HISTORICAL APPROACHES TO ESTIMATING INTERCONNECTOR DE-RATING FACTORS

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Approved by:

Gareth Davies

Prepared by:

Anser A. Shakoor, Nicolas Meyer, James Cox

INTRODUCTION

- A GB capacity market was introduced in December 2014 and new and existing interconnectors will be eligible to participate in the 2015 auction for capacity in 2019/20.
- All capacity in the auction will have a de-rating factor applied.
- DECC has indicated that, in the new Capacity Market Rules to be published in March 2015, interconnectors may be guaranteed a minimum de-rating factor based on historical evidence to provide some degree of certainty.
- There is a risk that some approaches using historical data may not be 'appropriately conservative'.

Can a robust and transparent methodology based on historical data be constructed that would estimate conservative de-rating factors (DRFs) for existing and future interconnectors?

SPECIFIC QUESTIONS ASKED DURING THE STUDY

The over-arching question for the project has been informed by answering several narrower questions related to aspects of potential methodologies

Q1. What are the appropriate historical approaches and system parameters for calculating conservative de-rating factors of interconnectors in GB context?

Q2. What is the appropriate length of historical time series (i.e. number of years) and periods (within a year) to provide credible and conservative estimates of interconnector de-rating factors?

Q3. How do historical approaches differentiate in estimating conservative estimates of de-rating factors for existing and new interconnectors?

Q4. What are the market specific factors that can impact the historical de-rating factors of existing and new interconnectors?

Q5. How do historical approaches compare with forecast based approaches for assessing de-rating factors of interconnectors?

KEY MESSAGES

- There is not always a strong correlation between system margin, peak demand and peak prices. However, peak demand and capacity margins are highly correlated during the window (winter quarter) used to determine conventional generation de-rating factors (DRFs) under the Capacity Auction Rules.
- Considering a larger number of periods in a year will generally reduce historical DRFs.
- From the current position, selecting a longer time series (i.e. more years) lowers historical DRFs.
- Historical DRFs should be interconnector specific reflecting different conditions between markets.
- A common methodology across future and existing interconnectors (i.e. based on price differentials) would increase DRFs for existing interconnectors, where conditioning on 'efficient' behaviour is most conservative.
- If separate methodologies are applied to existing and new interconnectors, an interconnector should be considered 'new' until it has been operational for the full time series from which relevant periods are assessed.
- Historical DRFs for future interconnectors should have separate adjustments for technical availability and losses.
- A more conservative methodology to estimate historical DRFs makes it more likely that it will provide lower DRFs relative to a forecast based approach.

SUMMARY OF PROPOSED APPROACH AND IMPLIED DRF

Proposed approach

Relevant periods	Metrics	Metrics
• 50% of peak demand periods during winter quarter • Time series of last 6 years	**Existing interconnector:** Contribution to DRF only when price differentials are positive and interconnector is importing electricity to GB	**New interconnector:** Contribution to DRF when price differentials are positive

Historical de-rating factors of existing and new interconnectors

50% peak demand periods during each winter (7am – 7pm business days, 2008–2013) (2304 relevant period)

DRF calculations based on:	Interconnector from GB to:				
	France	Ireland	Netherlands[1]	Norway[1]	Belgium[1]
Price differential (+ve)	56%	17%	62%[2]	74%	58%
GB imports	36%	16%	79%[3]	-	-
Price differential (+ve) & GB imports	29%	2%	66%[3]	-	-

Interconnector to the Netherlands has a short history of performance and should be treated as a new interconnector.

NOTE: DRF of new interconnectors will need separate adjustment for technical reliability (including ramping) and a minimum positive price differential threshold to compensate transmission losses.

1 Interconnector losses set at zero as no analysis was conducted to assess them
2 DRF based on +ve price differential: 62% for April 2008 – April 2014 and 81% for April 2012 – April 2014 data
3 DRFs for the Netherlands interconnector are based on April 2012 – April 2014 data

CONTENTS

BACKGROUND

- The Department of Energy and Climate Change (DECC), under its Electricity Market Reform (EMR) programme, introduced a capacity market in December 2014.
- The Capacity Market is designed to ensure that security of electricity supply is maintained for GB consumers, while offering rewards for those capacity providers most economically able to contribute towards security of supply.
- DECC is keen to enable the participation of interconnected capacity in the 2015 capacity market auction (for delivery in 2019/20) and is examining how it might facilitate the participation of "interconnected capacity" via the existing (or new) electricity interconnectors that link the GB electricity system with those in neighbouring countries.
- Similar to electricity generation technologies, the participation of interconnectors in GB capacity market requires an assessment of the 'de-rating factor' for each individual interconnector.
- A 'de-rating factor' should reflect the percentage of time a given interconnector is expected to be importing electricity to GB when it is required to provide security of supply (i.e. during times of system stress on the GB system).
- National Grid are developing a range of de-rating factors as part of their Future Energy Scenario work using a forecast methodology, which the Secretary of State will be able to draw upon in making his/her decision on the amount of capacity to procure in 2015.
- In its response to the consultation on supplementary design proposals, DECC indicated the preference for a DRF based on historical evidence to act as a floor for interconnectors to provide certainty to investors.
- This project considers the risks associated with alternative methodologies to estimate DRFs of interconnectors on historical evidence.

DEFINITIONS

- **De-rating factor (DRF)**: We have defined the de-rating factor as the percentage of time when GB is expected to be importing electricity from an interconnector during identified system stress periods.
  - DRF represents the capacity credit of an interconnector. For example, a 90% de-rating factor of an interconnector will mean that 90% of the time it is available to provide electricity imports to GB from the connected market during GB system stress periods.
  - High DRF of an interconnector means that it can provide more percentage of its capacity to support GB security of supply during system stress periods
- **Capacity margin** in every hour is computed using the following expression:

  Capacity margin = (Total Available Capacity - Demand) / Demand

  (Where total available capacity is the sum of available (de-rated) thermal plant capacity and output of renewables in each hour)
- **Relevant periods**: These are the chosen periods within a year when the behaviour of an interconnector is examined for assessing its de-rating factor.
- **Existing vs. New interconnectors**: An interconnector that has operational data covering the full time series for which the relevant periods are defined is considered ‘existing’. All others are considered ‘new’.
- **Yearly data** in this analysis represents 12 months period from April to March in order to include one complete winter season in each year. For example, 2013 data will include April 2013 to March 2014 period.

DATA SOURCES

Calculating system margin for assessing DRF

Data	Period	Source
Demand	Apr 2008 – April 2014	National Grid UK
IC flows	Apr 2008 – April 2014	National Grid UK
Thermal availability	Apr 2008 – April 2014	ELEXON
Wind generation	April 2008 – Oct 2008	Anemos wind atlas
Wind generation	Nov 2008 – April 2014	ELEXON

Historical electricity price data sources

Market	Period	Source (power exchange)
Great Britain	Apr 2008 – Oct 2011	APX UK for within day prices and Heren day-ahead price index
Great Britain	Nov 2011 – April 2014	N2EX for day-ahead prices
France	Apr 2008 – April 2014	EPEX (former Powernext) for day-ahead prices
Netherlands	Apr 2008 – April 2014	APX Netherlands for day-ahead prices
Ireland	Apr 2008 – April 2014	SEMO Ireland for day-ahead prices
Norway	Apr 2008 – April 2014	Nordpool for day-ahead prices
Belgium	Apr 2008 – April 2014	Belpex for day-ahead prices

Other assumptions

- The currency conversion rates (for each day) are adopted from OANDA (http://www.oanda.com/currency/historical-rates/)

CONTENTS

OVERALL APPROACH

- We have assessed several methodologies for estimating DRFs using historical data that differ in terms of a few core 'building blocks'. The building blocks identify what time series of data is relevant to the calculation and how we interpret the extent to which the interconnector is contributing to security during that period.

- The main building blocks are:
  - How 'relevant periods' for analysis within a year are determined
    - The ranking characteristic – system margin, peak demand or peak prices
    - The window – annual or narrower (e.g. winter quarter)
    - The selection threshold – an absolute value (e.g. all periods with a system margin lower than X%), or a specific number of periods (e.g. top X% of peak demand periods)
  - The length of the time series (i.e. the number of years of data to be included).
  - The basis for determining a contribution to security of supply during the relevant periods – i.e. a positive price differential, observed imports or 'efficient behaviour' (when interconnector imports coincide with a positive price differential).

- In comparing alternative combinations of these building blocks, we have considered not only whether they deliver a conservative DRF, but how representative they are of likely behaviour in a stress situation, their statistical significance, their consistency (with existing rules and between interconnectors) and robustness.

PÖYRY

HISTORICAL BASED APPROACHES FOR IC DE–RATING FACTORS

Steps involved	Metrics for computing historical DRF		
1 Choice of criteria that represents GB system tightness	**Prices**	**Demand**	**System margin**
2 Define threshold for metric to identify periods when GB system was tight	Annual or winter period with: a). Top X (20/50/100) number or %age of periods b). Percentage or absolute threshold level (e.g. capacity margin <10%, demand > 90% of peak demand or Prices > £X/MWh)		
3 Choice of metric for IC de-rating calculation	**IC flows** IC flows suffer from poor historical coupling and is not relevant if ICs don't exist	**Price differentials** Price differentials have high data availability Relevance of historical prices to system stress condition is questionable	**System margin differential** Data to calculate system margin for all relevant markets could be an issue.
4 Count/average periods when metric favours GB	IC flows favour GB when flowing into GB during periods of system stress. Can either count periods or average volume flows	Lower prices in neighbouring countries than GB favours GB – presumption is that IC flows would follow price differentials	Less tight system would expect imports from connected countries
Example	If we examined the last 5 years of historical data. We select 20 hours each year that represent system stress conditions (e.g. based on top 20 tightest capacity margin periods/year). In those 100 (20 x 5) hours, price differential favours GB 65 times. Hence interconnector de-rating factor is 65%.		

