CMP213 – TransmiT TNUoS Modification

Workgroup Seminar

Chair – Patrick Hynes

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Agenda

	Time	Topic	
	10:00 – 10:20	Teas and coffees on arrival	
1	10:20 – 10:30	Welcome and overview	Chair
2	10:30 – 11:00	Background: Existing TNUoS methodology and GSR-009	NGET
3	11:00 – 11:30	Original Proposal: (i) Sharing, (ii) HVDC and (iii) Islands	NGET
4	11:30 – 12:00	Q & A	All
5	12:00 – 12:30	Lunch	
6	12:30 – 13:45	Industry Workgroup progress to date	Industry WG member
7	13:45 – 14:50	Q & A	All
8	14:50 – 15:00	Closing remarks	Chair

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TransmiT Process to date

Call for Evidence and Academic Reports	Oct. '10 – June '11
Industry Technical WG develop options	July '11 – Oct.'11
Economic Assessment of 3 options	Aug.'11 – Dec.'11
Ofgem SCR consultation	Dec.'11 – Feb. '12
Ofgem conclusions and direction to NGET	May'12
NGET raise CUSC modification proposal	20th June 2012

- Development, debate and consultation has taken place
- Direction set out elements included in modification proposal and Workgroup terms of reference
- First Workgroup meeting held in July 2012

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CUSC process

- Defect
- Proposed solution – the Original

- Discussion, development & analysis
- Possible alternative solutions
- Workgroup consultation

- Final proposals
- Assessment against CUSC objectives
- Final consultation

- Submission to Ofgem

2. Background: Existing TNUoS & NETS SQSS

Workgroup Seminar

Proposer – Ivo Spreeuwenberg

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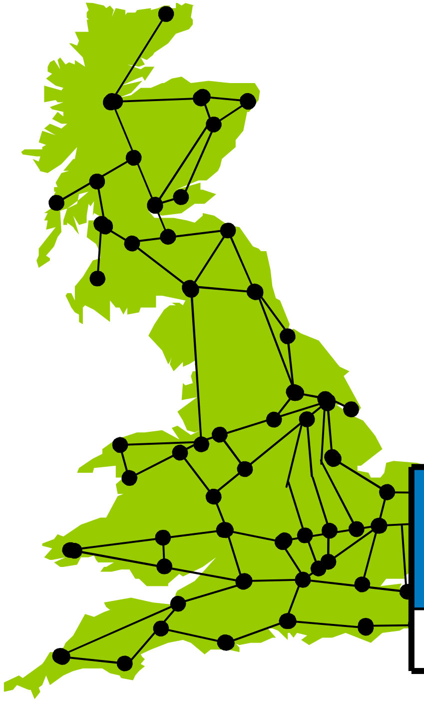
Transmission Network Use of System Charges

- Collect revenue on behalf of transmission companies
- Promote effective competition
- Reflect costs of transmission network assets
- Take account of developments in transmission business
- Non-discrimination

TransmiT issues focus on cost reflectivity and developments

Reflecting transmission network costs

- Tariffs reflect network cost of increasing/decreasing generation/demand at a point on the system



Parameter	Value
Network, generation & demand data	Ten year statement
Expansion constant	£11.72318/MWkm
Annuity factor	6.6%
Overhead factor	1.8%
Security factor	1.8

TO Area	Cable factor			OHL factor		
	400kV	275kV	132kV	400kV	275kV	132kV
NGET	22.39	22.39	30.22	1.00	1.14	2.80

- Charging model calculates power flows across the network as a result of background assumptions

No sub-sea or HVDC circuit expansion factors

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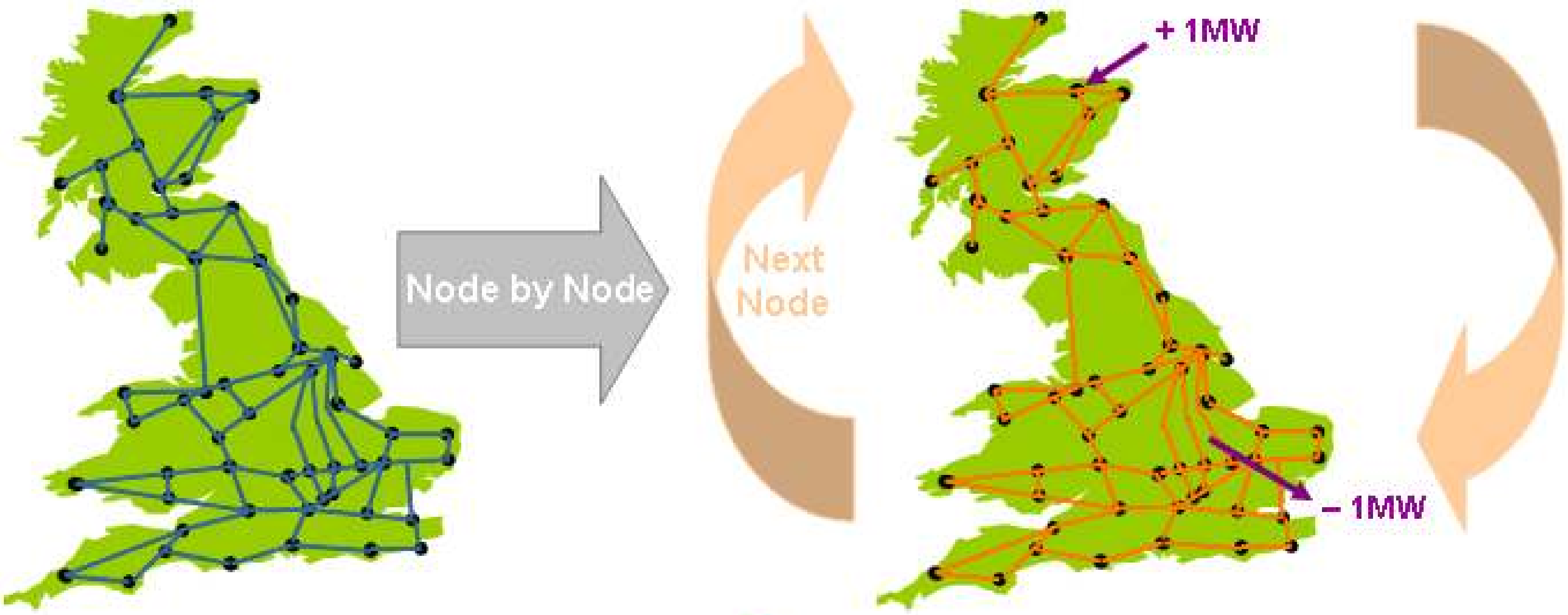
Reflecting transmission network costs

Base Case MWkm

1) Scale G to meet D
2) Calculate flows on circuits
3) Sum total network MWkm

Incremental MWkm

4) +1MW (-1MW at reference)
5) Calculate flows on circuits
6) Sum total network MWkm



7) Nodal Incremental MWkm = Incremental MWkm – Base Case MWkm

Assume all incremental MWs have the same impact ~ NETS SQSS

Reflecting transmission network costs

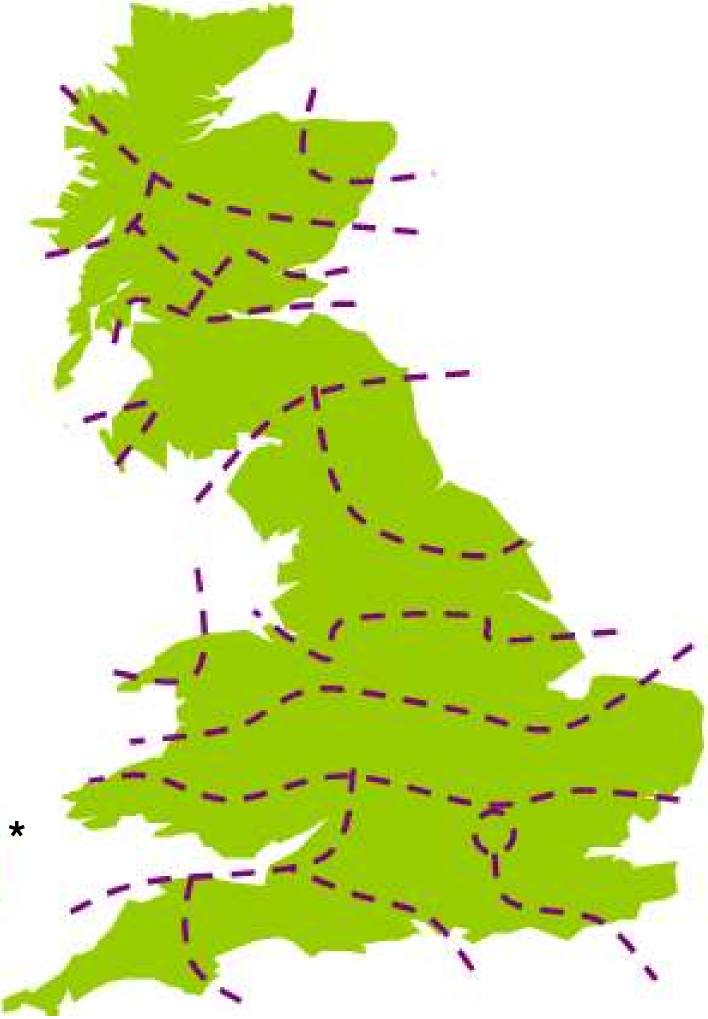
8) Zonal Incremental MWkm:

i. nodal incremental MWkm
ii. zoning criteria
iii. demand weighted average

Zonal Incremental MWkm

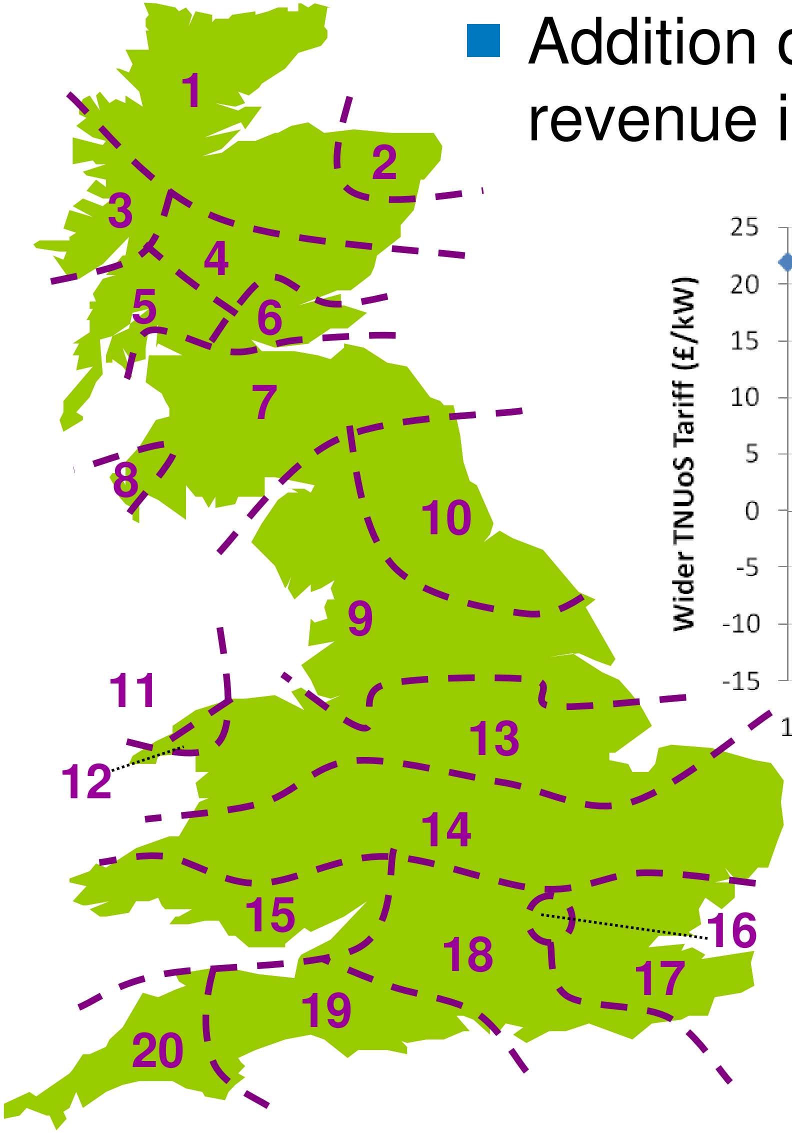
x EC x 1.8

= Wider Locational Tariff *

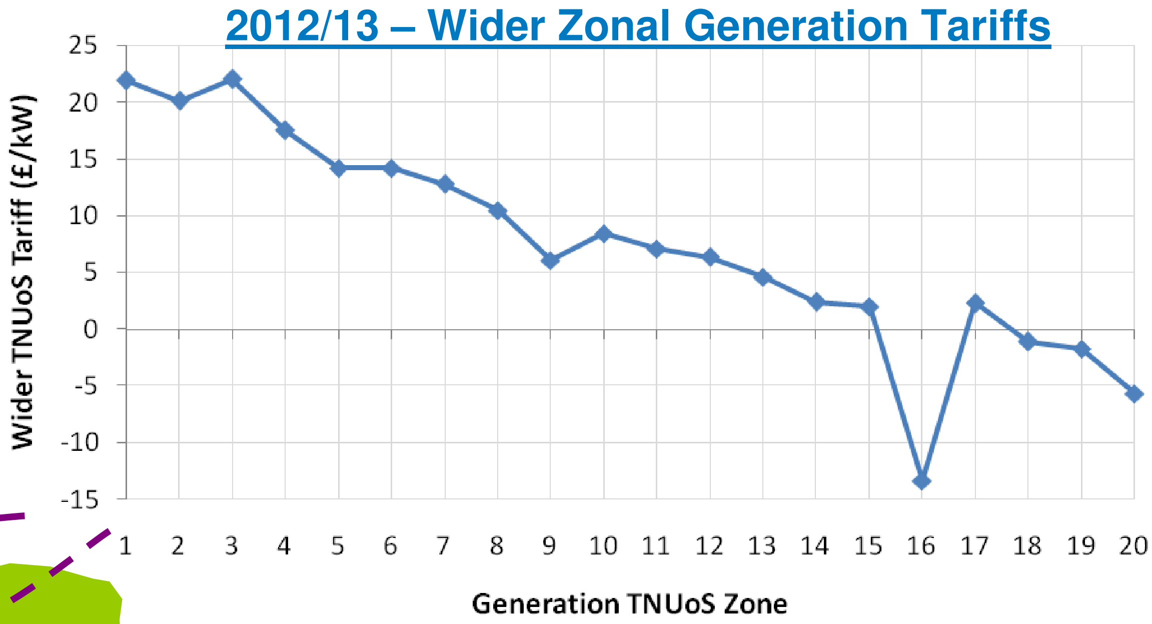


*Generation tariff is equal and opposite to demand tariff until zoning takes place

