

# ENSG “Bootstraps”

Investigating the charging treatment of HVDC Links operated in parallel with the AC network



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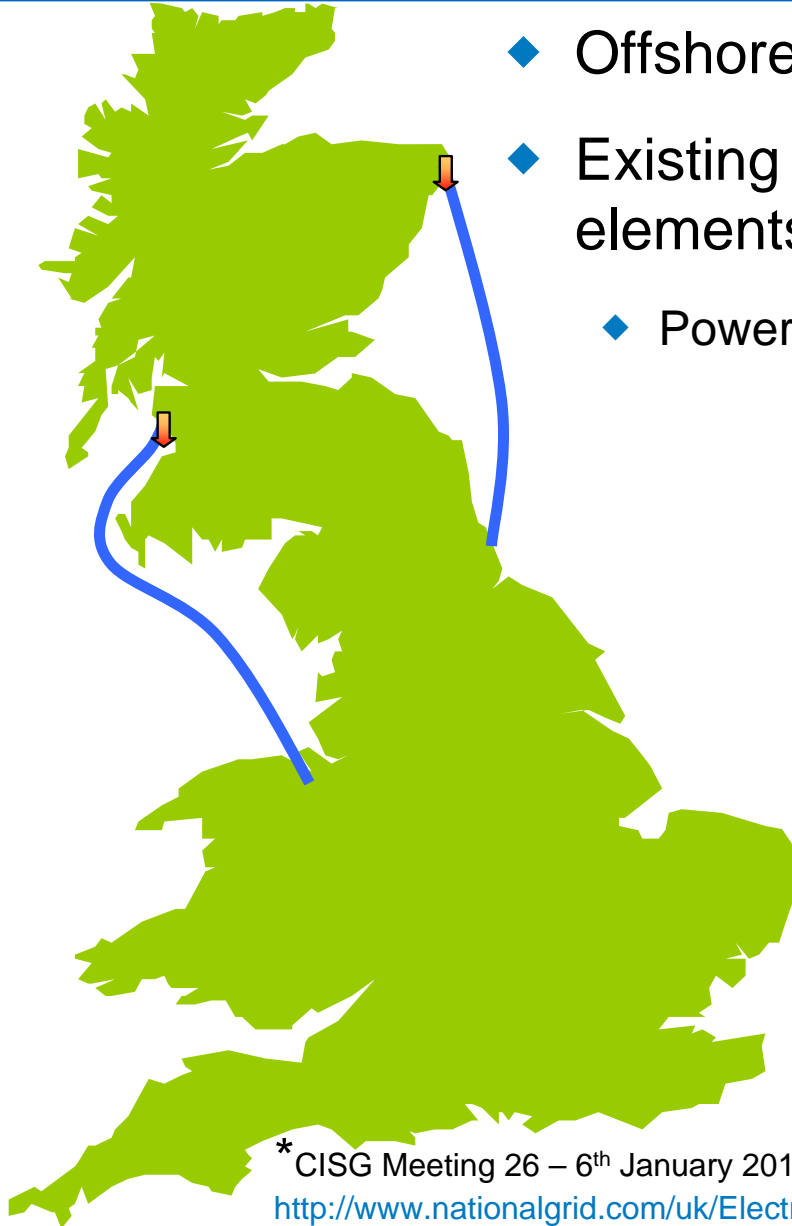
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# Agenda

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1. Background
2. Tariffs could be calculated based on a 'required capacity'; arising out of market conditions in the transport model
  - ◆ Only incremental capacity requirement is modelled
3. HVDC links could be operated such that power transported is not changed following fault outages
  - ◆ Security is provided by the parallel AC circuits
  - ◆ Re-calculate locational security factor to reflect costs
4. Expansion factor could be modified to factor in additional operational flexibility of HVDC
  - ◆ Further work not yet taken forward

# Background – The “Bootstraps”



- ◆ Offshore HVDC links proposed through ENSG
- ◆ Existing ICRP DCLF based on passive network elements
  - ◆ Power flows based on circuit impedance only
- ◆ HVDC operated in parallel to the AC system; represents an active component of the network
- ◆ Not had to be modelled to date
- ◆ Other characteristics differentiating DC from AC
- ◆ Previous work\* investigated possible range of impact on charges