CHOICE OF CONSERVATIVE METHODOLOGY BALANCES SEVERAL FACTORS

Choice of methodology involves trade-offs between:

- **Representative behaviour**
  - Capturing *how* an interconnector should respond in a period of stress and *what* the market signals look like in a period of system stress
- **Statistical significance**
  - Sufficient observations for meaningful estimation
- **Consistency**
  - Comparability with approach applied to other participating technologies in the auction to address claims of bias or discrimination
  - Applicability to existing and future interconnectors
- **Robustness**
  - Applicability to future periods
  - No over estimation of likely contribution

CONTENTS

DEFINING RELEVANT PERIODS AND CHOOSING THE METRIC FOR DETERMINING THE SECURITY CONTRIBUTION

- The de-rating factor is intended to reflect the likely contribution during periods of system stress, so in defining relevant periods, this is a key consideration.
- While system margin is a direct measure of system stress, it was noted that an alternative basis (peak demand) had been applied to this calculation for conventional generation. The initial analysis therefore considers when system tightness has been experienced and whether this is correlated with periods of peak demand and peak prices.
- If a consistent methodology with conventional generation is applied then there is a high correlation between periods of peak demand and low system margin, so the basis for choosing periods has less of an influence.
- Dependent on whether the interconnector is existing or proposed, we have one or two key data observations demonstrating (actual or potential) interconnector behaviour during relevant periods – prices (or, more explicitly, price differentials between markets) and/or flows. We look at these separately and in combination to consider the advantages and disadvantages of basing the security contribution on these metrics.
- Price differentials are the only basis for assessing new interconnectors, but observation of existing interconnectors shows that their past performance has not always been ‘efficient’ and alternative conditions can be placed on these assets.

DEFINITION OF RELEVANT PERIODS

The basis for choosing relevant periods affects accuracy of the DRF. It should be representative of periods of system stress in GB and be simple and transparent to calculate.

System margin is a direct measure of system stress (i.e. risk to security of supply) and other proxies (e.g. peak demand or peak prices) can be used if they are highly correlated with low system margin)

CORRELATION OF SYSTEM TIGHTNESS WITH PEAK DEMAND AND PEAK PRICES
(considering system stress periods across the entire year)

Number of times peak demand hours have coincided with tightest capacity margin

	Avg	2008	2009	2010	2011	2012	2013
Top 20 periods	5	8	1	11	6	0	4
Top 50 periods	8	22	0	11	0	8	7

Number of times peak price hours have coincided with tightest capacity margin hours

	Avg	2008	2009	2010	2011	2012	2013
Top 20 periods	1	0	0	2	0	0	3
Top 50 periods	3	1	3	7	0	0	9

Lack of coincidence of both peak demand and peak prices with tightest system margin periods (when chosen across the entire year) indicates that that these metrics are not most relevant to identify relevant periods for calculating historical DRF

CAPCITY MARGIN TO DEFINE RELEVANT PERIODS

Use of capacity margin and its threshold for defining relevant periods involves a trade-off between producing sufficient data and focussing on representative interconnector behaviour under stress

Issues in applying capacity margin to define relevant periods:

- **Capacity margin below x% for each year of applied time series:**
  - Limited number of low capacity margins periods in recent years means that it is not possible to draw statistically robust conclusions regarding IC de-rating factors
  - Uneven distribution of number of relevant periods across different years will mean that DRF will be influenced by specific conditions that prevailed in the specific year
- **Top X number of tightest capacity margin periods across all years:**
  - Though it provides a more uniform selection of data sample sizes however, larger data set (for statistical significance) risks capturing high number of periods when system capacity margin was less tight capturing periods of exports from GB
- **Simulate history to re-create system stress periods** (i.e. similar to forecast based approaches):
  - Requires detailed simulation models and detailed historical data (weather data, fuel prices, etc.) to recreate history

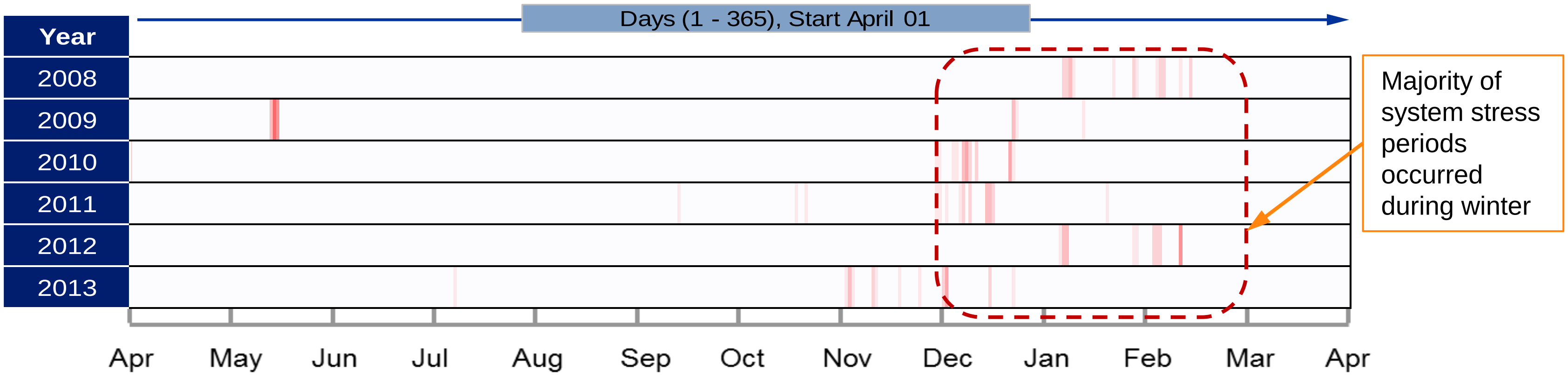
Conclusion:

- No satisfactory way to ensure a capacity margin threshold will be robust and representative; and
- Use of capacity margin to define relevant periods will be inconsistent with DRFs of conventional generation

CORRELATION OF SYSTEM TIGHTNESS WITH DEMAND DEPENDS ON THE TIME PERIOD CONSIDERED

Though some of the tightest system margins periods occur outside winter window, this is used as the basis for DRFs of conventional generation and our analysis shows a stronger correlation between tight system margins and peak demand

Historical occurrence of less than 15% system margin periods in GB



Percentage of time tightest capacity margin coincides with peak demand or peak price hours
(periods analysed during winter 7am–7pm business days, 2008–2013)

Peak demand periods	2008	2009	2010	2011	2012	2013	Average
5% (234)	54%	39%	62%	61%	25%	60%	50%
10% (460)	67%	59%	71%	75%	59%	67%	66%
25% (1152)	87%	73%	78%	79%	68%	82%	78%
50% (2304)	79%	80%	84%	89%	78%	88%	83%

Correlation between system tightness and peak demand increases if we constrain the period in the year we look at, and consider a larger number of periods

COMPARISON OF OPTIONS TO DEFINE RELEVANT PERIODS

Options		Benefits	Risks
Relevant periods basis	Capacity margins	• direct measure of system stress	• DRFs less conservative • requires generation availability, renewables output and demand data • not comparable with the DRF assessment of conventional technologies
	Peak demand	• easy to apply no significant calculations involved • comparable with the DRF assessment of conventional technologies	• imperfect proxy of system stress • low coincidence with tightest margins • misses stress periods when low demand
Period window within a year	Entire year	• captures system stress periods across the entire year including random outages or periods of low output of renewables	• DRFs less conservative • not comparable with the DRF assessment of conventional technologies
	Winter window	• comparable with the DRF assessment of conventional technologies • DRFs conservative	• exclude some of the tightest periods (e.g. random outages or periods of low output of renewables)
Number of periods within a year	Small (e.g. 20/50/100)	• focus on most stressful conditions	• DRFs less conservative • not comparable with the DRF assessment of conventional technologies • Insufficient observations to provide statistical significant results
	Large (e.g. 50% of total relevant periods)	• comparable with the DRF assessment of conventional technologies • DRFs conservative	• captures more of normal or slack conditions (less representative of system stress)
	Threshold based (CM < 5% or demand > 50GW)	• captures conditions of system stress	• risk of limited relevant periods with lack of significance of results • uneven distribution of periods across years • DRF biased by conditions of specific years • DRFs less conservative

Conclusions

If a consistent methodology with conventional generation is applied then there is a high correlation between periods of peak demand and low system margin, so the basis for choosing periods has less of an influence.

METRICS TO ASSESS CONTRIBUTION TO SECURITY DURING RELEVANT PERIODS – 1/2

Having identified relevant periods, the DRF of an interconnector can be determined by counting the periods when it was supporting GB security of supply

Metric defining interconnector support to GB security of supply

	Interconnector flows	Price differentials[1]
Key factors	- Interconnector flows suffer from poor historical coupling - Not applicable for new interconnectors	- Price differentials have high data availability - Important to capture the 'correct' price on which flow decisions are made - Applicable to both existing and new interconnector

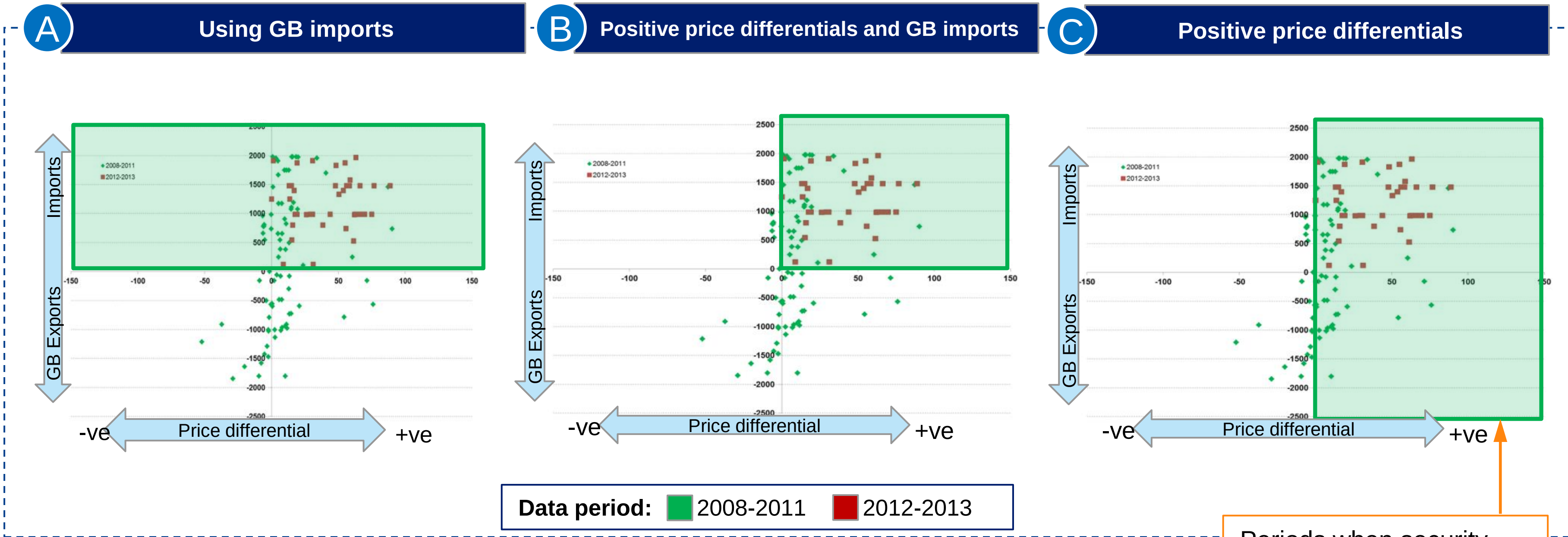
	A	B	C
Counting periods	When GB is importing or imports are greater than X% of IC capacity	When price differentials are +ve and GB importing or when imports greater than X% of IC capacity and price above a certain threshold	Counting periods when price differentials are positive or above a certain threshold (e.g. > €10/MWh)

The two metrics (or their combination) would result in different historical DRFs, reflecting the fact that markets have not necessarily been operating efficiently – a result that has been raised in other analysis of GB interconnectors[2,3].