Example: Generation TNUoS Tariffs



- Addition of residual element to collect correct revenue in proportion (27% G : 73% D)



- Vary by location (distance related)
- Local circuit and local substation tariff added to wider tariff

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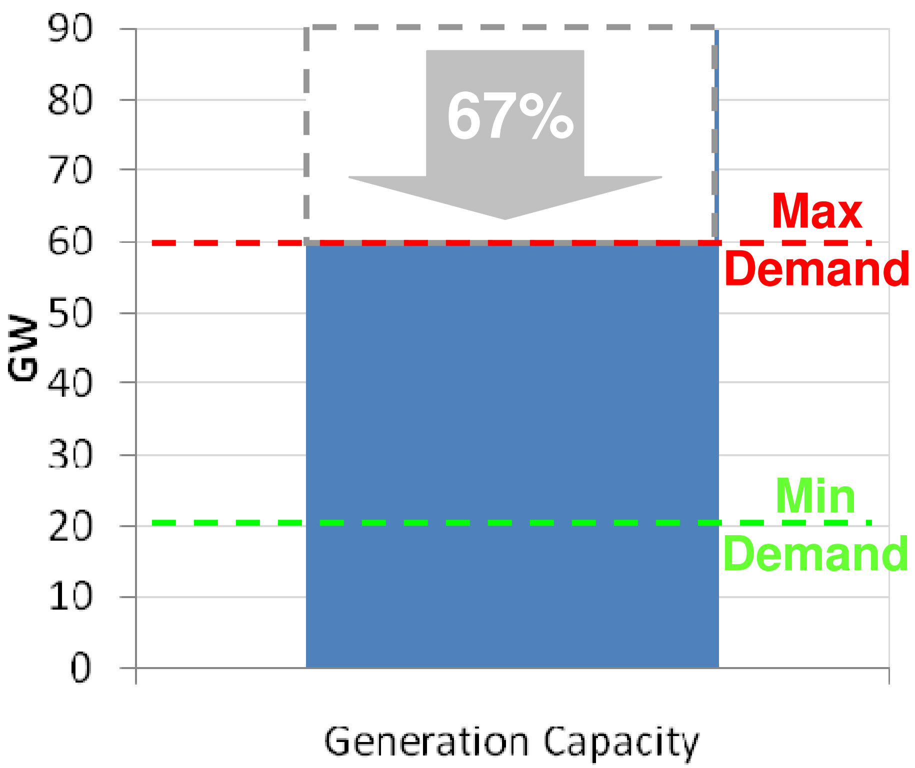
NETS Security & Quality of Supply Standards

- Planning standard for investment in network capacity
- Network model and "load flow" calculation used for planning

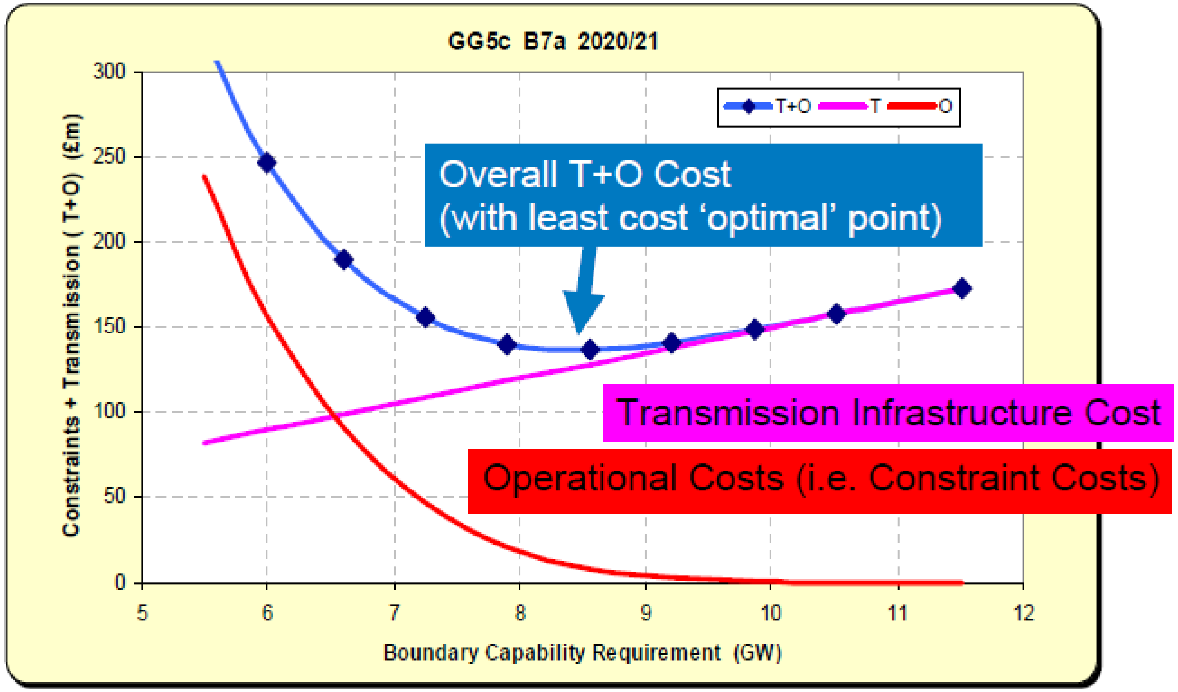


- Historically investment driven predominately by requirements at peak demand
- 1MW of additional generation capacity ≠ 1MW of additional network capacity

Largely uniform treatment of generation capacity

GSR-009: Review of NETS SQSS for Intermittent

- Total transmission cost = operational + infrastructure



- GSR-009 set out to create deterministic standards from detailed cost-benefit analysis (CBA)

http://www.nationalgrid.com/uk/Electricity/Codes/gbsqsscode/LiveAmendments/

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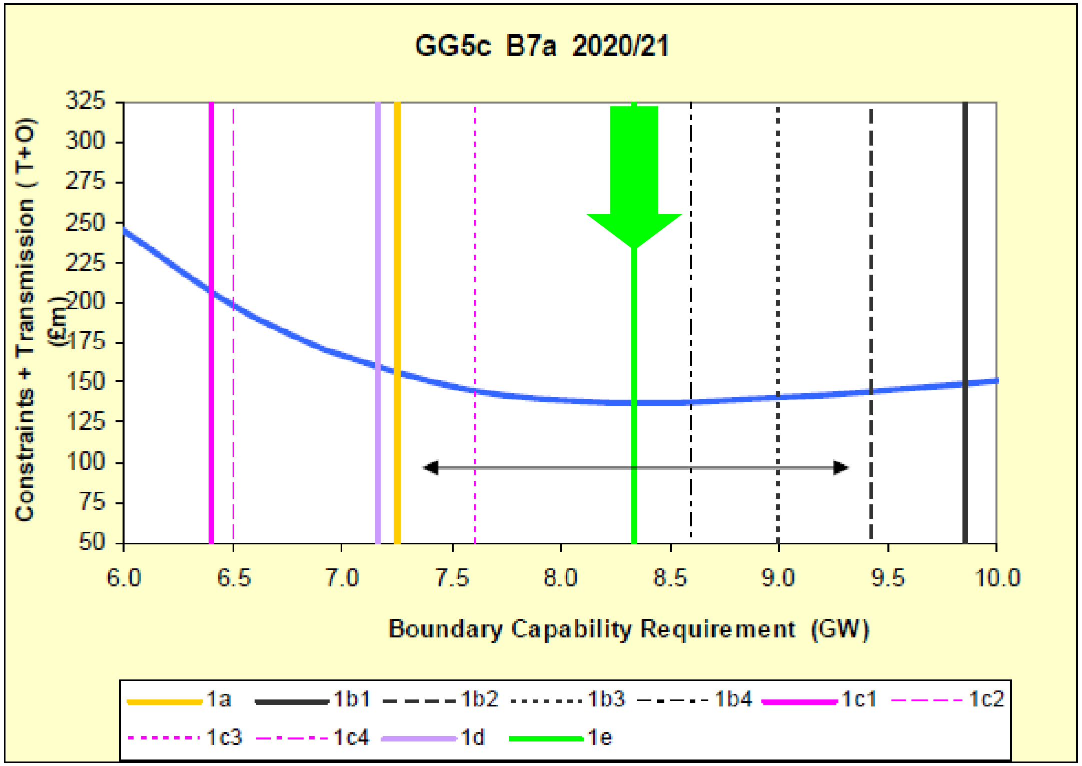
GSR-009: Review of NETS SQSS for Intermittent



- Various approaches to the grouping and scaling of generation to meet peak demand investigated
- Address both demand security and CBA requirements

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GSR-009: Results

- Split planning background into peak and pseudo-CBA
- Fixed scaling factors for some generation

Generator Type	TEC	Current Methodology	Peak Background	Pseudo-CBA Background
Intermittent	5,460	65.5%	0%	70%
Nuclear & CCS	10,753	65.5%	72.5%	85%
Interconnectors	3,268	65.5%	0%	100%
Hydro	635	65.5%	72.5%	66%
Pumped Storage	2,744	65.5%	72.5%	50%
Peaking	5,025	65.5%	72.5%	0%
Other (Conventional)	61,185	65.5%	72.5%	66%

Values in grey vary depending on the total demand level, whilst values in black are fixed scaling factors

Supported by full blown CBA for large investments

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Summary – “Defect”

- Increasing amounts of variable generation
- Changes in network planning to reflect differential impact of various generation plant types
  - GSR-009 changes to NETS SQSS and increasing use of a CBA approach
- Charges need to evolve to properly reflect costs

- Use of technologies such as HVDC circuits that parallel the AC network and sub-sea island connections
- Additions required to take account of developments

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3. CMP213 – Original proposal

Workgroup Seminar

Proposer – Ivo Spreeuwenberg

Elements of the Modification Proposal

- Modification to reflect network investment cost impact of different generation technologies (capacity sharing)

1 Capacity Sharing

- Addition of parallel HVDC circuits

2 Parallel HVDC

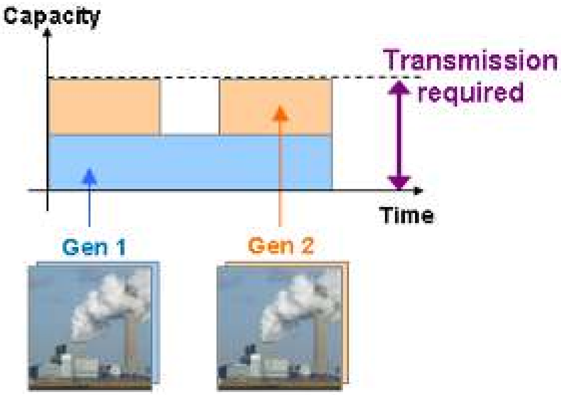
- Addition of sub-sea island connections

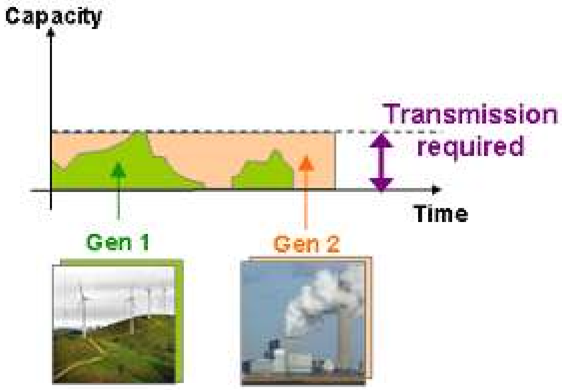
3 Islands

Drafted to provide flexibility in addressing defect

Capacity Sharing – Defect

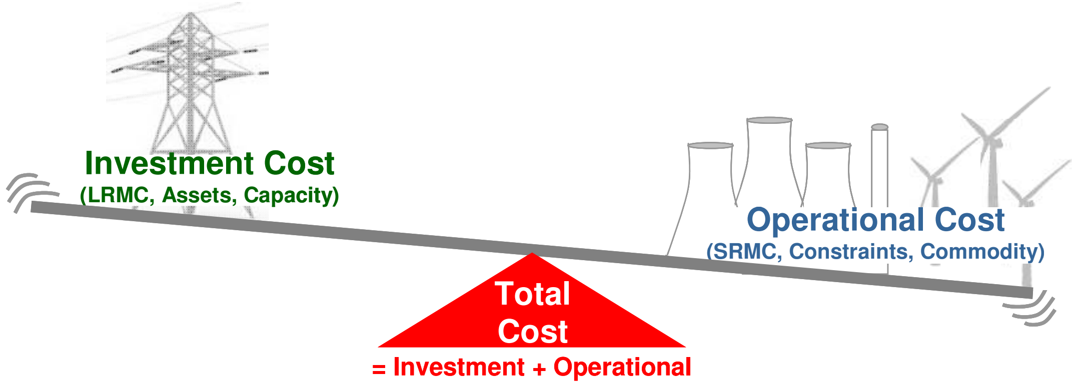
- Increasing variable generation = increased network sharing