\* CISG Meeting 26 – 6<sup>th</sup> January 2010

<http://www.nationalgrid.com/uk/Electricity/Charges/cisg/meeting/>

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# 1. Effect of 'Required Capacity' on Tariff

- ◆ Tariffs could be calculated based on a 'required capacity' arising out of market conditions in the transport model
  - ◆ AC network capacity is maximised / only incremental requirement modelled
- ◆ Flows on the HVDC link set to:
  - = *Planned Transfer* – AC network capability
  - = Scaling Factor x  $G_{\text{Scotland}} - D_{\text{Scotland}} - \text{AC cap.}$
- ◆ Examples for 2015 and 2020 Gone Green



# 1. Effect of 'Required Capacity' on Tariff

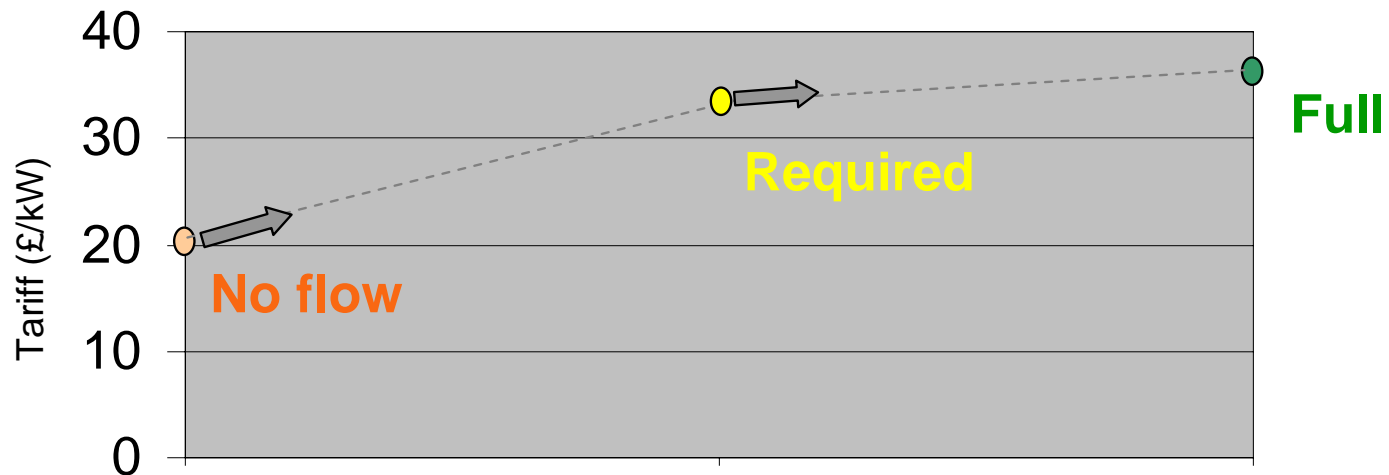
Example – Gone Green 2015\*

$$= \text{Scaling Factor} \times G_{\text{Scotland}} - D_{\text{Scotland}} - \text{AC Capability}$$

$$= 0.746 \times 14.948 \text{ GW} - 5.284 \text{ GW} - 4.3 \text{ GW}$$

$$= 1.57 \text{ GW on western link}$$

Excel Solver utilised to calculate required HVDC Link Reactance of ~ 2.5 to set flow to 'required capacity'



- Year 2014-15 from Condition 5 modified to simulate Gone Green 2015 (adding ~1GW gen. in Scotland removing 24GW in E&W);
- HVDC Expansion Factor of 10 assumed; Expansion Constant not inflated
- £130m additional revenue for full Stage 1 ENSG;
- £70m additional revenue for incremental only.

