

DTI Centre for Distributed Generation and Sustainable Electrical Energy

Update of GB SQSS to Include Intermittent Generation:

Integrated reliability and economics assessment

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GB SQSS meeting

Birmingham, 21 August 2007

Imperial College
London

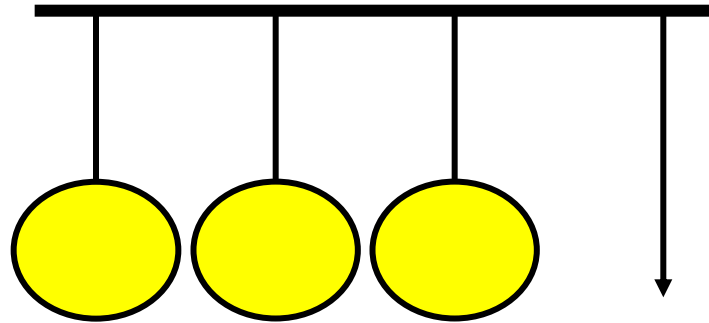
Contents

- Guiding principles, objectives, approach
- Security driven transmission capacity
- Economic efficiency driven transmission capacity
- Issues for considerations and recommendations

Approach to updating existing transmission security standards

- In 2005, integrated transmission planning methodologies, based on security and economics, has been developed by the Centre for GD&SEE to inform the process of updating the GB SQSS to include intermittent generation (wind)
- Guiding principles:
 - Maintain at least the current level of security of supply
 - Maintain the principles of the existing GB SQSS while expanding its scope to include intermittent generation
- Key drivers of transmission capacity
 - Reliability
 - Economics (CBA)
- Project Liaison Group
 - 3TLs, 3Gen Companies, 2DNOs, BWEA, AIEP, Ofgem, DTI
 - Comprehensive presentations sets circulated to the PLG and a summary report ***“Transmission Investment, Access and Pricing in Systems with Wind Generation”*** issued (*available on www.sedg.ac.uk*).

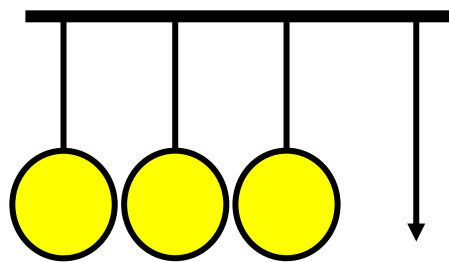
Link between generation and transmission security standards /1



