of this reserve capacity and it has been estimated that up to 2 TWh/year is wasted as water is dumped into spillways [13], [14]. Figure 5 below illustrates this conceptually for a base year by comparing water entering spillways against actual energy consumption in Iceland.

Figure 5: Water entering spillway versus actual energy consumption 2012 [45]



If there was an interconnector between the UK and Iceland, this water entering the spillways has the potential to be sold to consumers in the UK instead of wasted. This wasted value would no longer be necessary as ancillary services such as reserve capacity would be of decreasing

importance as there would be a potential to import electricity during periods of increased demand or decreased supply.

Finally, the opportunity for risk management in the Icelandic energy sector should not be underestimated. Approximately 80% of electricity generation in Iceland is devoted to energy-intensive industries, particular aluminum smelting. This overexposes the Icelandic energy industry and consequently the Icelandic economy to price fluctuations of aluminum. The presentation by Hörður Arnarson, CEO of Landsvirkjun, at the Iceland Energy Summit of 2013 argues that investment in an interconnector and energy-intensive industry are not mutually exclusive activities. In fact, Hörður Arnarson argues that an interconnector and energy intensive industry have the potential to be a synergistic relationship, particularly concerning areas of risk management and security of supply issues.

4.6 SUMMARY OF POTENTIAL BENEFITS FOR ICELAND-UK HVDC INTERCONNECTION

The previous sections looked at an overview of some of the technical, economic, and policy benefits for an Iceland-UK HVDC interconnector. While the exact scale and distribution of these effects cannot be ascertained without a detailed quantitative study - and even still, the benefits remain unclear until the project is realized and operational - it can be assumed that one or more of these benefits for will be seen from the project. Thus, interconnection has been placed at the forefront of interest for many stakeholders in the energy sector, from regulators to policymakers to generators. The development of these interconnections has been more problematic than expected and presents a series of issues that are highly pertinent to the development of an Iceland-UK HVDC interconnector. The following sections will examine these issues in the guise of

providing insight to a strategy that should be undertaken for parties interested in developing the proposed Iceland-UK HVDC interconnector.

5 THE NATURE OF ELECTRICITY AS A COMMODITY AND THE EMERGENCE OF LIBERALIZED ELECTRICITY MARKETS

Understanding the nature of electricity as a commodity is vital in understanding the regulatory models for the proposed Iceland-UK interconnector. There are two paradigms for the nature of electricity. The first is that electricity is a public service which requires government regulation in order to command and control the supply and anticipate demand. The more dominant view over the last 20 years in Europe, is to view electricity as any other commodity and have it sold on a liberalized, deregulated market [46]. Section 5.1 will look at some of the unique qualities of viewing electricity as a commodity. This brief overview will lead into a discussion in Section 5.2 concerning the motivations for the development of modern, liberalized electricity markets in the UK and Europe and the complications these institutions could have in the development of an Iceland-UK HVDC interconnection.

5.1 NATURE OF ELECTRICITY

Electricity has a few special characteristics that separate it from other commodities. These special characteristics dictate the structure of regulation in order to create efficient and effective electricity markets. These will be briefly discussed in the following sub-sections.

5.1.1 Inability to Store Product

Electricity, unlike other commodities, is not able to be stored in its final form. Electricity must be first converted to other forms of energy such as chemical energy in the case of conventional batteries or as potential energy as is the case in hydro reservoir storage. This unique characteristic means that electricity supply must match demand in real-time. This places particular stress on transmission system operators (TSOs) which control the transmission of electricity in liberalized electricity systems. They are tasked with the obligation to transmit to consumers but have no control over the generation of the product.

5.1.2 Lack of Substitutes

Substitute goods in economics refer to the relationship between two goods whereby one good can replace another in a particular use. For most users, there are no direct substitutes for electricity and consumers are generally locked into the equipment they use [18]. Substitutes act as a discipline on suppliers which places downward pressure on prices and upward pressure on availability.

5.1.3 Standardized Product

In addition to a lack of substitutes, electricity is generally a standardized commodity. Incentives for switching suppliers for consumers are generally price driven decisions as “better” quality electricity cannot be supplied [18], [47].

5.1.4 Capital Intensive

Electricity systems are textbook examples of a capital intensive industry. Capital intensive industry refers to industries where the ratio of capital vastly outweighs the labor required [48]. Generation and transmission systems typically require large fixed costs which limit the ability of new participants to enter the market [49].

5.1.5 Natural Monopolies in Transmission and Distribution Systems

An extension of the capital intensive nature of electricity systems is present in the natural monopolies that are formed from the transmission and distribution systems. Natural monopolies are industries where production is most efficient and least costly when only one supplier controls the market [50]. This is the case in electricity transmission and distribution systems where the dominant supplier has an overwhelming cost advantage over new market competitor. In simplified terms, it is most efficient for one supplier to build power lines to consumers versus many competitors building overlapping systems.

5.1.6 Environmental Impacts

Another area electricity as a commodity differs from many other good is the environmental impact of the entire system. In the UK, the production of electricity accounts for 39.5% of total CO₂ emissions [51]. Due to the negative externalities of electricity production, it cannot be assumed that markets will deliver the necessary reductions to socially optimal levels. The scale of this impact makes electricity generation a prime target for governments looking to curb CO₂ emissions.

5.2 ENERGY SYSTEM STRUCTURES IN THE UK

Electricity's particular characteristics have implications on how these systems should be structured. Their deviation from the characteristics of other more 'normal' commodities place constraints on policy makers looking to have electricity sold in a competitive market structure. The aforementioned characteristics make distributing electricity efficiently and effectively particularly difficult. The following section will discuss the regimes and institutions that have emerged in the last decades in the UK. This will lead into a discussion about the implications and complications these institutions have on the development of interconnectors.

5.2.1 Electricity Generation, Transmission, Distribution and Supply Systems

The electricity sector can be described by four separate sections – generation, national transmission, regional distribution and supply. Electricity transmission and distributions systems are a classic example of a natural monopoly. Capital intensive investment in transmission systems create scale economies that limit the ability of competitors to enter the market. Traditionally, electricity transmission and distribution systems developed in a vertically integrated manner with the other sectors of the electricity sector. Generators generally developed transmission, distribution and supply systems and owned and operated the system from generation to end user—in Europe and the UK this was most often by publically owned monopolies [18].

The United Kingdom pioneered electricity market liberalization in Europe starting with the 1983 Energy Act which sought to bring competitive market reforms to a these publically owned, monopolized electricity systems [52]. Through conservative governments throughout the 1980s and early 1990s these publically owned entities were privatized and unbundled in order to spur

competition in supply and generation sections of the electricity sector. Microeconomic theory suggests that competition spurs efficiency gains in market participants and this efficiency is passed onto consumers through reduced costs and consequently reduced prices. This is considered to be the prime motivation behind liberalization in the electricity sectors [49].