# 1. Effect of 'Required Capacity' on Tariff

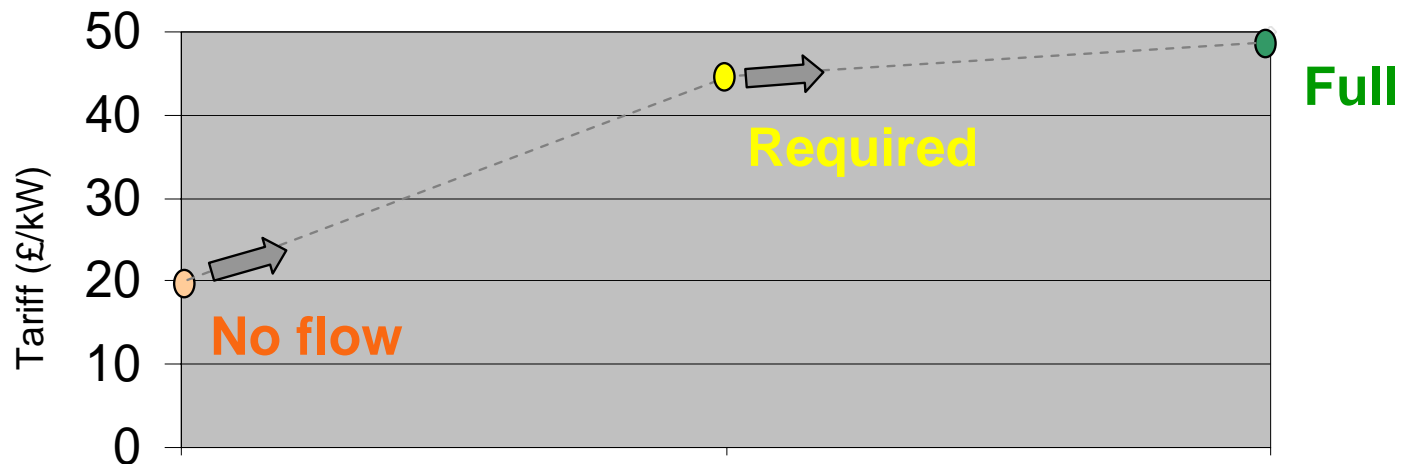
Example – Gone Green 2020\*

$$= (\text{Scaling Factor} \times G_{\text{Scotland}} - D_{\text{Scotland}} - \text{AC Capability}) / 2$$

$$= (0.641 \times 19.63 \text{ GW} - 5.284 \text{ GW} - 4.3 \text{ GW}) / 2$$

$$= 1.49 \text{ GW each link}$$

Excel Solver utilised to calculate required HVDC Link Reactance of 3.45 for western and 6.05 for eastern link