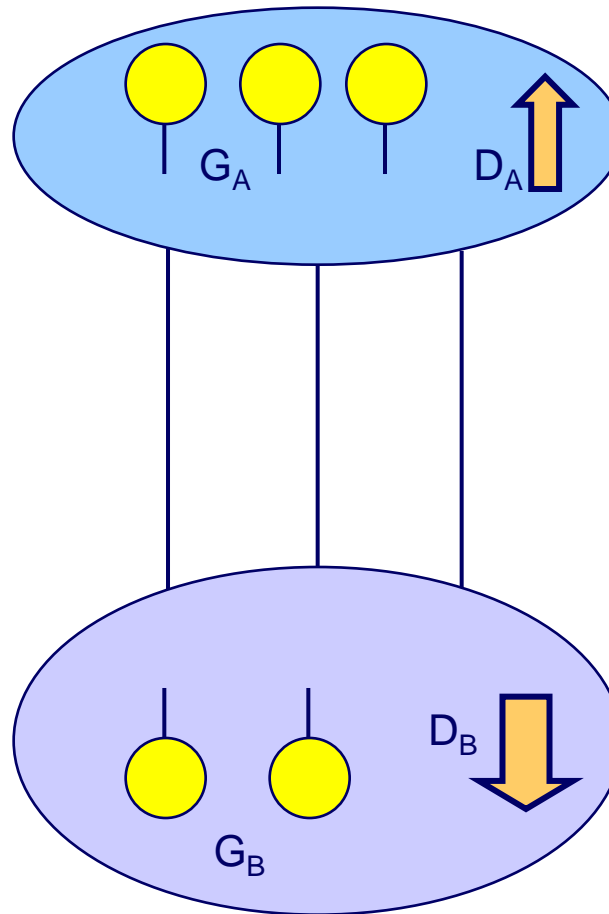
Peak Demand Condition

- Generation system adequacy established during **peak demand** condition
- ~20% capacity margin deemed to provide adequate reliability of supply, i.e. load reductions not expected to occur for more than “**9 winters in 100 years**”
- $LOLP = 0.09$

Link between generation and transmission security standards /2



~20% capacity margin

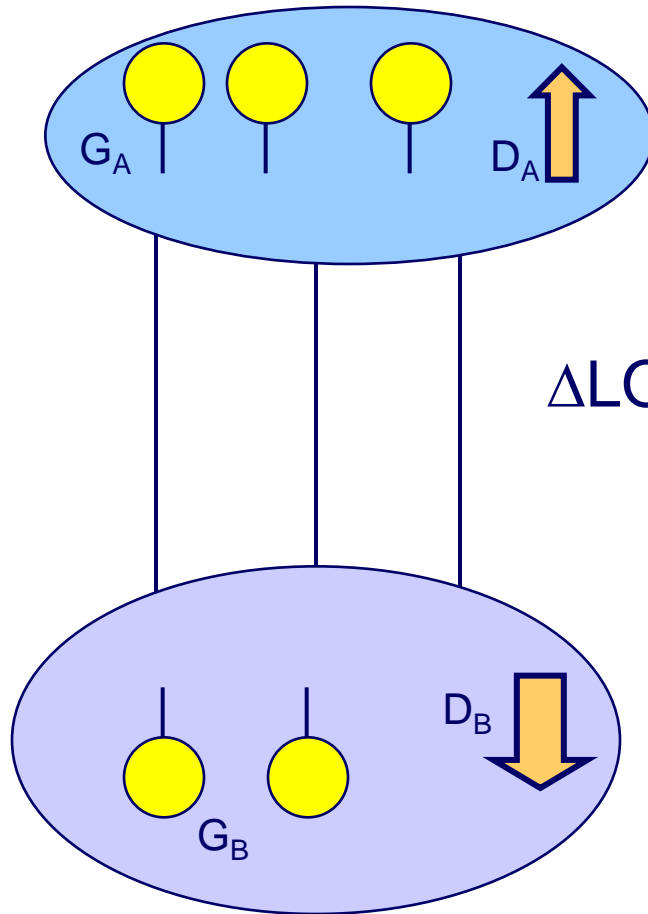


“Transmission network should not unduly restrict generation to contribute to security of supply (peak demand)”

Interpretation:
transmission network should not increase the underlying 9% risks (LOLP = 0.09) too much.

How much is appropriate?

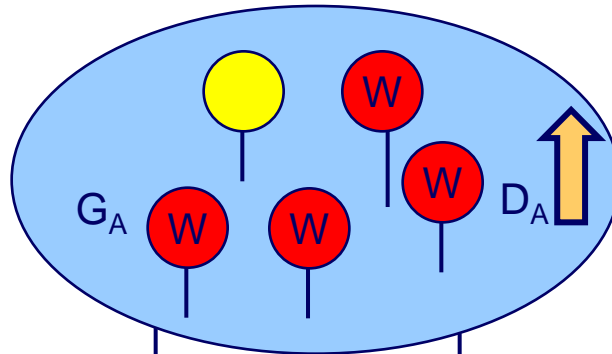
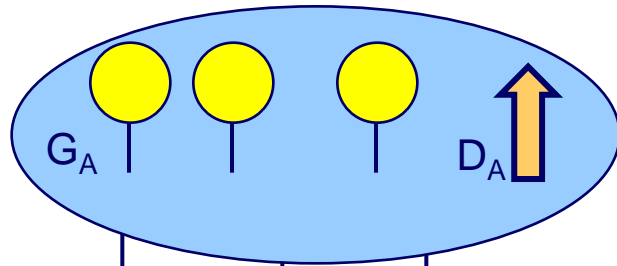
Increase in risk of load reductions induced by transmission is defined by the existing standard (similar approach adopted with P2/6 update)