Table 2 below outlines the general steps required to reforming the traditional publically owned, vertically integrated entities into the modern, privatized and regulated electricity markets [49]:

Table 2: Steps for Electricity Market Liberalization [40]

| | |
|--------------------------------|--|
| Restructuring | <ul style="list-style-type: none"> - Vertical unbundling of generation, transmission, distribution and supply activities - Horizontal splitting of generation and supply activities |
| Competition and Markets | <ul style="list-style-type: none"> - Wholesale market and retail competition - Allowing new entry into generation and supply |
| Regulation | <ul style="list-style-type: none"> - Establishing an independent regulator - Provision of third-party network access - Incentive regulation of transmission and distribution networks |
| Ownership | <ul style="list-style-type: none"> - Allowing new private actors - Privatizing the existing publically owned businesses |

Liberalization required the creation of market structures which could foster the growth of competition and reduce barriers to entry for new generators and suppliers. The former publically owned entities in the UK were vertically unbundled from generation, transmission, distribution and supply. Furthermore their concentration on a horizontal level was reduced by unbundling of the horizontal activities of generation and supply. The natural monopolies present in transmission and distribution systems were spun off into privately owned but regulated national

transmission system operators (TSOs) and distribution system operators (DSOs) and generators and suppliers, which are not subject to the properties of a natural monopoly, were sold off to private operators.

This vertical unbundling and horizontal separation of firms is vital for achieving competitive wholesale electricity markets [53]. The vertical and horizontal unbundling was an effort to prevent anti-competitive behavior by the newly privatized generators and provide access to new suppliers and generators into the market.

As discussed above, generation and supply activities were seen as potential candidates for liberalization but distribution and transmission systems became regulated monopolies. In this scenario the regulator, Ofgem, acts as a virtual competitor to the TSOs and DSOs by placing price caps on revenues. This cap on revenue is a type of incentive regulation that seeks to protect consumers from potential abuse by monopolized TSOs and DSOs [54].

5.2.2 Implications for HVDC Interconnectors

As large transmission projects, HVDC interconnectors theoretically should fit under the role of regulated monopolized and publically owned TSOs. Transmission is considered to be the domain of a natural monopoly and consumers should be protected from potential abuse by the transmission owner. This is largely the standard model for interconnection in continental Europe. However in the EU, TSOs have little incentive to invest in interconnectors for a few reasons. TSOs are tasked with keeping the transmission systems running in their respective countries however they aren't able to control every aspect of the system. This results in the regulatory frameworks

placing more emphasis on ensuring security versus new investment in interconnection, even if interconnection carries net social benefits [55]. Moreover, tariffs on TSO's systems are often calculated using the regulated asset base (RAB) of the TSO. The RAB is the TSO's asset value that is used by the regulator in setting the allowed revenue for the TSO [56, p. V]. Interconnector assets owned by TSOs and included in their RAB will likely increase tariffs on the system and consequently increase final electricity prices for consumers. As transmission and distribution systems are the only part of liberalized electricity systems that are regulated and consequently political institutes, there are few incentives to increase short term prices on system users for long term welfare benefits. For these reasons, the short term nature of political cycles has been argued to be incompatible with the long term nature of interconnection investments [55][57]. It is important to note that including interconnector assets in the RAB tariff calculation is not allowed under UK law. Also, interconnection often results in winners and losers. Congestion of an interconnector is most often driven by price differences between the two interconnected countries. Flows from the lower price region to a higher price region due to arbitrage opportunity has the potential to raise prices in the lower price region. As TSOs are often tasked with providing stable, secure and inexpensive electricity, the potential for increased prices on the 'losing side' of the interconnection create little incentive to approve, let alone invest, in interconnection [55].

6 MODELS FOR ICELAND-UK INTERCONNECTION

For to these reasons, a few models of interconnection have developed in Europe and the UK. Publically owned and operated TSO models have largely dominated continental Europe while

privately developed merchant interconnectors have been dominant in the UK [56]. Continental Europe cross border interconnection has been overseen since the European Commission's (EC) Internal Market in Electricity Directive 2003/54/EC (repealed by Directive 2009/72/EC, the Third Package) by the European Network of Transmission System Operators for Electricity (ENTSO-E) which is an association of 41 TSOs in 34 countries. The 41 TSOs, as part of the ENTSO-E, share the synchronous and interconnected grid throughout Continental Europe [58]. See Appendix for map of the ENTSO-E grid. TSOs in the UK are not part of the ENTSO-E and the UK grid operates on an asynchronous frequency. To date, interconnection in the UK has amounted to 4 GW of capacity which is less than 5% of total capacity [13]. This amounts to 2 GW between France and the UK via the IFA cable, 1 GW to the Netherlands via the BritNed cable, 500 MW between Scotland and Northern Ireland via the Moyle interconnector, and 500 MW between the Republic of Ireland and the UK via the East-West interconnector [59]. Both the Moyle interconnector and the IFA interconnector were developed before the implementation of the European Commission's Internal Market in Electricity Directive 2003/54/EC (repealed by Directive 2009/72/EC). Directive 2003/54/EC promoted new EU wide rules promoting market liberalization and set new rules concerning interconnection. For this reason the IFA and Moyle interconnectors, as well as other interconnectors developed before 2003/54/EC, will not be discussed further in this paper.

Underinvestment in interconnection continues, especially in the UK, and this has resulted in the emergence of new regulated models which are being developed for future projects. The traditional models and emerging models available following the EC's Directive 2003/54/EC (repealed by Directive 2009/72/EC, the Third Package) concerning rules on electricity markets will be discussed in the following sections. This will provide a background for understanding

which model should be applied to the proposed Iceland-UK interconnector which will be discussed in Section 7.

6.1 REGULATED, TSO-OWNED MODEL

The status quo for cross border and regional interconnection models in Europe is the regulated return, TSO constructed, owned and operated model. In the regulated model of interconnection, the TSO argues to the national regulator that the interconnector will result in some net welfare gains. As an example, the Dutch Electricity Act of 1998 [60] allows substantial interconnector investments to be included in the TSOs regulatory asset base (RAB) which is used to underwrite the costs of the project through an increase in system transmission tariffs across all users of the transmission system in either country. Put more simply, the investment in the interconnection is underwritten by customers of electricity and the cost of the interconnector is socialized across all users of the transmission system. Under Article 16(6) of Electricity Regulation EC no. 714/2009 stipulates that some of the revenue from the auctioning of interconnector capacity during periods of congestion may be used to partially recover the costs of the investment. The directive stipulates that an auction of capacity can only take place during times of congestion on the interconnector. This is referred to as congestion rents. During periods where there is no congestion on the cable, interconnector operators must allocate capacity in a non-discriminatory manner. The detailed rules concerning Use of Revenue are further detailed in Article 16(6). In particular, it states revenues from allocating capacity on an interconnector may be used for one or more of the following (i) guaranteeing the actual availability of the allocated capacity; (ii) maintaining or increasing interconnection capacities through network investments, in particular

in new interconnectors; (iii) as an income to be taken into account by regulatory authorities when approving the methodology for calculating network tariffs, and/or in assessing whether tariffs should be modified; (iv) The rest of revenues shall be placed on a separate internal account line until such time as it can be spent on the purposes set out in points (i) and/or (ii) [61].