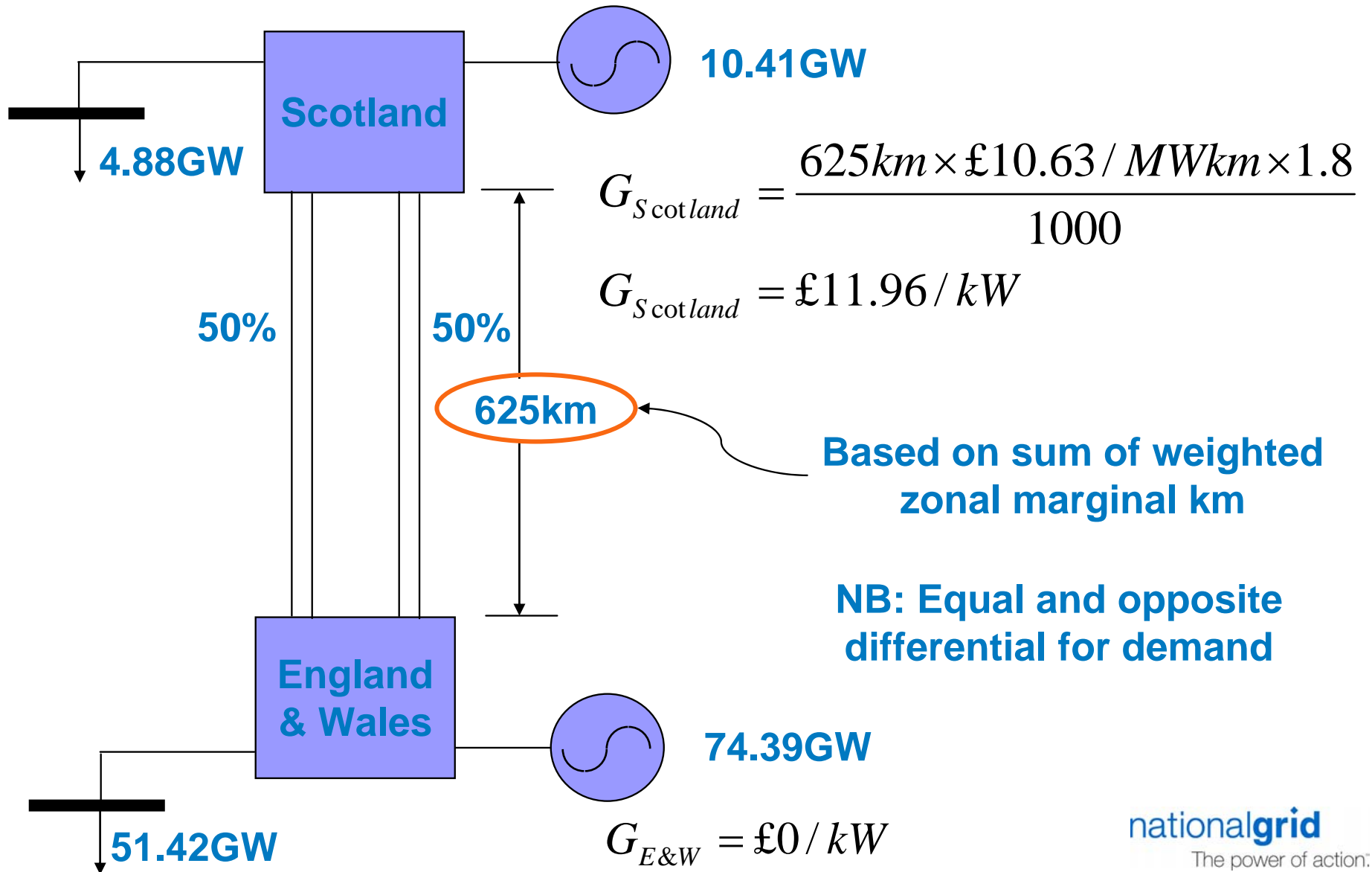
- Year 2014-15 from Condition 5 modified to simulate Gone Green 2020 (adding ~5GW gen. in Scotland removing 14GW in E&W);
- HVDC Expansion Factor of 10 assumed; Expansion Constant not inflated
- ~£400m additional revenue for full ENSG;