1 Price differential = GB electricity price - electricity price in other market
2 Integrated Single Electricity Market (I-SEM), SEM Committee Decision on High Level Design Impact Assessment, September 2014
3 Benefits of an integrated European energy market, Booz & Company, July 2013

METRICS TO ASSESS CONTRIBUTION TO SECURITY DURING RELEVANT PERIODS – 2/2

With increase in efficiency in the operation of interconnectors in more recent years (2012-2013) we have seen convergence in the impact of metrics



Periods when security contribution is considered for DRF calculation

- The dots on the above charts show the response of GB-France interconnector to price differentials between markets the top 20 tightest capacity margin periods/year.
- Recent trend in interconnector flows (red dots on the charts) shows a stronger correlation between the direction of physical flows and price differentials with improvement in market efficiency.

CONTENTS

APPROPRIATE NUMBER OF PERIODS IN A YEAR AND LENGTH OF TIME SERIES

- One of the challenges for historical analysis is ensuring there are sufficient data points to deliver a statistically significant and unbiased result. We have investigated how varying the selection threshold for relevant periods can affect the DRFs, their statistical significance, the extent to which the observed behaviour is representative of times of system stress.
- We have looked at varying:
  - the level of absolute thresholds – e.g., 5% or 10% or 15% capacity margins;
  - The number of periods within a year – e.g. top 5%, 10%, 25%, 50% of periods; and
  - The length of the time series (within a constraint of 2008 to 2014)
- Use of high (50%) peak demand periods in winter quarter and longer time series (>=6 years) is consistent with the DRF assessment of conventional generation and provides more conservative estimates of DRFs.

Note: GB-France interconnector case is used for illustrations

CHOICE OF DATA SAMPLE SIZE

Expanding the number of 'relevant periods' in a year involves a trade-off between statistical significance and capturing representative interconnector behaviour under stress (as larger data set captures 'normal' or 'slack' conditions)

Average annual DRF based on different number of peak demand periods during winter (7am–7pm business days, 2008–2013)

DRF calculations based on:	Relevant periods			
	5% (230)	10% (460)	25% (1150)	50% (2304)
Price differential (+ve)	67%	68%	64%	56%
GB imports	35%	37%	36%	36%
Price differential (+ve) & GB Imports	32%	34%	31%	29%

Conclusions

- **Using a larger number of periods in a year :**
  - **generally reduces historical DRFs; and**
  - **provides statistically more significant results**

CHOICE OF THE LENGTH OF HISTORICAL TIME SERIES

A longer times series captures periods when performance of existing interconnectors was less efficient and leads to lower DRFs under all metrics of contribution*

DRF based on 50% peak demand periods during winter (7am–7pm business days, 2008–2013)

	Annual DRF						Average annual DRF		
	2008	2009	2010	2011	2012	2013	2008-2011	2012-2013	2008-2013
Number of periods	380	380	380	384	390	390	1524	780	2304
DRF calculations based on:									
Price differential (+ve)	50%	14%	55%	57%	79%	80%	44%	79%	56%
GB Imports	12%	1%	29%	32%	66%	76%	18%	71%	36%
Price differential (+ve) & GB Imports	6%	1%	20%	26%	55%	68%	13%	62%	29%

Interconnector flows have become more responsive to price differentials with market coupling in recent years

Average annual DRF significantly depends on which length of time series is considered

Applying combination of import flows and price differentials provides conservative estimates of DRF

Conclusion

Use of longer time series is preferred because:
- **it provides conservative estimates of DRFs; and**
- **is consistent with DRF assessment of conventional generation**

* We have used only six years of data while DRF assessment of conventional generation has considered 7 years time series.

CONTENTS

CHOICE OF METHODOLOGY FOR CONSISTENT AND CONSERVATIVE DRFs

- We have identified different sets of relevant periods within a year using both tightest margin and peak demand periods within winter quarter across the six year time series of data.
- During these sets of relevant periods DRFs are calculated by counting only those periods when GB is expected to be importing electricity from an interconnector.
- Following methodologies were applied to count the periods contributing to the DRF of an interconnectors.
  - For existing interconnectors we have calculated DRFs counting those periods when; a). price differentials were positive b). GB was importing c). when both price differentials were positive and GB was importing.
  - For new interconnectors counting only those periods when price differentials were positive is applicable. These DRFs need adjustment for technical availability and transmission losses which we have not analysed being out of scope of this work requiring technical expert input. However, impact of alternative price differential thresholds on DRFs was analysed.
  - Those interconnectors where operational data was less than the full length of analysed time series, are treated as 'new' interconnectors.
- Use of high (50%) peak demand periods in winter quarter and longer time series (>=6 years) in defining relevant periods provides conservative estimates if DRFs are calculated using:
  - positive price differentials and GB imports for existing interconnectors
  - positive price differentials for new interconnectors

COMPARISON OF METHODOLOGIES FOR EXISTING ICs

Comparison of DRFs based on peak demand and capacity margin show that:

- **Peak demand based DRFs are consistently more conservative than tightest capacity margin based DRFs for all data sizes of relevant periods**
- **DRFs based on price differential and GB imports are consistently lower across both approaches**
- **Increase in data sample size leads to convergent results between two approaches and lowers the calculated DRFs**

Average annual DRFs based on winter periods (7am–7pm business days, 2008–2013)

GB – FRANCE IC

Relevant period basis	DRF calculations based on:	Relevant periods			
		5% (230)	10% (460)	25% (1150)	50% (2304)
Peak demand	Price differential (+ve)	67%	68%	64%	56%
	GB Imports	35%	37%	36%	36%
	Price differential (+ve) & GB Imports	32%	34%	31%	29%
Tightest capacity margin	Price differential (+ve)	80%	71%	67%	59%
	GB Imports	49%	46%	44%	41%
	Price differential (+ve) & GB Imports	45%	41%	38%	33%

Conclusions

Conservative DRFs of existing interconnectors are found when:

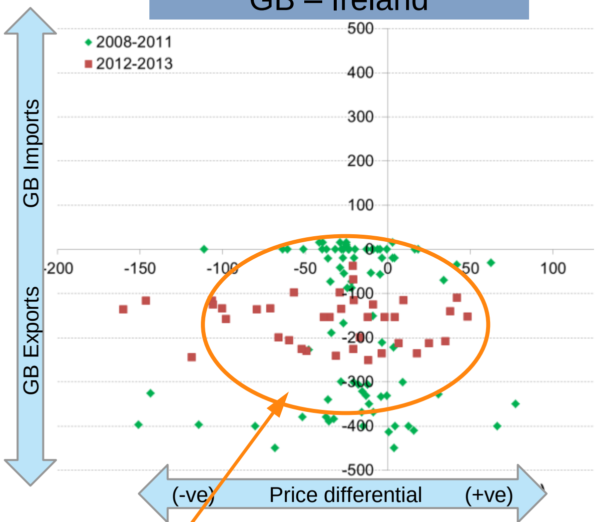
- **The relevant periods are identified using peak demand and over 50% of highest demand periods in winter window; and**
- **A capacity contribution is considered when flows are efficient i.e. GB imports when price differentials are positive.**

INTERCONNECTOR RESPONSE DURING GB STRESS PERIODS

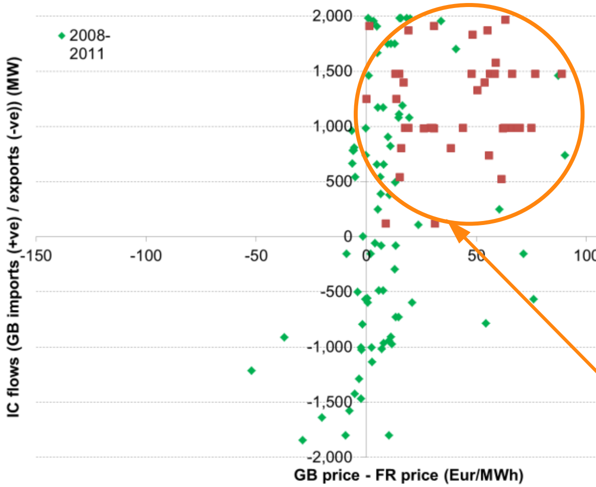
Interconnectors have responded differently in the past during GB system stress periods driven by characteristics of the connected markets. This requires separate assessment of DRF of each interconnector

Correlation of interconnector flows with price differentials
(Top 20 tightest capacity margin period, 2008-2013)

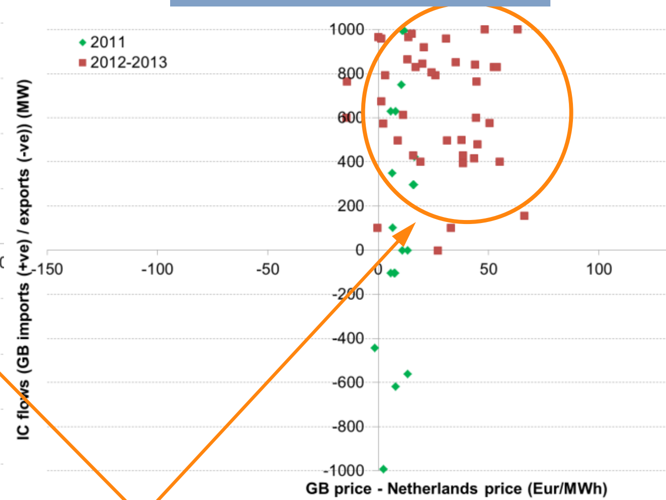
GB – Ireland



GB – France



GB – Netherlands



Data period: 2008-2011 2012-2013

Interconnector to Ireland has performed less efficiently and does not indicate reliable support to GB during stress conditions when market fundamentals support this conclusion.