$\Delta\text{LOLP} \approx \sim 5\%$

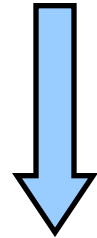
With adequately built transmission, load reductions are not expected to occur for more than about “**9.5 winters in 100 years**”

Benchmark defined by the existing standard

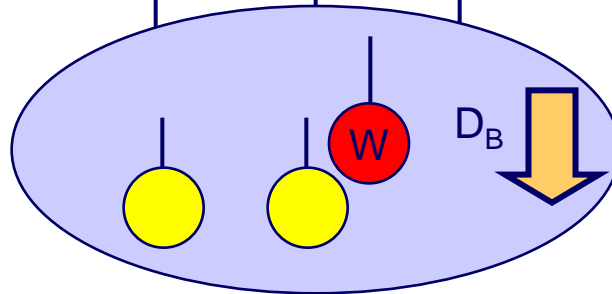
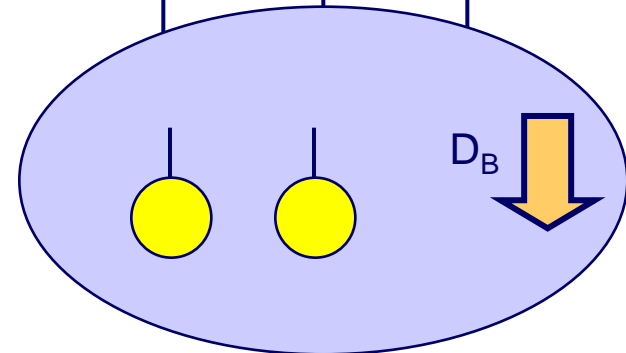


ΔLOLP
(for N-1
and N-2)

$\Delta\text{LOLP} =$
constant



Transmission
capacity for
system with
any form of
generation can
be determined



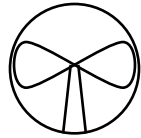
Introducing renewables in the generation mix (wind)

- Capacity value of a generating source in thermal generation dominated system is driven by its contribution to peak demand.
- The ability of wind generation to displace capacity of conventional plant is the key to answering the question as to much transmission should be built for it. sources that have ***no capacity value*** (i.e. cannot displace conventional generation) ***drive no transmission*** from the reliability perspective)
 - PV generation, for example, makes no contribution to system peak, and hence no transmission would be for it, from the security perspective
- Wind power is predominately an energy source with limited ability to displace conventional generation)
- The ability of wind to displace conventional generation is measured by so called capacity value or capacity credit of wind.

What is the capacity value of wind, i.e. how much can you rely on wind in the UK?

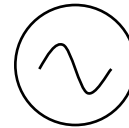
How does wind compare with conventional generation (wind capacity value)?: CEGB results

