Gas Entry Tariff Model

Initial modelling evidence

23rd September 2014

Contents

1 OVERVIEW OF MODEL

Overview of model

Key concepts

- The model has a set of core inputs that can be changed within the model
- ***Allowed revenue*** to be recovered [default set to €200m]
- ***Entry-exit split*** for cost recovery from entry versus exit [default set to 50:50]
- ***Capacity-commodity split*** for cost recovery between capacity and commodity charge [default 100:0]
- ***Secondary adjustment*** is made through a 'fixed adder' to arrive at allowed revenue
- ***Equalisation*** of exit tariffs through other secondary adjustment

Overview of model

An illustrative model of how ACER guideline options could be applied to the Irish gas transmission system …

- Model developed with the objective to identify the issues of applying alternative cost allocation methodologies approaches to the Irish system

- Model accommodates all current and future entry points (Moffat, Inch, Corrib and Shannon). The model currently includes ten exit zones (location weighted by technical capacity):
  - Dublin
  - Galway
  - Limerick
  - Cork
  - Waterford
  - CorkDublin
  - North East (NEP)
  - Western Region (PTTW)
  - IOM (single point)
  - Gormanston (single point)

Not included in model calculations to date

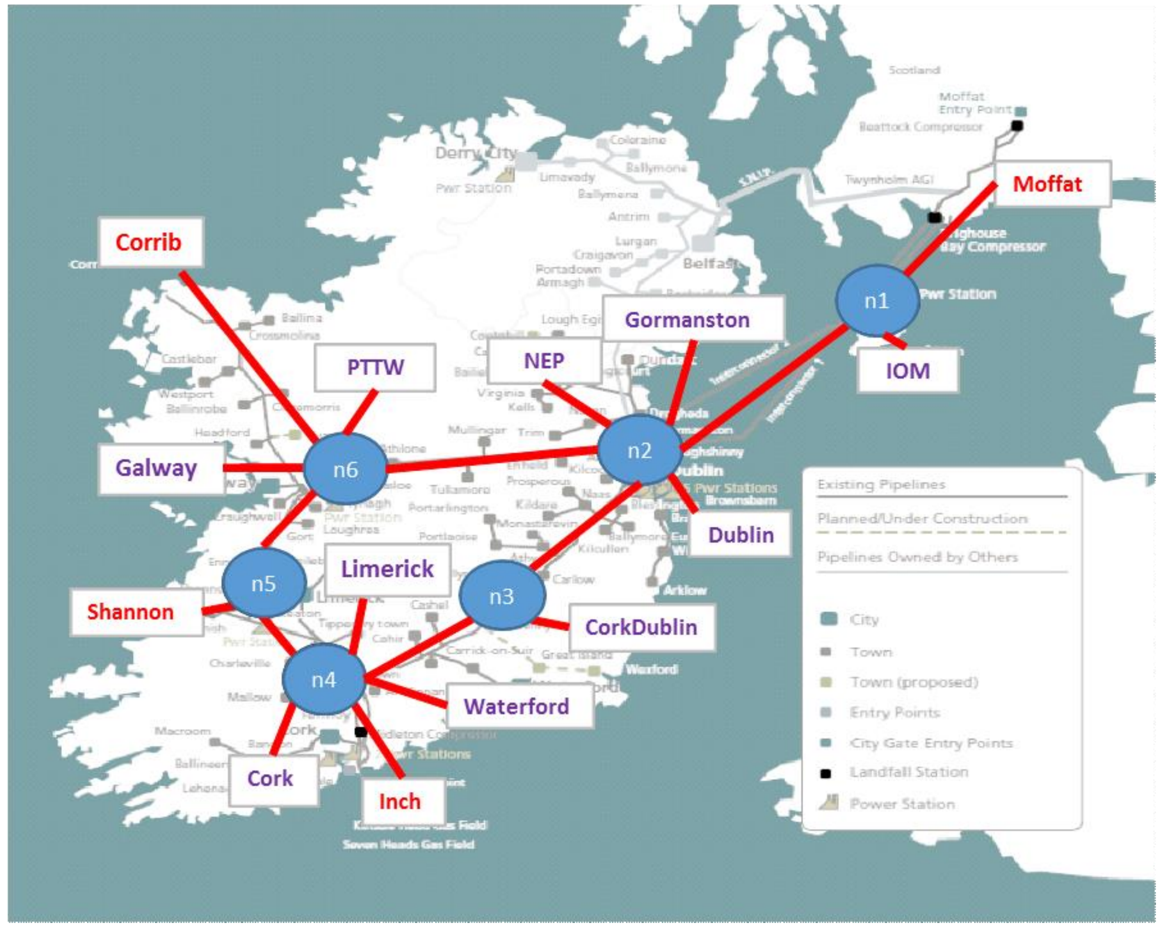
- Twynholm

Attributing of exit points to exit zones provided by BGN– use co-ordinates for clustering

Overview of model

… with simplifying assumptions for the representative network

- For the options that require a representative network (i.e. VP A and matrix) we assume six internal nodes.
- Each entry and exit "zone" is assumed to connect to the nearest internal node in the representative network.
- We model a balanced (average) peak supply and demand scenario based on this representative network with determined flow directions.
- Pipeline distances used from entry to node, otherwise straight line distance used.



Overview of model

Supply Scenarios

There are four different supply scenarios included within our model.

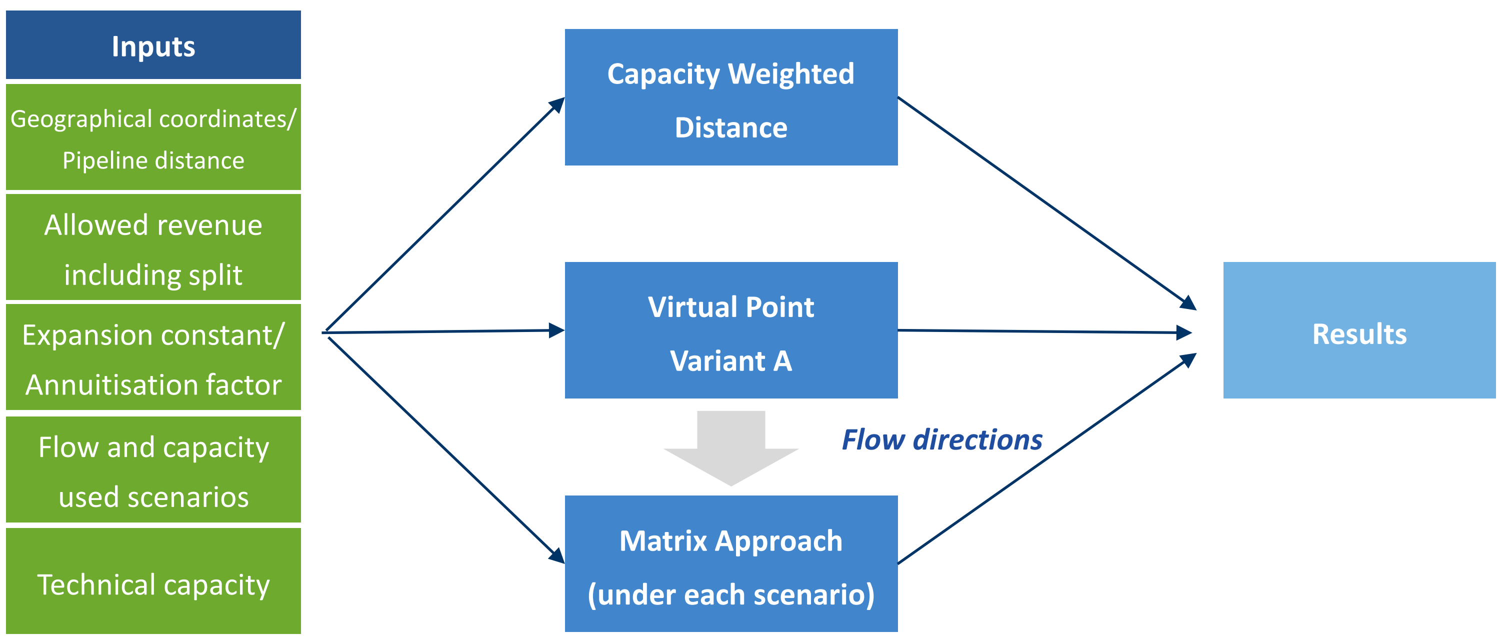
- **Scenario 1**: Only Moffat and Inch entry; all exits active.
- **Scenario 2**: Moffat, Inch and Corrib entry; all exits active.
- **Scenario 3**: Moffat, Inch, Corrib and Shannon (Phase 1); all exits active.
- **Scenario 4**: Moffat and Shannon (Phase 1); all exits active.

In each supply scenario, the listed entries and exits are assumed to have both an average peak flow (balanced demand and supply) and proxy capacity demand where active.

Exit charges under all models and scenarios are equalised – tariff is €336.62/ MWh day.

Overview of model

Model schematic



Overview of model

Use of expansion constants

- An expansion constant is used to provide a value for the cost of expanding pipeline capacity so that one unit of gas can travel over a specified distance.
- An expansion constant takes a blended average of past projects to arrive at a standardised expansion cost that can apply across the network.
- Differing expansion constants can be used in the modelling to reflect cost characteristics of network expansion. In our modelling we have identified two separate expansion constants; an onshore expansion constant and an offshore constant.
- An expansion constant of c.€11,000/MWh/km is used for onshore, with an expansion constant three times that magnitude for the offshore segments.