A strong response to price differentials indicates that market efficiency is improving for GB-France and GB-Netherlands interconnectors
(note red dots showing 2012–2014 data).

COMPARISON OF METHODOLOGIES FOR FUTURE ICs

DRFs calculated across peak demand are consistently more conservative than those on tightest capacity margin

Price differential based calculation of DRF is the only option as approaches using flows (i.e. imports) are not applicable to future interconnectors. However, DRFs will need to be adjusted for technical reliability including ramping and a minimum positive price differential threshold to compensate transmission losses (These are not included here and need to be determined by technical experts).

Average annual DRFs using positive price differential based
based on winter periods (7am–7pm business days, 2008–2013)

	Relevant period basis	Relevant period			
		5% (230)	10% (460)	25% (1150)	50% (2304)
Norway	Peak demand	85%	84%	79%	74%
	Tightest capacity margin	93%	87%	82%	77%
Belgium	Peak demand	76%	79%	69%	58%
	Tightest capacity margin	81%	76%	70%	59%

- Higher historical DRF of interconnector to Norway is higher than Belgium due to consistently higher price differentials between GB and Norway driven by hydro based low electricity prices in Norway
- Increase in data sample size increases the conservativeness of DRFs for both interconnectors

Conclusions

Conservative DRFs of future interconnectors are found when:

- **The relevant periods are identified using peak demand and over 50% of highest demand periods in winter window; and**
- **A capacity contribution is considered when price differentials are positive**

These DRFs will need to be adjusted to account for technical reliability (including ramping) and a minimum positive price differential threshold to compensate interconnector transmission losses.

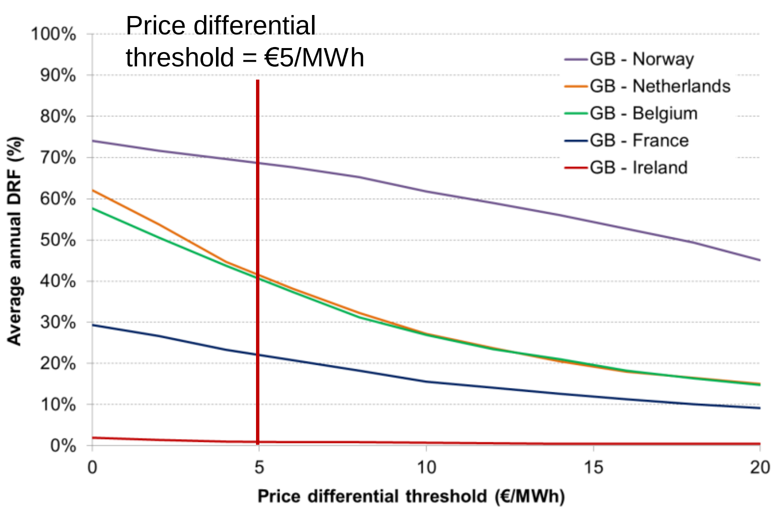
IMPACT OF ALTERNATIVE PRICE DIFFERENTIAL THRESHOLD ON DRFs

A positive price differential[1] threshold reflects a minimum level of price difference below which arbitrage across the interconnector will cease. This reflects the costs associated with the decision to export across the interconnector rather than supply the home market.

A minimum justifiable price differential level could be set to compensate expected transmission losses across interconnectors. This would be interconnector specific (e.g. we would expect losses on a Norwegian interconnector to be much greater than those on a French interconnector because of the longer distance).

Average annual DRFs based on winter periods (7am–7pm business days, 2008–2013)

- **Applying positive price differential and GB imports for existing interconnectors; and**
- **Applying positive price differential for new interconnectors (including GB–Netherlands)**



- Setting a minimum positive price differential threshold will exclude those periods when price differential is small resulting in more conservative estimate of DRFs.
- DRF for interconnectors to the Netherlands and Belgium shows a rapid drop with increase in price differential threshold due to smaller price differences between these markets and GB.
- Historical DRF of interconnector to Norway shows relatively less rapid drop with increase in price differential threshold as price differential between GB and Norway has remained significantly large.

Conclusions

A minimum positive price differential threshold, that is justifiable on economic grounds e.g. to compensate transmission losses across the interconnector, would be required and leads to more conservative estimates of new interconnectors.

[1] Price differential = GB electricity price - electricity price in other market

WHEN IS AN INTERCONNECTOR CONSIDERED 'NEW'

Shorter historical time series of the physical operation of the Netherlands IC means that treating it as an existing IC will be inconsistent with other existing ICs

If GB-Netherlands interconnector is treated as an existing interconnector using price differentials and GB imports:

- Its DRF will be higher based on more recent period of efficient operation of interconnectors which creates a bias particularly, for GB-France interconnector.

On the other hand, if all existing interconnectors are treated as new*****, it will:

- not capture the actual (physical) performance of interconnector during relevant periods;
- not capture the interactions between interconnectors; and
- lead to less conservative estimates of existing interconnectors.

DRF based on 50% peak demand periods during winter 7am–7pm business days, 2008–2013)

	Annual DRF						Average annual DRF	
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2012-2013**	**2008-2013**
Number of periods	380	380	380	384	390	390	780	2304
DRF calculations based on:								
Price differential (+ve)	54%	31%	58%	68%	78%	84%	81%	62%
GB Imports				37%	71%	87%	79%	
Price differential (+ve) & GB Imports				31%	57%	75%	66%	

Unreliable data & ramping period

A consistent approach will give conservative DRF

Conclusions

Shorter historical time series of the physical operation of the Netherlands IC requires that it should be treated as a new IC, thus avoiding inconsistencies and providing conservative DRF

***** This assumes the DRFs will be based on price differentials and specific adjustment for technical reliability including ramping and transmission losses.

CONTENTS

COMPARISON OF POTENTIAL HISTORICAL APPROACHES

- Potential historical approaches have been examined in this analysis in terms of their:
  - Robustness;
  - Transparency;
  - Applicability to existing and future interconnectors;
  - Ease of application (including data availability).
  - Representative behaviour of IC during GB stress conditions
  - Estimation of conservative DRFs;
  - Consistency with DRF assessment of conventional generation.

- Methodologies to estimate conservative and consistent DRFs of both existing and new interconnectors are proposed along with their associated benefits and risks.

OPTIONS TO IDENTIFY RELEVANT PERIODS

Benefits and risks of alternative options to identify relevant periods are provided below

Options		Benefits	Risks
Relevant periods basis	Capacity margins	• direct measure of system stress	• DRFs less conservative • requires generation availability, renewables output and demand data • not comparable with the DRF assessment of conventional technologies
	Peak demand	• easy to apply no significant calculations involved • comparable with the DRF assessment of conventional technologies	• imperfect proxy of system stress • low coincidence with tightest margins • misses stress periods when low demand
Period window within a year	Entire year	• captures system stress periods across the entire year including random outages or periods of low output of renewables	• DRFs less conservative • not comparable with the DRF assessment of conventional technologies
	Winter window	• comparable with the DRF assessment of conventional technologies • DRFs conservative	• exclude some of the tightest periods (e.g. random outages or periods of low output of renewables)
Number of periods within a year	Small (e.g. 20/50/100)	• focus on most stressful conditions	• DRFs less conservative • not comparable with the DRF assessment of conventional technologies • Insufficient observations to provide statistical significant results
	Large (e.g. 50% of total relevant periods)	• comparable with the DRF assessment of conventional technologies • DRFs conservative	• captures more of normal or slack conditions (less representative of system stress)
	Threshold based (CM < 5% or demand > 50GW)	• captures conditions of system stress	• risk of limited relevant periods with lack of significance of results • uneven distribution of periods across years • DRF biased by conditions of specific years • DRFs less conservative
Length of time series	Short (e.g. <3 years)	• captures recent efficient history of ICs	• DRFs less conservative
	Long (e.g. >= 6 years)	• DRFs conservative	• captures inefficient operation periods • inconsistency for different existing interconnectors

OPTIONS TO ASSESS INTERCONNECTOR CONTRIBUTION TO SECURITY OF SUPPLY DURING RELEVANT PERIODS

Benefits and risks of alternative options to assess interconnector contribution to security of supply within defined relevant periods are provided below

Options	Benefits	Risks
Positive price differentials	• applicable to both existing and new ICs • reflects efficient response of an IC	• DRFs less conservative for existing ICs as also counts periods when GB exports while price differentials +ve • misses technical reliability of ICs and impact of transmission losses so overestimates DRFs
GB imports	• reflects actual contribution to security of supply • captures the technical reliability of ICs • captures the interactions between ICs	• not applicable to new ICs • risk of consistency if time series varies for existing ICs • misses recent efficiency improvements
Positive price differentials and GB imports	• reflects the expected response of an IC (i.e. efficient operation) • captures the technical reliability • leads to more conservative DRFs particularly for longer time series • captures the interactions between ICs	• not applicable to new ICs
Positive price differential with thresholds >€X/MWh	• compensates transmission losses across the IC • leads to more conservative DRFs • applicable to both existing and new ICs • reflects efficient response of an IC	• DRFs less conservative for existing ICs as also counts periods when GB exports while price differentials +ve • misses technical reliability of ICs

PROPOSED HISTORICAL APPROACH AND IMPLIED DRF

Proposed approach

Relevant periods

- 50% of peak demand periods during winter quarter
- Time series of last 6 years

Metrics

Existing interconnector: Contribution to DRF only when price differentials are positive and interconnector is importing electricity to GB

Metrics

New interconnector: Contribution to DRF when price differentials are positive

Historical de-rating factors of existing and new interconnectors

50% peak demand periods during each winter (7am – 7pm business days, 2008–2013) (2304 relevant period)

DRF calculations based on:	Interconnector from GB to:				
	France	Ireland	Netherlands[1]	Norway[1]	Belgium[1]
Price differential (+ve)	56%	17%	62%[2]	74%	58%
GB imports	36%	16%	79%[3]	-	-
Price differential (+ve) & GB imports	29%	2%	66%[3]	-	-

Interconnector to the Netherlands has a short history of performance and should be treated as a new interconnector.

NOTE: DRF of new interconnectors will need separate adjustment for technical reliability (including ramping) and a minimum positive price differential threshold to compensate transmission losses.