- NETS SQSS GSR-009

- Greater proportion of investment driven by CBA



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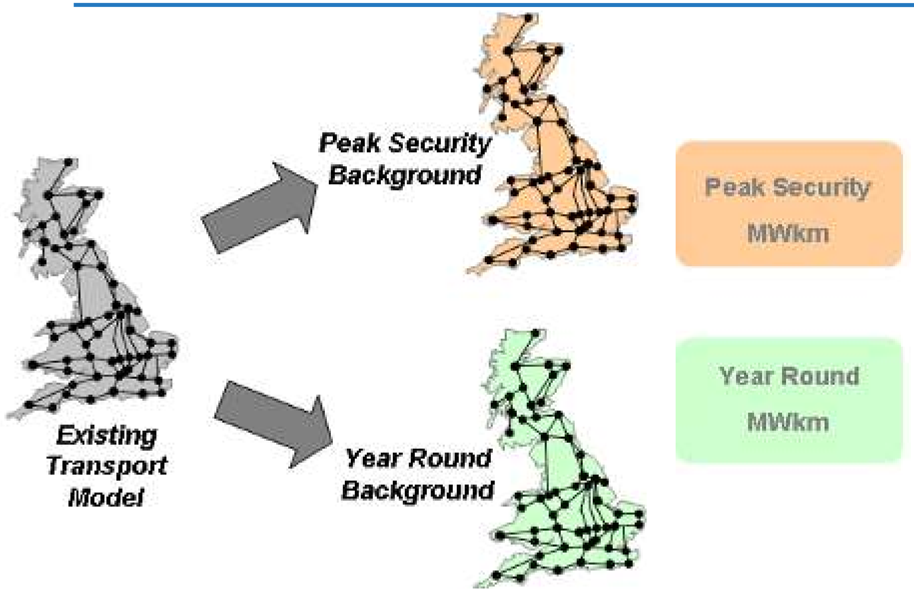
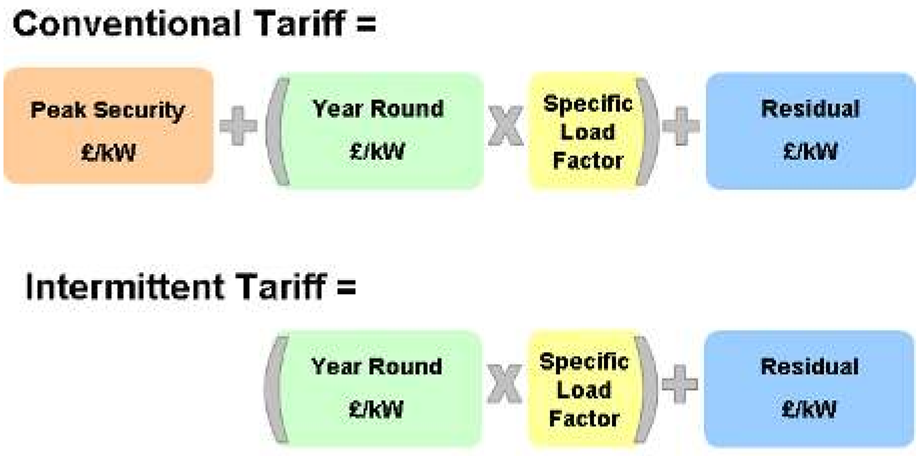
Sharing – Proposal



- Sharing takes place on the wider network
- Dual backgrounds in the Transport Model – SQSS
- Separate tariffs consistent with network planning
- Generator specific load factor multiplier for year round



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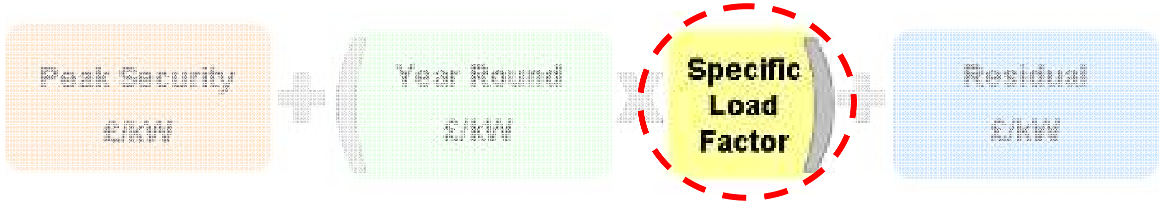
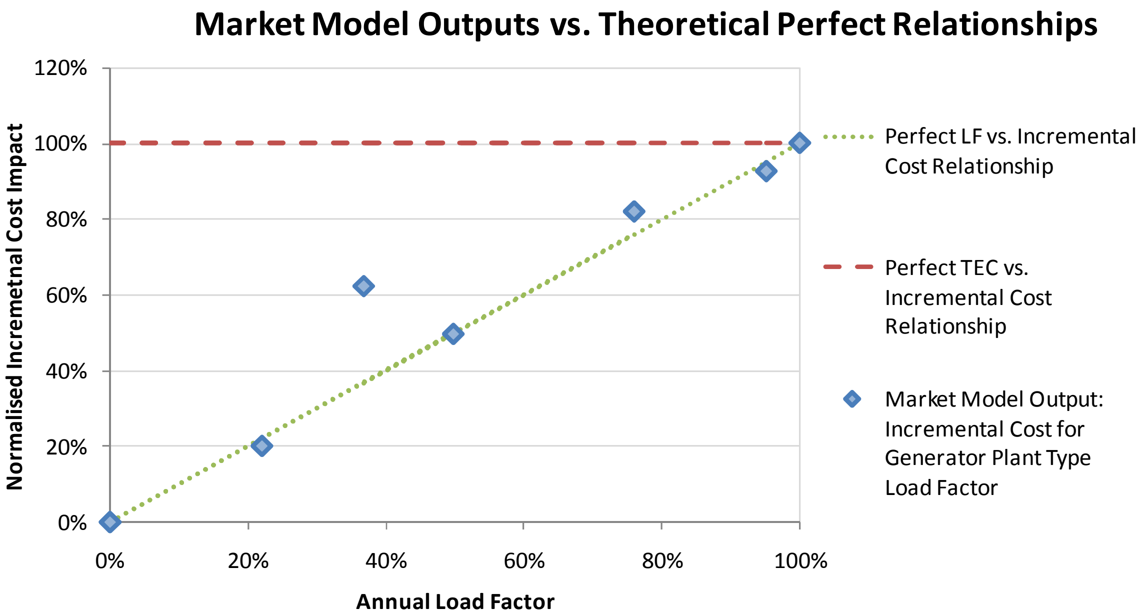
Sharing – Proposal



- Many characteristics of a generator contribute to incremental impact on network costs



- Market model; relationship between generators and network costs
- Proposer concluded annual load factor is good representation

Imperfect relationship; balances simplicity with cost reflectivity

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Parallel HVDC – Defect

- Parallel HVDC circuits – 'Bootstraps'
- Existing charging model based on passive network elements
    - HVDC represents an active component
    - High relative £/MWkm cost
    - Some precedent offshore

1 Which costs go into EF calculation?

2 Where does incremental MW flow?

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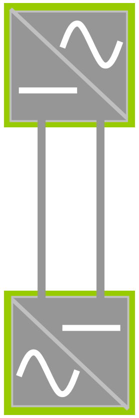
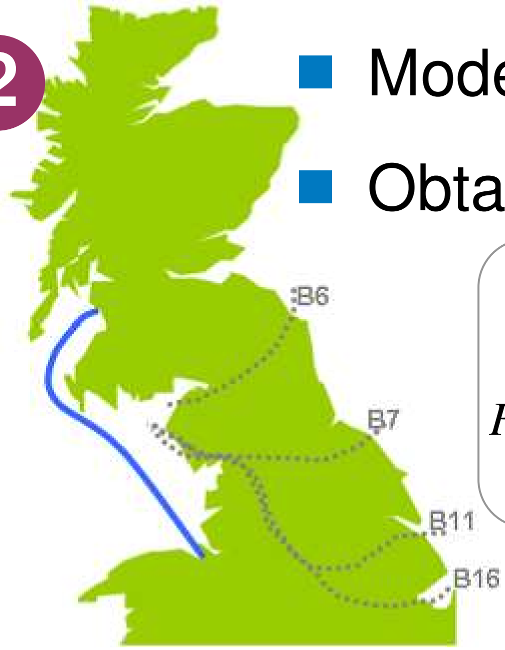
Parallel HVDC – Proposal



1

- Annuitised, unit capital cost – £/MWkm/year
- Include cable and converter costs into calculation
- Consistent with existing treatment of radial HVDC circuits; appropriate for parallel links?

2



- Model HVDC as pseudo-AC → need impedance
- Obtained by calculating power flow in base case

$$Flow = \frac{\sum_{0}^{N_B} BF_{MW} \times \left(\frac{HVDC_{cap}}{BR} \right)}{N_B}$$

Where:

BF_{MW} = MW boundary flow from Transport model with no HVDC

$HVDC_{cap}$ = MW capacity of HVDC circuit

BR = Total secured rating of boundary

N_B = No. of boundaries crossed

- Impedance dictates incremental MW flow

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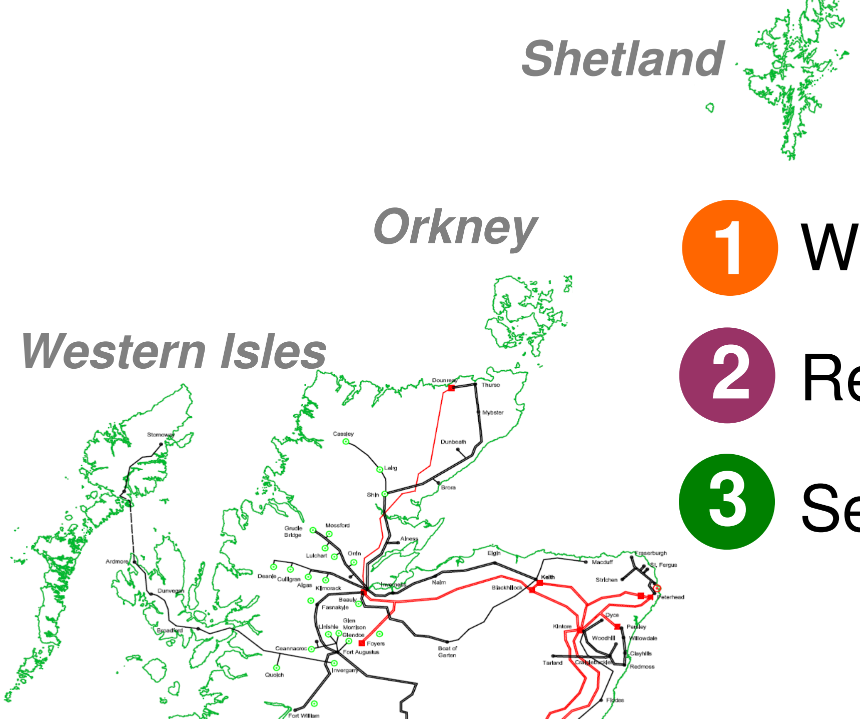
Scottish Island Connections – Defect

- Circuits proposed comprised of sub-sea cable technology
- Not accommodated in onshore charging methodology
- Configuration not envisaged when ‘local circuit’ charging was introduced



1. Which costs go into EF calculation?
2. Revise MITS (local/wider) definition?
3. Security factor (1.8) for MITS nodes?

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Scottish Island Connections – Proposal

1
- Different network technology proposed for each island
- Calculate technology specific expansion factors
- Based on annuitised, capital unit costs

2
- Maintain existing MITS definition (i.e. local/wider)

3
- Specific for island connections classed as ‘local’
- Circuit spans of lower redundancy would have adjusted Expansion Factor calculation (i.e. multiply by 1.0/1.8)
- Tariff commensurate with access rights

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4. Question and Answer Session

Lunch ~ 12:00

5. Lunch

Back at 12:30 please

6. Industry Workgroup progress to date



Sharing

Workgroup member – Simon Lord

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Sharing

- Where does sharing occur?
  - Diversity
  - Local / Wider application
- Factors affecting incremental network costs?
  - Bid price / Correlation
  - Modelling and assumptions
- Sharing Factors (based on annual load factor)
  - Historical, forecast, hybrid, specific or general, ex-ante / ex-post
- Intermittent exposed to both tariff elements?