2 CAPACITY WEIGHTED DISTANCE

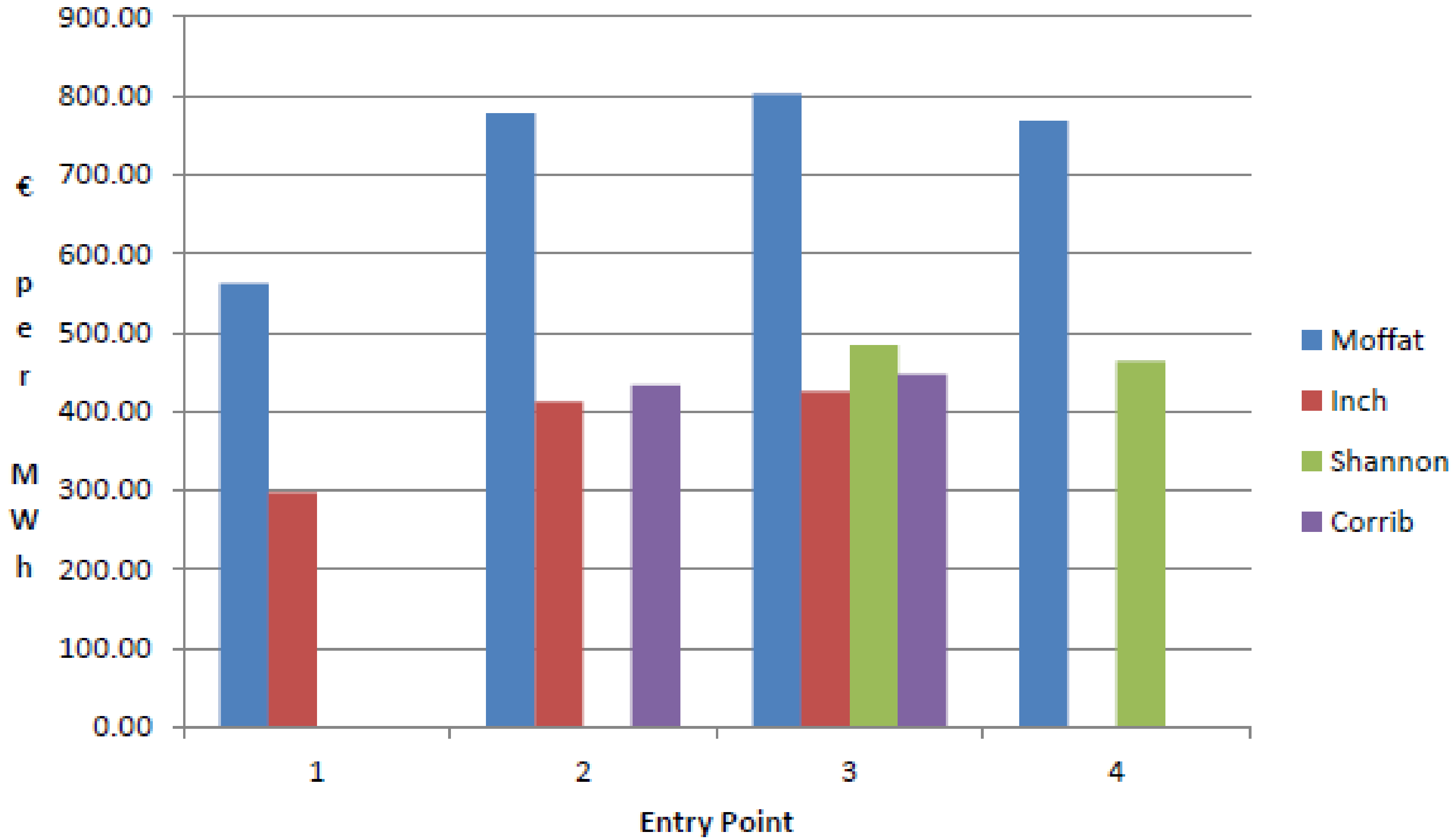
Capacity Weighted Distance

Recap on concept

- Capacity demand (proxy for bookings) used in calculation methodology
- Pipeline distances used in the Capacity Weighted Average Distance calculations – not straight line length
- Does not require use of representative network
- No need for secondary adjustments to reach allowed revenue
- Cost drivers are distance and capacity demand – not flow based
- Detailed methodology available in Technical Annex

Capacity Weighted Distance

Initial modelling results



3 VP VARIANT A

VP Variant A

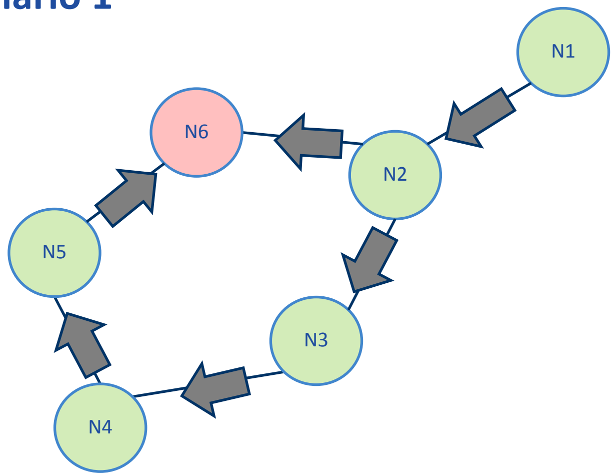
Recap on concept

- Forward looking cost approach
- Requires (representative) network modelling
- Have a reference node (Node 2 in model)
- Flow modelling minimises flow distances under balanced peak flow scenario – flow directions change between scenarios
- Constraint prevents non-negative primary tariffs
- Adjust flow distance values by moving the reference node to a virtual point to reflect entry:exit split
- Uses expansion constant(s)
- Fixed adder as secondary adjustment on entry and equalisation adjustment on exit
- Primary tariffs driven by flow direction, expansion constants, distance and flows

