nationalgrid
THE POWER OF ACTION

Project TransmiT



Theme 4 – Reflecting new transmission technology: HVDC

Ivo Spreeuwenberg

nationalgrid
THE POWER OF ACTION

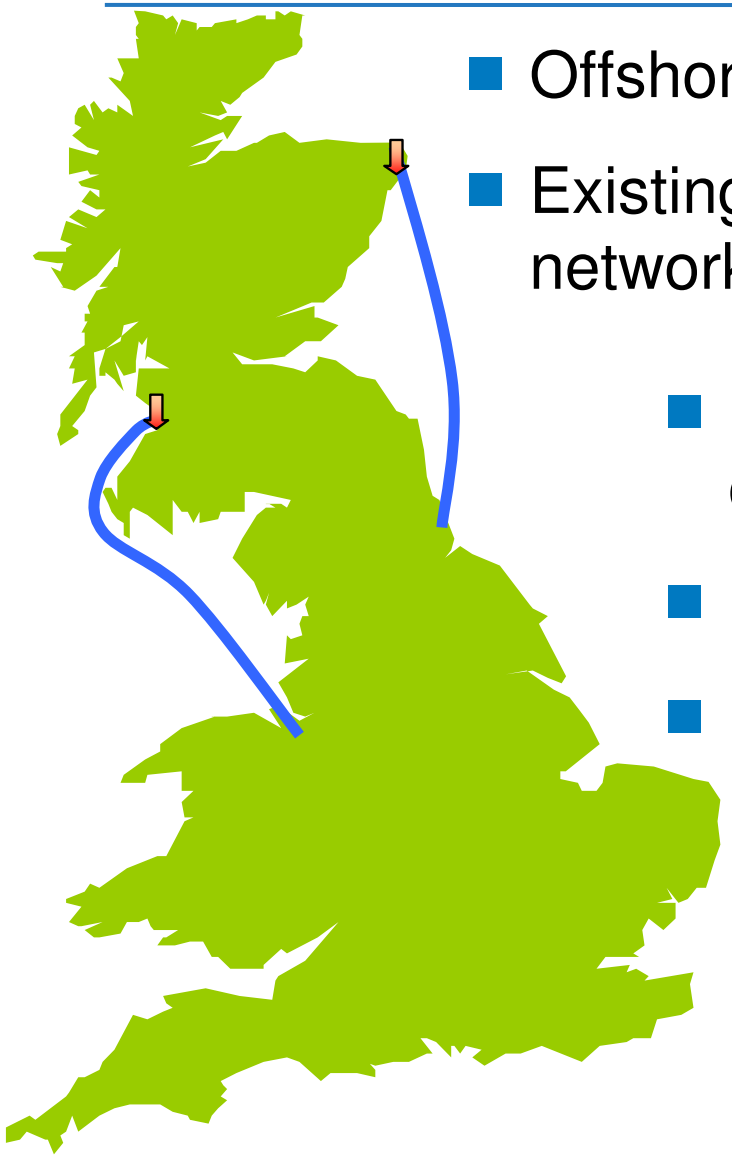
Project TransmiT

The slides that follow produce illustrative tariffs for alternative approaches to incorporating HVDC links into the ICRP charging methodology. They are included for educational purposes only in order to increase awareness of the effects of different elements of the model. The tariffs are based on the 2011/12 T&T model and contain other simplifications and therefore should not be considered as indicative for any purpose other than education.

4

nationalgrid
THE POWER OF ACTION

Reflecting New Technology



- Offshore HVDC links – 'Bootstraps'
- Existing charging model based on passive network elements
  - HVDC represents an active component of the network
  - High relative £/MWkm cost
  - Lack of suitable onshore alternative

1. Which costs go into EF calculation?
2. Where does incremental MW flow?

4

nationalgrid
THE POWER OF ACTION

HVDC

- Impact on tariffs is combination of:

Cost Components

£/MWkm

Marginal MW flow

MWkm

- Which **cost components** are included in the model?
  - Need to calculate cost relative to 400kV OHL – Expansion Factor
- How much of the **marginal MW** flows down the link?
  - Need to calculate an impedance for the model
- Relevant for both ‘Status Quo’ and ‘Improved ICRP’ Redpoint modelling