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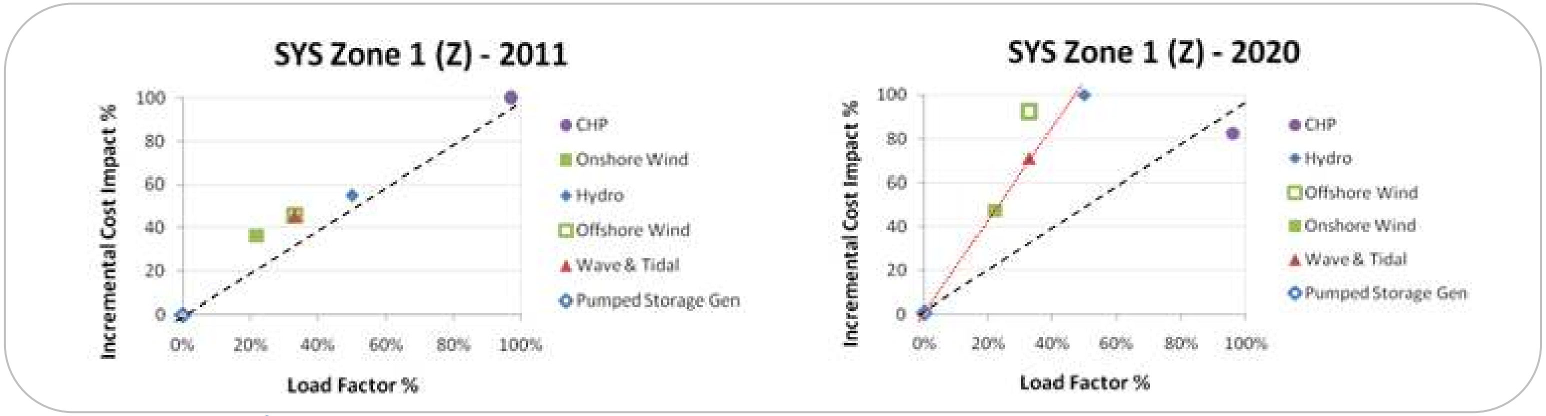
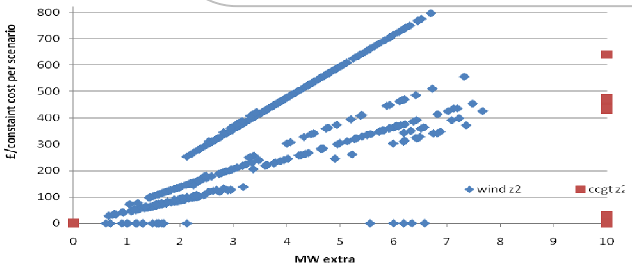
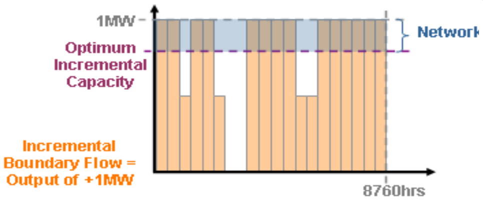
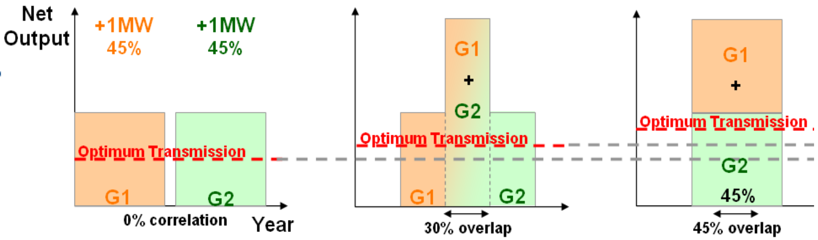
Sharing

- Despite its outward simplicity, the original proposal for sharing is based on somewhat complex underlying theory
- Considerable amount of time spent on understanding, debating and developing the sharing aspect









- Market modelling and theory used to explore network cost impacts

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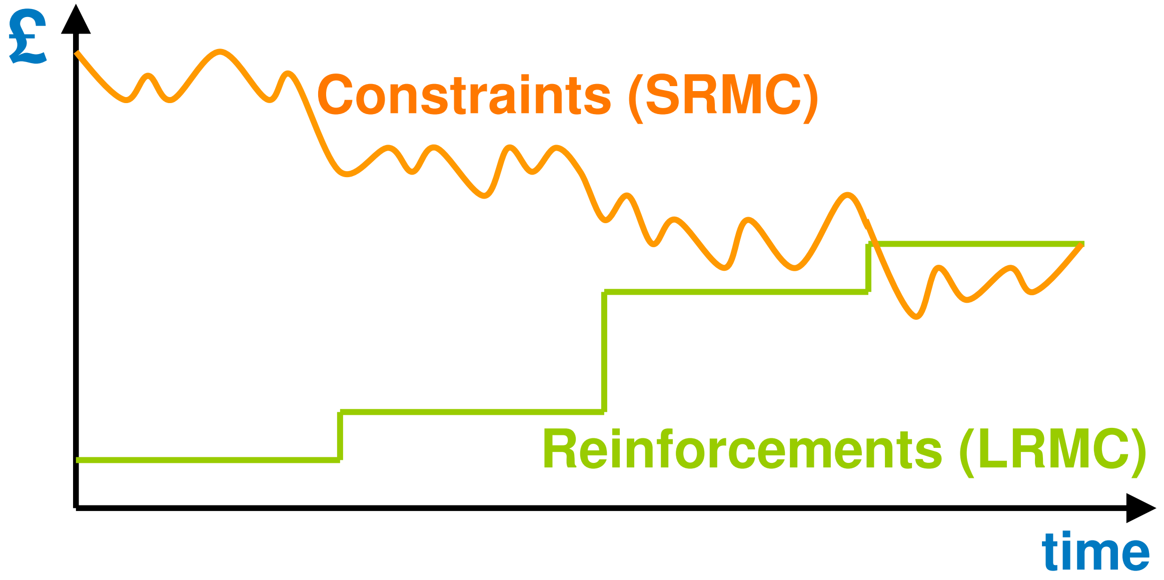
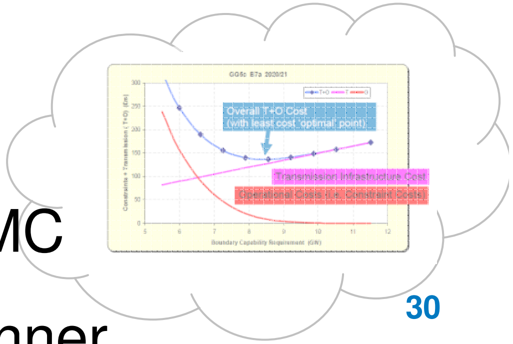
What does CBA planning seek to achieve?

- Explicit information is not available (TAR)
- Implicit assumptions made when planning network capacity
- For investment driven by “year round” conditions, these should reflect assumptions made in cost benefit analysis





- TSOs incentivised to balance SRMC and LRMC
- Market model utilised by the transmission planner

How does a market model function?

Unconstrained Dispatch

- Fuel Price
- CO_2 Price
- ROC/FiT Price
- Capacity
- Unit Avail.
- Fuel Avail.
- Efficiency
- Demand
- Merit Order

Prices

- Fuel Price
- CO_2 Price
- ROC/FiT Price

Gen. Unit

- Capacity
- Unit Avail.
- Fuel Avail.
- Efficiency

Market

- Demand
- ↓
- Merit Order

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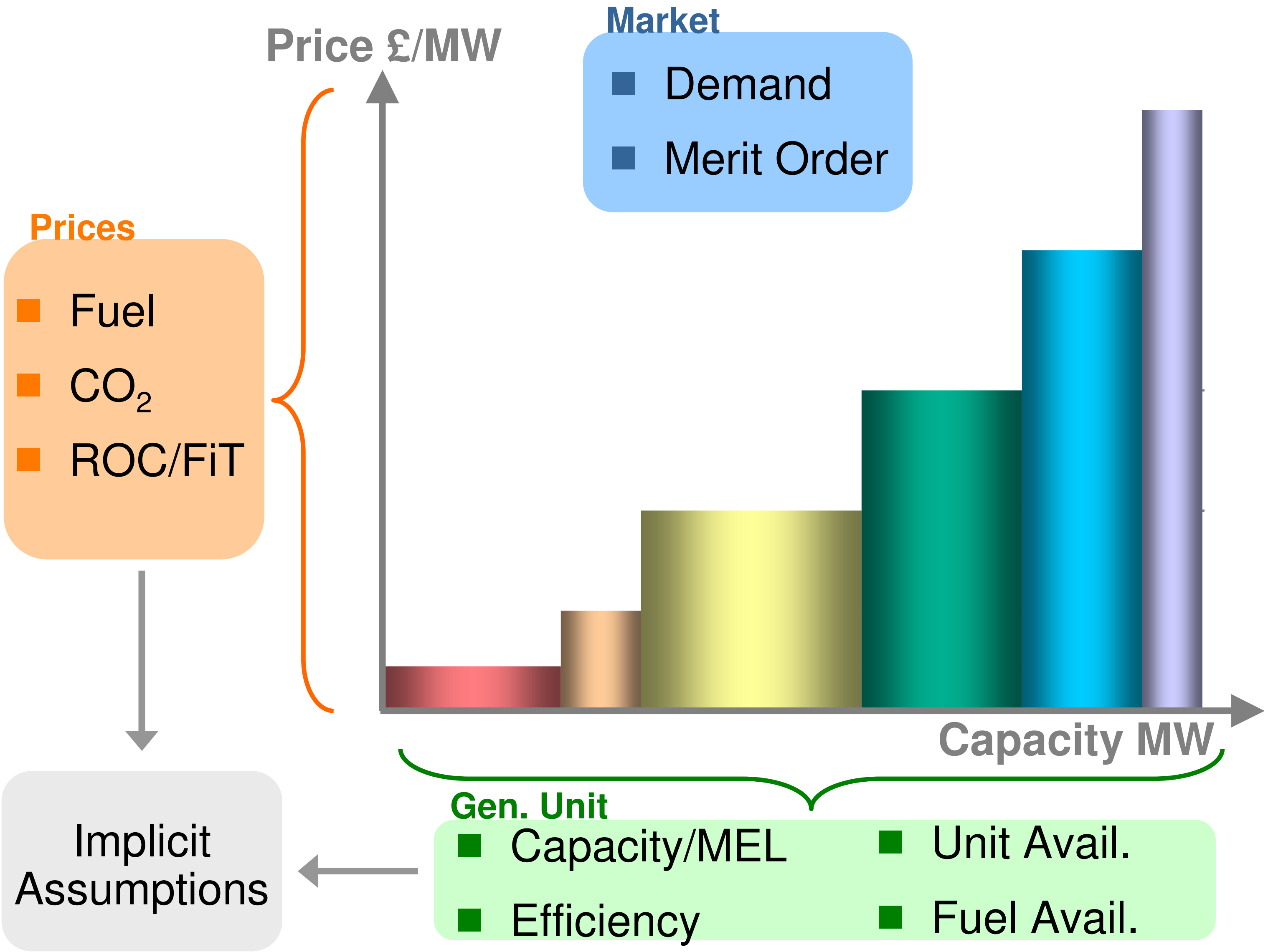
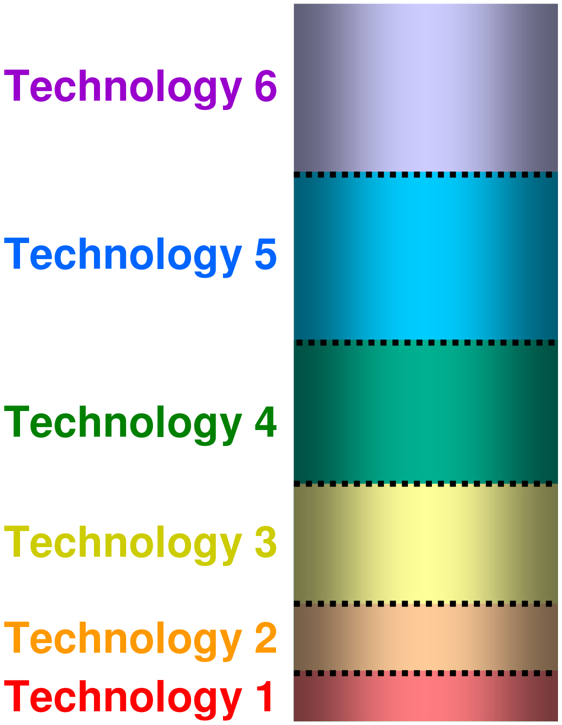
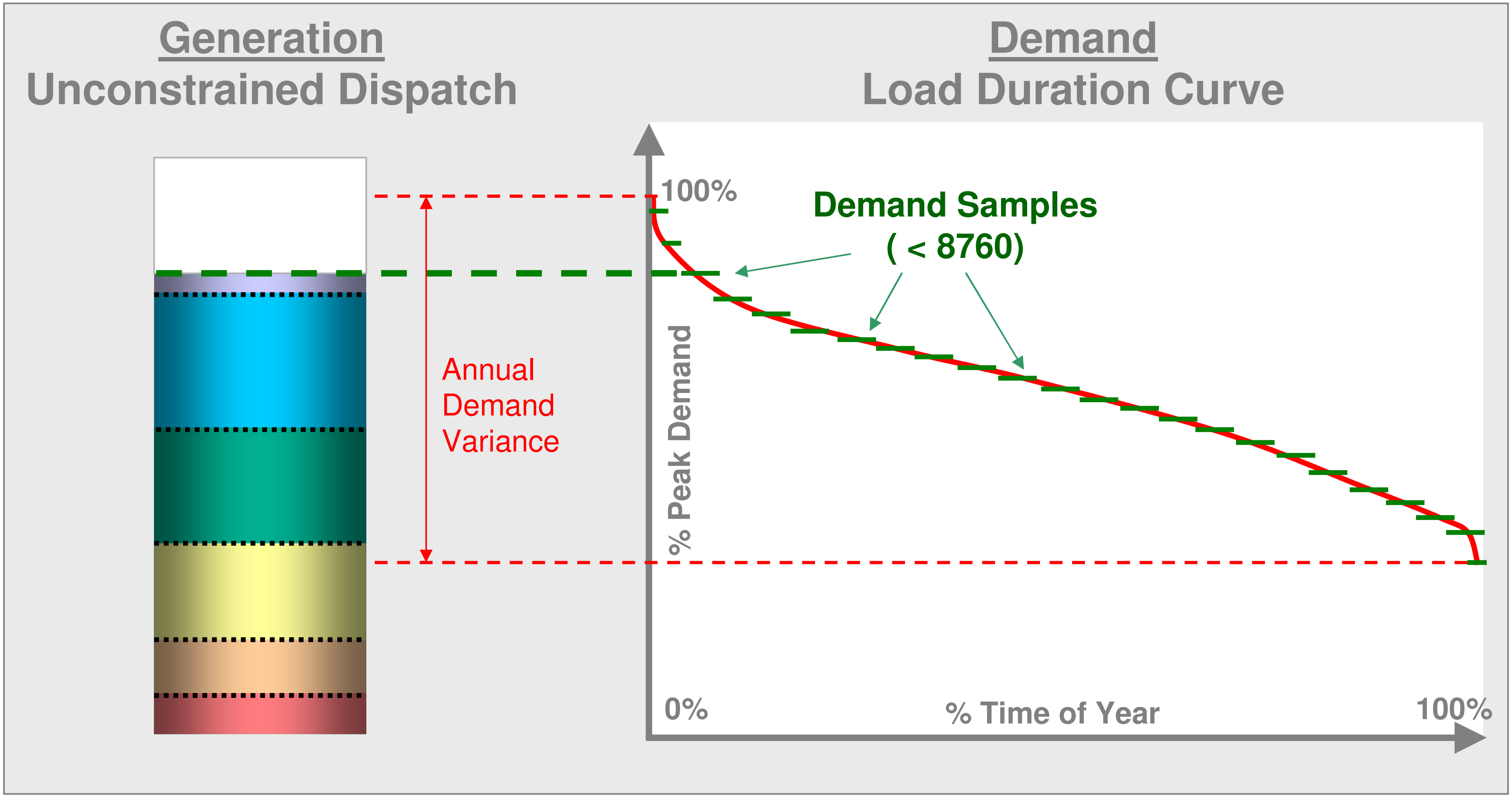
Market Model - Generation Inputs



