INTERCONNECTOR VALUATION ANALYSIS

2012 to 2014

FOR

October 2014

CONTENTS

1. Introduction

Energy-Link has agreed to provide Mutual Energy Limited ("MEL") with an historical valuation analysis of its Moyle Interconnector, following an email request from Mutual dated 23rd July, Energy-Link's proposal dated 29th July and Mutual's acceptance email dated 1st August 2014.

The assignment relates to historic valuation modeling of MEL's 500 megawatt Moyle Interconnector between Scotland and Northern Ireland, from August 2012 the end of July 2014. Energy-Link had the majority of the raw source data required to perform the analysis. The work requested is to replicate the analysis and approach from a previous study conducted by Energy-Link over a prior period from February 2008 to July 2012 inclusive[1].

The primary analysis was conducted in Euros as the base currency with financial results presented in Sterling where appropriate.

This document sets outs Energy-Link's analysis and conclusions on the Stack, Uplift and Reserve analysis.

[1] Interconnector Valuation Analysis_January 2013 V10

2. Executive Summary

This updated analysis shows benefits for the Moyle Interconnector of a similar order to those identified in the previous study up to July 2012. The tables below summarises the estimated benefits from Shadow Price/Uplift impacts.

Year	NI Benefit £m	AI Benefit £m
2012 from Aug	18.1	70.7
2013	40.9	163.0
2014 to July	22.8	92.2
Total	81.8	325.9

The absolute size of Shadow Price/Uplift impacts is similar over the update study period, even though the Moyle capacity was only 250 MW. This may be a slightly unexpected result, though the period does correspond with the introduction of Intra-Day trading on Interconnectors, which may have increased efficiency of use. Further, the first 250MW of capacity is likely to be of more value than incremental capacity.

The quantity (MW) of notional Reserve provision was assumed equal to that in the previous study, notwithstanding the actual lower Interconnector capacity over the period, to aid comparison of results. Whilst the value of Reserve provision has risen, this reflects the general rise in Imperfections Charges over the period. The table below presents the summary result of the metric used to approximate Reserve provision value.

	£ M[2]
Q1 13 SPC Cost Change	17.4
Q2 13 SPC Cost Change	14.2

[2] Converted from Euros at a notional exchange rate of 0.8 €/£

3. Valuation Approaches

Three valuation approaches were applied in this analysis, two of which, Stack Model and Uplift Analysis (“SMP Metric”), are complimentary.

The SMP Metric approaches were based primarily on assessing Interconnector value based on its impact on reducing overall market costs through SMP, rather than the intrinsic value to MEL though auction revenue and/or inter-market rent. The primary approach adopted in the SMP Metric analysis is a “Stack Model”, i.e. an assessment of the price of the marginal plant in each half hour. A further subsidiary element of this analysis is to estimate the impact on the Uplift component of System Marginal Price (“SMP”) due to Interconnector import quantities (MWh).

A further separate analysis has been conducted to estimate the value to the system of the Reserve capacity provided by the Interconnector.

4. Stack Model

Energy link used the its Stack Model[3], used for the previous study, of the inferred historic SEM plant merit order following removal of the actual historic Moyle Interconnector offered quantities. This removal was for SEM import quantities only. The analysis range was August 2012 to July 2014 inclusive.

The resulting primary output is the change in Shadow Price ("SP") over the period as a result of removing the Moyle Interconnector import quantities, being a proxy for the estimated change in SMP. The estimated £m implied benefit (or cost) was then calculated for each year based on the demand (TWh) in Northern Ireland. It is likely that removal of Interconnector quantities would also have an impact on constraint costs (and therefore customer costs through Imperfections Charges). It may be more likely that this removal would have a detrimental impact on constraint costs, though no assessment was made of the impact of this element.

Following initial Stack Model runs it was necessary to introduce a number of modifications which are detailed in Appendix 1, after which the Stack Model provided a better overall estimate of actual SPs.

The Stack Model was run over the period August 2012 to July 2014 inclusive. The average annual Stack Model SP results are provided in the table below, along with the actual published SP values for comparison.

[3] Further details on the Simple Stack Model are provided in Appendix 1

Annual Average €/MWh			
Year	Stack SP	Actual SP	%
2012 from Aug	49.31	48.62	101.4%
2013	46.79	46.67	100.3%
2014 to July	41.37	40.56	102.0%

4.1 Interconnector Analysis

The valuation analysis is based on removing the actual historic Moyle Interconnector offered quantities[4] from the Stack Model and returning the resulting revised SPs. Only SEM import quantities were removed from the Stack Model.[5] The change in the Stack average SP is summarised in the table below. These half hourly changes in SP are weighted to the forecast All Island demand profile (2013) published by SEMO[6], averaged monthly.