However, TSOs in the UK are legally barred from including interconnectors in their RAB which restricts the route of the TSO regulated return model which largely rules this model out for discussion of a Iceland-UK interconnectors [62].

6.2 LEGAL FRAMEWORK FOR MERCHANT MODEL

Including the issues of TSO ownership and operation outlined in section 5.2.2 in addition to the inability of UK TSOs to include interconnector assets in their RABs, a commercial alternative was developed in the UK to provide a route for investment in new interconnections. These private investments in interconnectors are often called ‘merchant interconnectors.’ Particularly interesting in situations where there is long term price arbitrage potential [57], private developers can invest in interconnector assets in order to collect the congestion rents. Congestion rents, as were discussed in previous sections of this paper, refer to the auction of capacity during periods of tight capacity. When there is a price differential between the two interconnected markets, generators from the market with the lower prices look to take advantage of potential price arbitrage opportunities, can congest the capacity of the interconnector leading the interconnector operator requiring a market mechanism such as an auction in order to efficiently allocate capacity. Private developers are fully exposed to risks of demand for capacity and electricity price which is largely uncertain ex-ante. In order for this

model to work, developers seek exemptions from EU legislation concerning interconnector assets (e.g. Third-Party Access (TPA), power of national regulatory agencies and Use of Revenues). Regulation EC no. 714/2009 outlines the necessary preconditions for granting exemptions for merchant interconnectors in Article 17:

New direct current interconnectors may, upon request, be exempted, for a limited period of time, from the provisions of Article 16(6) of this Regulation and Articles 9, 32 and Article 37(6) and (10) of Directive 2009/72/EC under the following conditions:

- (i) the investment must enhance competition in electricity supply;
- (ii) the level of risk attached to the investment is such that the investment would not take place unless an exemption is granted;
- (iii) the interconnector must be owned by a natural or legal person which is separate at least in terms of its legal form from the system operators in whose systems that interconnector will be built;
- (iv) charges are levied on users of that interconnector;
- (v) since the partial market opening referred to in Article 19 of Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity, operating costs of the interconnector has been recovered from any component of charges made for the use of transmission or distribution systems linked by the interconnector; and

(vi) the exemption is not to the detriment of competition or the effective functioning of the internal electricity market, or the efficient functioning of the regulated system to which the interconnector is linked [61].

The application for exemptions is sent to the respective national level regulators where a decision is made on a case-by-case basis. After the national level regulators reach a decision on the scale and period of the exemptions, a report is delivered to the European Commission which reserves the right to ask the national level regulatory agencies to withdraw or amend the exemptions. The European Commission seeks to ensure EU wide interests take precedence over national interests[55].

Developers attracted to the merchant model of interconnection are motivated by potential revenues from congestion rents on the cables. Therefore, all merchant interconnectors seek exemptions from the rules concerning Use of Revenues under Article 16(6) of Electricity Regulation Directive 2009/72/EC in order to repay both the investment and turn a profit for the developers.

When a merchant interconnector is developed, the investor receives returns from the allocation of scarce capacity on the cable. These returns are received in periods of years, months or daily allocation auctions. This results in relatively long pay back periods and high risk for interconnector investors as day to day demand and price for electricity are uncertain ex-ante. Article 17 allows exemptions from Third-Party Access rules (TPA rules) as defined in Article 32 of EU Directive 2009/72/EC [63]:

1. Member States shall ensure the implementation of a system of third party access to the transmission and distribution systems based on published tariffs, applicable to all eligible customers and applied objectively and without discrimination between system users. Member States shall ensure that those tariffs, or the methodologies underlying their calculation, are approved prior to their entry into force in accordance with Article 37 and that those tariffs, and the methodologies — where only methodologies are approved — are published prior to their entry into force.
2. The transmission or distribution system operator may refuse access where it lacks the necessary capacity. Duly substantiated reasons must be given for such refusal, in particular having regard to Article 3, and based on objective and technically and economically justified criteria. The regulatory authorities where Member States have so provided or Member States shall ensure that those criteria are consistently applied and that the system user who has been refused access can make use of a dispute settlement procedure. The regulatory authorities shall also ensure, where appropriate and when refusal of access takes place, that the transmission or distribution system operator provides relevant information on measures that would be necessary to reinforce the network. The party requesting such information may be charged a reasonable fee reflecting the cost of providing such information [63]

This exemption allows both long-term contracts and priority access, even by owners, for interconnectors. These exemptions are seen to be targeting these issues with risk and long pay

back periods of merchant interconnectors as investors are given the opportunity for more returns earlier in the project and less uncertain risk over the long term[55], [64].

Lastly, Article 17 allows for exemptions from Articles 9 and 37(6) and (10) of EU Directive 2009/72/EC [63] concerning the regulatory power of the national level regulatory agencies. This article includes provisions for exemptions from regulatory agencies selecting the tariff methodologies and exemptions from ownership unbundling (i.e. unbundling of generation and transmission activities).

6.3 MERCHANT INTERCONNECTOR EXEMPTIONS IN PRACTICE

It is important to note that merchant interconnector investors do not have to apply for all of these exemptions and the regulatory agencies have granted exemptions to varying degrees [65]. As discussed above, all merchant interconnector projects seek exemption from Article 16(6) of Electricity Regulation Directive 2009/72/EC concerning use of revenues in order to both pay back the investment on the cable and turn a profit. Exemptions from third party access rules, unbundling and tariff methodology as defined in 9, 32 and Article 37(6) and (10) of Directive 2009/72/EC are given on a case-by-case basis. The following subsections will examine a sample of European merchant exempt interconnector projects to date as well as a new interconnection project that is still pending European Commission exemption decision.

6.3.1 Estonia-Finland Estlink HVDC Submarine Cable

The Estlink 1 HVDC submarine cable is a 350 MW power cable between Estonia and Finland was first brought online in December 2006. Estlink 1 was the first merchant cable built under new

merchant interconnector exemptions with EU Directive 2003/54/EC (repealed by Directive 2009/72/EC) and was developed by a group of five Baltic and Finnish generators under the collective name of Nordic Energy Link AS [66]. Estlink 1 was granted full exemptions from regulated third party access rules, use of revenues, and congestion rent methodology until December 31, 2013. After this point, ownership of the cable will be sold to the TSOs in Finland and Estonia. The investors (also incumbent generators in their respective countries) were given priority access to capacity allocation on the cable for a period of 8 years. This relatively short period of time was augmented with a “Use-it-or-lose-it” mechanism to prevent strategic hoarding by the generators [55]. Use-it-or-lose-it mechanisms refer to the ability of interconnector operators to reauction unused short term interconnector capacity contracts or underutilized long term interconnector capacity contracts without a return of proceeds to the previous owner [67]. The European Commission’s final approval process did not require any modification of the terms as it was seen the project would enhance competition, risk necessitated exemption and exemptions would leave existing competition unharmed [65]. To this point, Estlink 1 is the only project approved by the European Commission without imposing any new conditions [68][65]. Estlink 1 will be followed by Estlink 2 which is a TSO operated regulated line [69].