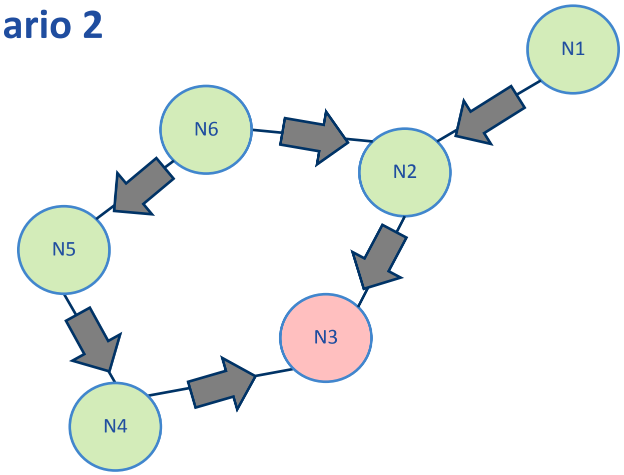
VP Variant A

Flow directions

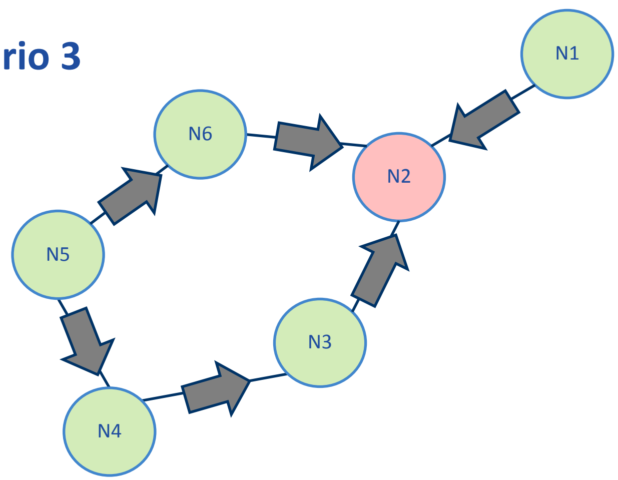
Scenario 1



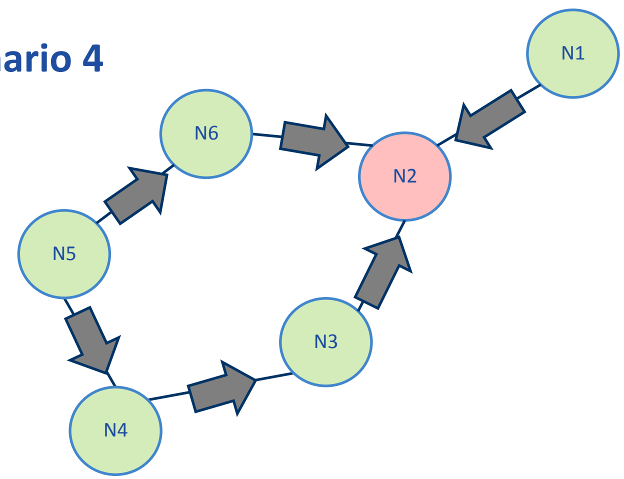
Scenario 2



Scenario 3

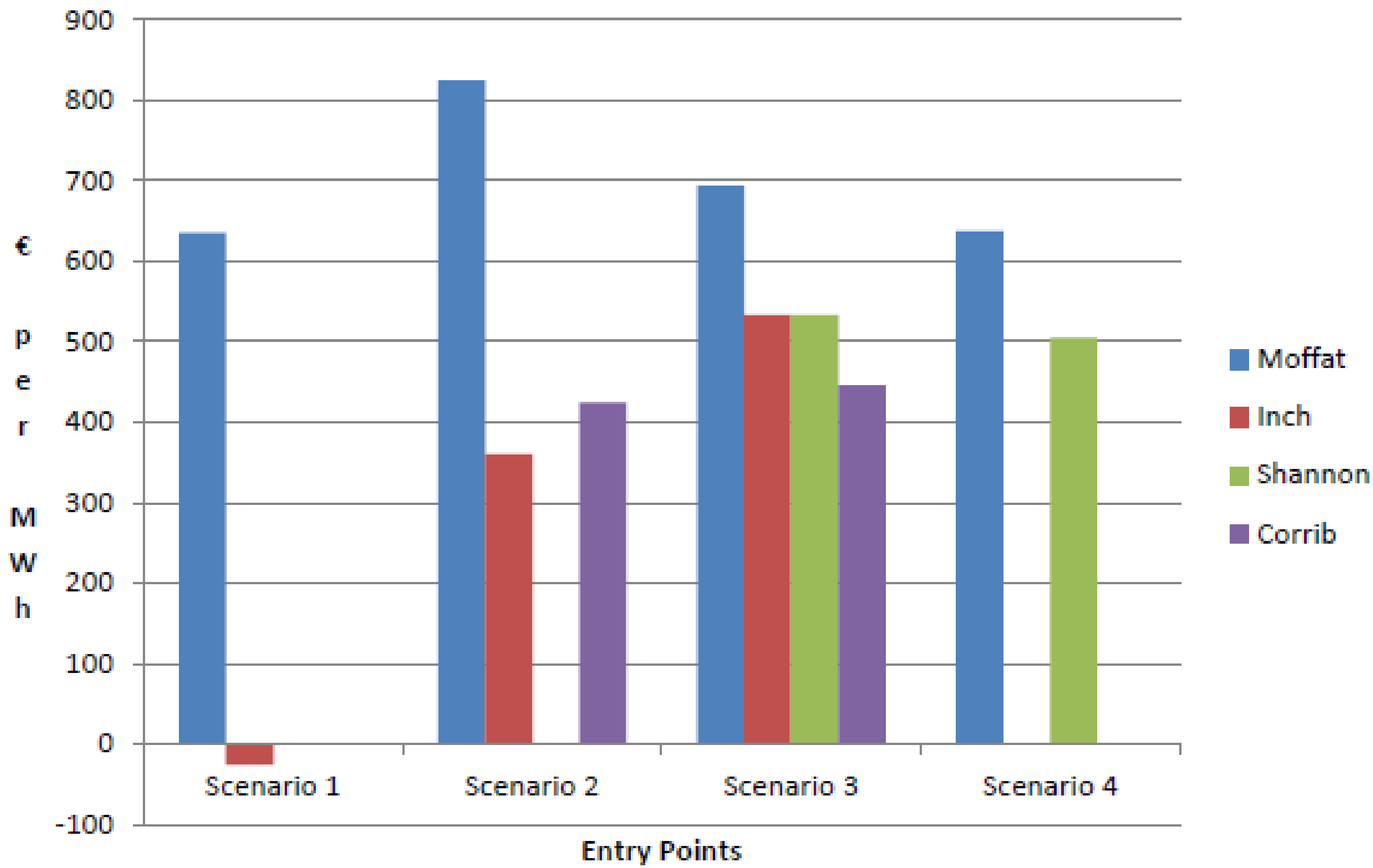


Scenario 4



VP Variant A

Initial modelling results



4 MATRIX

Matrix

Recap on concept

- Forward looking cost approach
- Requires (representative) network modelling
- No need for use of Virtual Point
- Calculates unit costs for entry-exit paths – if going 'with' the flow, the positive marginal cost is applied, if going 'contra' flow, then negative marginal cost is used for pipeline segment*
- Uses expansion constant(s)
- Constraint within calculation prevents non-negative primary tariffs
- Fixed adder as secondary adjustment on entry and equalisation adjustment on exit
- Primary tariffs driven by flow direction, expansion constants, distance and flows

* please see next slide

Matrix

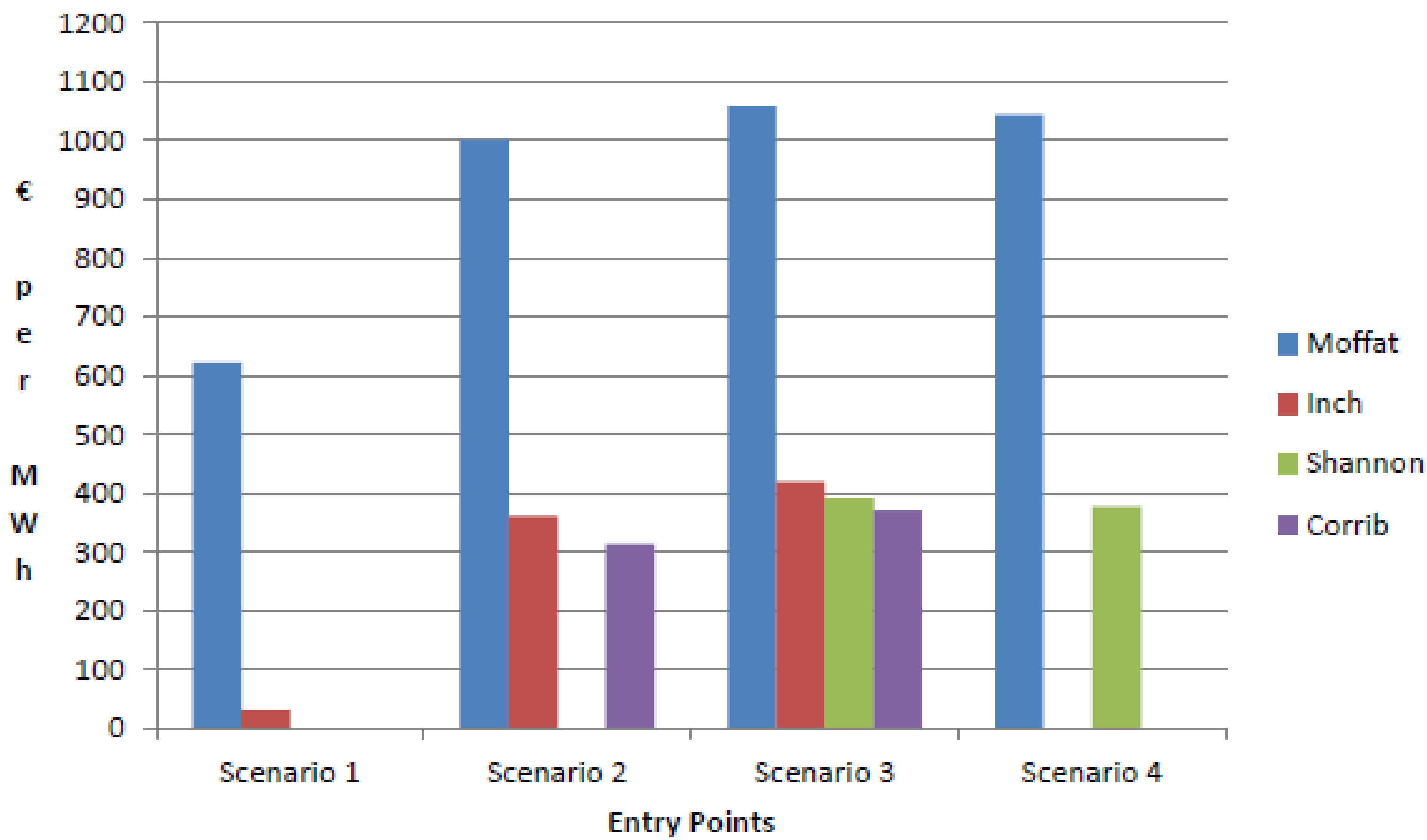
Revision to the published paper

- Our intention was to assign a fully positive marginal cost for pipeline going contra-flow – however the paper states that a negative marginal cost is applied. As per article 14 of the draft Network Code

- The numbers reflect a positive value NOT a negative one

Matrix

Initial modelling results – only positive LRMCs



5 PROJECT BASED COSTS

Project based costs

Methodology

- A project costs approach does not require the calculate of unit costs for each pipeline segment. Instead it uses costs associated with specific future projects for reinforcing the system for demand.