Increase in Stack Prices	
	Month Load Wgt. €/MWh
2012 from Aug	3.96
2013	3.80
2014 to July	3.65

The resulting revised SPs over the period, as a result of removing the historic (i.e. including outages) Interconnector quantities, are then used as a proxy for the estimated change in SMP. The estimated £m implied benefit (or cost) of the Interconnector import quantities is then calculated for each year based on the historical demand (TWh) in Northern Ireland and All Island[7]. The

[4] These quantities may not represent the full physical capability of the Moyle Interconnector due to the more limited quantities offered by participants and the resulting ex-ante dispatch scheduling processes.
[5] Removal of both import and export quantities could also be assessed.
[6] Filename SEM-12-078c Appendix 2 - Load Forecast for 2013
[7] Values from All-Island Generation Capacity Statement 2013-2022, forecasts.

estimated financial benefit of reductions in SP due to Interconnector import quantities in each year is presented in the table below[8].

Year	NI Benefit £m	AI Benefit £m
2012 from Aug	12.3	47.4
2013	27.5	108.1
2014 to July	15.1	60.6
Total	54.9	216.1

4.2 Constraint Costs

It is likely that removal of Interconnector quantities would also have an impact on constraint costs (and therefore customer costs through Imperfections Charges). However, as it may be more likely that the removal of Interconnector quantities would have an upward impact on constraint costs no assessment was made of the impact of this element on Imperfections Charges.

[8] See Appendix 1, paragraph 7.4 for comment on level of accuracy of these results.

5. Uplift - Market Engine Simulation

A sample analysis over part of the Stack Model study range was also conducted to assess the likely scale of impact on Uplift from the removal of the actual historic Moyle Interconnector offered quantities. This was performed by full simulation over a short period using Market Engine Simulation (see below). The estimated change in Uplift was then summed with the change in Shadow Price obtained above to calculate a revised £m implied net benefit.

Energy-Link used its in–house developed Market Engine Simulation model, STM, to perform a full dynamic analysis on the impact on Uplift by removing historical Interconnector quantities as above.[9] This reflects the change in dispatch schedules due to both commercial offer prices and plant dynamics, e.g. MSG, minimum on times etc. The SMP outputs are comparable with the historical SMPs and with those that would be obtained by using other models commonly used within SEM to forecast SMP. The analysis range was January 2013 to June 2013 inclusive. This period was selected as it covers one winter and one summer quarter and is towards the middle of the entire 31 month range, so should be reasonably representative.

5.1 Uplift Results

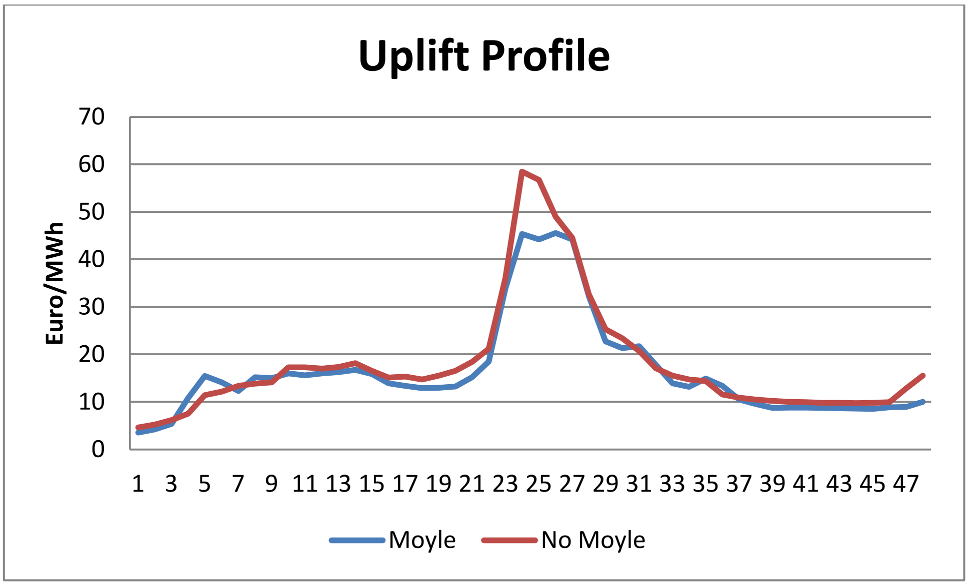
The analysis involved two separate STM runs, firstly with historical Moyle import and export quantities, and secondly without Moyle import/export quantities. The results of these runs reflect the change in dispatch schedules due to both commercial offer prices and plant dynamics, e.g. MSG, minimum