Market Model - Generation Merit Order



Market Model - Unconstrained Dispatch



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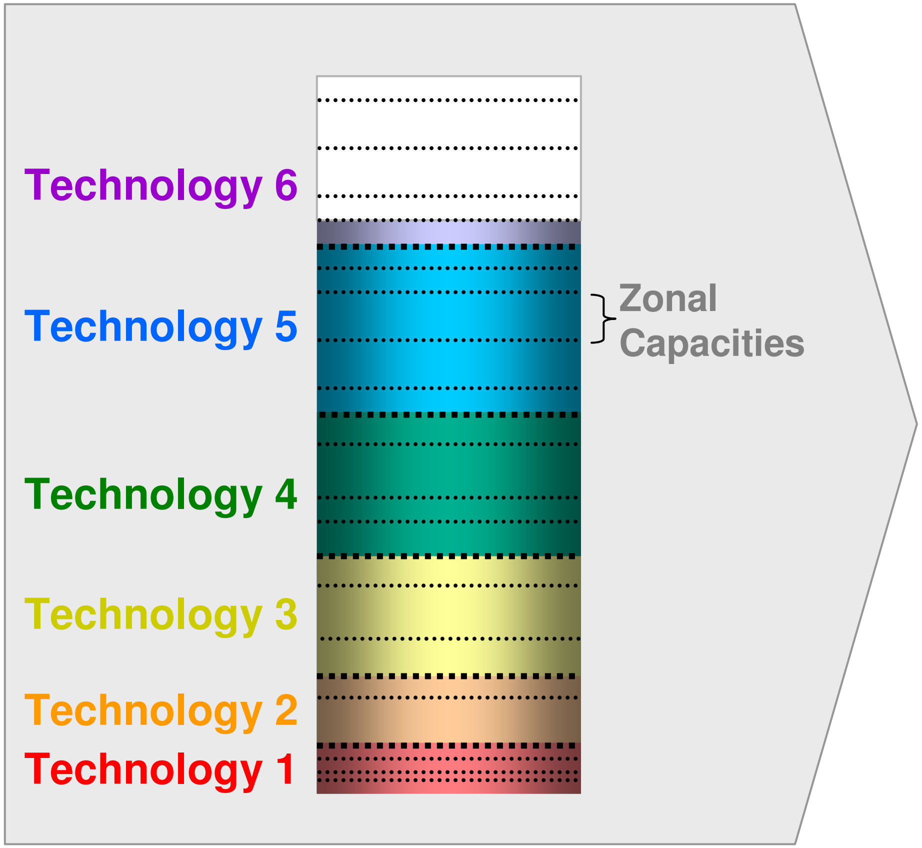
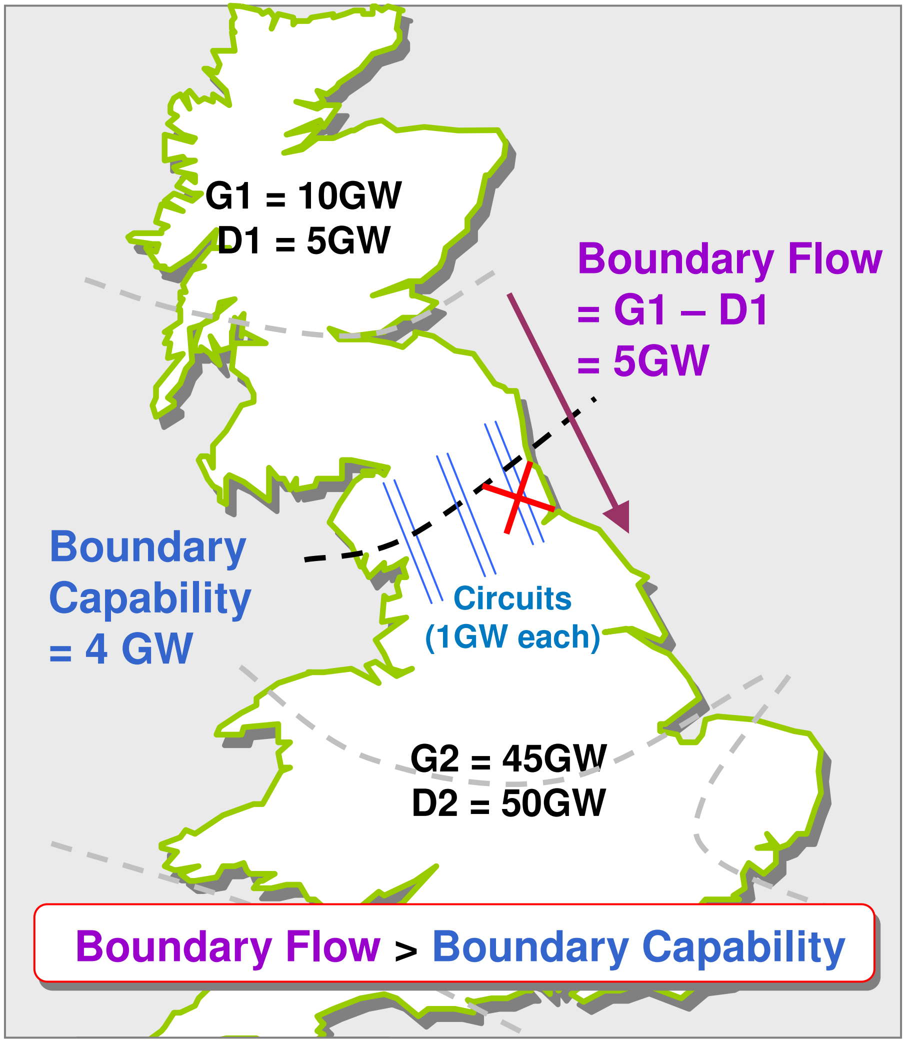
Market Model - Network Capability

Unconstrained Dispatch
(One Demand Sample)



Zonal Network Representation



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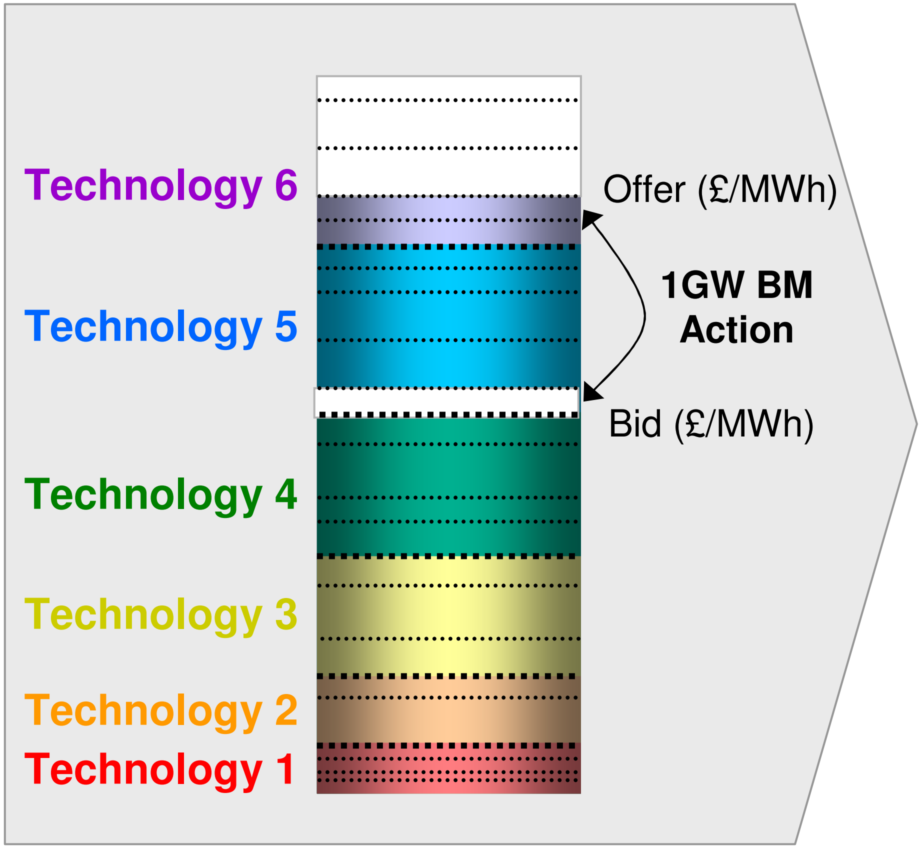
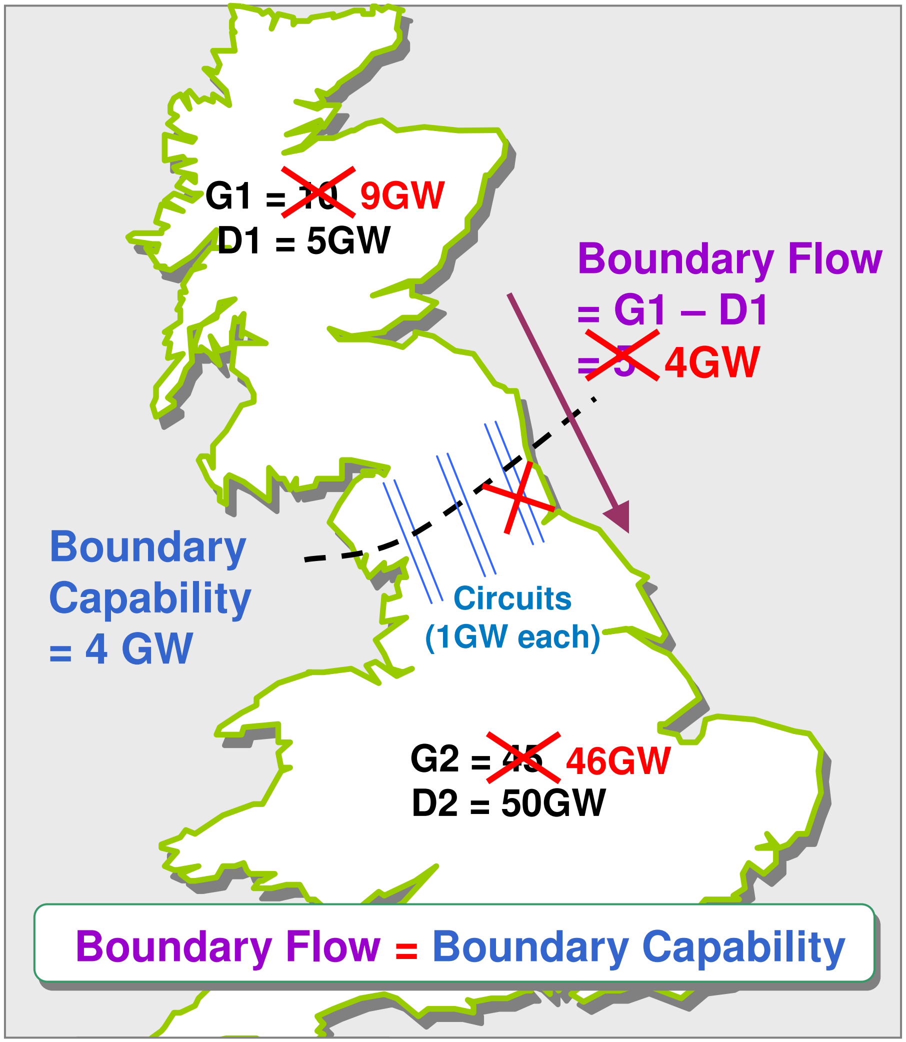
Market Model - Constrained Dispatch

Constrained Dispatch



Zonal Network Representation



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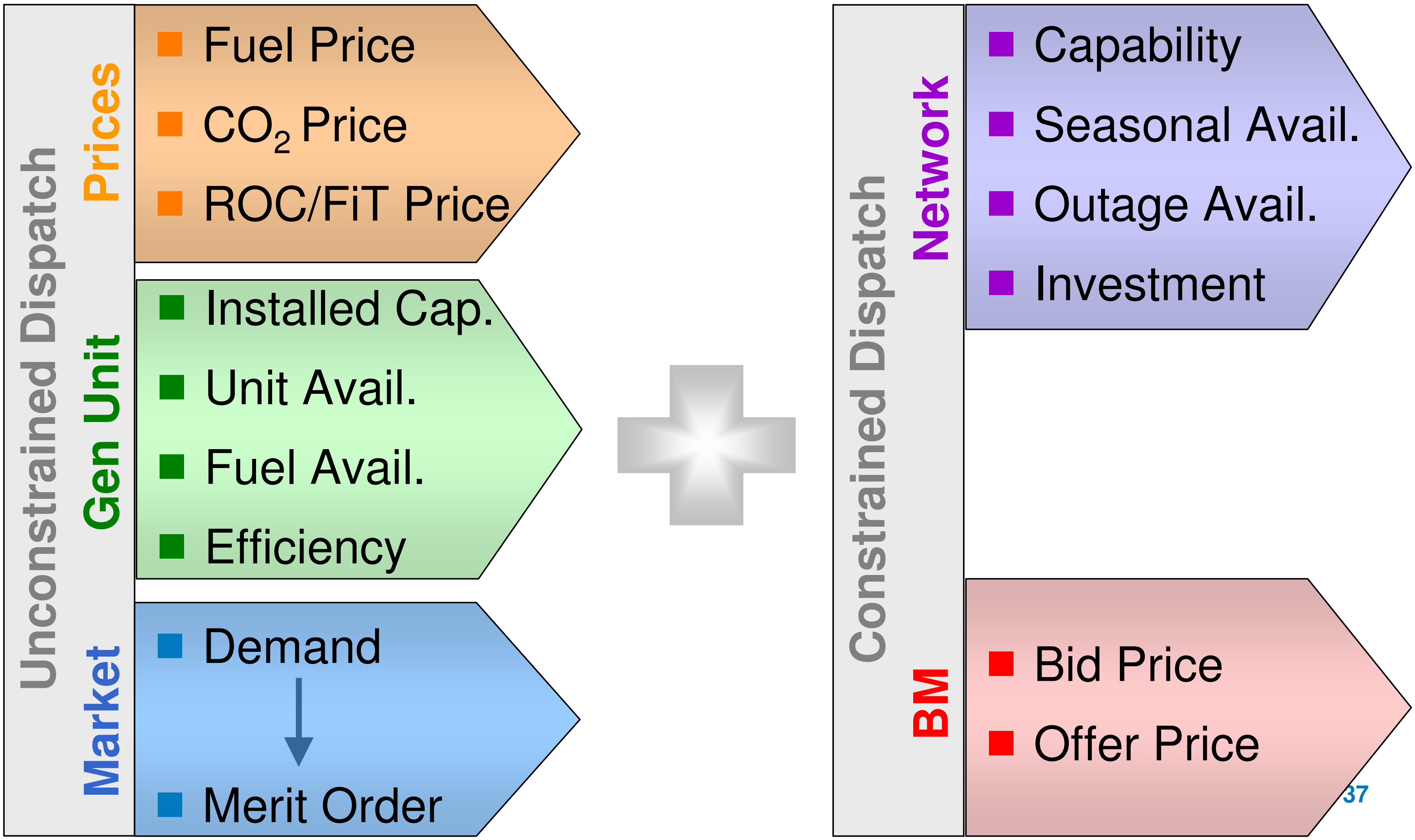
Elements Influencing Constraint Costs