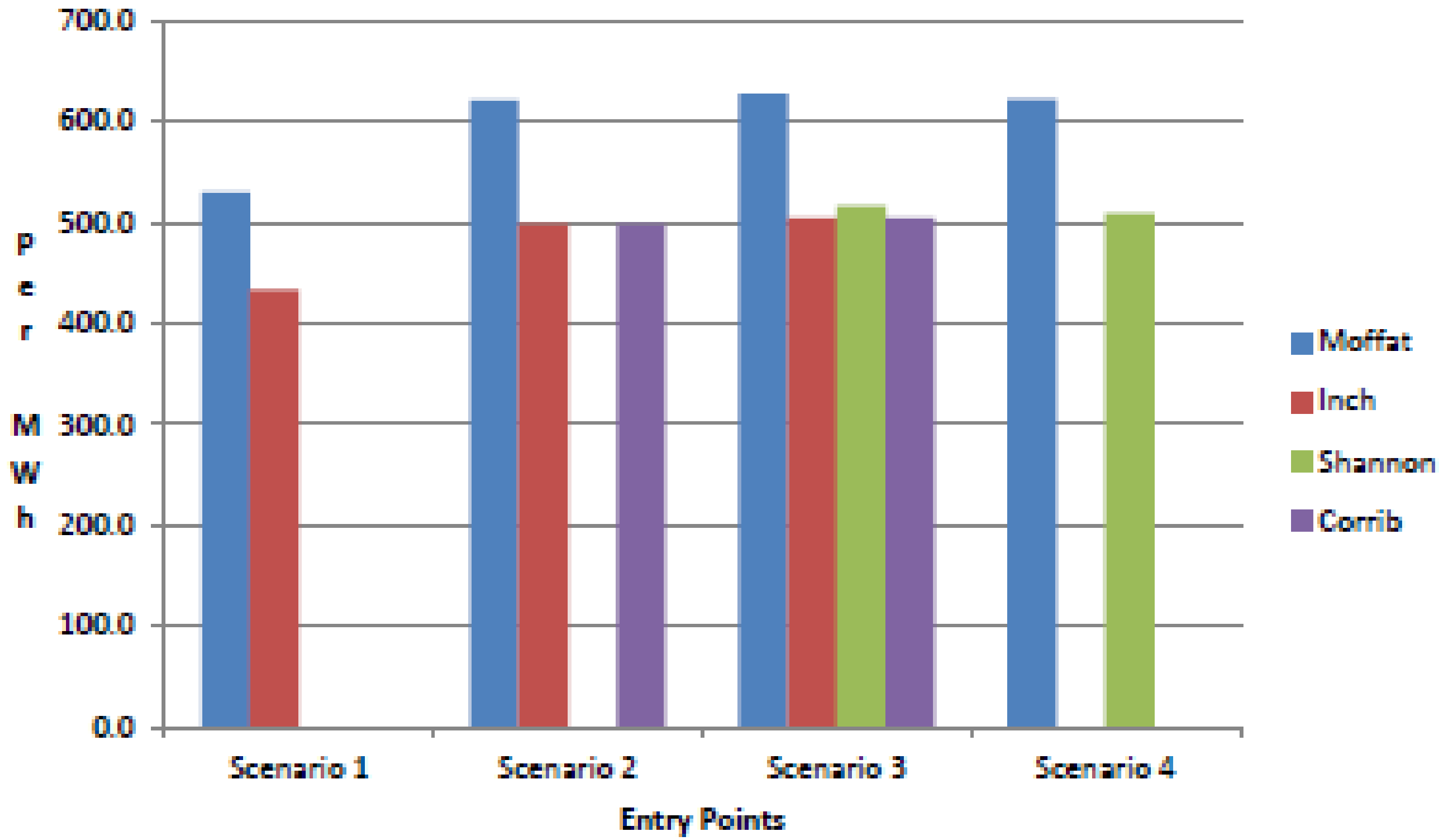
- The calculation uses project costs identified in the Gaslink Network Development Plan, with the Twinning of the South West Scotland Onshore System (SWSOS) and Strategic Reinforcement between Goast Island and Curraleigh.

- The LRAICs are used to populate the matrix, with it solved using the steps under the Matrix method.

	Moffat	Inch	Shannon	Corrib
Dublin	Moffat LRAIC	-	-	-
Galway	Moffat LRAIC	-	-	-
Limerick	Moffat LRAIC	-	-	-
Cork	Moffat LRAIC	-	Shannon LRAIC	-
Waterford	Moffat LRAIC	-	Shannon LRAIC	-
Cork Dublin	Moffat LRAIC	-	Shannon LRAIC	-
North East	Moffat LRAIC	-	Shannon LRAIC	-
Western region	Moffat LRAIC	-	Shannon LRAIC	-
Gormanston	Moffat LRAIC	-	-	-
Isle of Man	Moffat LRAIC	-	-	-

Project based costs

Initial results



A PREDICTABILITY AND STABILITY OF TARIFFS

Tariff predictability and stability

Tariff predictability and in some cases stability …

- Gas market participants require a degree of certainty and foresight of transmission tariffs paid for entry and exit to the network. This is important for:
  - **Efficient investment**
  - **Entry and exit decisions**
  - **Flow decisions**
- Uncertainty of transmission tariffs can create risks for customers and suppliers in the market which could deter them from:
  - Undertaking efficient investment in new or expanded upstream supply sources
  - Retaining existing facilities (e.g. storage)
  - Efficient choices of contracted supply
- However providing **tariff stability** through the adopted charging methodology is a very different regulatory objective to providing **tariff predictability**.

… are often key regulatory objectives for a transmission tariffing regime in addition to cost reflectivity

Tariff predictability and stability

In the Irish market, tariff predictability may be preferable …

- Our modelling suggests that with planned changes in the supply of gas to the Irish market, long term tariff stability faces a number of practical issues in an Irish context
    - **Development of new entry points causes tariffs to change (even with the more stable CWD approach)**
    - **Changes in modelled flow patterns on the network and allowed revenues could in future also result in tariff volatility**
- However transparency of the assumptions and methodology used to calculate future tariffs should be able to provide tariff predictability to Irish gas market participants
- This is the approach adopted in GB, where tariff models are published to allow market participants to anticipate their charging incidence
- Tariff predictability may enable customers and producers to make decisions (or prevent decisions) that they may not have done had they had more limited information on tariffs

… and tariff stability may not even be achievable in the medium term

B

DETAILS ON MODELLING APPROACH

Details on modelling approach

Introduction

- The purpose of this technical annex is to provide further detail on the cost allocation methodologies underlying the CER Gas Entry Tariff model.
- This includes details on the steps followed under each cost allocation methodology, additional detail on input assumptions and sources used in the model, details on pre-adjusted primary tariff outcomes and more information on the use of expansion constants within the model.
- Annex C then looks more specifically at the model, seeking to permit a greater understanding of the calculation steps involved - this can be cross-checked against the approach within this Annex.
- It should be noted that the model is not intended to be used for implementation of gas transmission entry tariffs in Ireland.
- The purpose of the model is to inform stakeholder understanding of the possible change in tariffs that *may* arise under different plausible supply/entry point scenarios and cost allocation methodologies permitted by ACER's Framework Guidelines on gas transmission tariffs.

Details on modelling approach

Data sources

- Locations and capacity of entry and exit points = BGN
- Expansion constants (wet and dry) = BGN
- Pipeline distances between entry and exit points = BGN
- Conversion factor (SCM to GWh/day) = CER
- Peak flows and capacity demand = Network Development Plan, BGN, CEPA

Details on modelling approach

Assumptions on flows and capacity

- The average peak flow scenario has a balance between entry and exit
- Average peak flows and proxy capacity demand for entry and exit points is described in Annex D
- Average peak flows for entry (and exit) are around 238 GWh days
- Proxy capacity demand under Scenarios 2-4 are c.186 GWh days
- For calculating flows at exit, we include power stations within an exit zone
- Location of the exit “zone” is the (capacity) weighted average of all exit points included in that zone
- Technical entry/exit point network capacity data is sourced from BGN; summation of individual exit points for exit zones
- Both average peak flows and demand remain constant under all scenarios for exit points

Details on modelling approach

Assumptions on expansion constant

- For the model representative network, the segment of pipe from Moffat to Node 1 (Isle of Man offtake) contains both onshore and offshore segments.

- We have taken Brighouse Bay as the point where the pipeline reaches the sea and then calculated the proportions of the pipeline onshore and offshore.

- This gives an expansion constant for the Moffat – N1 pipe of 2.06 x the onshore expansion constant.

e.g. Moffat to N1 = 139.7km
Moffat to Brighouse Bay = 65.6km (onshore)
Brighouse Bay to N1 = 74.2km (offshore)

The proportion onshore is 74.2/139.7 = 46.9%, thus 53.1% is offshore.

These proportions multiplied by the factor of 1.0 x and 3.0 x give a blended figure of 2.06 x to multiply by the dry expansion constant.

- For Moffat – N2, we take a weighted Moffat – N1 expansion constant and a wet N1 – N2 expansion constant. *This gives a blended factor of 2.50 x to multiply by the dry expansion constant.*

Details on modelling approach

Modelling methodology under CWD

1. Pipeline distances are pulled in from the 'Inputs' worksheet, and provide the distance between each of the four entry points and ten exit zones.

2. Proxy capacity demand figures are also presented for the scenario with 'Inputs' as the source.

3. Proportion factors are calculated as entry (exit) point demand (or capacity) as a proportion of all entry (exit) point capacity.

4. Capacity Weighted Average Distance (CWAD) is calculated as the sum-product of distances to all exit zones from the given entry point and the proportion factor of each exit zone (and vice-versa).

5. CWAD as calculated in Step 4 is multiplied by proxy capacity demand to give a weight for each entry point and exit zone. The weights will sum to 1 for entry points and sum to 1 for exit zones.

6. Revenue share for each entry point and exit zone are calculated based on the total amount (€m) to be recovered from entry or exit, multiplied by the weighting of the individual entry point or exit zone.

7. This revenue share is divided by the amount of demand that this will be recovered over to give a tariff (exit zone tariffs are then equalised).

Details on modelling approach

Modelling methodology under VP(A) (i)

1. Representative network is constructed and a reference node is chosen.

2. The nearest node and distance to the nearest node is calculated for each entry and exit point.

3. The (straight-line) distance between connecting nodes are calculated.

4. Nodal balances are calculated based on the average peak flow flows (coming into the node from entry, leaving the node for exit).

5. Excel solver is used to ensure that each node has a zero balance, giving a set of flow directions.

6. A flow distance to the reference node is calculated for all entry and exit points, using the distance to the nearest node and the distance from the nearest node to the reference node – where this was going against the flow a negative value was assumed i.e. if 20km against the flow, a figure of -20 would be used for a flow distance. For exit zones, the values are calculated from the reference node to the exit zone.