## 2. Effect of Security Factor recalculation on Tariff

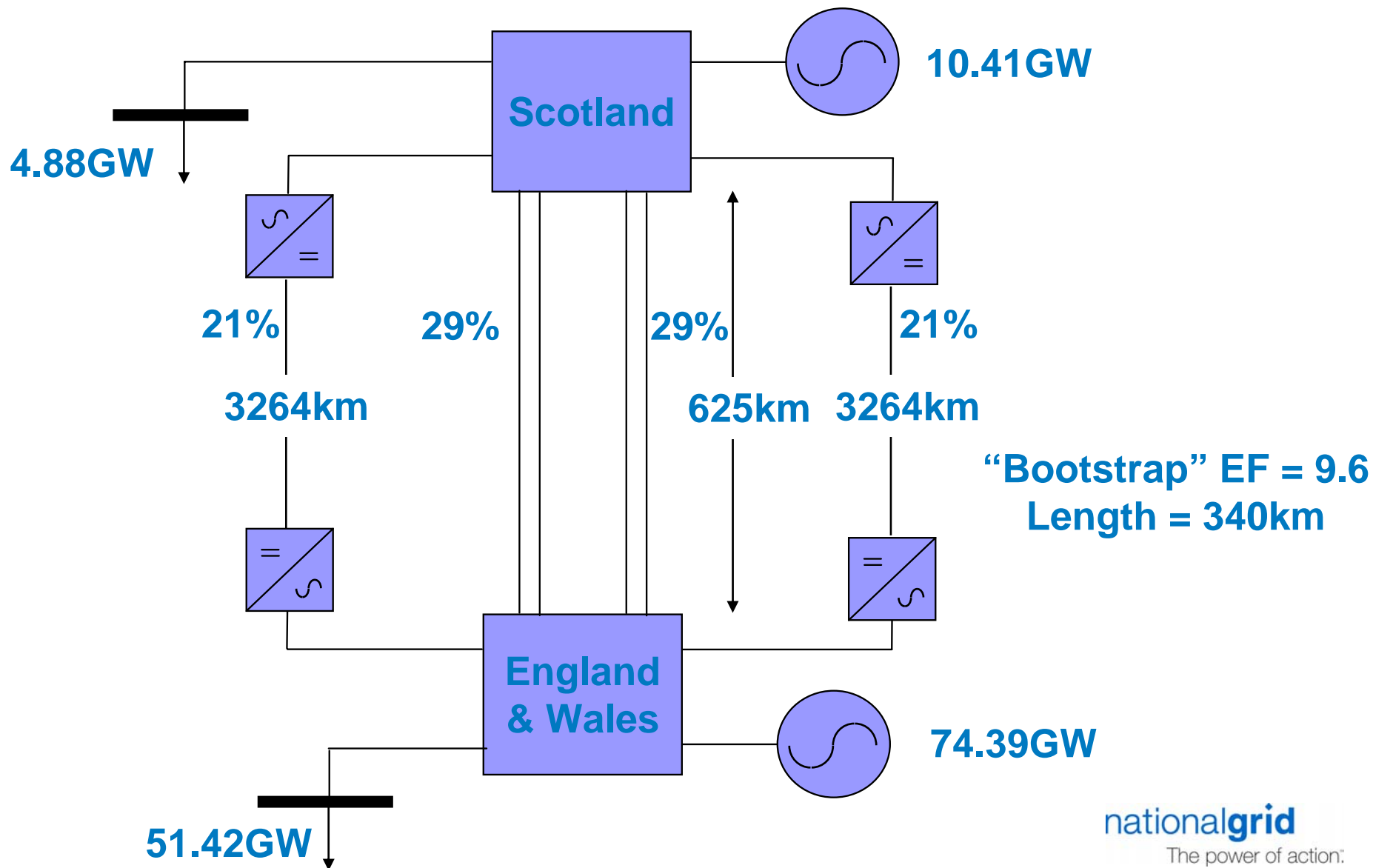
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- ◆ HVDC links to be modelled such that power transported is not changed following fault outages
  - ◆ Security is provided by the parallel AC circuits
- ◆ Need to recalculate the locational security factor to properly reflect the cost of the “bootstraps” in TNUoS charges
  - ◆ Locational security factor calculated using SECURED LoadFlow (SECULF) program
  - ◆ Simplified example calculation presented here to demonstrate effect