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Components of incremental constraint costs

- Breakdown of component parts of incremental constraint costs to help explain observed market model behaviour

- Annual incremental constraint costs for a generator with a given TEC (i.e. £/MW/annum) =

Volume of Incremental Constraints (MWh)

i. Generator output over the year

ii. Correlation with constraint times

iii. Correlation between generation running within an area

x

Price of Incremental Constraints (£/MWh)

iv. Bid price of the marginal generator on the exporting side

v. Offer price of the marginal generator on the importing side

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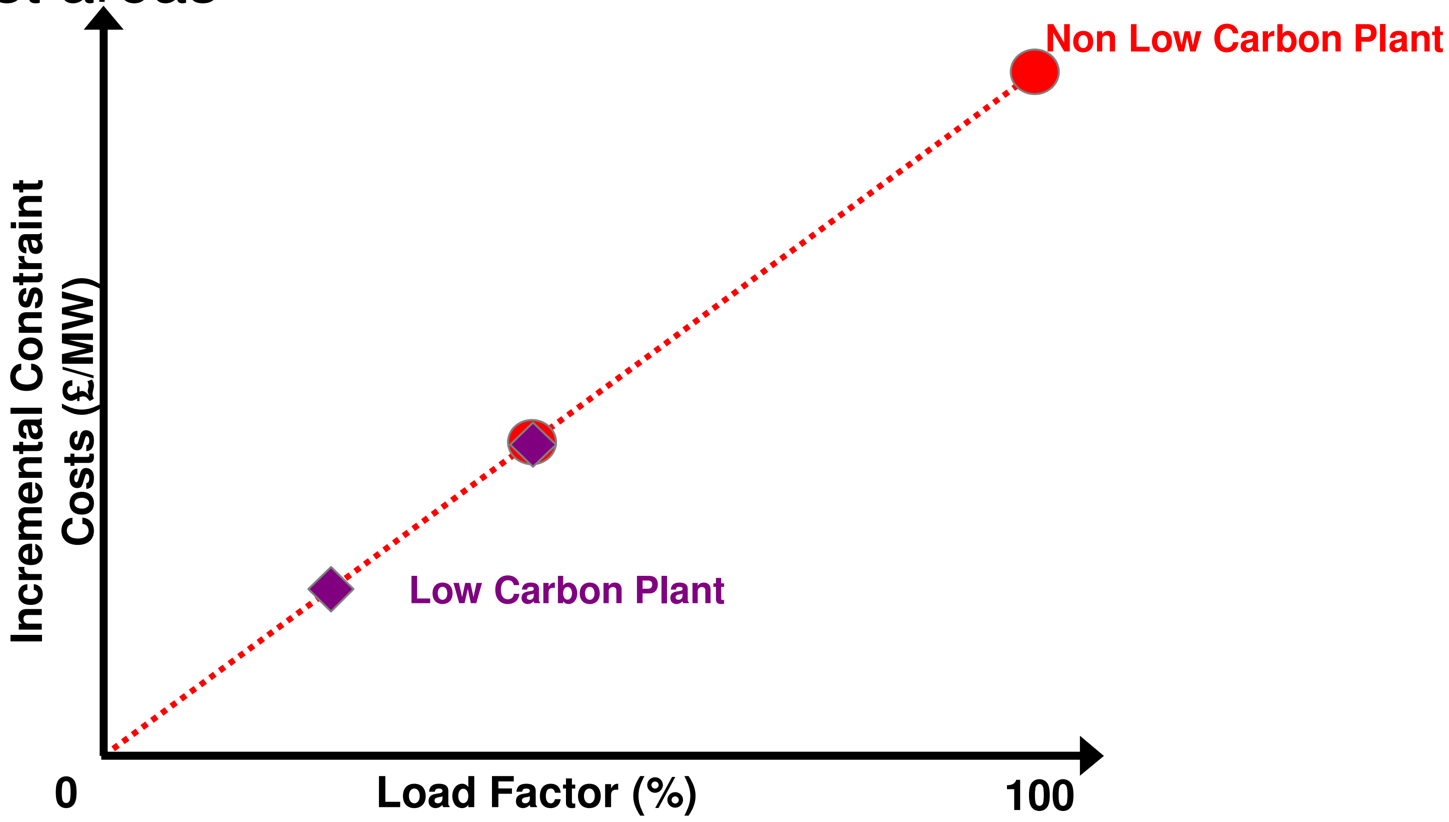
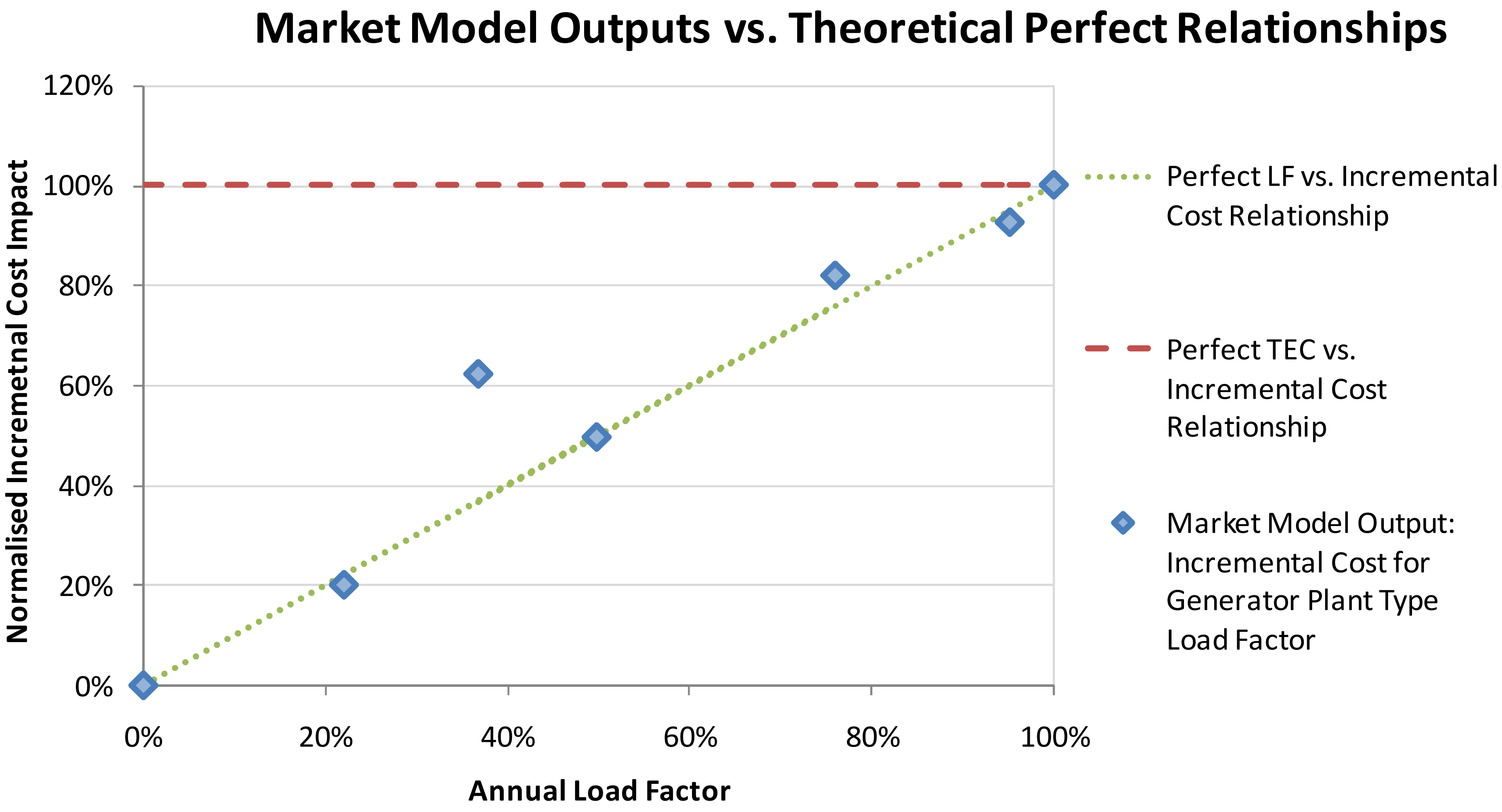
Simple LF vs. Constraint Costs

- Where sufficient diversity exists; good linear relationship in most areas

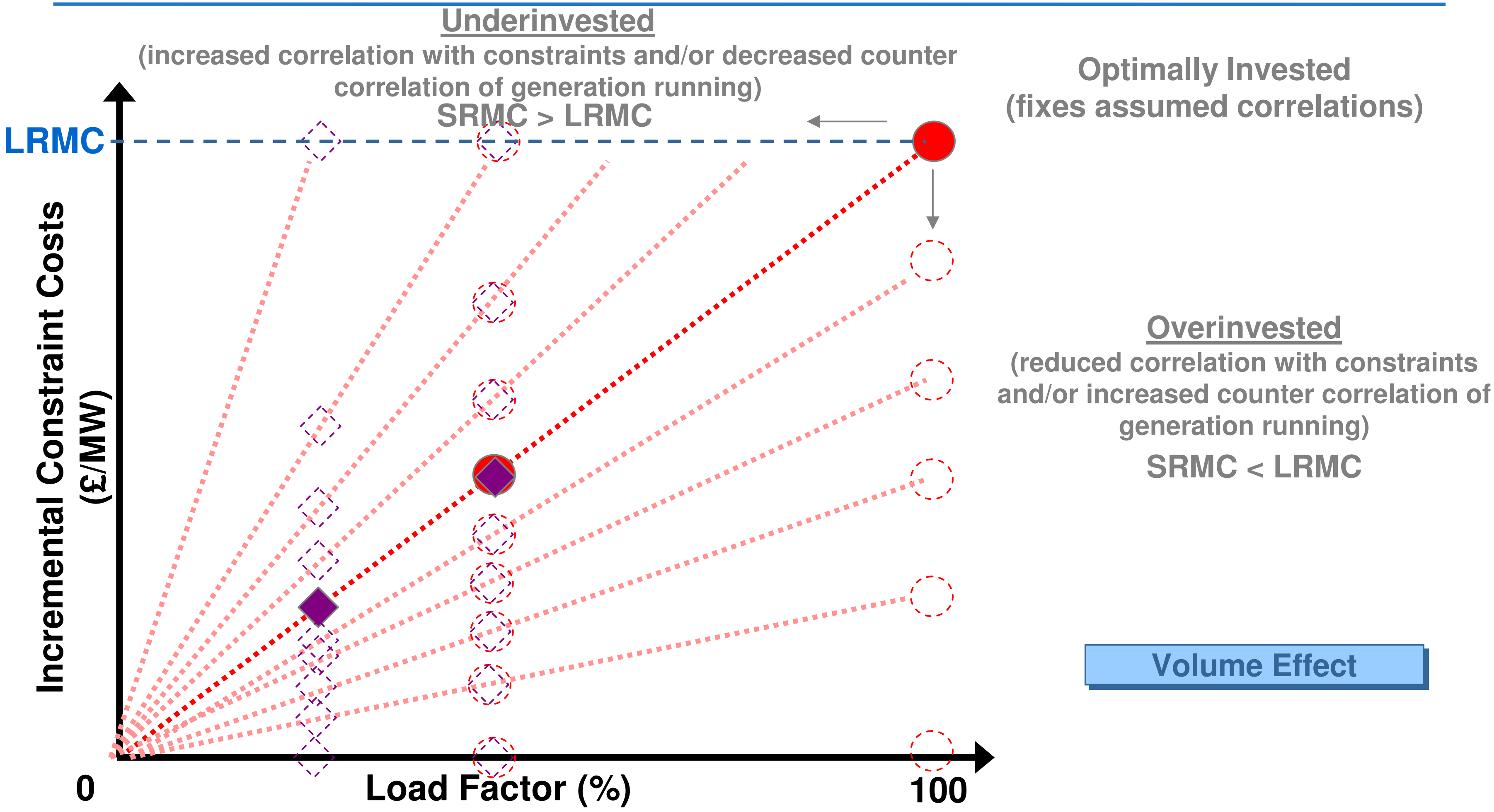


- Primary factor of cost is unconstrained despatch over the year (load factor x 1MW)