Details on modelling approach

Methodology under VP(A) (ii)

7. Steps 1 to 6 gives the figures noted in black text. The sum of entry and exits are the blue text.

Flow distance to reference node BEFORE adjustment (MWhkm)						
			Entry 1 Moffat UK	Entry 2 Inch	Entry 3 Shannon	Entry 4 Corrib
			276	0	266	0
Exit 1	Dublin	20	296	20	286	20
Exit 2	Galway	-160	116	-160	106	-160
Exit 3	Limerick	-170	106	-170	96	-170
Exit 4	Cork	-160	116	-160	106	-160
Exit 5	Waterford	-130	146	-130	136	-130
Exit 6	CorkDublin	-50	226	-50	216	-50
Exit 7	North East	10	286	10	276	10
Exit 8	Western region	-160	116	-160	106	-160
Exit 9	Gormanston	10	286	10	276	10
Exit 10	IOM Offtake	-120	156	-120	146	-120

8. Excel goal seek is used to establish a value, ‘d’, that is added to entry and subtracted from exit in order to reach a specified entry/ exit split. The matrix is then adjusted to reflect the use of ‘d’.

9. Tariffs are calculated as the adjusted value for each entry/exit point on the matrix multiplied by expansion factor multiplied by the annuitisation factor.

Details on modelling approach

Modelling methodology under Matrix (i)

1. There are separate excel tabs for modelling the matrix methodology under each supply scenario in the model – where the correct scenario is not selected in the 'Inputs' tab, an error message should appear.

2. The matrix modelling is based on the VP(A) representative network framework and flow direction modelling calculations (based on the selected balanced entry and exit flow scenario).

3. For the matrix methodology distances to the nearest node are then calculated. The notation '12 represents the pipeline from Node 1 to Node 2, whilst '21 would represent going from Node 2 to Node 1.

4. An expansion constant is calculated for each network segment based on an assumed proportion of onshore and offshore pipeline – see discussion of expansion constants in previous slides.

5. A unit cost is calculated for each segment of the representative network, by multiplying the relevant expansion constant, distance of the pipeline segment and annuitisation factor.

6. The pipeline segment costs are used to calculate unit costs for entry – exit combinations, with the first segment representing the entry point to nearest node, the second segment representing the exit point to nearest node, and the third segment connecting these two nodes.

Details on modelling approach

Methodology under Matrix (ii)

7. Unit costs from Step 6 are entered into a matrix showing active entry points and exit zone combinations.

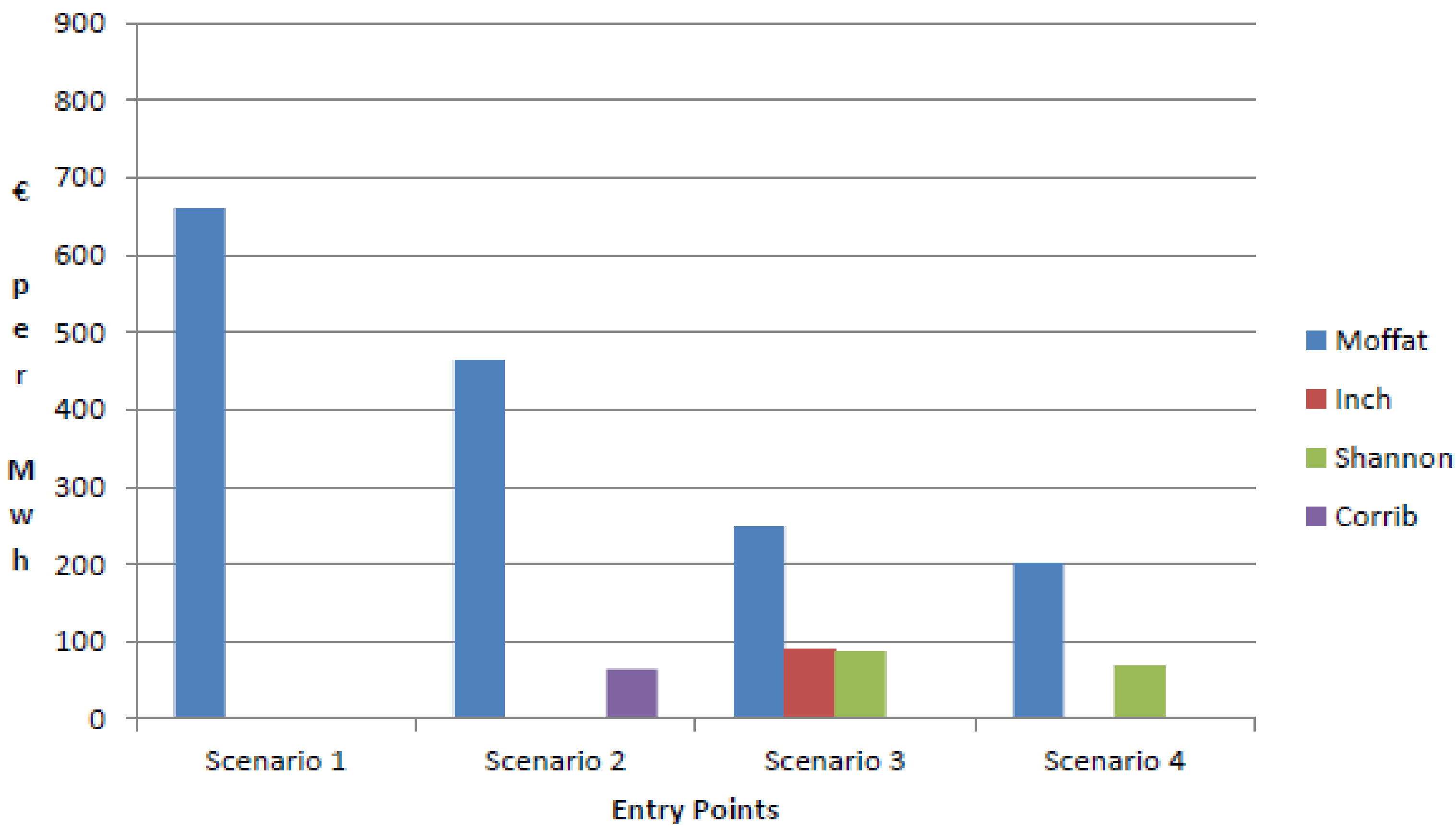
8. A combination of tariffs at each entry point and exit zone are calculated using a goal seek function minimising the sum of squared error from the inner figures within this table relative to the unit cost matrix calculated at Step 7. A constraint on the goal seek ensures that tariffs are non-negative and that the selected entry – exit split is obtained at the primary tariff stage.

Tariffs and sum of tariffs						
			Entry 1	Entry 2	Entry 3	Entry 4
			Moffat	**Inch**	**Shannon**	**Corrib**
			0.59	0.00		
Exit 1	**Dublin**	0.33	0.92	0.33		
Exit 2	**Galway**	0.35	0.94	0.35		
Exit 3	**Limerick**	0.29	0.88	0.29		
Exit 4	**Cork**	0.32	0.91	0.32		
Exit 5	**Waterford**	0.34	0.93	0.34		
Exit 6	**CorkDublin**	0.29	0.88	0.29		
Exit 7	**North East**	0.27	0.86	0.27		
Exit 8	**Western region**	0.36	0.95	0.36		
Exit 9	**Gormanston**	0.26	0.85	0.26		
Exit 10	**IOM Offtake**	0.12	0.71	0.12		

9. This gives a set of tariffs for all entry and exit points, with a secondary adjustment made as a fixed adder for any over or under recovery.

Details on modelling approach

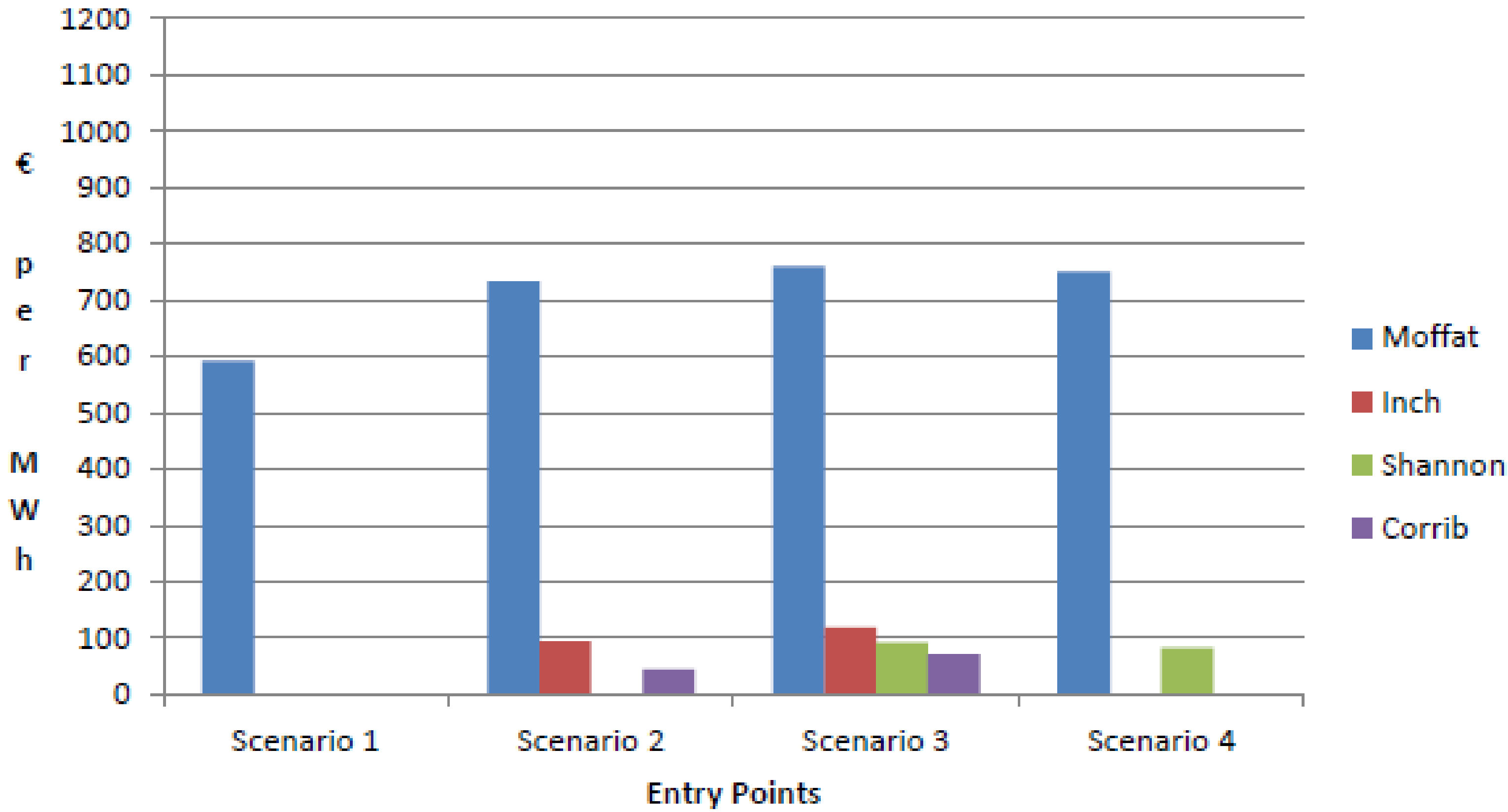
Pre-adjustment 'raw' tariffs under VP(A)