1 Interconnector losses set at zero as no analysis was conducted to assess them
2 DRF based on +ve price differential: 62% for April 2008 – April 2014 and 81% for April 2012 – April 2014 data
3 DRFs for the Netherlands interconnector are based on April 2012 – April 2014 data

PROS AND CONS OF PROPOSED APPROACH FOR EXISTING ICs

Using 50% peak demand periods in winter quarter (for 6 or more years of time series) and applying imports and price differentials to determine the DRF of existing interconnectors has several benefits:

- it provides consistency with DRF assessment of conventional generation in the Capacity Auction market;
- it represents the periods when the interconnectors were operating efficiently and actually contributing to security rather than relying on an assumption of how we expect them to operate (i.e. considering price differentials);
- it incorporates technical availability for existing interconnectors;
- it implicitly captures the interactions between interconnectors (i.e. if the interconnectors are competing at the margin to supply GB) and of system tightness in GB and the connected markets;
- it implicitly includes physical performance therefore, it creates a simple argument for using a different approach for new interconnectors;
- in our analysis, the DRFs thus calculated would be lower for the existing interconnectors.

Few issues related to the approach include:

- the question of consistency between existing interconnectors if the time series of physical flow data varies. Therefore, interconnector to the Netherlands is proposed to be treated as a new interconnector;
- historical DRFs may rise over time as efficiency of interconnectors improves and this may lead to some risk of very high historical DRFs in subsequent years.

PROS AND CONS OF PROPOSED APPROACH FOR NEW ICs

Using 50% peak demand periods in winter quarter (for 6 or more years of time series) and applying price differentials to determine the DRF of new interconnectors has following benefits:

- it provides consistency with DRF assessment of conventional generation in the Capacity Auction market;
- it reflects expected efficient response of new interconnectors representing market coupling efforts;
- in our analysis, the DRFs thus calculated would be lower for the new interconnectors.

Few issues related to the approach include:

- it does not capture the interactions between interconnectors and of system tightness in GB and the connected markets;
- it does not incorporate the technical availability and ramping of new interconnectors requiring adjustment to DRFs; and
- DRFs will also need adjustment i.e. a minimum positive price differential threshold to reflect transmission losses across the interconnector.

CONTENTS

IMPACT OF MARKET CHANGES ON IC OPERATION RELATIVE TO HISTORICAL DRFs

- The DRFs calculated are based on past performance and past market conditions. We know that there will be material changes to both GB and interconnected markets between now and 2019/20 (the date the next capacity auction is tendering capacity for) and so have qualitatively assessed the key market factors which would impact the future behaviour of interconnectors.
- This is important as the historical DRF is expected to be a floor, with an undefined forecast approach anticipated to be the applied DRF for the auction. If the historical DRF is too high, then this could distort the auction results and affect security of supply.
- We have focussed on whether market factors are likely to increase or decrease price differentials from where they are now and whether, given the historical methodology applied, the historical DRFs would remain conservative.

KEY MARKET FACTORS AFFECTING FUTURE IC BEHAVIOUR

We have identified following key factors which would impact the behaviour of interconnector connected to specific markets

Interconnector to:	Key factors
Ireland	• Market coupling (intra-day and day-ahead) • GB cash-out reforms and Irish market (I-SEM) design development • Growth in wind generation in both countries
France	• Market coupling (intra-day) and increased intra-day trading • GB cash-out reforms • Growth in renewables
Netherlands	• Change in generation mix in the Netherlands • Interactions between interconnectors • GB cash-out reforms
Norway	• Interactions between new and existing interconnectors • GB capacity mechanism
Belgium	• Outcome of the ongoing system tightness situation in Belgium due to nuclear plant failures and planned phased decommissioning • Decisions regarding capacity tenders

Note: In next slides, for each relevant market we have assessed the impact of individual factors in terms of their significance and likely direction of impact. However, assessing the magnitude and direction of the combined effect of all market factors on the future behaviour of an interconnector is complex to be assessed qualitatively.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF
GB–FRANCE INTERCONNECTOR

Market factors	Significance	Applicable to		Impact on hist. DRF
		GB	France	
Cash-out reforms	High	✓		▲
Increased intra-day trading	High	✓	✓	▲
Change in generation mix	High	✓	✓	?
Introduction of day-ahead market coupling	Medium	✓	✓	▲
Uncertainty in the level and profile of future demand	Medium	✓	✓	▼
Capacity mechanism	Low	✓	✓	▼
Interactions between new and other/existing interconnectors	Low	✓	✓	▼
Other factors: - GB time zone changes, - CO2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low	✓	✓	?

Notes:
- Significance of a market factor means that its likelihood and impact is strong (high) or not (low/no).
- Direction of impact shows that a given market factor will push upwards or downwards a DRF of an interconnector relative to its historical DRF.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–IRELAND INTERCONNECTOR

Market factors	Significance	Applicable to		Impact on hist. DRF
		GB	Ireland	
Cash-out reforms	High	✓		▲
Intra-day market coupling	High	✓	✓	▲
Capacity mechanism	High	✓	✓	▲
Change in generation mix	Medium	✓	✓	?
Uncertainty in the level and profile of future demand	Medium	✓	✓	?
Day-ahead market coupling	Low	✓	✓	▲
Interactions between new and other/existing interconnectors	Low	✓	✓	▼
Other factors: - Changes in market rules e.g. I-SEM development - GB time zone changes, - CO_2 price differentials, - coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Unknown	✓	✓	?

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NETHERLANDS INTERCONNECTOR

Market factors	Significance	Applicable to		Impact on hist. DRF
		GB	Netherlands	
Change in generation mix	Medium	✓	✓	▼
Interactions between new and other/existing interconnectors	Medium	✓	✓	▼
Cash-out reforms	Low	✓		▲
Intra-day market coupling	Low	✓	✓	▲
Capacity mechanism	Low	✓		▼
Day-ahead market coupling	Low/no	✓	✓	▲
Uncertainty in level and profile of future demand	Low	✓	✓	▼
Other factors: - GB time zone changes, - CO_2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low	✓	✓	?

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NORWAY INTERCONNECTOR

Market factors	Significance	Applicable to		Impact on hist. DRF
		GB	Norway	
Interactions between new and other/existing interconnectors	Medium	✓	✓	▼
Capacity mechanism	Low	✓	✓	▼
Cash-out reforms	Low/no	✓		▲
Intra-day market coupling	Low/no	✓	✓	▲
Day-ahead market coupling	Low/no	✓	✓	▲
Change in generation mix	Low	✓	✓	?
Uncertainty in level and profile of future demand	Low/no	✓	✓	▼
Other factors: - GB time zone changes, - CO2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low/no	✓	✓	?

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–BELGIUM INTERCONNECTOR

Market factors	Significance	Applicable to		Impact on hist. DRF
		GB	Norway	
Change in generation mix	High	✓	✓	?
Interactions between new and other/existing interconnectors	Medium/High	✓	✓	?
Cash-out reforms	Low	✓		?
Intra-day market coupling	Low	✓	✓	▲
Capacity mechanism	Low	✓	✓	?
Day-ahead market coupling	Low/no	✓	✓	▲
Uncertainty in level and profile of future demand	Low/no	✓	✓	▼
Other factors: - GB time zone changes, - CO2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low/no	✓	✓	?

INDICATIVE PERIOD OF VALIDITY OF HISTORICAL DRF

Historical DRF for Norway is expected to be less affected due to sustained low electricity prices from hydro generation in Norway

GB interconnector to	Potential robustness		Key impacting market drivers
	To 2019/20	Beyond 2020	
Ireland	Low	Very low	Changes in market rules (both SEM and I-SEM in future), market coupling and new network codes will potentially change interconnector flows to/from Ireland. Wind development is projected to grow further in Ireland and GB which would also affect future flows.
France	Low	Very low	New capacity market by 2018 aimed at peak demand management in France. New interconnectors (IFA2 and ElecLink) likely. Growth in solar in south France and wind generally.
Netherlands	Low	Very low	Potential change in the current over capacity status of the Netherlands with scheduled coal plant closures and potential gas plant mothballing/closures by 2020 due to unfavourable plant economics.
Norway	Medium	Low	Norwegian system dominated by cheap hydro and prices systematically lower than GB. This is likely to continue into the future, so historical DRF estimates likely to be reasonable until 2020. Future interconnectors to/from Norway can impact historical DRFs
Belgium	Low	Very low	Currently Belgium system is very tight due to nuclear outages and strategic reserve has been arranged to ensure its security of supply. Price differential relative to GB can change depending on the market tightness condition.

Robustness: (Medium Low Very Low)

CONTENTS

COMPARISON OF HISTORICAL APPROACHES WITH FORECAST BASED APPROACHES

- We have briefly compared the advantages and disadvantages of forecast-based approaches with historical approaches. This is not intended to be a comprehensive assessment but highlights the different risks or issues with each.
- Forecast based DRFs will be highly dependent on the input assumptions used, such as:
  - the assumed market design (e.g. capacity mechanisms, market couplings etc.;
  - capacity mix in GB and connected markets;
  - Fuel and carbon prices; and
  - Level and timing of future interconnectors to/from commenced markets.
- Considering dependence of forecast DRFs on input assumptions, it will be uncertain that historical DRFs will always be more conservative compared to forecast based DRFs. To illustrate, we present some comparisons of forecast DRFs from previous studies for other purposes with our historical DRFs.
- Though these are generally higher than the historical DRFs, it should be noted that (a) conditions may have changed since these studies were undertaken; and (b) we do not know the methodology National Grid is proposing for its forecast DRF we understand it will focus on simulating stress situations not normal market conditions and this may deliver very different results.

COMPARISON OF DRFs BASED ON HISTORICAL AND FORECAST BASED APPROACHES

Below we compare historical DRFs with forecast based DRF from a study[1] conducted by Pöyry two years ago. Expectations regarding future market design and system characteristics of relevant markets might have evolved differently since the study was conducted.

Interconnector to	Forecast based DRF for 2025 (15 tightest periods)	Historical DRF (50% i.e. 2304 peak winter demand periods across 2008–2013)
France[2]	44%	29%
Ireland[2]	23%	2%
Netherlands[3]	70%	62%
Norway[3]	96%	74%
Belgium[3]	55%	58%

A more conservative methodology to estimate historical DRFs makes it more likely that it will provide lower DRFs relative to a forecast based approach

Hist. DRFs of new interconnectors require adjustment for technical reliability and minimum price differential threshold to compensate interconnector losses.