Complex modelling – complex effects

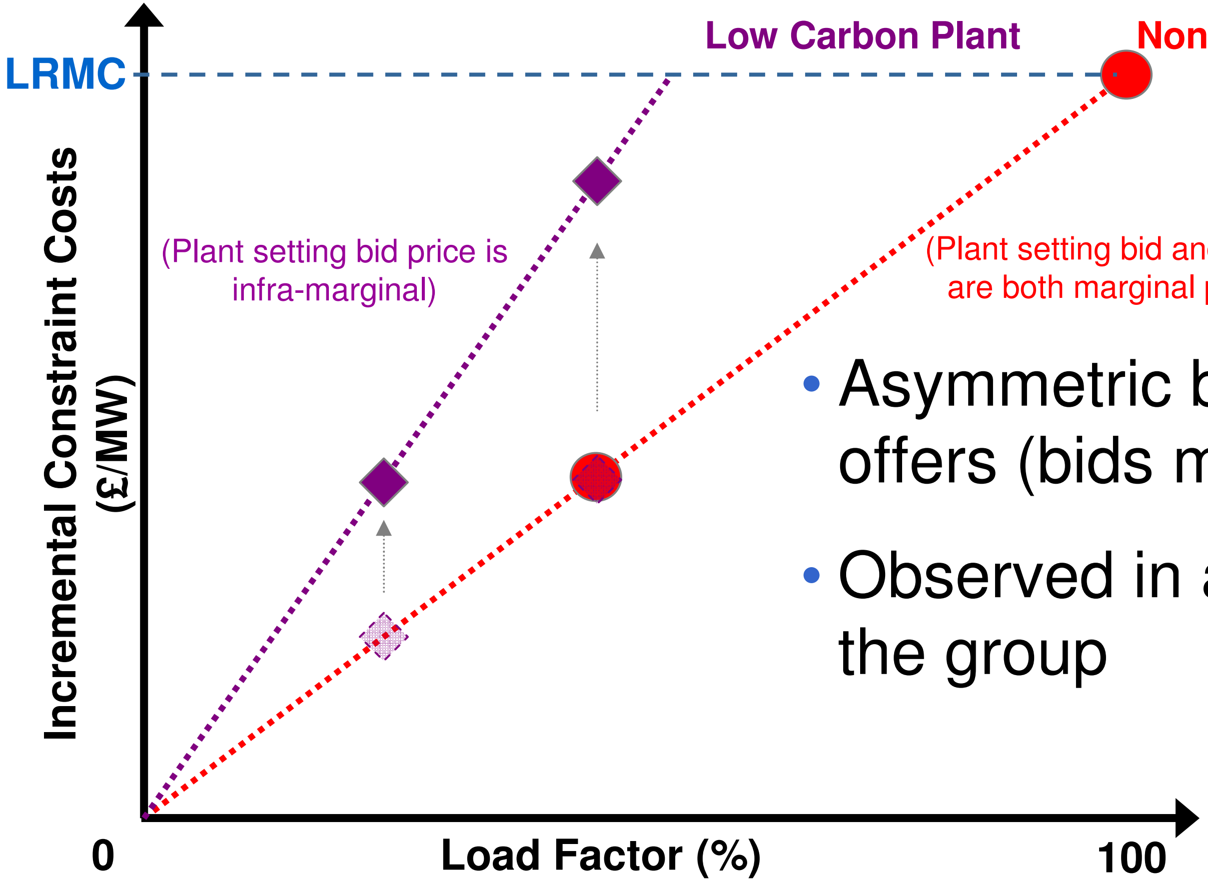


Effect of Boundary Capacity and Correlation



- Correlation with *constraints* and assumed counter correlation of *plant running* fixed at optimum

Effect of Bid/Offer Price



- Asymmetric between bids and offers (bids more important)
- Observed in analysis presented to the group

Price Effect

- In areas with insufficient diversity of plant the SO may be forced to accept bids from infra-marginal plant

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Where does this leave us? – Diversity options

Area	Original All wider Year Round (YR) shared	Method 1 YR zonal shared / not shared split	Method 2 YR zonal shared / not shared split	Method 3 Single background with zonal sharing factor
Dual background	Yes	Yes	Yes	No
Wider components	2	3	3	1
MITS sharing	All YR incremental costs	YR split into shared / not shared	YR split into shared / not shared	All incremental costs with zonal sharing factors
Generator specific	Yes	Yes; to shared element	Yes; to shared element	No
Diversity	None	Based on deterministic relationship between low carbon / carbon ratio	Based on minimum of low carbon / carbon generation in an area	Based on minimum of low carbon / carbon generation in an area
Split of Incremental Costs	None	Zonal boundary length using boundaries of influence	Zonal boundary length using boundaries of influence	Zonal boundary length using boundaries of influence

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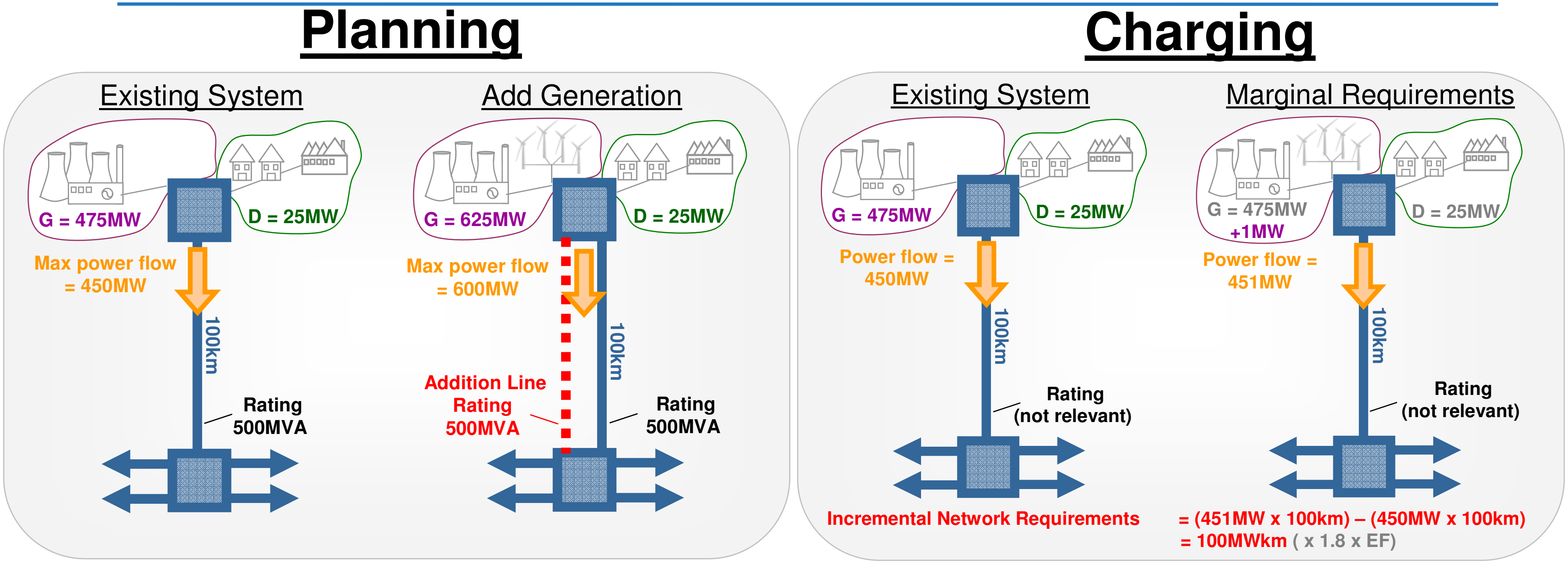
Is there sharing on local circuits?



- Planning undertaken on total capacity, with an uncertain background and network technology that is 'lumpy' in nature
- Charging done on the impact of an + 1 MW and assumes incremental network requirement is exact

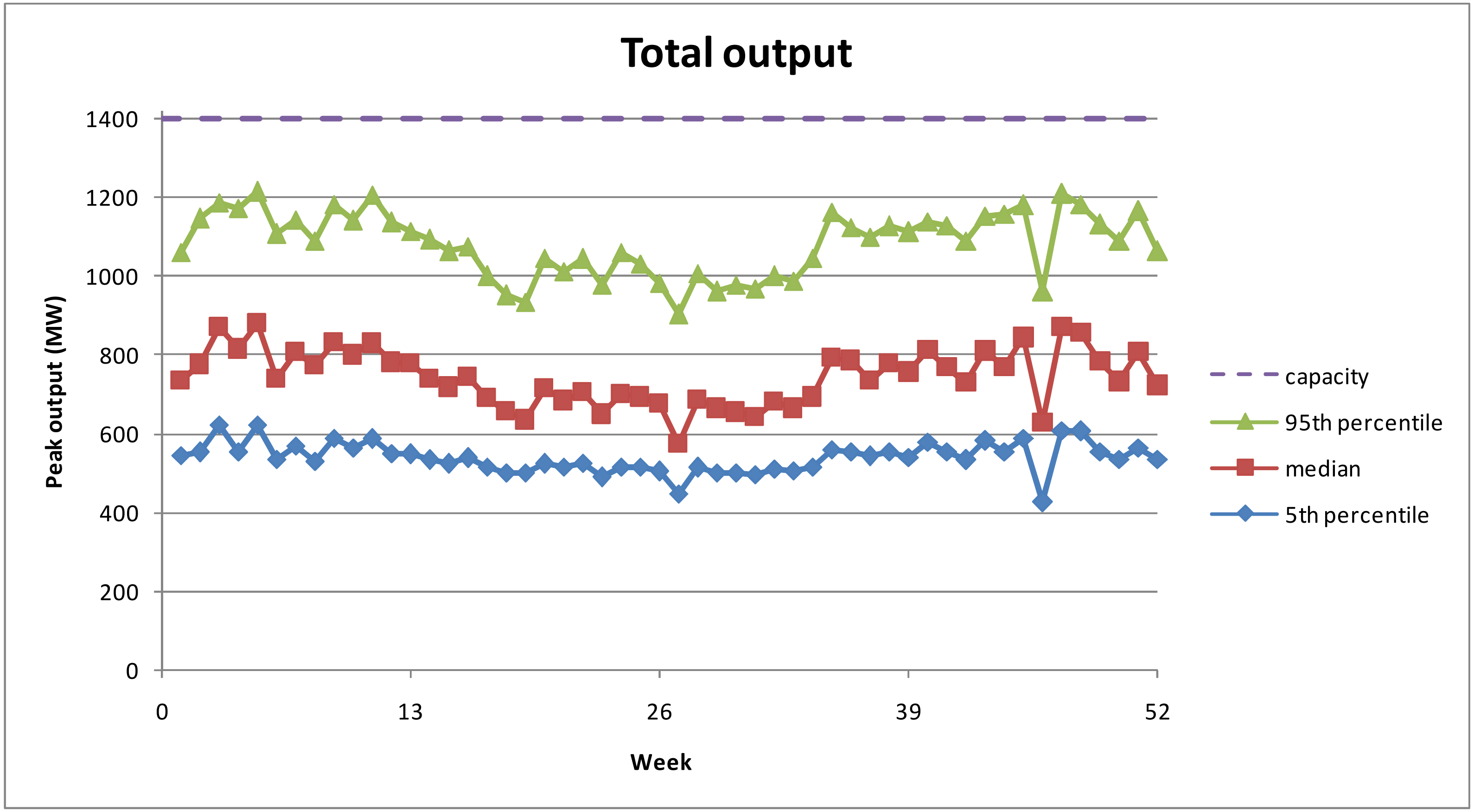
Local circuit capacity not planned < total generation capacity

Counter correlation on islands? (local or wider)

- Analysis undertaken by Heriot-Watt University
- Statistical analysis to isolate and represent non-random and random variations in output over the year
- Build up probabilistic half hourly generation profiles for each generation technology type (1000 simulations of 17,520 yearly half hours)
- Example “Orkney Gone Green 2022”:

300MW wind generation, 600MW wave generation and 500MW tidal generation (i.e. a total installed generation capacity of 1,400MW)

Counter correlation on islands? (local or wider)

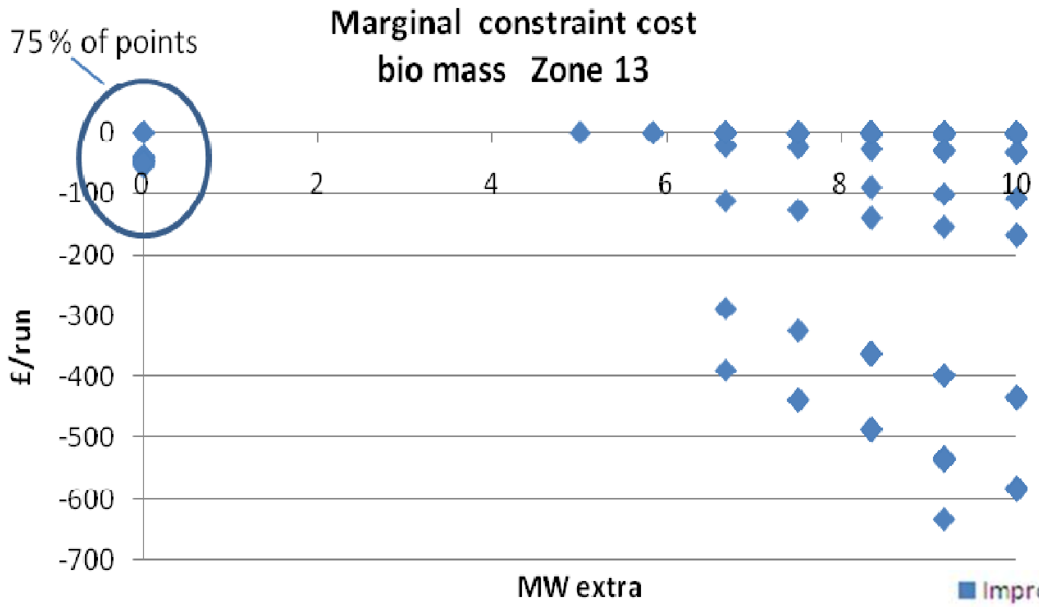


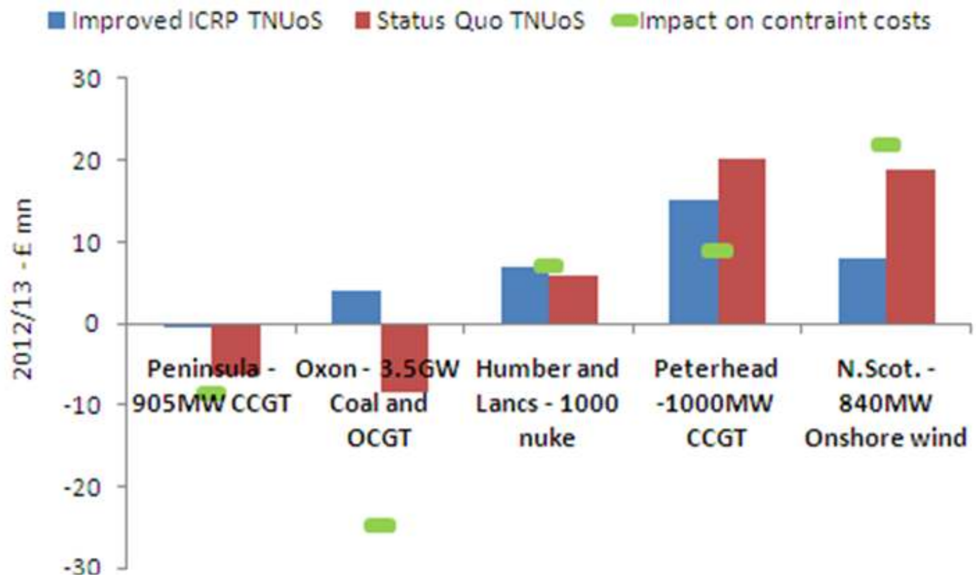
- Work in progress within the Workgroup
- How and why to incorporate into a diversity alternative

Options for applying sharing (ALF)?