Amount recovered from primary tariffs	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	€104.8m	€32.9m	€17.1m	€18.8m

Details on modelling approach

Pre-adjustment 'raw' tariffs under Matrix



Amount recovered from primary tariffs	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	€93.9m	€50.0m	€44.2m	€45.3m

C

MODEL SCREENSHOTS

Model screenshots

Inputs sheet

Co-ordinates are used for calculating straight line distances

This block of key inputs applies under each methodology

Demonstrate range of expansion constants used in the model

Calculates latitudinal distances and longitudinal distances before applying Pythagoras' theorem to get straight line distance

INPUTS

Coordinates

	Latitude	Longitude
One degree distance (km)	110	72
Moffat UK	55.28	-3.44
Inch	51.81	-8.18
Shannon	52.60	-9.05
Corrib	53.24	-8.70
Dublin	53.34	-6.27
Galway	53.50	-9.08
Limerick	52.50	-8.55
Cork	51.86	-8.32
Waterford	52.26	-7.19
CorkDublin	53.20	-6.54
North East	53.62	-6.27
Western region	53.09	-8.25
Gormanston	53.63	-6.25
IOM Offtake	54.34	-4.74
Node 1	54.44	-4.84
Node 2	53.54	-6.09
Node 3	52.98	-6.97
Node 4	52.27	-8.27
Node 5	52.61	-8.98
Node 6	53.24	-8.70

Technical capacity weighted average coordinates of individual exit points used for each exit zone

Inputs on allowed revenues

	€ million
Total allowed revenue	200
Total revenue entry points	100
Total revenue exit points	100

Entry-exit split	
% entry revenue	50.00%
% exit revenue	50.00%
Capacity-commodity split	
%capacity revenu	100.00%
%commodity rever	0.00%

Other specific inputs	**Dry**	**Wet (Moffat N1)**	**Wet (Moffat N2)**	**Wet (N1 N2)**
Expansion constants (l/MWh/km)	11.09	22.86	27.75	33.26
Annuitisation factor	0.10272			

Latitudinal distance (km)

	Moffat UK	Inch	Shannon	Corrib	Dublin	Galway	Limerick	Cork	Waterford
Moffat UK	0	382	295	224	213	195	305	376	332
Inch	-382	0	-87	-158	-169	-187	-77	-6	-50
Shannon	-295	87	0	-71	-82	-100	10	81	37
Corrib	-224	158	71	0	-11	-29	81	152	108
Dublin	-213	169	82	11	0	-18	92	163	119
Galway	-195	187	100	29	18	0	110	181	137
Limerick	-305	77	-10	-81	-92	-110	0	71	27
Cork	-376	6	-81	-152	-163	-181	-71	0	-44
Waterford	-332	50	-37	-108	-119	-137	-27	44	0
CorkDublin	-228	154	67	-4	-15	-33	77	148	104
North East	-182	200	113	42	31	13	123	194	150
Western region	-241	141	55	-16	-28	-45	65	136	91
Gormanston	-181	201	114	43	32	14	124	195	151
IOM Offtake	-103	279	192	121	110	92	202	273	229
Node 1	-92	290	203	132	121	103	213	284	240
Node 2	-191	191	104	33	22	4	114	185	141
Node 3	-253	129	42	-29	-40	-58	52	123	79
Node 4	-331	51	-35	-106	-118	-135	-25	46	1
Node 5	-294	88	1	-70	-81	-99	11	82	38
Node 6	-224	158	71	0	-11	-29	81	152	108

Longitudinal distance (km)

Model screenshots

Inputs sheet

Calculated based on distances in columns to the left of this

Distances for VP(A) and Matrix use pipeline distances to the node from entry or exit. Between nodes uses straight-line distances, estimated using co-ordinates.

Distances to use for VP(A) & matrix

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Nearest node	Distance to neare
Moffat UK	146	285	378	503	570	472	Node 1	146
Inch	405	275	192	67	134	228	Node 4	67
Shannon	419	289	212	74	6	93	Node 5	6
Corrib	326	196	282	167	100	0	Node 6	0
Dublin	150	20	60	180	210	170	Node 2	20
Galway	320	210	160	140	90	30	Node 6	30
Limerick	340	210	120	30	30	80	Node 4	30
Cork	370	240	150	40	90	150	Node 4	40
Waterford	290	160	80	70	130	150	Node 4	70
CorkDublin	180	40	30	160	180	150	Node 3	30
North East	130	10	80	200	220	180	Node 2	10
Western region	280	160	90	90	70	30	Node 6	30
Gormanston	130	10	80	200	220	180	Node 2	10
IOM Offtake	10	130	210	340	350	300	Node 1	10
Node 1	0	130	220	340	350	300	-	-
Node 2	130	0	80	210	230	190	-	-
Node 3	220	80	0	120	150	120	-	-
Node 4	340	210	120	0	60	110	-	-
Node 5	350	230	150	60	0	70	-	-
Node 6	300	190	120	110	70	0	-	-

Distances reflect actual pipeline distance from entry points to nearest node & straight-line distances for the rest of the network)

Conversion of SCM into GWh/day

CER conversion factor	11.19	Conversion factor to use	CER
IEA conversion factor	10.47		
Calorific value (MJ/m3)	37.71	Conversion factor	0.28

Scenario to use 1

Change supply scenarios using this cell value if required

These scenarios are converted into GWh day using the conversion factors above and these inputs – please see annex B for discussion of how these inputs were derived.

Capacities & Historic peak flow Inputs

	SCENARIO 1 (historic)			SCENARIO 2 (w Corrib)			SCENARIO 3 (w Shannon Corrib)			SCENARIO 4 (w Moffat and Shannon)		
	Technical capacity (SCM)	Average peak flows (GWh/day)	Proxy capacity demand (kWh/day)	Technical capacity (SCM)	Average peak flows (GWh/day)	Proxy capacity demand (kWh/day)	Technical capacity (SCM)	Average peak flows (GWh/day)	Proxy capacity demand (kWh/day)	Technical capacity (SCM)	Average peak flows (GWh/day)	Proxy capacity demand (kWh/day)
Moffat UK	1,274,217	202.8	158,800,000	1,274,217	109.9	58,000,000	1,274,217	42.0	42,000,000	1,274,217	45	44742584
Inch	132,500	35.0	36,400,000	132,500	35.0	35,500,000	132,500	16.4	16,400,000	-	-	-
Shannon Phase 1	-	-	-	-	-	-	710,000	109.3	58,000,000	710,000	193.0	141,679,759
Corrib	-	-	-	385,000	92.9	92,900,000	385,000	70.0	70,000,000	-	-	-
Dublin	1,411,850	87.91	151,135,798	1,411,850	87.91	151,135,798	1,411,850	87.91	151,135,798	1,411,850	87.91	151,135,798
Galway	77,500	0.87	1,272,306	77,500	0.87	1,272,306	77,500	0.87	1,272,306	77,500	0.87	1,272,306
Limerick	159,417	2.20	3,234,210	159,417	2.20	3,234,210	159,417	2.20	3,234,210	159,417	2.20	3,234,210
Cork	806,206	54.08	59,085,323	806,206	54.08	59,085,323	806,206	54.08	59,085,323	806,206	54.08	59,085,323
Waterford	122,913	18.56	19,096,717	34,913	18.56	19,096,717	34,913	18.56	19,096,717	34,913	18.56	19,096,717
CorkDublin	494,670	13.09	19,198,705	494,670	13.09	19,198,705	494,670	13.09	19,198,705	494,670	13.09	19,198,705
North East	268,000	31.01	11,008,128	268,000	31.01	11,008,128	268,000	31.01	11,008,128	268,000	31.01	11,008,128
Western region	288,855	23.43	18,880,345	288,855	23.43	18,880,345	288,855	23.43	18,880,345	288,855	23.43	18,880,345
Gormanston	250,000	0.37	541,247	250,000	0.37	541,247	250,000	0.37	541,247	250,000	0.37	541,247
IOM Offtake	24,500	6.22	13,622,000	24,500	6.22	13,622,000	24,500	6.22	13,622,000	24,500	6.22	13,622,000