At the penetration level of 3%



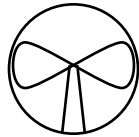
1 MW

=



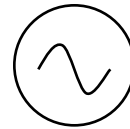
0.29 MW

At the penetration level of 15%



1 MW

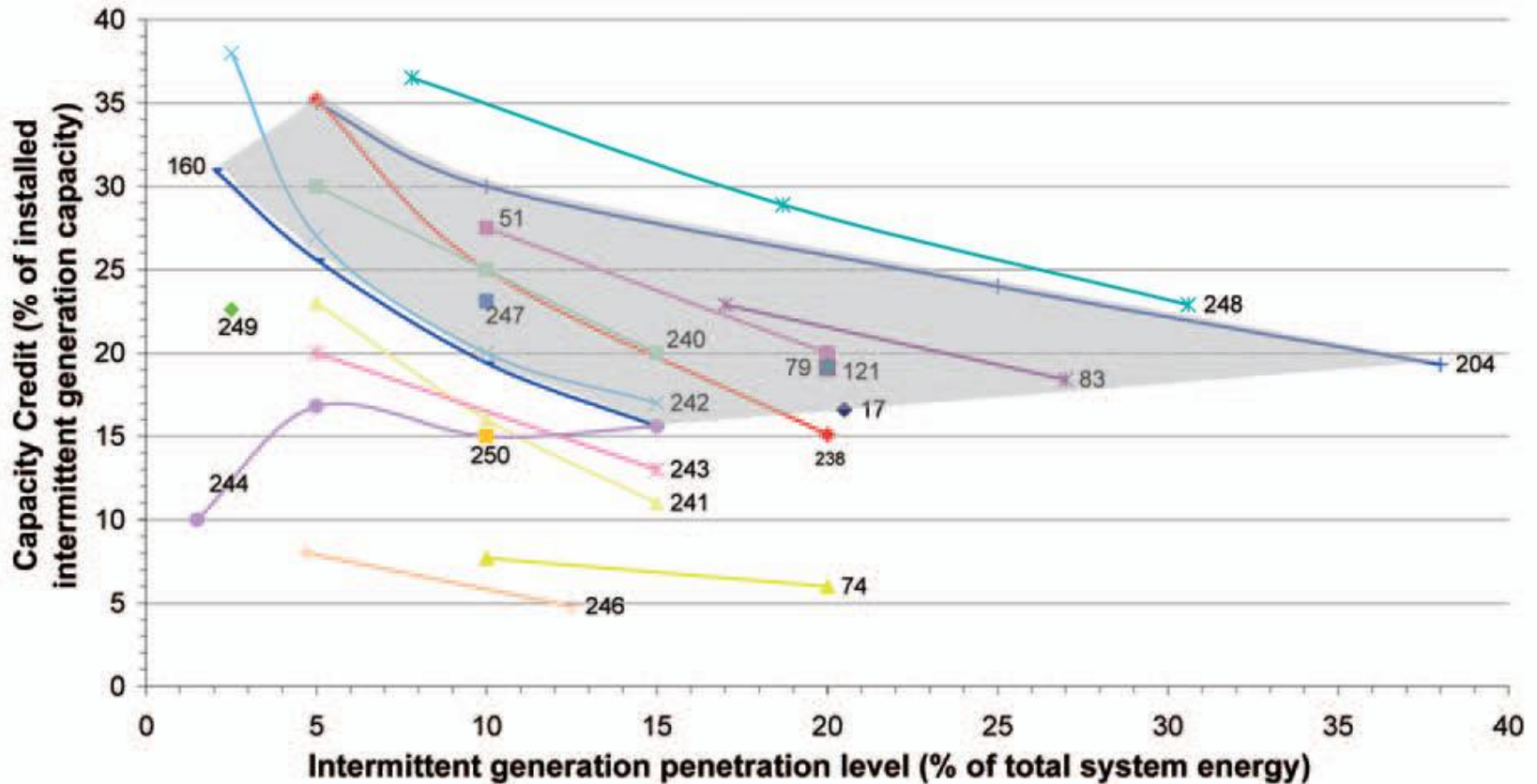