4

HVDC

Cost Components

£/MWkm

nationalgrid
THE POWER OF ACTION

Annuity Factor:	0.06567
Asset Life:	50
Rate:	0.0625
Overhead Factor %	1.8
Expansion Constant (£/MWkm)	11.142856

Existing Expansion Factor Parameters			
Projected Relative Cost of Asset	NGC	SP	SSE
400kV cable factor	22.390	22.390	22.390
275kV cable factor	22.394	22.394	22.394
132kV cable factor	30.220	30.220	27.790
400kV line factor	1.000	1.000	1.000
275kV line factor	1.137	1.137	1.137
132kV line factor	2.796	2.796	2.238

Calculations

HVDC Details:	370.0	Length (km)
	2,000.0	Rating (MW)
	1,000.0	Total Cost (£m)
	65.7	Annuitised cost
	18.0	Overheads cost
	83.7	Total Annual Cost (£m)
£/MWkm:	113.1	£/MWkm
	10.1	HVDC expansion factor
Transport Model:	167.7	Equivalent length of 400kV cable
		or
	3754.4	Equivalent length of 400kV OHL

Assumptions for illustration

Bus 1	Bus 2	R	X	OHL Length	Cable Length
DEES40	HUER40	0.000	????	3754.400	0.00

4

HVDC

Cost Components

£/MWkm

nationalgrid
THE POWER OF ACTION

Option A	Option B	Option C
No suitable onshore alternative	**SO flexibility akin to SVC or QB**	**Full marginal signal**
■ Treat as 400kV OHL ■ Little impact on tariffs ■ Regardless of MW flow	■ Remove converters from EF ■ Some impact on tariffs ■ Varies by MW flow	■ Include all elements in EF ■ Significant impact on tariffs ■ Varies by MW flow

Calculation - Option A

HVDC Details:	370.0	Length (km)
	2,000.0	Rating (MW)
	1,000.0	Total Cost (£m)
	-	Annuitised cost
	-	Overheads cost
	-	Total Annual Cost (£m)
£/MWkm:	11.1	£/MWkm
	1.0	HVDC expansion factor
Transport Model:	16.5	Equivalent 400kV cable km
		or
	370.0	Equivalent 400kV OHL km

Calculation - Option B

HVDC Details:	370.0	Length (km)
	2,000.0	Rating (MW)
	550.0	Total Cost (£m)
	36.1	Annuitised cost
	9.9	Overheads cost
	46.0	Total Annual Cost (£m)
£/MWkm:	62.2	£/MWkm
	5.6	HVDC expansion factor
Transport Model:	92.2	Equivalent 400kV cable km
		or
	2064.9	Equivalent 400kV OHL km

Calculation - Option C

HVDC Details:	370.0	Length (km)
	2,000.0	Rating (MW)
	1,000.0	Total Cost (£m)
	65.7	Annuitised cost
	18.0	Overheads cost
	83.7	Total Annual Cost (£m)
£/MWkm:	113.1	£/MWkm
	10.1	HVDC expansion factor
Transport Model:	167.7	Equivalent 400kV cable km
		or
	3754.4	Equivalent 400kV OHL km

Transport Model

Option	Bus 1	Bus 2	R	X	OHL Length	Cable Length
A	DEES40	HUER40	0.000	????	370.00	0.00
B	DEES40	HUER40	0.000	????	2064.90	0.00
C	DEES40	HUER40	0.000	????	3754.40	0.00

4

HVDC

Marginal MW flow

MWkm

nationalgrid
THE POWER OF ACTION

- Marginal flow dictated by relative impedance of all routes to centre of the network

- Impedance can vary from very small to very large
  - Scenario 1: ***X*** = 0.0001
  - Scenario 2: ***X*** = 2
  - Scenario 3: ***X*** = 99999

  sets out a maximum range

- Transport model market input data (i.e. G and D) and generic flow sharing rules could be used to set out a specific methodology for calculating network flows and associated impedance - ***X***

4

HVDC: A Starter for 10?

Marginal MW flow

MWkm

nationalgrid
THE POWER OF ACTION

- 2 existing double circuit routes + 1 HVDC link = 3 Anglo-Scottish routes
- Planned Transfer (PT) calculated on capacity:

$$= \left(\text{Scottish Generation} \times \frac{\text{GB Demand}}{\text{GB Generation}} \right) - \text{Scottish Demand}$$

$$= \left(9.998 \times \frac{58321}{89072} \right) - 4.917$$

$$= 1.63$$

- Assume equal sharing = 1.63 ÷ 3 = 543MW each
- Requires impedance of ~ 3.89 in the 2011/12 model
- Should Interconnection Allowance be added to PT?