1 Impact of EMR on interconnection, A Pöyry report to DECC (Dec. 2012), (DRFs from High interconnector scenario)

2 Historical DRFs of France and Ireland interconnectors are calculated applying positive price differential and GB imports

3 Historical DRFs for the Netherlands, Norway and Belgium interconnectors are based on positive price differential

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COMPARISON OF HISTORICAL APPROACHES WITH FORECAST BASED APPROACHES FOR ASSESSING DRF OF INTERCONNECTORS

The trade-off between historical and forecast approaches revolves around simplicity and transparency (historical) vs. accuracy (forecast)

Area	Historical	Forecast based	Implied preferred approach
Data required	Relatively low amount of data needed	Amount of data varies, but more accurate approaches require a lot of data	Historical
Transparency of assumptions	Can be calculated by industry participants	Calculation may require complex model	Historical
Price elasticity of interconnectors	Only accounted for when interconnectors existed (And of same size)	Approaches allow future interconnectors to be added	Forecast based
Market design	Only existing market designs are incorporated	Different market designs in different countries can be included such as capacity markets or cash-out reform	Forecast based
Lack of data for tight periods	Sample size may be too small to be valid, or not consider tight periods to ensure large enough sample	No constraint on tight periods as can be simulated	Forecast based
Market coupling impact	Historically coupling of some interconnectors has been poor	Perfect market coupling can be modelled (may suffer from over-optimisation)	Forecast based
Plant mix and supply/.demand balance	Dependent on historical mix which may be entirely unrepresentative of future	Forecasts can represent expected pathways and policy targets	Forecast based
Increase in intermittent generation	Does not capture the impact of wind or solar on prices and flows as well as changes in the coincidence of system stress periods between markets	Forecasts can include realistic amounts of wind or solar and their subsequent impacts on prices and flows	Forecast based

Conclusion

Forecast approaches will lead to a more accurate answer, at the expense of opaque and complex assumptions and potentially high computation time

ARE HISTORICAL APPROACHES MORE OR LESS CONSERVATIVE THEN FORECAST BASED APPROACHES?

Below we list the key differences between the methodologies and the likely direction of impact

Bias	Detail	Impact[1]	Comment
Few historical periods of system tightness	In last 8 years there have been few tight periods in GB market. Thus to get a statistically significant sample size, one must include non-tight periods. This leads to conservative bias as flows driven by factors other than system tightness.	↓ Reduces DRF	Forecast based approach allows a tighter system in GB to be tested, avoiding this problem
Poor historical interconnector coupling	Has meant that flows often do not follow price differentials or vice versa. Thus tight periods in GB have exports despite price signals for imports.	↓ Reduces DRF	Forecast based approach guarantees price coupling through modelling
Cash-out reform	Proposals in GB would make prices more 'marginal' (spiky) and should feed into market prices. Since historical prices has been less spiky, implies that historical approaches will underestimate future de-rating factors.	↓ Reduces DRF	Impact of cash-out arrangements will always be subjective
Price elasticity of interconnection	When countries connected together, prices likely to converge. Thus historical price differentials, where no interconnector existed, can overstate the DRF of new interconnector.	↑ Increases DRF	Forecast based approach allows interconnectors to be explicitly included and hence tested
Historically low wind/solar	Tight periods historically mainly driven by demand, and future tightness driven by demand and wind. Thus impact depends on shift in the occurrence of system stress periods and their correlation with connected market and is unknown.	? Unknown	Forecast based approach allows capturing of the changes in timing of occurrence of system stress periods
Capacity market	No capacity market in GB historically, nor in surrounding countries where planned (e.g. France). GB capacity market should decrease price signals as less need for scarcity value. However, same effect should be observed in France.	? Unknown	Forecast based approach can test the implications of capacity market

Conclusion → **On balance, historical approaches based on large number of peak demand periods are likely to provide conservative de-rating factors relative to a forecast based approach that uses tightest system margin periods**

1 Impact as 'Reduces DRF' means that historical approach is likely to underestimate the DRF

PROS & CONS OF KEY FORECAST BASED APPROACHES

There is a trade-off in the approaches between high complexity, long computational time and large data requirements, vs. accuracy

Approach	Description	Data requirements	Computational time	Can handle multiple zones	Accounts for impact of Ics on each other	Energy constraints (pumped storage, hydro, DSR etc.)	Market design (implicit/explicit price caps)	Summary	Comments
Unit commitment model	Generating hourly interconnector flows and prices using a supply/demand model	◔	◑	●	●	●	●	◕ 4.2	A robust approach that is computationally and data intensive
Unit commitment model with identical LOLE	As above, but ensuring that all countries have an equally tight system	◑	◔	●	●	●	●	◕ 4.2	Probably the best approach, though most time consusming
Simple system tightness calculation	Calculating future hourly system tightness, based on expectations of installed capacity, and hourly demand, wind, solar and plant	◕	◕	◑	◔	◔	◔	◑ 2.8	Probably consistently overstates de-rating factors
Optimised flow approach	As above, but model optimises the capacity contribution of interconnectors to ensure that they 'point' in the direction most needed.	◕	◕	◕	◑	◔	◔	◑ 3.2	Probably slightly overstates de-rating factors due to lack of accounting for energy storage
Hybrid price approach (regression)	Forecasting future prices from a regession approach, and then examining differentials	◑	◑	◔	◔	○	◔	◔ 2.2	Not clear a regression based approach is valid 4 years into future
Hybrid price approach (UC model)	Forecasting future prices from a Unit Commitment model, and then examining price differentials	◔	◔	◑	◔	◑	◔	◔ 2.3	Not clear why you would run a UC model and ignoring the IC flows that result
●	More advantageous								
○	Less advantageous								

Conclusion

Given the importance of this analysis, and the infrequency with which it must be performed (once a year), we suggest that the more computationally intensive approaches (unit commitment) would be more robust

CONTENTS

KEY MESSAGES

- There is not always a strong correlation between system margin, peak demand and peak prices. However, peak demand and capacity margins are highly correlated during the window (winter quarter) used to determine conventional generation de-rating factors (DRFs) under the Capacity Auction Rules.
- Considering a larger number of periods in a year will generally reduce historical DRFs.
- From the current position, selecting a longer time series (i.e. more years) lowers historical DRFs.
- Historical DRFs should be interconnector specific reflecting different conditions between markets.
- A common methodology across future and existing interconnectors (i.e. based on price differentials) would increase DRFs for existing interconnectors, where conditioning on ‘efficient’ behaviour is most conservative.
- If separate methodologies are applied to existing and new interconnectors, an interconnector should be considered ‘new’ until it has been operational for the full time series from which relevant periods are assessed.
- Historical DRFs for future interconnectors should have separate adjustments for technical availability and losses.
- A more conservative methodology to estimate historical DRFs makes it more likely that it will provide lower DRFs relative to a forecast based approach.

PROPOSED HISTORICAL APPROACH AND IMPLIED DRF

Proposed approach

Relevant periods	Metrics	Metrics
• 50% of peak demand periods during winter quarter • Time series of last 6 years	**Existing interconnector:** Contribution to DRF only when price differentials are positive and interconnector is importing electricity to GB	**New interconnector:** Contribution to DRF when price differentials are positive

Historical de-rating factors of existing and new interconnectors

50% peak demand periods during each winter (7am – 7pm business days, 2008–2013) – (2304 relevant period)

DRF calculations based on:	Interconnector from GB to:				
	France	Ireland	Netherlands[1]	Norway[1]	Belgium[1]
Price differential (+ve)	56%	17%	62%[2]	74%	58%
GB imports	36%	16%	79%[3]	-	-
Price differential (+ve) & GB imports	29%	2%	66%[3]	-	-

Interconnector to the Netherlands has a short history of performance and should be treated as a new interconnector.

NOTE: DRF of new interconnectors will need separate adjustment for technical reliability (including ramping) and a minimum positive price differential threshold to compensate transmission losses.

1 Interconnector losses set at zero as no analysis was conducted to assess them
2 DRF based on +ve price differential: 62% for April 2008 – April 2014 and 81% for April 2012 – April 2014 data
3 DRFs for the Netherlands interconnector are based on April 2012 – April 2014 data

Annex

- **Winter peak demand based historical DRFs for Ireland and the Netherlands**
- Annual tightest capacity margin based DRF
- Impact of market factors on historical DRF – detailed qualitative analysis

HISTORICAL DRF

(based on peak demand periods in winter quarter)

Contribution of Irish interconnector to GB security of supply has been very low and no significant variation in its DRF is found across all the analysed years

DRF based on 50% peak demand periods during winter 7am–7pm business days, 2008–2013)

	Annual DRF						Average annual DRF		
	2008	2009	2010	2011	2012	2013	2008-2011	2012-2013	2008-2013
Number of periods	380	380	380	384	390	390	1524	780	2304
DRF calculations based on:									
Price differential (+ve)	21%	9%	29%	12%	14%	17%	18%	16%	17%
GB Imports	17%	0%	0%	57%	6%	17%	19%	11%	16%
Price differential (+ve) & GB Imports	4%	0%	0%	4%	0%	3%	2%	2%	2%

No significant change in average annual DRF i.e. interconnector behaviour is observed during the last 6 years.

COMPARISON OF DRFs BASED ON HIGHEST DEMAND AND TIGHTEST CAPACITY MARGIN PERIODS

Identification of system stress periods based on demand or capacity margins give similar i.e. very low DRF of GB-Ireland interconnector

Average annual DRFs based on winter periods (7am–7pm business days, 2008–2013)

Basis for relevant periods identified	DRF calculations based on:	Relevant periods			
		5% (230)	10% (460)	25% (1150)	50% (2304)
Peak demand	Price differential (+ve)	19%	17%	17%	17%
	GB Imports	12%	12%	13%	16%
	Price differential (+ve) & GB Imports	1%	2%	1%	2%
Capacity margin	Price differential (+ve)	22%	21%	19%	18%
	GB Imports	16%	13%	15%	16%
	Price differential (+ve) & GB Imports	2%	1%	2%	2%

GB – NETHERLANDS

COMPARISON OF DRFs BASED ON HIGHEST DEMAND AND TIGHTEST CAPACITY MARGIN PERIODS

Identification of system stress periods based on demand or capacity margins give more similar DRFs with increase in number of periods considered per year

The DRFs shown in below table are based on two years of data, hence less conservative relative to DRFs based on longer time series

Average annual DRFs based on winter periods (7am–7pm business days, April 2012–April2014)

Basis for relevant periods	DRF calculations based on:	Relevant periods			
		5% (230)	10% (460)	25% (1150)	50% (2304)
Demand	Price differential (+ve)*	86%	91%	85%	81%
	GB Imports	70%	81%	80%	79%
	Price differential (+ve) & GB Imports	63%	75%	70%	66%
Capacity margin	Price differential (+ve)*	89%	87%	88%	82%
	GB Imports	85%	86%	84%	80%
	Price differential (+ve) & GB Imports	75%	76%	75%	68%

Demand and system margin based DRFs converge with increase in number of total periods used for DRF calculations