=



0.16 MW

UKERC Study

Capacity credit values

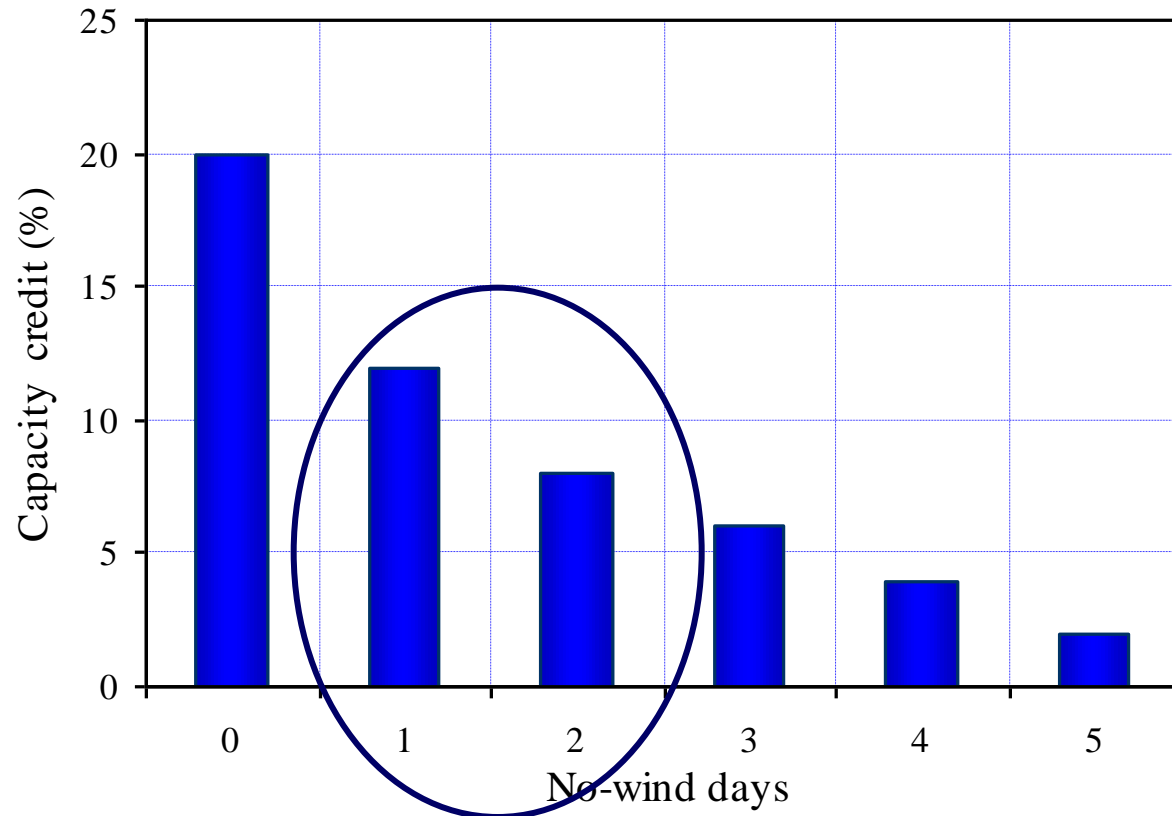


Shaded area represents the results from UK studies

Wind Capacity Credit (extracts form the UK ERC report)