6.3.2 Imera East-West Interconnectors

The Imera East-West HVDC submarine cable was a dual line 700 MW project that sought to interconnect Wales and Ireland. The project would consist of two 350 MW cables. The project developer, Imera Power Ltd, was a subsidiary of Norwegian offshore shipping firm, Oceanteam ASA, which specialized in vessel solutions for offshore renewables, HVDC interconnectors, and

the oil and gas industries [70]. The project developer stated that it did not intend to use the cable itself and would only receive revenue from the congestion rents on the line [55]. The Imera East-West Interconnector applied for exemptions through subsidiaries under the name of East West Cable One Ltd and East West Cable Two Ltd from EU Directive 2003/54/EC concerning use of revenues, congestion rent methodology and third party access rules for a period of 25 years for cable one and 20 years on cable two. The two cables sought financing under the helm of a single project, so it was determined there would only be a single exemption decision [71]. The project would allocate capacity on the cable in two ways. 80% of capacity would be sold through a long-term contract to cover the risk of long term revenue [55]. The remaining 20% would be sold through daily, monthly, and yearly explicit auctions. Explicit auctions refer to a method of auctioning interconnector capacity whereby the auction for capacity is done in a separate marketplace from the auctioning of electricity [72]. This arrangement can be argued to be negotiated third party access as any market player can partake in both the long term and short term capacity allocation auctions but the risk is reduced through more stable contractual returns.

The European Commission's final decision on the exemption granted a 25-year exemption with a series of conditions. The Imera project satisfied the risk criteria for merchant exemptions only because it was being developed in competition with a fully regulated HVDC project developed by the Irish TSO, EirGrid. The EirGrid East-West interconnector will be completely owned and operated by EirGrid. Due to this it, can largely be thought of as an extension of the Republic of Ireland's grid and doesn't fit the traditional model of 50/50 TSO ownership. The actual available capacity and completion of the EirGrid project was the first condition placed on the exemption request by Imera. The second condition was a maximum of 40% of capacity could be allocated to

each dominant incumbent generator in either country. All other non-dominant market participants would be limited to 70% of capacity. This combined with effective congestion management through intraday trading on the 20% short term allocation is seen as a way to combat potential collateral damage to existing competition in either connected market. This is per the exemption preconditions set out in the European Commission directives [55][71][73].

Following the exemption decision it was published that the Imera project had failed to secure financing through an EU grant [74][75]. Oceanteam ASA, the Norwegian parent company, subsequently divested its 70% stake in Imera Power LTD [76]. The current status of this project is unclear but the framework developed for the project can still provide an interesting precedent to examine for future projects, particularly the proposed Iceland-UK HVDC interconnector.

6.3.3 ElecLink Channel Tunnel HVDC

ElecLink is a proposed 1000 MW HVDC cable between France and the UK where the cable would be run through the existing Channel Tunnel railway tunnel. The project, which started in 2011, is currently being developed jointly by Star Capital and Groupe Eurotunnel with an expected commencement date in 2016. ElecLink has requested a 25 year exemption from use of revenue, third party access, unbundling, and transmission tariff methodology[77]. The exemption request is still under consultation and French regulator CRE and UK regulator Ofgem are planning to publish an exemption decision by March 17, 2014. After this point, the exemption request will be sent to the European Commission for a final decision.

It is interesting to note the similarity of the proposed terms for capacity allocation between the proposed ElecLink and Imera East-West Interconnectors. Oceanteam ASA the former parent company of Imera Power Ltd, Star Capital and Groupe Eurotunnel are all 3rd party developers with no current assets in the electricity sector and no plans to use the capacity of the cable for own use. ElecLink will auction off 80% of the capacity of the cable through long term contracts up to 20 years. 20% of the capacity will be sold through a day ahead and intraday trading market. Furthermore, any generator or supplier in either country above 25% market share will be limited to 50% of total capacity of the cable in order to mitigate potential competition issues. ElecLink says it will facilitate a secondary market for the resale of long term capacity contracts through a third party. This secondary market will provide an opportunity for holders of long term capacity contracts to resell their obligation which arguably provides some opportunity for TPA even in the long term capacity allocation of the cable. Short-term market capacity allocation “will be in line with those prevailing in the market[78].” Lastly, ElecLink proposes that any physical transmission rights will be bundled with a “Use it or Sell it” mechanism to prevent potential hoarding[77].

These proposals largely fit within the framework for the Imera East-West Interconnector exemptions, including the European Commission’s conditions. The outcome of this exemption request may do much to bring to light to the European Commission’s exemption process which currently lacks both clarity and precedent.

6.3.4 UK-Netherlands BritNed HVDC Submarine Cable

BritNed is a 1000 MW, 250 km HVDC submarine cable running between the UK and the Netherlands. BritNed is a 50/50 joint venture by the TSOs National Grid in the UK and TenneT in

the Netherlands [79]. The national TSOs requested exemptions from Article 6(6) EU Directive 2003/54/EC (same wording as Article 16(6) in EU Directive 2009/72/EC) concerning use of revenues. BritNed developers were most interested in exemptions from Use of Revenue rules as outlined in Article 6(6) of EU Directive 2003/54/EC as UK law prohibits TSOs from including interconnector assets in their RABs. BritNed investors consequently sought an exemption from Use of Revenues in order to guarantee that investors would not only face the full downside risk but also potential benefit from the full upside [71]. Furthermore, despite the desire to implement a full TPA capacity allocation system similar to a regulated interconnector, BritNed sought exemption from Third Party Access rules and regulatory oversight [55]. The reasons stated for seeking exemptions from Third Party Access and regulatory oversight rules was to protect investors from what was seen as asymmetrical risk for the duration of the exemption. Regulators might step in and cap returns (if not entirely remove) to investors if the project turned out to be commercially successful. However, if the project turned out to be commercially unsuccessful, it was unlikely regulatory agencies would step in to stem losses [80]. BritNed requested the exemption for a period of 25 years, which matches their forecasted payback period. BritNed's use of daily implicit auctions and monthly and yearly explicit auctions with no long term contracts results in a high degree of revenue uncertainty. In opposition to explicit auctions defined above, implicit auctions integrate spot markets in each country with interconnector capacity allocations, effectively coupling the two markets. Implicit auctions maximize social welfare and increase the tendency towards price convergence in the two interconnected markets. In more simple terms, interconnector capacity and the spot price are bundled together into a single price which is bid upon. Due to the uncertainty of the price of electricity on a day to day basis,, BritNed developers

sought a comparably lengthy exemption period. If the exemption period was any shorter, the BritNed developers stated it was likely the project would become unfeasible.