DRF is 62% for 6 years (April 2012–April2014) time series

* These do not include specific adjustments for technical reliability including ramping and transmission losses

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ANNEX

- Winter peak demand based historical DRFs for Ireland and the Netherlands
- **Annual tightest capacity margin based DRF**
- Impact of market factors on historical DRF – detailed qualitative analysis

HISTORICAL DRF OF GB–FRANCE INTERCONNECTOR

Longer data series and increased size of data sample does not guarantee robustness of historical DRFs

DRF based on tightest capacity margin periods/year

Number of tightest periods	DRF calculations based on:	Annual 2008	2009	2010	2011	2012	2013	Average 2008-2011	2012-2013	2008-2013
Top 20	Price differential (+ve)	95%	100%	100%	90%	100%	100%	96%	100%	98%
	GB Imports	0%	80%	65%	65%	90%	100%	53%	95%	67%
	Price differential (+ve) & GB Imports	0%	80%	65%	65%	90%	100%	53%	95%	67%
Top 50	Price differential (+ve)	80%	84%	88%	90%	96%	100%	86%	98%	90%
	GB Imports	10%	60%	52%	52%	92%	100%	44%	96%	61%
	Price differential (+ve) & GB Imports	10%	56%	48%	52%	88%	100%	42%	94%	59%
Top 100	Price differential (+ve)	81%	78%	81%	79%	95%	100%	80%	98%	86%
	GB Imports	18%	56%	51%	45%	95%	100%	43%	98%	61%
	Price differential (+ve) & GB Imports	18%	50%	44%	42%	91%	100%	39%	96%	58%

Divergence in REF ← | → Convergence of REF based on different metrics

Conclusions

- Increased number of relevant periods within a year risk capturing higher number of periods when system capacity margin is less tight and biases down the DRF due to capturing periods of export from GB
- Longer time series captures more periods when interconnector operation was not 'efficient'
- DRFs based on different metrics converge as market efficiency improves

HISTORICAL DRF OF GB–NORWAY INTERCONNECTOR

Focus on a smaller number of periods provides less conservative estimates of DRFs

DRF based on tightest capacity margin periods/year and using positive price differential

Relevant periods	2008	2009	2010	2011	2012	2013	Average 2008-2013
Top 20 Tightest periods	100%	100%	100%	100%	100%	100%	100%
Top 50 Tightest periods	100%	96%	82%	100%	100%	100%	96%
Top 100 Tightest periods	100%	93%	75%	97%	100%	100%	94%

Average annual DRF decreases with increase in number of relevant periods

The DRFs provided in above table will need to be adjusted to account for technical reliability (including ramping) and a minimum positive price differential threshold to compensate interconnector transmission losses.

ANNEX

- Winter peak demand based historical DRFs for Ireland and the Netherlands
- Annual tightest capacity margin based DRF
- **Impact of market factors on historical DRF – detailed qualitative analysis**

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–FRANCE INTERCONNECTOR – 1/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	France		
Cash-out reforms	High	✓		▲	Cash-out reforms would results in electricity prices to rise in GB during system stress periods reflecting scarcity thus encouraging increase in GB imports via GB-France interconnector during system stress periods. Assuming future flows will be more reflective of price differentials, these reforms are expected to increase historical DRF of this interconnector.
Increased intra-day trading	High	✓	✓	▲	Intraday (ID) target model implementation will make it easier for market participants to trade electricity across borders close to gate closure and balance their positions particularly, in the context of growing intermittent generation. However, increased intra-day trading will also need: - Adequate volume of interconnector capacity available for intra-day trading; - A transparent and robust pricing methodology for determining the interconnector capacity price during intra-day time frame; - Availability of flexible products to facilitate intra-day trading. With increased ID trading (a key expectation of ID market coupling), interconnector flows will be more reflective of intra-day price differentials (including cost of interconnector capacity). However, cross border flows will also be dependent on how the coincidence of system stress periods emerges between GB and France (and with markets to which France and GB are connected), where tighter of the two markets are expected to attract more imports during system stress periods. Intra-day market coupling and increased ID trading are expected to result in upwards movement of DRF relative to historical DRF.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–FRANCE INTERCONNECTOR – 2/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	France		
Change in generation mix	High	✓	✓	uncertain	In both GB and France potential changes in generation mix include increase in the share of wind generation and retirement of baseload generation (mainly coal) by 2020. The impact of change in generation mix will be defined by the correlation of wind output during system stress periods in each market (and with other connected markets) and the coincidence of system stress periods between the two markets. The direction and magnitude of the overall impact is complex to be assessed qualitatively.
Introduction of day-ahead market coupling	Medium	✓	✓	▲	Market coupling dealing with day-ahead (DA) timeframe will mainly impact day-ahead prices making day-ahead scheduled flows more reflective of DA electricity prices. Therefore, its impact on DRF, considering system stress periods arise within intra-day timeframe, will be a modest increase.
Uncertainty in the level and profile of future demand	Medium	✓	✓	▼	Annual and peak demand is expected to be low in the near-term future in GB whereas in case of France peak and annual demand are now expected to grow at the same rate although peak demand has been growing at a faster rate historically. French demand is also more sensitive to weather conditions (i.e. temperature) which can make French market more tight compared to GB and less able to support GB under extreme weather conditions which directly result in significant increase in French demand. Demand side response (DSR) is part of capacity mechanism in both markets with different contribution levels and products. Objective of DSR actions within capacity mechanisms) is to manage system stress events within the market resulting in fewer system stress periods. The overall impact of future demand changes in both markets are expected to be low in the near-term and will depend on demand profiles in the long-term (e.g. impacts on peak demand levels due to introduction of electric vehicles).

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–FRANCE INTERCONNECTOR – 3/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	France		
Capacity mechanism	Low	✓	✓	▼	GB capacity mechanism will lower DA prices in GB with potential increased interconnector exports. On the other hand, France will also have its capacity mechanism introduced in 2017 potentially lowering its wholesale prices. Hence, the DA price differentials between the two markets are not expected to be significantly different from historical levels. The net impact of both capacity mechanisms on DRF is likely to be low as flows during system stress periods will be more dependent on ID price differentials.
Interactions between new and other/existing interconnectors	Low	✓	✓	▼	In general, additional interconnection or increased imports through existing interconnectors will push electricity prices downwards in GB. Increased available imports from other markets particularly, from Norway (where prices remain consistently lower than in France) and expected to be the same in future would put a downward pressure on imports from France and reduce historical DRF of GB-French interconnector.
Other factors: - GB time zone changes, - CO_2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low	✓	✓	uncertain	Other market factors will have different degree of impact however, these are considered to have less significance particularly, with reference to system stress periods, hence they will have either low or no impact on DRF.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–IRELAND INTERCONNECTOR – 1/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Ireland		
Cash-out reforms	High	✓		▲	Cash-out reforms in GB would results in electricity prices to rise during system stress periods reflecting scarcity thus encouraging increase in GB imports via GB-SEM interconnectors during system stress periods. Assuming future flows will be more reflective of price differentials, these reforms are expected to increase historical DRF of this interconnector.
Intra-day market coupling	High	✓	✓	▲	Intraday target model implementation will make it easier for market parties to trade electricity across borders close to gate closure and keep their position in balance particularly, in the context of growing intermittent generation. Intra-day market coupling between GB and Ireland under the Target Model will mean that there will be a continuous intra-day market in forthcoming market arrangements 'I-SEM' (which does not exist at present) allowing I-SEM to respond to stress-events that emerge at short-notice in GB. (New market arrangements i.e. I-SEM is meant to go-live in October 2017 in Ireland). Currently, limited forward market liquidity in Ireland means that Irish retail companies tend to rely on interconnector imports (combined with the GB forward market) as a hedging tool. This results to bias the flows towards exports to Ireland to some degree. The I-SEM should improve this however, the impact on DRF will be low. Hence, during GB system stress periods the flows across the interconnector will depend on wholesale electricity price differentials (both intraday as well as day-ahead) and recalculated interconnector capacity costs. The overall potential impact is an increase in the DRF of this interconnector compared to the historical (low) levels.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–IRELAND INTERCONNECTOR – 2/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Ireland		
Capacity mechanism	High	✓	✓	▲	Capacity mechanisms in GB and Ireland will lower prices. Hence, during GB system stress periods the flow across the interconnector will depend on the wholesale electricity price differentials (both intraday as well as day-ahead) which will also be reflective of capacity payment level (clearing prices in both markets) and recalculated interconnector capacity costs. The net impact on interconnector DRF is a potential increase depending on the coincidence of system stress periods between the two markets.
Change in generation mix	Medium	✓	✓	uncertain	a). Retirement of baseload generation in either GB or Ireland will push the prices upwards. b). Impact of increased wind generation will be dependent on the level of wind output with high demand periods in each country, this can also shift system stress periods away from peak demand periods or new coincidence of system stress periods between the two markets. c). Decrease in share of flexible generation in a system would increase prices during system stress periods and vice versa, however, no major changes are expected share of flexible generation in the near-term in both systems. The overall effect of these changes and their interaction between GB and Ireland is complex to be assessed qualitatively.
Uncertainty in the level and profile of future demand	Medium	✓	✓	uncertain	Annual and peak demand is expected to be low in the near-term future in both GB and Ireland driven by energy efficiency measures and demand side response. Some radical demand side changes (including participation of demand side response DSR in the capacity market) in GB as well as Smart metering and DSR in Ireland can reduce the frequency of system stress periods. However, the level of interconnector support available during such periods resulting in a decrease/increase in the DRF of interconnector is uncertain.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–IRELAND INTERCONNECTOR – 3/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Ireland		
Day-ahead market coupling	Low	✓	✓	▲	Market coupling dealing with day-ahead (DA) timeframe will mainly impact day-ahead prices making DA scheduled flows more representative of DA electricity prices. Therefore, its impact (when implemented as part of I-SEM) on DRF will be a modest increase considering system stress periods arise within intra-day timeframe.
Interactions between new and other/existing interconnectors	Low	✓	✓	▼	In general, additional interconnection or increased imports through existing interconnectors will push electricity prices downwards in GB. Increased available imports from other markets particularly, from Norway or France (where prices generally remain lower than in Ireland) would put a downward pressure on imports from Ireland and reduce historical DRF of GB-Ireland interconnector.
Other factors: - Changes in market rules e.g. I-SEM development - GB time zone changes, - CO2 price differentials, - coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Unknown	✓	✓	**uncertain**	Other market factors will have different degree of impact, for example: - Carbon price support (CPS) in GB would lead to a high differential if coal is on the margin rather than gas plant during the stress period; - A GB time zone change would be significant due to change in the coincidence of peak demand periods, but it is unlikely to happen. Net effect of these factors on DRF of interconnector is uncertain.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NETHERLANDS INTERCONNECTOR – 1/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Netherlands		
Change in generation mix	Medium	✓	✓	▼	In GB potential near-term changes in generation mix include increase in the share of wind generation and retirement of baseload generation (mainly coal). The Netherlands is currently an overcapacity market with scheduled coal plant closures and potential gas plant mothballing/closures by 2020 due to unfavourable plant economics. It is also expected to be unable to meet its 2020 renewables targets while increased subsidies are being provided to encourage investment in renewable generation. A significant reduction in generation capacity in the Netherlands can result in reduced or no imports available to GB if both markets have concurrent market stress periods. this situation can be even more exacerbated coincidence of system stress periods is more wide spread including other markets connected to the Netherlands.
Interactions between new and other/existing interconnectors	Medium	✓	✓	▼	In general, additional interconnection or increased imports through existing interconnectors will push electricity prices downwards in GB. Increased available imports from other markets particularly, from Norway (where prices remain consistently lower than in the Netherlands) can put a downward pressure on imports from the Netherlands and reduce historical DRF of GB-Netherlands interconnector.
Cash-out reforms	Low	✓		▲	Cash-out reforms would results in electricity prices to rise in GB during system stress periods reflecting scarcity thus encouraging increase in GB imports. On the other hand, high imbalance prices already exist in the Netherlands driven by the marginal plant brought online during imbalance (system short) conditions. GB prices have been consistently higher than prices in the Netherlands, new price differentials between the two markets are expected to be even more higher than in the past resulting in a further increase in DRF if not already maxed (assuming the coincidence of system stress periods between the two markets does not change).