... Results | Inputs | CWD | VP (A) | Matrix S1 | Matrix S2 | Matrix S3 | Matrix S4

Model screenshots

CWD sheet

Calculations

		Proportion factors	CWAD to all entry/exit points	Capacity * CWAD	Weight
		Demand		Demand	
Entry 1	Moffat UK	0.81	382	60722	0.89
Entry 2	Inch	0.19	203	7381	0.11
Entry 3	Shannon	0.00	231	0	0.00
Entry 4	Corrib	0.00	213	0	0.00
	Total Entry		1029	68103	
Exit 1	Dublin	0.51	305	46167	0.45
Exit 2	Galway	0.00	427	543	0.01
Exit 3	Limerick	0.01	465	1505	0.01
Exit 4	Cork	0.20	461	27217	0.26
Exit 5	Waterford	0.06	438	8370	0.08
Exit 6	CorkDublin	0.06	312	5986	0.06
Exit 7	North East	0.04	277	3051	0.03
Exit 8	Western region	0.06	424	8007	0.08
Exit 9	Gormanston	0.00	273	148	0.00
Exit 10	IOM Offtake	0.05	195	2651	0.03
	Total Exit		3577	103647	

Tariff calculation

		Revenue share over year (I)	Amount of MWh/day to recover this	Tariff (I/MWh day)
Entry 1	Moffat UK	89,161,645	158,800	**561.47**
Entry 2	Inch	10,838,355	36,400	**297.76**
Entry 3	Shannon	-	-	**0.00**
Entry 4	Corrib	-	-	**0.00**
Exit 1	Dublin	44,543,044	151,136	**294.72**
Exit 2	Galway	523,606	1,272	**411.54**
Exit 3	Limerick	1,452,320	3,234	**449.05**
Exit 4	Cork	26,259,134	59,085	**444.43**
Exit 5	Waterford	8,075,883	19,097	**422.89**
Exit 6	CorkDublin	5,775,597	19,199	**300.83**
Exit 7	North East	2,944,020	11,008	**267.44**
Exit 8	Western region	7,725,756	18,880	**409.20**
Exit 9	Gormanston	142,572	541	**263.41**
Exit 10	IOM Offtake	2,558,068	13,622	**187.79**

Tariff calculation	Revenue (I)	Demand	Tariff (I/MWh day)
Equalised exit	100,000,000	297,075	336.62

Results | Inputs | CWD | VP (A) | Matrix S1 | Matrix S2 | Matrix S3 | Matrix S

Proportion factors = proportion of total entry or exit demand from individual point

CWAD multiplies proportion factors of corresponding exit (entry) values by distances to entry (exit) point

Next column multiplies CWAD by capacity of entry (exit) point

Col I gives a weight of values in Col H for all entry (exit) – sum to 1.0

Weights are then multiplied by the allowed revenue to be recovered from entry for entry points and exit for exit zones.

The revenue share of each point is divided by the level of demand at a point to calculate tariffs.

There is no need for a secondary adjustment under CWD.

Model screenshots

VP(A) sheet

Calculations

		Nearest node (based on geographical location)	Distance between entry/exit point and nearest	Average peak flow (GWh/day)	Entry On or off	Flow distance to/from nearest node	Flow Distance to/from reference node		Exp constant
Entry 1	Moffat UK	Node 1	146	203	1	146	276		27.75
Entry 2	Inch	Node 4	67	35	1	67	-133		11.09
Entry 3	Shannon	Node 5	6	0	0	0	0		11.09
Entry 4	Corrib	Node 6	0	0	0	0	0		11.09
Exit 1	Dublin	Node 2	20	88	1	20	20		11.09
Exit 2	Galway	Node 6	30	1	1	30	220		11.09
Exit 3	Limerick	Node 4	30	2	1	30	90		11.09
Exit 4	Cork	Node 4	40	54	1	40	100		11.09
Exit 5	Waterford	Node 4	70	19	1	70	130		11.09
Exit 6	CorkDublin	Node 3	30	13	1	30	-30		11.09
Exit 7	North East	Node 2	10	31	1	10	10		11.09
Exit 8	Western region	Node 6	30	23	1	30	220		11.09
Exit 9	Gormanston	Node 2	10	0	1	10	10		11.09
Exit 10	IOM Offtake	Node 1	10	6	1	10	-120		11.09

Connecting node distances

Node 1	Node 2	130	Node 1	Node 3	210	Node 1	Node 4	330
Node 2	Node 3	80	Node 1	Node 5	390	Node 1	Node 6	320
Node 3	Node 4	120	Node 2	Node 4	200	Node 2	Node 5	260
Node 4	Node 5	60	Node 3	Node 5	180	Node 4	Node 6	130
Node 5	Node 6	70						
Node 6	Node 2	190						

Nodal balances	In	Out	Total
Node 1	203	6	197
Node 2	0	119	-119
Node 3	0	13	-13
Node 4	35	75	-40
Node 5	0	0	0
Node 6	0	24	-24

Node				Output				
197	n1	n1n2	130	196.55	a	0	0.0	1.0
77	n2	n2n3	80	52.96	b	4237	0.0	1.0
-13	n3	n3n4	120	39.88	c	4785	0.0	1.0
-40	n4	n4n5	60	0.00	d	0	0.0	1.0
0	n5	n5n6	[illegible]	0.00	e	0	0.0	1.0
-24	n6	n6n2	19…	-24.30	f	4617	0.0	-1.0
						13639		

Starting	Node 1	Node 2	…3	Node 4	Node 5	Node 6
Node 1	0	130	[illegible]	190	250	320
Node 2	-130	0	-6…	60	120	190
Node 3	-210	-80	0	…20	40	110
Node 4	-330	-200	-120	[illegible]	-80	-10
Node 5	-390	-260	-180	[illegible]	0	-70

… | Results | Inputs | CWD | **VP (A)** | Matrix S1 | Matrix S2 | Matrix S4

This is an output not input. For example, Inch would be the sum of flow distance to nearest node (+67) and the flow distance from nearest node to reference node (-200, see cell G55)

Flow distance to nearest node comes from Inputs sheet calculation (does not require flow modelling)

The flow distance from that nearest node to the reference node requires flow modelling – see flow direction slide in main section

The first step for this is calculating nodal balances – under a balanced demand and supply scenario there is no residual amount at any node

The solver calculates flows that are required to achieve a balanced network scenario – uses least flow distance modelling to achieve this (minimising cell J49 subject to all nodal balances in column K equalling zero by changing flow amounts (grey cells) in column H))

These output flow distances are then shown in the table at the bottom of this snapshot

n1n2 means the pipeline segment from n1 to n2

Model screenshots

VP(A) sheet

Flow distance to reference node BEFORE adjustment (MWhkm)

			Entry 1 Moffat UK	Entry 2 Inch	Entry 3 Shannon	Entry 4 Corrib
			276	-133	0	0
Exit 1	Dublin	20	296	-113	20	20
Exit 2	Galway	220	496	87	220	220
Exit 3	Limerick	90	366	-43	90	90
Exit 4	Cork	100	376	-33	100	100
Exit 5	Waterford	130	406	-3	130	130
Exit 6	CorkDublin	-30	246	-163	-30	-30
Exit 7	North East	10	286	-123	10	10
Exit 8	Western region	220	496	87	220	220
Exit 9	Gormanston	10	286	-123	10	10
Exit 10	IOM Offtake	-120	156	-253	-120	-120

Values on outside of matrix represent flow distances to reference node

The values inside the matrix are the sum of the outer cells

Solving for d

Number of positive values | **Number of overall values**

Entry 1 | Entry 2

Exit 8 | Exit 10

% entry 0.50

Sum of positive only values

Entry 276

Exit 800

D -44.80 | Check LHS 57.92 RHS 57.92

calculated using goal seek | Difference 0

RUN GOAL SEEK

Goal Seek sets cell H87 to zero by changing cell E86 – detailed approach as set out under ACER framework guidelines– based on entry/ exit split

Flow distance to reference node AFTER adjustment (MWhkm)

			Entry 1 Moffat UK	Entry 2 Inch	Entry 3 Shannon	Entry 4 Corrib
			232	-178	0	0
Exit 1	Dublin	65	296	-113	65	65
Exit 2	Galway	265	496	87	265	265
Exit 3	Limerick	135	366	-43	135	135
Exit 4	Cork	145	376	-33	145	145
Exit 5	Waterford	175	406	-3	175	175
Exit 6	CorkDublin	15	246	-163	15	15
Exit 7	North East	55	286	-123	55	55
Exit 8	Western region	265	496	87	265	265
Exit 9	Gormanston	55	286	-123	55	55
Exit 10	IOM Offtake	-75	156	-253	-75	-75

Adjustment to outer cells are a function of the ‘d’ adjustment (add to entry, subtract from exit)

Outer cells are then multiplied by expansion constant and annuitisation factor to arrive at primary tariffs

Primary tariffs are uplifted by a secondary adjustment to reach allowed revenue

Model screenshots

Matrix sheets

Model should be set up to reflect expansion constants on each segment of pipeline – calculated based on blended expansion constants where appropriate