[9] Further details on STM are provided in Appendix 2.

on times etc. The baseload SMP outputs, with Moyle Interconnector, are comparable with the historical SMPs, and are shown in the table below.

€/MWh	Q1 13	Q2 13
STM SMP	73.22	62.79
Actual SMP	71.75	63.13

The resulting increase in Uplift over the period as a result of removing the Moyle Interconnector import quantities was €1.5/MWh[10] averaged over Q1 and Q2 2013. This is distributed heavily to peak periods, see graph below for the average Q1/Q2 2013 profile.



This profile was then applied to the above forecast 2013 load shape to determine an approximate benefit of ~€13.4M and ~€54.9M p.a. for Northern Ireland and All Island respectively.

[10] It should be noted that different average SPs were produced by each run due to the changes in marginal plant.

The estimated change in Uplift benefit was then combined with the change in SP benefit obtained at paragraph 4.1 above to calculate a revised £m implied benefit, based on a six month sample extrapolated to 12 months.

The combined financial benefit from reductions in SMP due to Moyle Interconnector import quantities in each year is presented in the table below.

Year	NI Benefit £m	AI Benefit £m
2012 from Aug	18.1	70.7
2013	40.9	163.0
2014 to July	22.8	92.2
Total	81.8	325.9

The absolute size of Shadow Price/Uplift impacts is similar over the update study period, even though the Moyle capacity was only 250 MW. This may be a slightly unexpected result, though the period does correspond with the introduction of Intra-Day trading on Interconnectors, which may have increased efficiency of use. Further, the first 250MW of capacity is likely to be of more value than incremental capacity.

6. Reserve Provision Valuation

It is understood that, at full Interconnector Import capacity, 75MW of Moyle capacity is utilised for providing system reserve, though this is subject to commercial flows, particularly when total capacity is reduced to 250MW. Energy-Link again used STM, in constrained mode, to assess the benefit (cost) to total system costs of the reserve element with and without the Interconnector reserve capacity being available. The analysis range was also August 2012 to July 2014 inclusive.

In practise this analysis was performed by increasing the total reserve requirement from thermal generation plant in winter[11] by ~50MW and ~75MW in summer.[12] This mirrors the approach taken in the previous study, and is prudent in assuming that commercial import flows in winter affect the level of reserve provided. A consequence of this approach is that some reserve could be provided by generators located in the Republic of Ireland, and this may therefore undervalue any locational value from Moyle to Northern Ireland. However, this approach should be conservative in its estimate of reserve value.

The change in constraint costs was measured as the difference between the Scheduled Production Costs (“SPC”) between two constrained STM runs, both including the remaining commercially available (i.e. to market participants) Interconnector capacity.

The analysis did not take into account the actual costs of reserves when called to run. So for example the cost of GB power purchased over the Interconnector may be higher (or lower) than the marginal costs of the

[11] April-October inclusive

[12] It was not possible with the historic input data set to schedule the required reserve levels in all periods, and certain constraints were relaxed on occasion.

alternative thermal plant which would provide running reserve. Depending on the frequency of use of reserves this differential cost could be material.

6.1 Reserve Valuation Results

The table below shows the change in Schedule Production Costs in each quarter with the additional reserve requirement.

	£ M[13]
Q1 13 SPC Cost Change	17.4
Q2 13 SPC Cost Change	14.2

It can be seen that the cumulative increase in system costs is ~ £32M over the six month period, implying an annual value of around £64M to system reserve costs. This compares with forecast Imperfections Charge[14] revenue (largely driven by constraint costs) of ~€142m for 2012/13. The above results must be taken with a degree of caution, with further details on the limitations of this methodology provided in Appendix 3. It would therefore appear prudent to use the lower quarterly value to estimate an annualised value of the provision of reserve, giving a value around £57m/annum during periods of high Interconnector availability.