The National Regulatory Agencies on either side of the deal granted the exemptions and the report was sent to the European Commission for final approval. In October 2007, the European Commission granted the exemption for a 25-year period. The caveat is that the European Commission cites concerns that BritNed undersized the capacity of the cable below socially optimal levels in order to buoy returns. As a result, they asked the National Regulatory Agencies to amend the exemptions with a 10-year financial review of the rate of return, total revenues, and total costs using 2007 as a base year. If the ex-post revenue exceeds 1% of the estimate supplied in the exemption request, BritNed will be given two options. BritNed can either surrender excess revenue above 1% of the estimates provided with the exemption request to be used in the TSOs RABs or increase capacity of the interconnector[81]. As the capacity of a subsea interconnector is static, an increase of capacity implies building a new cable. BritNed developers communicated to Ofgem that these additional conditions created significant regulatory uncertainty for future interconnector merchant exemptions[62].

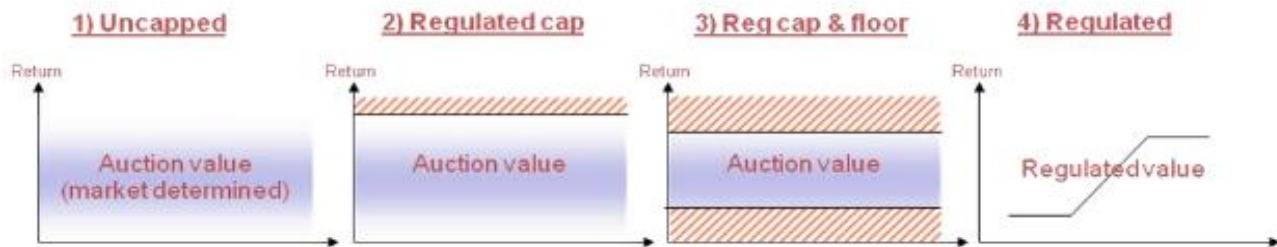
6.4 CAP-AND-FLOOR AND THE NEMO INTERCONNECTOR

In response to the conditions applied to previous merchant interconnector exemption requests, particularly the BritNed conditional exemption, Ofgem stated that it had become clear that the merchant exemption could be interpreted as an exception to the rule. Following the BritNed exemption decisions, it was clear that the regulated path was the preferred first option for interconnection [82]. This exemption regulatory uncertainty, new cross-border codes that came

with the Third Package (including EU Directive 2009/72/EC), and continued perceived underinvestment led Ofgem to conclude that a new clear and predictable regulatory framework should be developed to facilitate efficient investment in new interconnection projects. Ofgem launched a consultation in January 2010 to examine industry participant's opinions on potential models to pursue for further development. Model 1 is the merchant model discussed above where auctions for capacity are the only revenues taken by investors. Investors are fully exposed to the potential risk of the interconnectors and investors must apply for exemptions from EU regulation. Model 2 is a regulated cap model such as was applied in the conditions placed on the BritNed case. All revenues or returns above a certain level would be either returned to customers or invested in increased capacity. Model 3 is a regulated cap-and-floor model. Above the cap, revenues or returns would be reinvested in capacity or returned to customers. Asymmetrical risk for investors is tackled by a floor on returns, or revenues, which is provided through a socialization of risk via the TSOs transmission tariff. However, because of the uncertainty of interconnector costs and revenue ex-ante, the setting of the cap-and-floor can be a particularly difficult question. Model 4 is the regulated approach where by interconnector assets are included in tariff mechanisms and revenue or returns are used to cover the costs of the investment. The main risk with this model is stranding which is a scenario where revenue from capacity auctions are not enough to cover costs and the difference is supplemented by customers. This difference results in increased transmission tariffs for all users resulting in an increase in the price of electricity. The potential risk for stranding exists in both the cap-and-floor and fully regulated model. It is important to note that Model 3 is a composition of the three other models. Depending on what the cap-and-floor are set at they can represent any of the models. If the

spread of the cap-and-floor is wide, it can resemble Model 1. If the floor is so low that it is not useful for mitigating risk and the cap low enough to cap revenue it can resemble Model 2. If the spread is narrow, it can resemble the fully regulated route of Model 4. Figure 6 below graphically displays these four models:

Figure 6: Four Models Examined in Ofgem Interconnector Consultation [82]



From the consultation Ofgem found that while support continues for the merchant interconnector, regulatory uncertainty concerning the exemption process places particular risk on investors. The regulated cap model garnered little support unless the cap was placed at a sufficiently high enough value. In the fully regulated route of Model 4, there were potential perks of synergy between the dominant model in mainland Europe and the clarity of it being the default model under EU legislation. However respondents noted the potential for the slowing of investment due to the introduction of TSOs into the process and potential for an inefficient number of interconnectors being developed. This is coupled with the potential for stranding, as discussed above, and the scale of departure from traditional merchant route in the UK.

The findings of this consultation led into the discussion for a new interconnector between Belgium and the UK, the NEMO Link project. Following the consultation, Ofgem and the Belgian regulator, CREG, settled on developing a regulated cap-and-floor regime to be applied to the

NEMO project. NEMO is being co-developed by the UK TSO, National Grid, and the Belgian TSO, Elia. Elia stated that it was unwilling to invest in the project unless there was the potential for an upside on returns to the project. This effectively ruled out the regulated route of Model 4. Project NEMO would act as the pilot for the new model which potentially could be applied to future interconnector projects [83]. It is important to note that the cap-and-floor regime is expected to co-exist with the merchant model [84].

The regime will be designed with a 20 or 25-year period in mind. Developers can choose between these periods for each project. The floor and cap will be set ex-ante and remain in place for the length of the regime. The cost setting will be determined ex-post by the project's capital expenditure (capex) and ex-ante for the project's operation expenditure (opex). Revenues above the cap will be returned to customers and revenues below the floor will be supplemented through socialized measures, namely TSO tariffs in the respective countries. Considering the difficulty analyzing potential congestion rents on an interconnector, periodic surveys will be undertaken to determine if the cap-and-floor are being triggered [62].

The cap-and-floor regime is still in the design and consultation phase and is expected to be piloted with the NEMO project. The actual impact this project will have on existing and future interconnectors is yet to be determined. BritNed, in response to the Ofgem consultation, urged regulators to ensure the new cap-and-floor regime limits any detrimental impact on existing interconnectors[85].

6.5 OFFSHORE GENERATOR

A final model, which warrants examination, does not fit the typical definition for interconnection. EU member states are mandated to enforce a target of 20% of energy from renewable sources by 2020 through EU DIRECTIVE 2009/28/EC concerning the promotion of the use of energy from renewable sources. The directive provides for alternative methods than generation build-out through the provisions for ‘flexibility mechanisms’. These flexibility mechanisms include provisions for EU member states to trade renewable energy in order to meet these targets[86]. In an offshore generator scenario, two transmission systems are connected via interconnector but interconnector flows are solely exported by one market and imported by the other.