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NETHERLANDS INTERCONNECTOR – 2/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Netherlands		
Intra-day market coupling	Low	✓	✓	▲	Intraday (ID) target model implementation will make it easier for market participants to trade electricity across borders close to gate closure and balance their position particularly, in the context of growing intermittent generation. However, increased ID trading will also need: - Adequate volume of interconnector capacity available for intra-day trading; - A transparent and robust pricing methodology for determining the interconnector capacity price during intra-day time frame; - Availability of flexible products to facilitate intra-day trading. With increased ID trading (a key expectation of ID market coupling), interconnector flows will be more reflective of intra-day price differentials (including cost of interconnector capacity). As Netherlands has already intra-day market coupling with Belgium and Norway, it can link available generation resources in these markets to GB if its own spare generation capacity is limited during system stress periods. Intra-day market coupling and increased ID trading are expected to result in upwards movement of DRF relative to historical DRF.
Capacity mechanism	Low	✓		▼	GB capacity mechanism will lower DA wholesale electricity prices in GB while no such mechanism is being discussed in the Netherlands being an over capacity market. Decrease in DA prices during system stress periods compared to the past can result in a small drop in DRF of this interconnector.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NETHERLANDS INTERCONNECTOR – 3/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Netherlands		
Day-ahead market coupling	Low/no	✓	✓	▲	Day-ahead market coupling already exists between the two markets and DA price differentials are also large resulting in significantly high DRF. Increased DA trading is therefore, expected to have minimal impact on historical DRF.
Uncertainty in level and profile of future demand	Low	✓	✓	▼	Annual and peak demand is expected to be low in the near-term future in GB whereas in case of the Netherlands no significant changes are expected in the overall demand as well as peak demand. Reduction in peak demand levels and demand side response (DSR) in GB can result in relatively lower prices during system stress periods compared to the past. This might result in a small drop in DRF of this interconnector.
Other factors: - GB time zone changes, - CO2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low	✓	✓	**uncertain**	Other market factors will have different degree of impact however, these are considered to have less significance particularly, with reference to system stress periods, hence they will have either low or no impact on DRF.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NORWAY INTERCONNECTOR – 1/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Norway		
Interactions between new and other/existing interconnectors	Medium	✓	✓	▼	In general, additional interconnection or increased imports through existing interconnectors would push electricity prices downwards in GB. However, large price differential between GB and Norway which is higher then any other market connected to GB means that this interconnector will be ahead in merit order than any other interconnector to GB. However, imports to GB during system stress periods can be affected by: - development of additional interconnector from Norway to Germany and Netherlands, imitating the spare (surplus) capacity available in Norway; or - relatively higher price differentials between Norway and another market (e.g. Germany). Overall development of new interconnector from Norway to other markets is expected to have a downwards impact of historical DRF of GB-Norway interconnector.
Capacity mechanism	Low	✓	✓	▼	GB capacity mechanism will decrease wholesale electricity prices in GB resulting in a reduction in historical price differentials between GB and Norway. However, considering large historical price differential due to difference in the type of generation mix - GB is thermal dominated while Norway is a hydro based system, the impact is not expected to reverse the direction of flow hence historical DRF will be least affected.
Cash-out reforms	Low/no	✓		▲	Cash-out reforms in GB would results in electricity prices to rise during system stress periods reflecting scarcity . However, in case of GB-Norway interconnector, considering large historical price differential, cash-out reforms in GB are expected to further encourage flows into GB with small upwards or no significant impact on historical based interconnector DRF.

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IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NORWAY INTERCONNECTOR – 2/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Norway		
Intra-day market coupling	Low/no	✓	✓	▲	Cross border intraday trading between GB and Norway will allow surplus capacity in Norway (which is an energy constrained country with ample spare capacity) to be available to GB during system stress periods near real time. Also GB can help Norway to conserve its hydro energy during off-peak periods when prices are low in GB to overcome any energy limitations affecting flows to GB during system stress periods. Assuming that system stress periods coincidence remains same as historical, increased intraday trading is not expected to alter direction of price differentials (or flows).
Day-ahead market coupling	Low/no	✓	✓	▲	Market coupling dealing with day-ahead (DA) timeframe will impact day-ahead prices making scheduled flows more representative of DA electricity prices. Therefore, its impact on DRF particularly considering system stress periods which arise within intra-day timeframe will be a medium level increase.
Change in generation mix	Low	✓	✓	uncertain	No significant changes in Norway capacity or generation mix are expected in the near-term while in GB retirement of baseload (coal) generation and increased wind generation is expected. High wind generation in GB can alter the coincidence of system stress periods between GB and Norway resulting in either increase or decrease in the availability of surplus capacity being available to GB during system stress periods. The impact of this development on DRF is uncertain and complex to be assessed qualitatively.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–NORWAY INTERCONNECTOR – 3/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Norway		
Uncertainty in level and profile of future demand	Low/no	✓	✓	▼	Annual and peak demand is expected to decrease (or remain flat) while peak demand to fall in the near-term in GB driven by energy efficiency measures and demand side response. On the other hand, no significant changes in demand level and profile is expected in Norway. This could result in fewer system stress periods or relatively higher capacity margins in GB than past with small (downwards) or no impact on DRF.
Other factors: - GB time zone changes, - CO2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low/no	✓	✓	uncertain	Other market factors will have different degree of impact however, these are considered to have no material impact on GB-Norway interconnector DRF.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–BELGIUM INTERCONNECTOR – 1/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Belgium		
Change in generation mix	High	✓	✓	**uncertain**	In GB potential near-term changes in generation mix include increase in the share of wind generation and retirement of baseload generation (mainly coal). Belgium is currently a tight capacity margin market driven by nuclear plant failures, planned decommissioning of nuclear by 2025 and potential economic closure of CCGT units. Government is keen to avoid risk of security of supply and has introduced Strategic Reserve measure besides planning for a Capacity Tender to avoid economic closures. Furthermore, planned phased decommissioning of nuclear plants is also being reviewed. This is a rapidly evolving situation and the exact outcome of these decisions and their impact is uncertain at this stage.
Interactions between new and other/existing interconnectors	Medium	✓	✓	**uncertain**	In general, additional interconnection or increased imports through existing interconnectors will push electricity prices downwards in GB. In order to mitigate risk to security of supply, Belgium is planning additional interconnectors to Germany as well as reinforcement of interconnector to France and the Netherlands. The impact of these interconnector additions/reinforcements to DRF of GB-Belgium interconnector will also be dependent on the development of system tightness condition in Belgium hence, the overall impact is uncertain.
Cash-out reforms	Low/no	✓		**uncertain**	Cash-out reforms would results in electricity prices to rise in GB during system stress periods reflecting scarcity thus encouraging GB imports. In Belgium, recently cash-out costs for imbalance have increased significantly. Consequently, the impact on historical DRF is uncertain and depends on the net impact on price differential between the two market.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–BELGIUM INTERCONNECTOR – 2/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Belgium		
Intra-day market coupling	Low	✓	✓	▲	In Belgium prices are often set by neighbouring countries and with intra-day market coupling and resulting increased trading, it can link available generation resources in these markets to GB if its own spare generation capacity is limited during system stress periods. It is therefore, expected to result in a small upwards movement of DRF relative to historical DRF.
Capacity mechanism	Low	✓	✓	**uncertain**	GB capacity mechanism will lower DA wholesale electricity prices in GB and a similar effect could also result in Belgium if its plan for Capacity Tender gets implemented. Hence the overall impact will depend on the decision regarding implementation of Capacity Tender in Belgium.
Day-ahead market coupling	Low/no	✓	✓	▲	Market coupling dealing with day-ahead (DA) timeframe will impact day-ahead prices making scheduled flows more representative of DA electricity prices. Assuming the presence of intra-day market, impact of a day-ahead coupling on DRF will be a small increase or no change.

IMPACT OF MARKET FACTORS ON HISTORICAL DRF OF GB–BELGIUM INTERCONNECTOR – 3/3

Market factors	Significance	Applicable to		Impact on hist. DRF	Comments
		GB	Belgium		
Uncertainty in level and profile of future demand	Low/no	✓	✓	▼	Annual and peak demand is expected to be low in the near-term future in GB whereas in case of Belgium no major changes are expected. However, both markets are encouraging reduction in peak demand levels through demand side response (DSR) which can result in relatively lower prices during high demand periods compared to the past. This might result in a small or no impact on DRF of this interconnector.
Other factors: - GB time zone changes, - CO2 price differentials, - Coal/gas price relativity or change in merit order, - Flow based allocation of interconnector capacity	Low	✓	✓	uncertain	Other market factors will have different degree of impact however, these are considered to have less significance particularly, with reference to system stress or high demand periods, hence they will have either low or no impact on DRF.

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Contact:

Gareth Davies
gareth.davies@poyry.com
Phone: +44 1865 812 204

Anser Shakoor
anser.shakoor@poyry.com
Phone: +44 1865 812 267