[13] Converted from Euros at a notional exchange rate of 0.8 €/£
[14] SEM-12-045 (1) Appendix 1- Imperfections Revenue Requirement Submission 2012-2013

7. Appendix 1 - Stack Model Methodology

7.1 Data Sources

Due to the large amounts of data the Energy-Link Stack Model has been developed in SQL Server. It utilises a number of key SEMO public sources including in particular the following files:

PUB_D_InitialExPostMktSchDetail.xml
PUB_D_CODStandardGenUnits .xml
PUB_D_CODInterconnectorUnits .xml

With the advent of Intra-Day trading there are now three different COD files submitted instead of one, with each having 48 entries instead of one. The study used the first 6 PQ pair bids declared for the WD1 run utilising the submitted data for delivery hour 16 and delivery interval 1.

7.2 Marginal Plant Analysis

From the SEMO data Energy-Link established the total demand met from PPMG generators, including the interconnector in each half hour and then established a base half-hourly merit order and running regime. It is assumed that the PPMG generators were the source of the additional energy required for the no Interconnector analysis. Given the modest levels of curtailment of non-PPMG generators and generally running at their availabilities this is considered a fair assumption.

The Stack Model was run against these scheduled quantities allowing the PQ pairs to be called in order until demand was met. The resulting marginal plant effectively set the shadow price unless it was running within 1 MW of its MSG in which case the next highest marginal plant was considered.

7.3 Methodology for bringing on Additional Plant

From previous analysis of the Energy-Link STM Model runs undertaken for Uplift it was observed that medium to large size plants generally fill in the volume shortfalls, with chunky contributions that do not generally have units two or three shifting. Therefore as, in reality, some control and limits must be applied to plant start ups (even in a stack model) so the Stack Model allows the following:

- Plant that had run a significant proportion of the day could two shift and/or pulse energy for brief periods. Significant is defined as for more than 20 periods in a day, following calibration analysis

- Any running plant below full load could ramp up to full load

- The six cheapest (at base-load) medium sized or above plant could be started up

7.4 Methodology Limitations

The Stack approach only reflects technical limitations to a basic extent. No Start Costs or No Load Costs are included in the Shadow Price and No Load Costs are only included to determine the initial merit order. The impact of this approximation is lessened in practice as the plant which is observed to replace the Moyle Interconnector when it is unavailable is generally larger Gas and Coal plant. If Start Costs were included in the Stack Merit order then mid merit plant would be brought on much more and Shadow Prices would be overstated.

The Stack Model does not consider minimum on or off times or generator cycling limits. Plant is assumed to be able to meet its offered bid quantities instantaneously with no ramp limits.

Pumped Storage and Hydro operations are complex as both are energy limited and Pumped Storage depends on spare capacity and prices. The Interconnector usually runs at a high load factor. The Pumped Storage assumption is more open to debate and can result in some pumping being in the schedule even when plant is being started up for shorts periods. The impact of this simplification is lessened by there being no start costs charged to plant.

Therefore the resulting annual values should be regarded as ballpark, with more comprehensive methods such as Dynamic Scheduling being used to provide comparison benchmarks.

8. Appendix 2

Currently there are two major Irish market participants using Energy-Link's SEM price and plant dispatch forecasting application, "STM". The objective of STM is to simulate the operation of the Two Stage relaxed integer unit commitment approach adopted by the SEM MSP Software. The basic STM model can be upgraded to include detailed capacity payment revenues, dispatch forecasting, back testing and real time (short term) forecasting. To assist the ease of use of STM, Energy-Link has developed a parallel application, Scenario Manager. The objectives of this application are to facilitate loading and validation of inputs to STM, creation and launching of runs, and extraction of Shadow Price, Uplift, Costs, MSQs, DQs and Capacity Payment results.

9. Appendix 3 - Reserve Modelling Methodology

The quarters selected for analysis may not be fully representative of the whole period from August 2012 to July 2014 inclusive.

The methodology also lacks of any quantification of the cost differential of GB and SEM reserve running. This valuation also reflects the marginal costs of providing reserve rather than the average cost across the full requirement.

In addition, EWIC will provide at least an additional 26[15] MW of reserve, though may frequently exceed this subject to commercial flows.

Further analysis over longer period may give higher confidence in assessment of the value.

[15] OperationalConstraintsUpdateVersion1_13_May2014 states import to Ireland not to exceed 504MW, 2014EstimatedNTC.pdf, Eirgrid states GB-Ireland NTC 530MW. Implies at least 26MW reserve always available.