In May 2012, the Icelandic government and the UK government signed a memorandum of understanding concerning energy issues. This includes statements of the respective parties’ willingness to pursue a route for Icelandic energy into the UK market[87].

In June 2012, the UK Department of Energy and Climate Change (DECC) released the results of a call to evidence consultation seeking stakeholder input on the potential for cross-border renewable energy trade by non-UK generation[88][87]. The DECCs Energy Market Reform (EMR), as discussed in section 4.4.3.1, introduced the development of a new Feed-in-Tariff with Contract-for-Difference (FiT CfD) regime. Low-carbon technologies will be subsidized through a contract that will pay the difference between the pre-agreed strike price and the market price for electricity, the reference price. The operational framework for this new regime suggests that the FiT CfDs could be applied to non-UK generators “where there is clear overall benefit to the

UK”[89, p. p24] Annex A. Following this, the UK Energy Bill of 2012-2014 included provisions for FiT CfD for non-UK generators[90].

Ofgem’s emerging thinking on the Integrated Transmission Planning and Regulation (ITPR) project is being developed in parallel with these developments. Part of the ITPR project will examine the potential impact on emerging regulatory and legal concerns with connecting non-UK generation into the grid. Ofgem notes in their *ITPR Fact Sheet* that complex, multipurpose projects, such as non-UK generation, have no clear regime [91]. In response, Ofgem is consulting opinions on potential models for creating a regime for supporting renewable energy from non-UK generation for delivery in 2014[92]. Under current UK legislation, non-UK generators looking to connect to the UK grid can only be licensed through the terms set out for interconnectors. It is not possible for transmission assets from outside the UK to be licensed under the terms of onshore or offshore transmission. As such, the options present for foreign generators are largely similar to those of full interconnection with bilateral flows. These consist of the status quo (in the UK) merchant exempt interconnector model, the fully regulated return model, and the emerging cap-and-floor regime[92, p. 24]. Consequently, these models carry many of the same pros and cons discussed in previous sections, namely regulatory uncertainty with the merchant model and the potential for stranding with the regulated return and Cap-and-Floor models. Ofgem sees two potential models for project identification with regulated models. These are the status quo developer led model where developers identify projects through potential price arbitrage opportunities or a centrally planned system where a central body undertakes project identification with a holistic view of system needs. This centrally planned system is most often associated with TSOs and is the status quo in Continental Europe [92, p. 26]

Ofgem plans to conclude its consultation on non-UK generation in mid-January. In light of the tight time scales for projects looking to help the UK meet its 2020 renewable energy targets, Ofgem plans on publishing a document that will seek to provide clarity on pertinent regulatory routes for non-UK generator connections in spring 2014.

The DECC has stated that the work focus for 2013-2014 will be on physical trading of goods such as electricity and gas. To begin, the UK government is drafting an Intergovernmental Agreement with the Republic of Ireland. The negotiations should yield more information on how a potential agreement would balance risk and benefits for either party. This agreement is expected sometime in 2014[87], [93]. If the offshore generator model is selected for the Iceland-UK case, a similar agreement would need to be struck in order to balance political and economic rent for Iceland and the UK. The results of the UK government's negotiations with the Republic of Ireland could do much to clarify how these arrangements could be made.

7 WHICH MODEL SHOULD BE APPLIED FOR ICELAND-UK CABLE?

The options for models for the proposed Iceland-UK cable can be broken down into a three categories. Table 3 below illustrates the breakdown of risk, state of deployment, and ownership of the three separate models.

Table 3: Breakdown risk, status and ownership of potential models for application to Iceland-UK interconnector

| | <u>Regulated Model</u> | <u>Regulated Cap-and-Floor Model</u> | <u>Merchant Model</u> |
|----------------------------|--|---|--|
| Risk | Socialized | Socialized | Privatized |
| State of Deployment | Established but requires changing UK legislation | Emerging - cross-jurisdictional cost burden unclear | Established but with some regulatory uncertainty |
| Ownership | Non-TSO/TSO | Non-TSO/TSO | Non-TSO |

In the regulated model, risk is largely socialized to the public through transmission tariffs. The cap-and-floor regime seeks to balance the risk between developers and the public. Developers face the risk that regulators will step in if the cap is reached and cap revenue while the public face the risk of stranding if the project turns out to be economically unprofitable. Merchant interconnectors expose project developers to the full risk of the project.

The expected cost of the interconnector was estimated in the May 2013 report to the Icelandic Parliament on the macroeconomic feasibility of the cable to be in the range of 2.4- 4.5 billion USD not including the cost of a build-out of new generation in Iceland [16, p. 42]. Assuming 50% ownership by the Icelandic TSO ownership and an approximate population of 320,000 people,

this amounts to the Icelandic public subsidizing 3750 to 7000 USD per capita. For a comparison of scale, the 700 billion USD bailout of the US financial system under the Emergency Economic Stabilization Act of 2008 across the US population of 313 million people amounts to public exposure of approximately 2000 USD per person. More informative is the comparison of the scale of the project to the size of the Icelandic economy. The 2012 GDP of Iceland amounted to 13.66 billion USD[94]. Using the estimated figures of 2.4–4.5 billion USD for the Iceland-UK interconnector and 50% ownership from the Icelandic side, this ranges from 8.5-16% of GDP.

The scale of this risk can largely be argued to be unacceptable and a potential political landmine for public officials in Iceland. In light of this, another potential set-up under the regulated models is the UK TSO, National Grid, developing the cable entirely on its own. The cable would act as an extension of the UK transmission system. This set-up is the one being used on the EirGrid East-West regulated interconnector which connects the Irish Republic with the UK. This is the regulated project that was expected to compete with the stalled Imera East-West merchant interconnector. EirGrid, the Irish TSO, developed the entire interconnector project in order to increase competition, increase security of supply and balance the increased penetration of wind energy in Ireland[95]. While this is a potential model for the proposed Iceland-UK interconnector, it is unclear if National Grid would be willing to undertake complete asymmetrical risk of supplying the full cost of the floor in a project the scale of the Iceland-UK interconnector. The only way to clarify this position is to begin negotiation with National Grid to ascertain their interest in undertaking this asymmetrical risk. This is coupled with the risk of stranding that comes with regulated models such as the cap-and-floor and fully regulated TSO model inhibits the potential for this model to be applied to the Iceland-UK interconnector.