4

HVDC

Cost Components

£/MWkm

Marginal MW flow

MWkm

nationalgrid
THE POWER OF ACTION

- Matrix of impedance scenarios and cost options modelled for illustrative purposes
- Note: Impact of proposals for other 'Themes' not modelled

			km		MW	MWkm
Scenario	Option	EF	400kV OHL km	X	Flow	Total flow cost
1	A	1	370	0.0001	1370.23	506985.1
	B	5.6	2064.9	0.0001	1370.23	2829387.9
	C	10.1	3754.4	0.0001	1370.23	5144391.5
2	A	1	370	2	768.79	284452.3
	B	5.6	2064.9	2	768.79	1587474.5
	C	10.1	3754.4	2	768.79	2886345.2
3	A	1	370	9999	0.35	129.5
	B	5.6	2064.9	9999	0.35	722.715
	C	10.1	3754.4	9999	0.35	1314.04

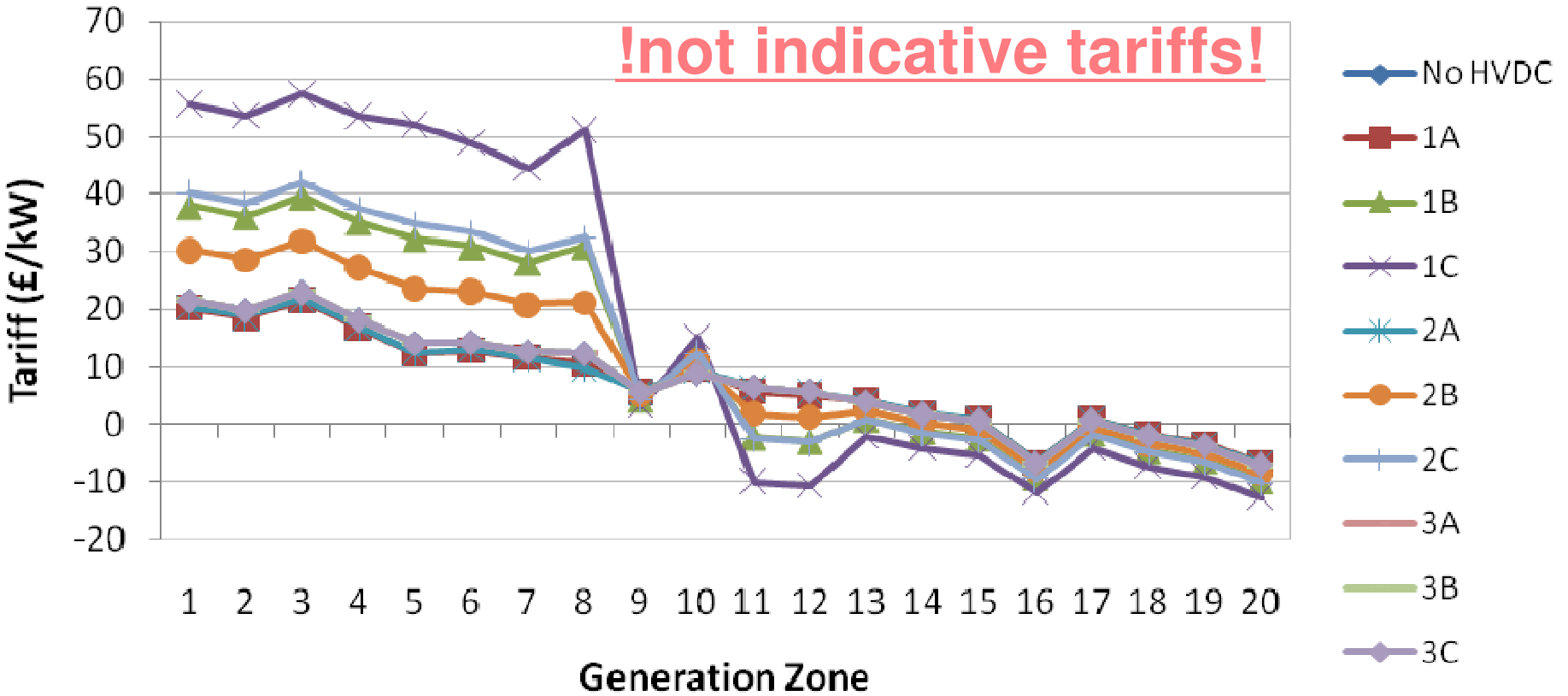
EF is relative 400kV OHL cost

***X* dictates MW flow**

4

nationalgrid
THE POWER OF ACTION

HVDC – Illustration of Effect on G Tariff

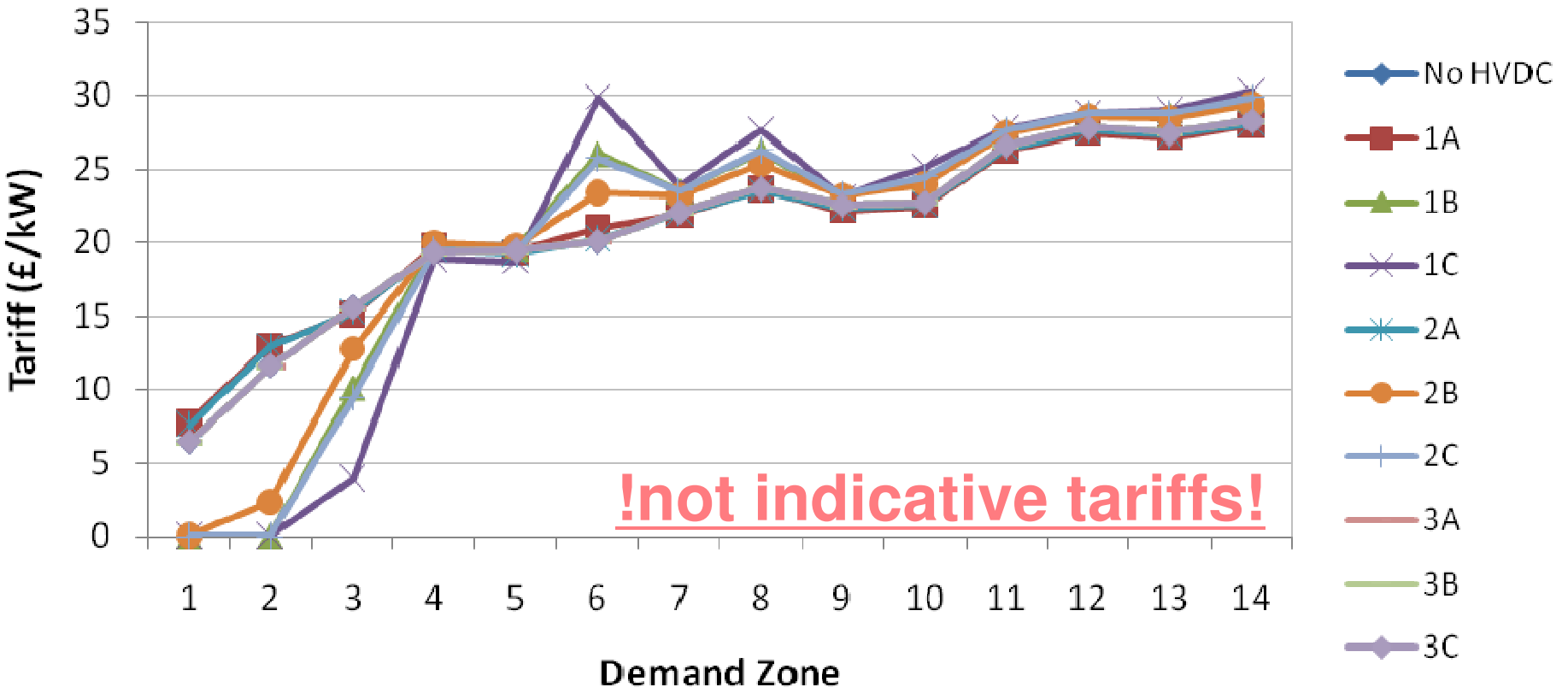


- Illustrative generation tariffs for 9 cases in matrix
- 1B, 1C, 2B, 2C have significant effect

4

nationalgrid
THE POWER OF ACTION

HVDC – Illustration of Effect on D Tariff



- Illustrative demand tariffs for 9 cases in matrix
- £0/kW tariff collar activated for 4 cases