Method	ALF	Description	Updated when?
i	TEC (MW)	ALF=100%; same result as approach used in existing charging methodology.	TEC register
ii	NETS SQSS generic	Generation plant based load factors from GSR-009	NETS SQSS updates
iii	Other generic	Generic historical average per generation plant type	Price Control
iv	User forecast	Ex-ante annual forecast, provided by the User, with ex-post reconciliation	Annually
v	Hybrid	Original proposal with option for User to provide own forecast (as per (iv))	Annually

Is it different for importing areas?





6. Industry Workgroup progress to date



Parallel HVDC Circuits

Workgroup member – Garth Graham

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Reflecting HVDC in Transport Model

- 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
- Use onshore technology costs?

HVDC

- General agreement on the issue and principle, discussion on the application
- Expansion factor
  - Exclude all or a % of converters
    - Parity with other onshore costs
  - Treat as onshore?
- Marginal flow calculation
  - Single or multiple boundary calculation

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Inclusion of HVDC links (1)

- HVDC - one of three elements in CMP213
- Covered in Section 5 of the consultation (pg 104-114)
- Original discussed, along with Options for Potential Alternatives.
- Focussed on 'bootstraps' - such as from Scotland to England – but principles could apply to island HVDC links (see Islands section for more on this).
- Original - include all costs of HVDC converter stations into the expansion factor calculation - deemed to be consistent with approach taken for offshore (OFTO) transmission TNUoS tariffs

Inclusion of HVDC links (2)

- Initial Scope:
- a) whether the cost of HVDC converter stations should be included in the expansion factor calculation?
  - i) Remove all converter station costs from the calculation;
  - ii) Remove some converter station costs from the calculation; and
  - iii) Treat HVDC cost as onshore AC transmission technology cost when calculating the expansion factor

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Inclusion of HVDC links (3)

- i) Remove all converter station costs from the calculation
  - Potential alternative where 100% sub-sea cables cost would be included in the expansion factor and 100% of the onshore converter stations costs would be excluded from the expansion factor calculation
  - Some members believed HVDC converter stations exhibit same traits as other fixed elements of the transmission system; such as transformers / substations and they can also provide system services
  - Other members disagreed - believe the costs of HVDC converter stations represent actual costs of investment in that technology so should (100%) be included in the expansion factor

Inclusion of HVDC links (4)

- ii) Remove some converter station costs from the calculation
- Options
  - 1) Remove % of costs based on elements of the converter station that are similar to elements of the AC transmission network currently not included in the locational signal (such as substation equipment); and
  - 2) Remove a portion of the costs based on similarity between power flow redirecting capability of HVDC converters stations and of Quadrature Boosters (QBs) - currently not included in the locational signal

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Inclusion of HVDC links (5)

- 1) Remove a percentage of the HVDC converter station costs based on elements similar to AC substations
  - *Noted* - charging methodology currently does not include many of the costs of the transmission network that do not vary with distance, such as substation costs, in the calculation of expansion factors – but lack of HVDC examples makes it difficult to determine for that technology
  - Found a source which provides a 'Breakdown of Typical HVDC Converter Station costs'
  - Looked at eight cost elements, plus the proportion of the total cost and characteristics (AC/DC) – see Table 18 (pg 108) for further details
  - Analysis shows approximately half the cost of a typical HVDC converter station is akin to AC substation elements that are not included in the locational (TNUoS) signal throughout the rest of the transmission network
  - Some members believe it may be reasonable to take this into account when calculating the expansion factor for HVDC circuit that parallel an AC network

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Inclusion of HVDC links (6)

- 2) Remove a portion of the costs based on similarity between power flow redirecting capability of HVDC converter stations and of Quadrature Boosters (QBs) -currently not included in the locational signal
  - Considered controllability of HVDC transmission circuits and potential benefits to the SO of this controllability
  - Some similarity to QBs - which can be used to redirect power flows on transmission circuits – which are not factored into the locational signal
  - Looked at cost comparison analysis by NGET – shows that if QB costs are removed from the HVDC converter station cost it would likely amount to ~10% cost reduction (i.e. 3% to 5% of the total HVDC link cost)

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Inclusion of HVDC links (7)

- iii) Treat HVDC cost as onshore AC transmission technology cost when calculating the expansion factor
- Some members believed that Western HVDC link should be treated in exactly the same way as the equivalent parallel (onshore) AC 400kV transmission circuits in the TNUoS charging methodology
- Discussed differences between sub-sea HVDC transmission link and alternative (onshore) 400kV AC transmission reinforcements in terms of capacity provided, costs and timescales. Not all members convinced that both cost and network capacity provided by the onshore AC and sub-sea HVDC options were comparable
- Potential alternative of sub-sea HVDC transmission circuit treated as (onshore) 400 kV transmission technology deemed plausible by some but was not widely supported by Workgroup
- Some members believed the expansion factor calculation for HVDC transmission circuits should be based on actual HVDC unit costs in order to be cost-reflective

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Inclusion of HVDC links (8)

- Potential Alternatives
  - i) Review the overhead factor (i.e. 1.8%) used when annuitising the capital cost in the calculation of the expansion constant;
  - ii) Calculate the ‘desired flow’, and hence impedance, by balancing flows across the single most constrained transmission boundary rather than all the transmission boundaries the circuit crosses; and
  - iii) Review security factor calculation in light of long (MWkm) HVDC transmission circuits comprised of single circuits that parallel the AC transmission network

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Inclusion of HVDC links (9)

- i) Review the overhead factor (i.e. 1.8%) used when annuitising the capital cost in the calculation of the expansion constant
  - Reviewed analysis on HVDC and other TO costs
  - Concluded that the overheads for (offshore) HVDC transmission circuits were likely to be higher than those of other transmission assets such as (onshore) overhead lines and underground cables
  - Discussed the benefits of simplicity and stability arising from the use of a single overhead factor for all transmission assets and concluded that the minor increase in cost-reflectivity associated with a more specific treatment did not warrant consideration of a potential alternative in this area

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Inclusion of HVDC links (10)

- ii) Calculate the 'desired flow', and hence impedance, by balancing flows across the single most constrained transmission boundary rather than all the transmission boundaries the circuit crosses
  - Original proposal would calculate the base case flow down the HVDC transmission circuit as a ratio of power flows to circuit ratings across all transmission network boundaries 'crossed' by the HVDC circuit [*but*]
  - Impedance calculation to model the HVDC transmission circuit as a pseudo-AC transmission circuit not an exact science due to the controllable nature of the HVDC circuit [*so could*]
  - Simply calculating the base case flows on the single most constrained transmission boundary that the HVDC circuit reinforces - this would increase the locational differentials relative to the multiple transmission boundary approach proposed in the Original and might not be as cost reflective

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Inclusion of HVDC links (11)

- iii) Review security factor calculation in light of long (MWkm) HVDC transmission circuits comprised of single circuits that parallel the AC transmission network
  - Prevailing security factor for the MITS is currently 1.8 - based on studies conducted by NGET
  - Some members believed that single circuit HVDC transmission circuit warranted a review of whether security factor of 1.8 was still cost-reflective
  - Other view – if cost of the HVDC transmission circuit was multiplied by 1.8 this should be done on the unit cost of a double transmission circuit rather than the single transmission circuit planned
  - Workgroup’s view - unit cost of a double circuit HVDC transmission circuit similar to that of a single transmission circuit link - no potential alternatives considered by the Workgroup in this area

6. Industry Workgroup progress to date



Island connections

Workgroup member –

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Including Island Links in the Methodology

- Harnessing renewable energy sources on the northern islands of Scotland will require new transmission circuits
- The existing charging methodology does not accommodate this
- Requires consideration of:
  - Expansion Factors
  - Local/Wider
  - Security Factor

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Islands

- Questions from the direction:
  - If island wider, should it have two part tariff?
  - If island local, should it be as onshore local?
  - Calculation of expansion factor
  - How to treat Security Factor / redundancy
  - Forward looking or anticipatory approach

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Islands – Local or Wider?

- Is definition robust
  - Concern that definition did not take account of islands
  - Consequences of extending it
- Islands can become wider, but little apparent sharing
  - Limited diversity - renewable / non renewable
- Some evidence of counter correlation
  - Specific island sharing factor?
  - When / should sharing apply on islands?
- Does 'Diversity' bridge the gap?
  - Addresses concerns in apply the definition

Islands – Expansion factor

- Expansions factor
  - Project specific (original)
  - Generic across all the whole system
    - e.g. inlc. onshore cable
  - Generic – across relevant technologies
    - e.g. island AC and island DC
  - Island group specific
    - Averaged across a group of islands (not project)
- Pros and Cons
  - Mainly: Predictability vs. Cost Reflectivity
- Consistency with HVDC

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Islands - Security and anticipatory

- Security Factor
  - Should reflect the redundancy
  - Commensurate with access rights
- Anticipatory
  - ‘lumpiness’ catered for (unit charges)
  - Alternative being developed based on potential future sharing

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7. Question and Answer Session

Closing remarks 14:50

8. Closing Remarks

Workgroup Seminar

Chair – Patrick Hynes

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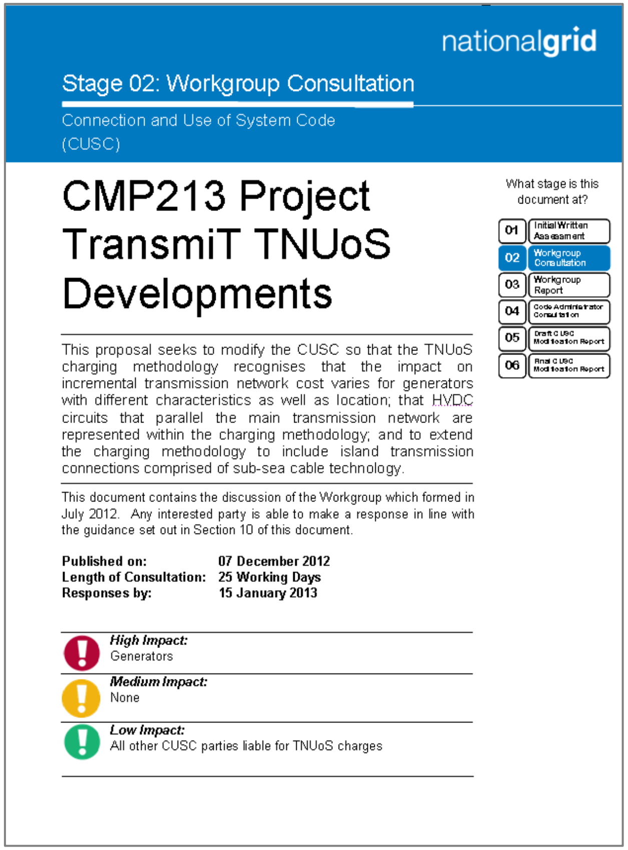
Summary and next steps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Stage 02: Workgroup Consultation

Connection and Use of System Code (CUSC)

CMP213 Project TransmiT TNUoS Developments

What stage is this document at?

01	Initial Written Assessment
02	Workgroup Consultation
03	Workgroup Report
04	Code Administrator Consultation
05	Draft CUSC Modification Report
06	Final CUSC Modification Report

This proposal seeks to modify the CUSC so that the TNUoS charging methodology recognises that the impact on incremental transmission network cost varies for generators with different characteristics as well as location; that HVDC circuits that parallel the main transmission network are represented within the charging methodology; and to extend the charging methodology to include island transmission connections comprised of sub-sea cable technology.

This document contains the discussion of the Workgroup which formed in July 2012. Any interested party is able to make a response in line with the guidance set out in Section 10 of this document.

Published on: 07 December 2012
Length of Consultation: 25 Working Days
Responses by: 15 January 2013

High Impact:
Generators

Medium Impact:
None

Low Impact:
All other CUSC parties liable for TNUoS charges

- Consultation published on 7th December 2012

- Closing date for responses on 15th of January 2013

Any queries contact:

Patrick Hynes*

01926 656319

http://www.nationalgrid.com/uk/Electricity/Codes/systemcode/amendments/currentamendmentproposals/

*Alternatively contact Ivo Spreeuwenberg on 01926 655897

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Summary and next steps

- Workgroup post consultation
  - Consider issues raised /evidence presented
  - Further / new analysis
  - Workgroup and consultation alternatives
  - Modelling market and environmental impact
  - Legal text
  - Assessment against objectives / vote
- Submit report
- Code admin consultation
- CUSC Panel voting
- Submit report to Ofgem

End

Have a safe journey home