For the purposes of this paper and under the current uncertainty of emerging models, the only model that could be reasonably be applied to the Iceland-UK cable is the established merchant interconnector model. Following the use-of-revenue conditions placed upon the BritNed interconnector, it was clear that merchant exemptions for interconnectors could be viewed as exceptions to the rule[96, p. 4]. However, if anything can be said about the proposed Iceland-UK interconnector, it is the exceptionality of the case. In addition, the proposed Iceland-UK interconnector project would be the longest submarine electricity cable in the world at over 1000km [11]. The interconnector would connect the small, island nation of Iceland with the very large UK electricity market (and arguably the wider EU market via existing and planned interconnectors). The interconnector would connect the Icelandic system, which is dominated by a surplus of inexpensive renewable energy (including a surplus of flexible hydropower and untapped wind resources), with one dominated by traditional fossil fuels—which is rapidly attempting decarbonization. Lastly, it can be argued that EU interconnector policy was developed with the concerns of continental Europe in mind. Cross-border interconnection in continental Europe is largely overland between bordering countries with synchronous grids. The UK grid runs on an asynchronous frequency and the UK's location on an island requires capital intensive investment in subsea cables. UK legislation does not allow TSOs to include interconnector assets in their transmission tariffs which is largely the reason merchant interconnection has been the status quo in the UK to date since the adoption of the EU's rules concerning energy systems in the EC's Directive 2003/54/EC (repealed by Directive 2009/72/EC, the Third Package). Despite the emergence of the new cap-and-floor regime for the NEMO project, Ofgem has stated the

desire to include this new regulatory model to complement the existing merchant interconnector model[84].

7.1 WHAT RECOMMENDATIONS CAN BE MADE FOR STAKEHOLDERS?

As there is regulatory uncertainty following the BritNed decision to pursue the merchant interconnector, it is important to examine the precedents of the merchant exemptions in the UK. Out of the cases discussed in Section 6 on merchant interconnectors, one framework stands out when applied to the Iceland-UK case. The Imera East-West cable project has stalled, however the framework for the Imera project has been mimicked in the recent ElecLink exemption request.

The framework included in the exemption request includes what could be best described as negotiated third-party access. 80% of the capacity on the cable will be sold through long-term contracts and the remaining 20% will be allocated through short term auctions. The 80% can be used to cover the bottom end of the project and concerns over competitive markets are covered through the 20% short-term auctions. This arrangement could help secure one of the conditions required for macroeconomic profitability, long-term contracts. Moreover, the project developer says it will facilitate the development of a secondary market for resale of the long term capacity allocation. The exemption request also includes a 50% cap on capacity that any dominant generator can gain through the long-term auctions (it was 40% in the Imera exemption). This could be a particular point of interest with regulators considering the 75% market dominance by Landsvirkjun[19].

While this exemption request isn't due for review by the European Commission until spring 2014, it is unclear at this point if the exemption request will be granted without further conditions placed upon it. It is important to note that in the case of the Imera East-West interconnector and the ElecLink interconnector, that the merchant interconnection were proposed to satisfy the risk condition for the EU exemption due to the fact that the proposed projects were in competition with existing regulated lines. A more detailed risk analysis of the proposed Iceland-UK interconnector could bring to light specific ways that the project could meet the risk exemption.

Most importantly, the sizeable risk of this project can be tackled through securing favorable, long-term electricity prices. UK legislation includes non-UK generators as potential recipients of the new FiT CfD program as outlined in section 4.4.3.1. Negotiations surrounding the project should discuss the potential for these feed-in-tariffs to be applied to part or all of the interconnector capacity flows coming from Iceland. This could be most easily done in the long-term contract capacity allocation. It can be argued that as with other businesses, potential for profits will spur development of this project. Hinkley Point C is a 2 reactor, 3200 MW nuclear power plant located in Somerset, England. Hinkley Point C, which is expected to be commissioned in 2023, recently secured a "strike price" under the new FiT CfD program of £92.50/MWh (approximately 150\$/MWh in 2013 dollars) which almost double the current wholesale price of electricity in the UK [97]. It can be argued that if the DECC is willing to extend this strike price to nuclear energy, then there should be a strong argument for supporting sustainable, clean energy from Iceland especially considering the legislation concerning FiT CfD includes the potential for foreign generators. At this point, stakeholders in the project should seek more information on the potential for this program to be applied to the Iceland-UK interconnector. The FiT CfD program

alone has the potential to increase the macroeconomic feasibility of this project, no matter the regulatory framework applied. If the ElecLink framework is pursued, the recommendations for stakeholders are summarized in Table 4 below.

Table 4: Steps to be undertaken by stakeholders if pursuing ElecLink framework

| Iceland | UK | EU | Interconnector Investors |
|--|--|---|---|
| Prepare law and legislation for proposed Iceland-UK interconnector | Provide clarity for ElecLink framework to be applied to proposed Iceland-UK interconnector | ElecLink exemption | Analyze potential for ElecLink model to be applied to Iceland-UK interconnector |
| Undertake detailed impact assessment detailing economic and social risk factors | Undertake detailed impact assessment detailing economic and social risk factors | Clarify merchant interconnector exemption process | Undertake detailed impact assessment detailing economic and social risk factors |
| Communicate results and build public support | | | |
| Undertake detailed risk analysis to be applied for the merchant exemption | | | |
| Negotiate with the UK on prices, specifically the application of FiT CfDs to generators in Iceland | Negotiate with Iceland on buildout of generation and terms of FiT CfD contracts | Identify applicable EU development funds | Negotiate prices, specifically the application of FiT CfDs to generators in Iceland |
| Agree on business plan for cable | | | |
| Conduct a thorough investment analysis from stakeholder perspectives | | | |
| Icelandic Regulators grant merchant exemption request | UK Regulators grant merchant exemption request | EU Regulators grant merchant exemption request | Apply for merchant exemption |

Items in Table 4 highlighted in yellow are strictly legal and regulatory steps that need to be undertaken for public interests by policy makers and regulators in their respective areas. Items

highlighted in orange are steps that need to be undertaken cooperatively by public and private interests. Items in green are recommendations for private interests.

The Imera/ElecLink framework with FiT CfDs create a potential route for interested stakeholders in achieving long-term, favorable electricity prices that have the potential to make this project macroeconomically feasible while still maintaining legal feasibility under the ECs Third Package on Energy. Moreover this framework limits the exposure and risk of the public if the project proves commercially unprofitable. If the case can be made that the proposed Iceland-UK interconnector fits the risk criteria under the ECs legislation concerning merchant interconnector exemptions, there is a strong argument that this is the framework that should be pursued.

8 CONCLUSIONS

UK energy policy is currently in a state of rapid change. In light of declining energy security and a continued interest in decarbonization of electricity generation, the UK government has undertaken a total review of the arrangements for electricity system development and management. UK energy policy can largely be simplified to securing energy supply, decarbonization and sustainability of generation, and facilitating competitive electricity prices. The proposed Iceland-UK interconnector is a promising prospect for helping to meet these goals.

The proposed Iceland-UK interconnector has the potential to provide a series of benefits for the two countries. Interconnectors, depending on which framework is used, have the potential to increase competition between generators and suppliers due to the increased access from international market participants. The Iceland-UK interconnector could also provide more

efficient use of resources and a reduction in ancillary services such as balancing markets. This is especially pronounced in the currently isolated Icelandic electricity market where a large portion of generation is currently used to provide a reserve during periods of peak demand or unforeseen technical issues. On the issue of increased penetration of variable renewables, such as wind power in the UK, the domination of hydro power and the potential for increased wind power utilization, provides the potential for technical and economic synergies between the two electricity systems.