Representative network

Pipe	Start	Finish	Distance (km)	Peak flow – in	Peak flow – out	Dry/Wet	Expansion constant	Unit cost (for 1GWh)	Ref	Unit cost
1	Moffat UK	Node 1	146	202.8	0.0	Wet Moffat N1	22,856	343,901		
2	Inch	Node 4	67	35.0	0.0	Dry	11,086	76,092		
3	Shannon	Node 5	6	0.0	0.0	Dry	11,086	7,163		
4	Corrib	Node 6	0	0.0	0.0	Dry	11,086	-		
5	Node 2	Dublin	20	0.0	87.9	Dry	11,086	22,775		
6	Node 6	Galway	30	0.0	0.9	Dry	11,086	34,163		
7	Node 4	Limerick	30	0.0	2.2	Dry	11,086	34,163		
8	Node 4	Cork	40	0.0	54.1	Dry	11,086	45,550		
9	Node 4	Waterford	70	0.0	18.6	Dry	11,086	79,713		
10	Node 3	CorkDublin	30	0.0	13.1	Dry	11,086	34,163		
11	Node 2	North East	10	0.0	31.0	Dry	11,086	11,388		
12	Node 6	Western region	30	0.0	23.4	Dry	11,086	34,163		
13	Node 2	Gormanston	10	1.0	0.4	Dry	11,086	11,388		
14	Node 1	IOM Offtake	10	2.0	6.2	Dry	11,086	11,388		
15	Node 1	Node 2	130	196.6	0.0	Wet N1 N2	33,258	444,114	12	444,114
16	Node 2	Node 3	80	53.0	0.0	Dry	11,086	91,100	23	91,100
17	Node 3	Node 4	120	39.9	0.0	Dry	11,086	136,650	34	136,650
18	Node 4	Node 5	60	0.0	0.0	Dry	11,086	68,325	45	68,325
19	Node 5	Node 6	70	0.0	0.0	Dry	11,086	79,713	56	79,713
20	Node 6	Node 2	190	0.0	24.3	Dry	11,086	216,363	62	216,363
21	Node 2	Node 1	130	0.0	196.6	Wet N1 N2	33,258	444,114	21	444,114
22	Node 3	Node 2	80	0.0	53.0	Dry	11,086	91,100	32	91,100
23	Node 4	Node 3	120	0.0	39.9	Dry	11,086	136,650	43	136,650
24	Node 5	Node 4	60	0.0	0.0	Dry	11,086	68,325	54	68,325
25	Node 6	Node 5	70	0.0	0.0	Dry	11,086	79,713	65	79,713
26	Node 2	Node 6	190	24.3	0.0	Dry	11,086	216,363	26	216,363

Unit costs (for 1GWh of flow) are calculated using expansion constants, annuitisation factor and flow modelling from VP(A) model for each segment of pipeline

Entry – exit paths unit costs

Entry	Exit				Segment 1	Segment 2	Segment 3	Total unit cost
Moffat UK	Dublin	Node 1	Node 2	12	343,901	22,775	444,114	810,790
Moffat UK	Galway	Node 1	Node 6	16	343,901	34,163	660,477	1,038,541
Moffat UK	Limerick	Node 1	Node 4	14	343,901	34,163	671,865	1,049,929
Moffat UK	Cork	Node 1	Node 4	14	343,901	45,550	671,865	1,061,316
Moffat UK	Waterford	Node 1	Node 4	14	343,901	79,713	671,865	1,095,479
Moffat UK	CorkDublin	Node 1	Node 3	13	343,901	34,163	535,214	913,278
Moffat UK	North East	Node 1	Node 2	12	343,901	11,388	444,114	799,403
Moffat UK	Western region	Node 1	Node 6	16	343,901	34,163	660,477	1,038,541
Moffat UK	Gormanston	Node 1	Node 2	12	343,901	11,388	444,114	799,403
Moffat UK	IOM Offtake	Node 1	Node 1	11	343,901	11,388	-	355,289
Inch	Dublin	Node 4	Node 2	42	76,092	22,775	227,751	326,617
Inch	Galway	Node 4	Node 6	46	76,092	34,163	148,038	258,292
Inch	Limerick	Node 4	Node 4	44	76,092	34,163	-	110,254
Inch	Cork	Node 4	Node 4	44	76,092	45,550	-	121,642
Inch	Waterford	Node 4	Node 4	44	76,092	79,713	-	155,804
Inch	CorkDublin	Node 4	Node 3	43	76,092	34,163	136,650	246,905
Inch	North East	Node 4	Node 2	42	76,092	11,388	227,751	315,230
Inch	Western region	Node 4	Node 6	46	76,092	34,163	148,038	258,292
Inch	Gormanston	Node 4	Node 2	42	76,092	11,388	227,751	315,230
Inch	IOM Offtake	Node 4	Node 1	41	76,092	11,388	671,865	759,344
Shannon	Dublin	Node 5	Node 2	52	7,163	22,775	296,076	326,014

Results | Inputs | CWD | VP (A) | **Matrix S1** | Matrix S2 | Matrix S3 | Matrix S4

Segment 1 reflects entry to nearest node
Segment 2 reflects exit to nearest node
Segment 3 reflects pipeline between two nearest nodes in Segments 1 & 2
These segments are totalled to get a unit cost for each combination of entry and exit

Model screenshots

Matrix sheets

Unit costs

		Entry 1 Moffat UK	Entry 2 Inch	Entry 3 Shannon	Entry 4 Corrib
Exit 1	Dublin	0.81	0.33		
Exit 2	Galway	1.04	0.26		
Exit 3	Limerick	1.05	0.11		
Exit 4	Cork	1.06	0.12		
Exit 5	Waterford	1.10	0.16		
Exit 6	CorkDublin	0.91	0.25		
Exit 7	North East	0.80	0.32		
Exit 8	Western region	1.04	0.26		
Exit 9	Gormanston	0.80	0.32		
Exit 10	IOM Offtake	0.36	0.76		

The network segment unit costs are used to construct unit costs for each entry and exit point combination

Tariffs and sum of tariffs

			Entry 1 Moffat	Entry 2 Inch	Entry 3 Shannon	Entry 4 Corrib
			0.59	0.00		
Exit 1	Dublin	0.33	0.92	0.33		
Exit 2	Galway	0.35	0.94	0.35		
Exit 3	Limerick	0.29	0.88	0.29		
Exit 4	Cork	0.32	0.91	0.32		
Exit 5	Waterford	0.34	0.93	0.34		
Exit 6	CorkDublin	0.29	0.88	0.29		
Exit 7	North East	0.27	0.86	0.27		
Exit 8	Western region	0.36	0.95	0.36		
Exit 9	Gormanston	0.26	0.85	0.26		
Exit 10	IOM Offtake	0.12	0.71	0.12		

Solver is run to minimise the sum of squared errors in the matrix - cell D119 subject to a non-negative constraint on outer cells

The annuitisation factor and expansion constant have already been applied to unit costs, so the values in orange form the primary tariffs

Instructions for the Solver set up in the model is provided in cells N5:Q10

Sum of squared differences (unit cost – sum of entry & exit tariffs)

		Entry 1 Moffat	Entry 2 Inch	Entry 3 Shannon	Entry 4 Corrib
Exit 1	Dublin	0.01	0.00		
Exit 2	Galway	0.01	0.01		
Exit 3	Limerick	0.03	0.03		
Exit 4	Cork	0.02	0.04		
Exit 5	Waterford	0.03	0.03		
Exit 6	CorkDublin	0.00	0.00		
Exit 7	North East	0.00	0.00		
Exit 8	Western region	0.01	0.01		
Exit 9	Gormanston	0.00	0.00		
Exit 10	IOM Offtake	0.13	0.41		
	SUM	0.78			

RUN SOLVER

Tariff calculation / **Adjustment to equal allowed revenue (at set split**

		Tariff (rescaled l/MWh day)	Flow/Demand (MWh day)	Total revenue recovered		Over (+) / Under (-) recovery (l)	Demand capacity used for adjustment	Adjust
			Demand					
Entry 1	Moffat UK	591.3	158800.0	93,893,801.31	Entry	-6,106,199	195,200	
Entry 2	Inch	0.0	36400.0	-	Exit	-6,106,218	297,075	
Entry 3	Shannon	0.0	0.0	-				

Secondary adjustment applied as a fixed adder where do not recover allowed revenue from entry or exit points

... Results | Inputs | CWD | VP (A) | Matrix S1 | Matrix S2 | Matrix S3 | Matrix S4

D

INPUT ASSUMPTIONS

Input assumptions

Entry

- Entry assumptions sourced from data provided to us by BGN

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Technical capacity	2014 NDP	2014 NDP	2014 NDP	2014 NDP
Average peak flows	Projected Flows including Great Island, Average Year Peak Moffat excludes NI flows	Projected Flows including Great Island, Average Year Peak Moffat excludes NI flows	Projected Flows including Great Island, Average Year Peak Moffat excludes NI flows Shannon and Inch however are based on 2018/19 values within NDP	Projected Flows including Great Island and SNLG online, Corrib offline, Average Year Peak
Proxy capacity demand	Bookings 2013/14	Projected bookings including Corrib 2015/16	Projected bookings for Shannon – other active points equal to peak flows	Moffat equal to peak flows – remainder (based on exit demand) assumed to be sourced from Shannon

Input assumptions

Exit

- Sourced from data provided to us by BGN

Element	Notes
Technical capacity	Based on the sum of individual exit point capacities in zone
Average peak flows	Average Year Peak (including Great Island) for all exit points in zone
Proxy capacity demand	Based on historic peak day flows, allocates projected bookings for 2015/16 to exit points, which are then summed for the exit zone

Contact us

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