# 2010/11 transport model data



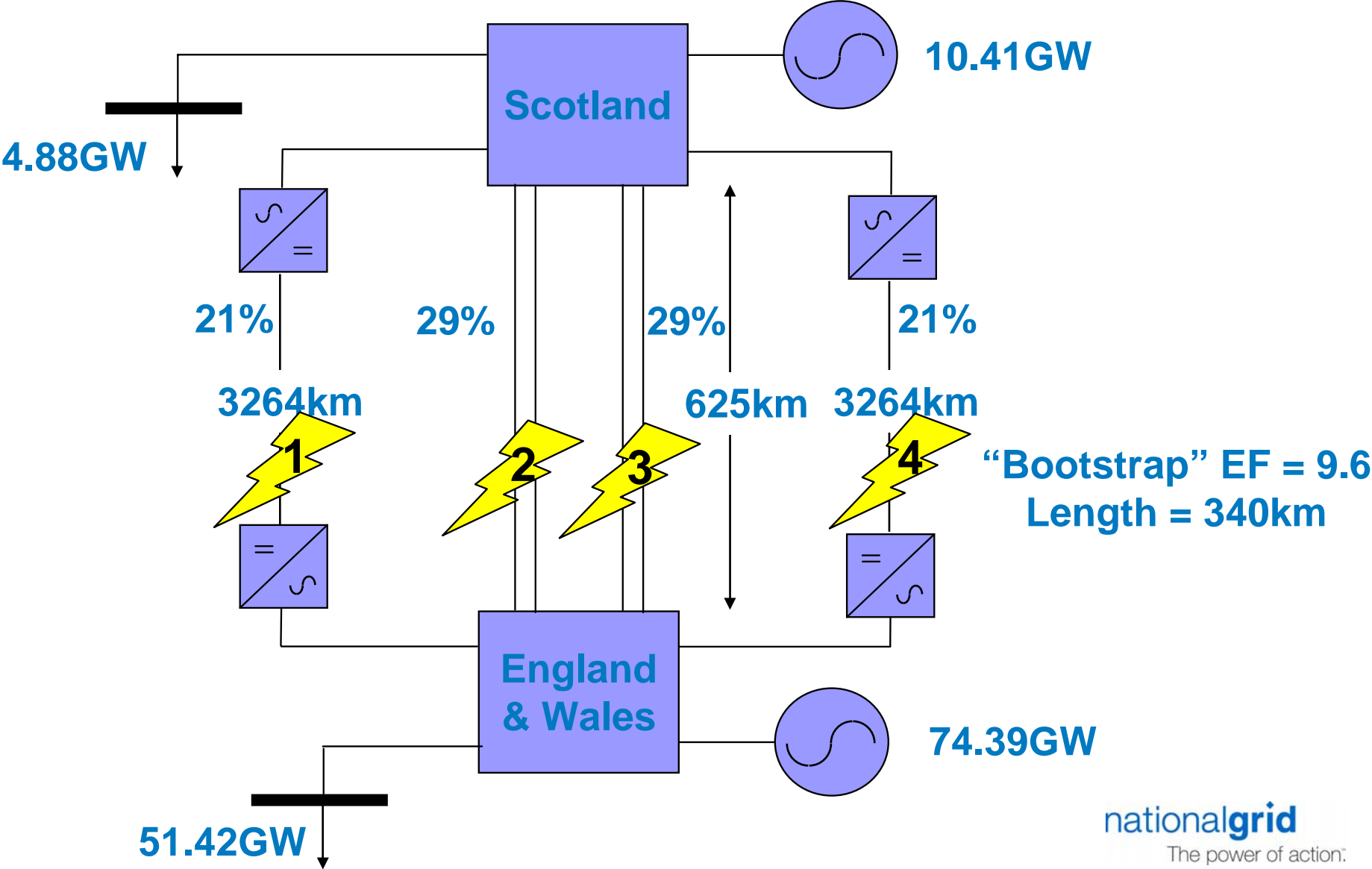
# Addition of HVDC “bootstraps”







# Marginal MW flows

|          | Route 1 | Route 2 | Route 3 | Route 4 |
|----------|---------|---------|---------|---------|
| Intact   | 0.21    | 0.29    | 0.29    | 0.21    |
| Outage 1 |         | 0.395   | 0.395   | 0.21    |
| Outage 2 | 0.21    |         | 0.58    | 0.21    |
| Outage 3 | 0.21    | 0.58    |         | 0.21    |
| Outage 4 | 0.21    | 0.395   | 0.395   |         |
| Max      | 0.21    | 0.58    | 0.58    | 0.21    |

# Addition of HVDC “bootstraps”



# Marginal MW flows

|            |  |  |  |  |
|------------|---|--|---|---|
| Intact     | 0.21  | 0.29   | 0.29  | 0.21  |
| Outage 1   |   | 0.395  | 0.395   | 0.21  |
| Outage 2   | 0.21  |  | 0.58  | 0.21  |
| Outage 3   | 0.21  | 0.58   |   | 0.21  |
| Outage 4   | 0.21  | 0.395  | 0.395   |   |
| <b>Max</b> | <b>0.21</b>   | <b>0.58</b>  | <b>0.58</b>   | <b>0.21</b>   |