However, despite the significant benefits that could be associated with the Iceland-UK interconnector there are also significant regulatory uncertainties. Due to the nature of electricity as a commodity and the current structure of electricity system regulation, there are serious blockades in the way of the development of interconnections. Transmission systems are typically regulated monopolies in Europe and in many cases lack incentives to pursue interconnection between countries.

There are a few separate models that exist for developing these interconnectors though. One is the TSO owned regulated model which acts much the same as domestic transmission assets. In the UK, however, TSOs are barred from including interconnector assets in their transmission system tariffs, which has barred this model from being applied in the UK. The dominant model to date has been the merchant interconnector. The merchant interconnector route seeks a market approach which avoids socializing risk and places the full risk on the project developers. Developers of merchant interconnection most often seek exemptions from EU directives on the rules guiding cross-border transmission assets. This exemption process has resulted in some

regulatory uncertainty for interconnector developers, especially since the additional conditions placed on the BritNed merchant interconnector project. This has resulted in Ofgem, the UK regulator, developing a new regulatory cap-and-floor model for application to the NEMO project. However, when applied to the Iceland-UK case, it is unclear how a regulated model would work in light of the potential risks for the public in Iceland.

Out of the potential models, the merchant interconnector status quo, stands as the most reasonable for application to the model. In light of the regulatory uncertainty concerning the EU exemption process, there is a potential for the framework pioneered under the stalled Imera East-West interconnector and mimicked for the proposed ElecLink Channel Tunnel interconnector. The final decision from the European Commission (EC) on the ElecLink exemption request in spring 2014, should bring some light to the potential for some reliable precedent to be pursued. Following a favorable outcome of the ElecLink exemption request, this framework should be examined more in depth via a comprehensive commercial feasibility assessment.

In the meantime, potential investors, developers and applicable development funds from the EU should be identified. Most importantly however, negotiations for the project should involve the potential for application of the new Feed-in-Tariff with Contract-for-Difference (FiT CfD) regime which is emerging in the UK under Ofgem's new Integrated Transmission Planning and Regulation (ITPR) policy review and the DECC's Electricity Market Reform (EMR). This will help secure favorable and stable energy prices for generators in Iceland which has the potential to be one of the most important deciding factors when analyzing macroeconomic feasibility. Domestically,

Iceland should develop legislation around the facilitation of merchant interconnection in line with the EU directives on cross border transmission.

The Imera/ElecLink framework adequately covers investor concerns over stable, long term returns while satisfactorily addressing regulator concerns over competition and third-party access rules for transmission assets. When combined with the FiT CfD program, there is a strong potential that this project can attain macroeconomic feasibility while still being feasible under EU energy legislation. If this project attains legal and macroeconomic feasibility and construction begins on the Iceland-UK interconnector, there is a strong possibility that both the UK and Iceland could reap significant technical and economic welfare benefits that would do much to strengthen the position of stakeholders on either side of the cable.

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10 APPENDIX

Figure 7: ENTSO-E Grid Map

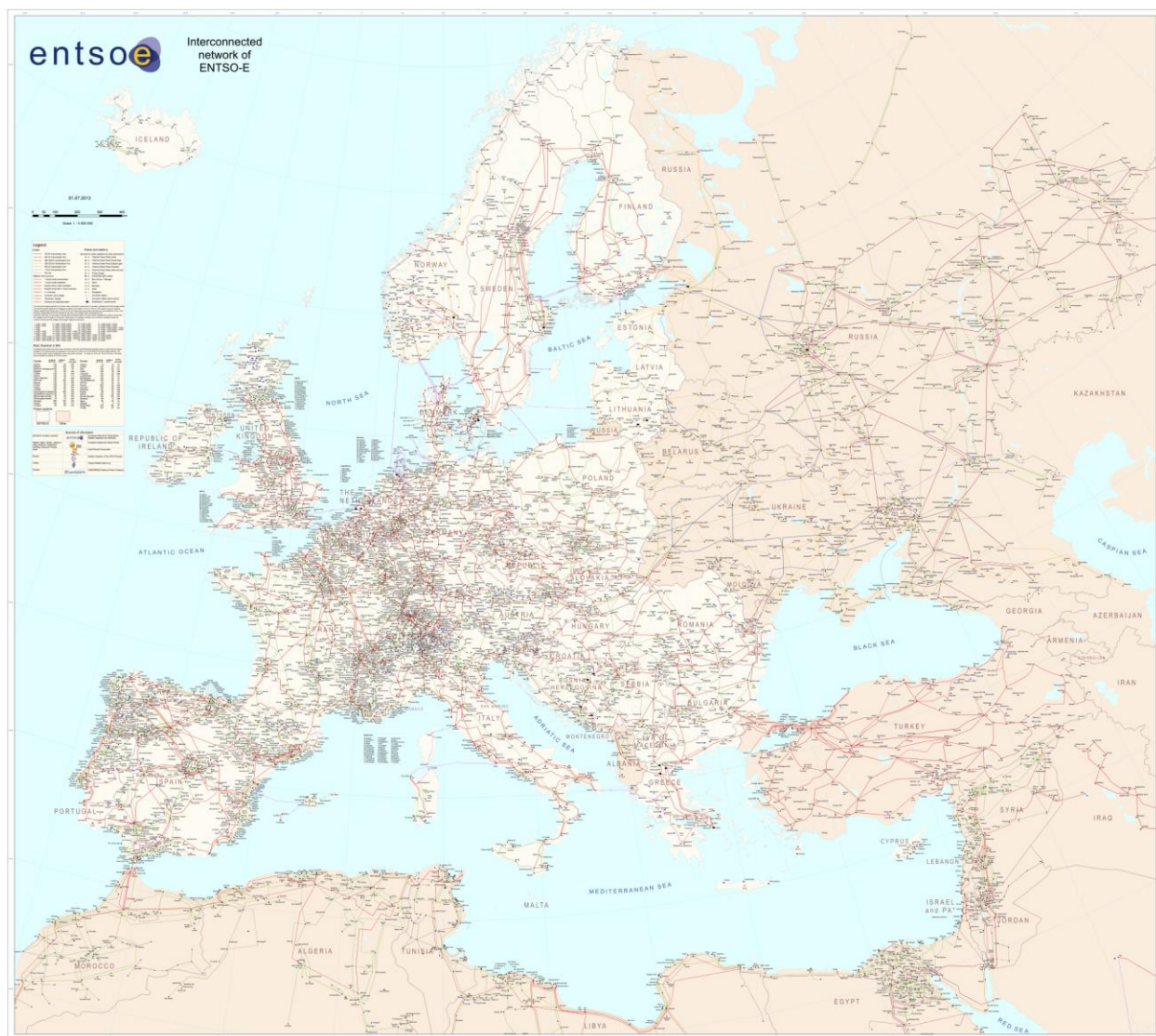


Figure 8: ENTSO-E Grid Map, Zoom NW Europe