# Calculation of revised $G_{\text{Scotland}}$

$$\text{Intact MWkm} = [(0.21 \times 3264\text{km}) + (0.29 \times 625\text{km}) + (0.29 \times 625\text{km}) + (0.21 \times 3264\text{km})]$$

$$\text{Intact MWkm} = 1733.38$$

$$\text{Secured MWkm} = [(0.21 \times 3264\text{km}) + (0.58 \times 625\text{km}) + (0.58 \times 625\text{km}) + (0.21 \times 3264\text{km})]$$

$$\text{Secured MWkm} = 2095.88$$

$$\text{Locational Security Factor} = \left[ \frac{2095.88}{1733.38} \right] = 1.21$$

**NB: Numbers presented previously based on LSF of 1.8**

$$G_{\text{Scotland}} = \frac{1733.38\text{km} \times \text{£}10.63 / \text{MWkm} \times 1.21}{1000}$$

$$G_{\text{Scotland}} = \text{£}22.30 / \text{kW}$$

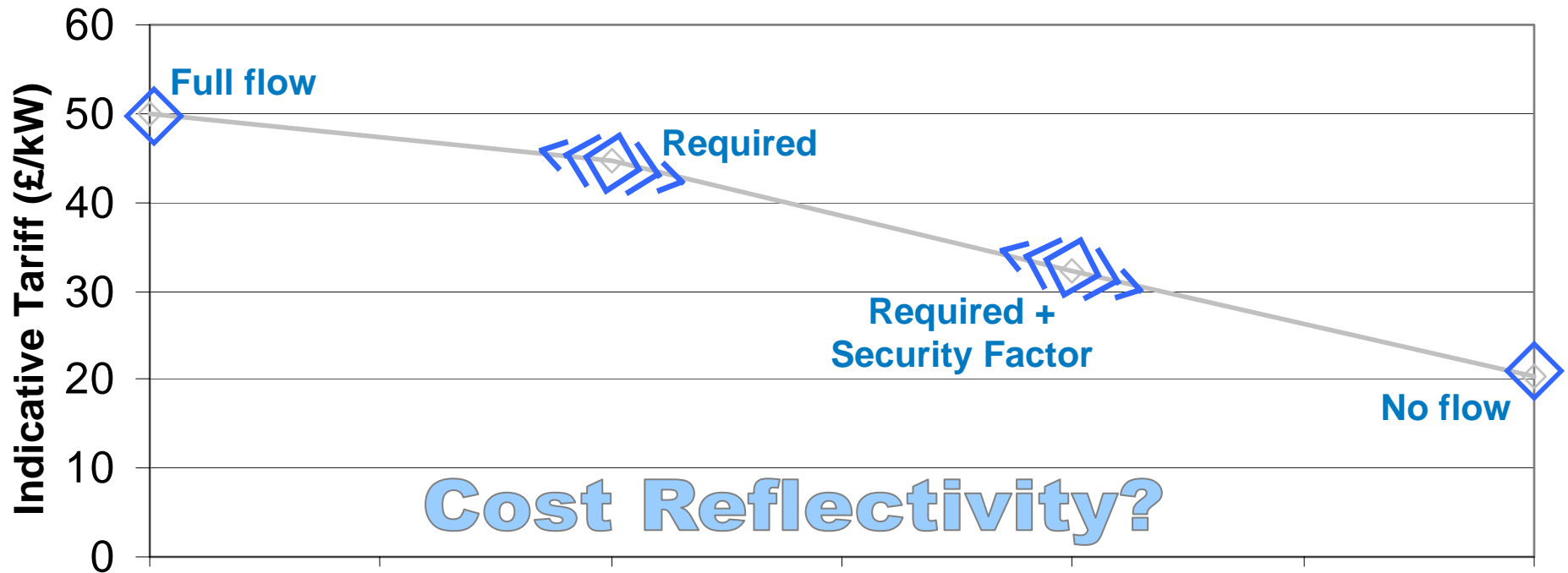
## 3. Expansion Factor Modification

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- ◆ Possible further work
- ◆ Recognising the difference in the way AC and DC circuits are rated
- ◆ This could have the effect of reducing the expansion factor for HVDC links, if deemed more cost reflective.

# Combination of Mechanisms – 2020

## Wider Locational Tariff in the North of Scotland\*



*Numbers purely indicative based on forecasts, assumptions and analysis undertaken*

# Thank you

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