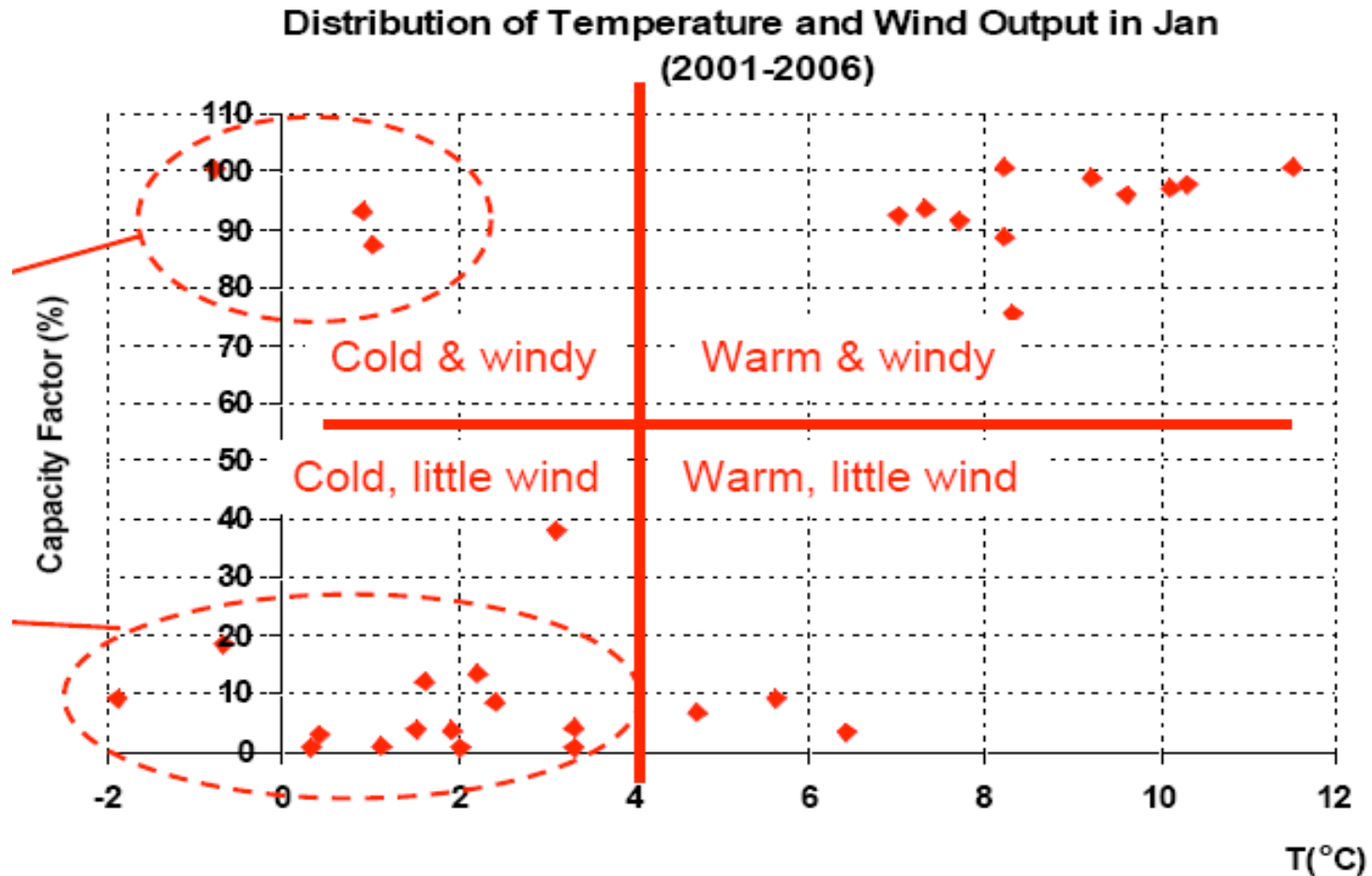
Study	Wind penetration	Capacity credit range
Mott MacDonald, 2003, Carbon Trust and DTI intermittency survey & roadmap	10 - 20%	27.5 - 20%
Dale et al, 2003,A shift to wind is not unfeasible (Energy Policy Elsevier)	20%	19.1%
Ilex & Strbac, 2002, Quantifying the system costs of additional renewables in 2020 ‘	17 - 27%	22.9 - 18.4%
Grubb, 1991,The integration of renewable electricity sources	5 - 38%	35 - 19.3%
Royal Academy of Engineering, 2003, Response to the House of Lords Science and Technology committee inquiry into the practicalities of developing renewable energy	11.6 - 31.3%	26.7 - 16%
Sinden (ECI Oxford), 2005,Wind power and the resource	10%	23.1%
Kema-xenergy, 2004, Intermittent wind generation: summary of report of impacts on grid system operations	4.8%	25.9 - 0%

Effect of No Wind During Peak Demand On Capacity Credit Of Wind Generation



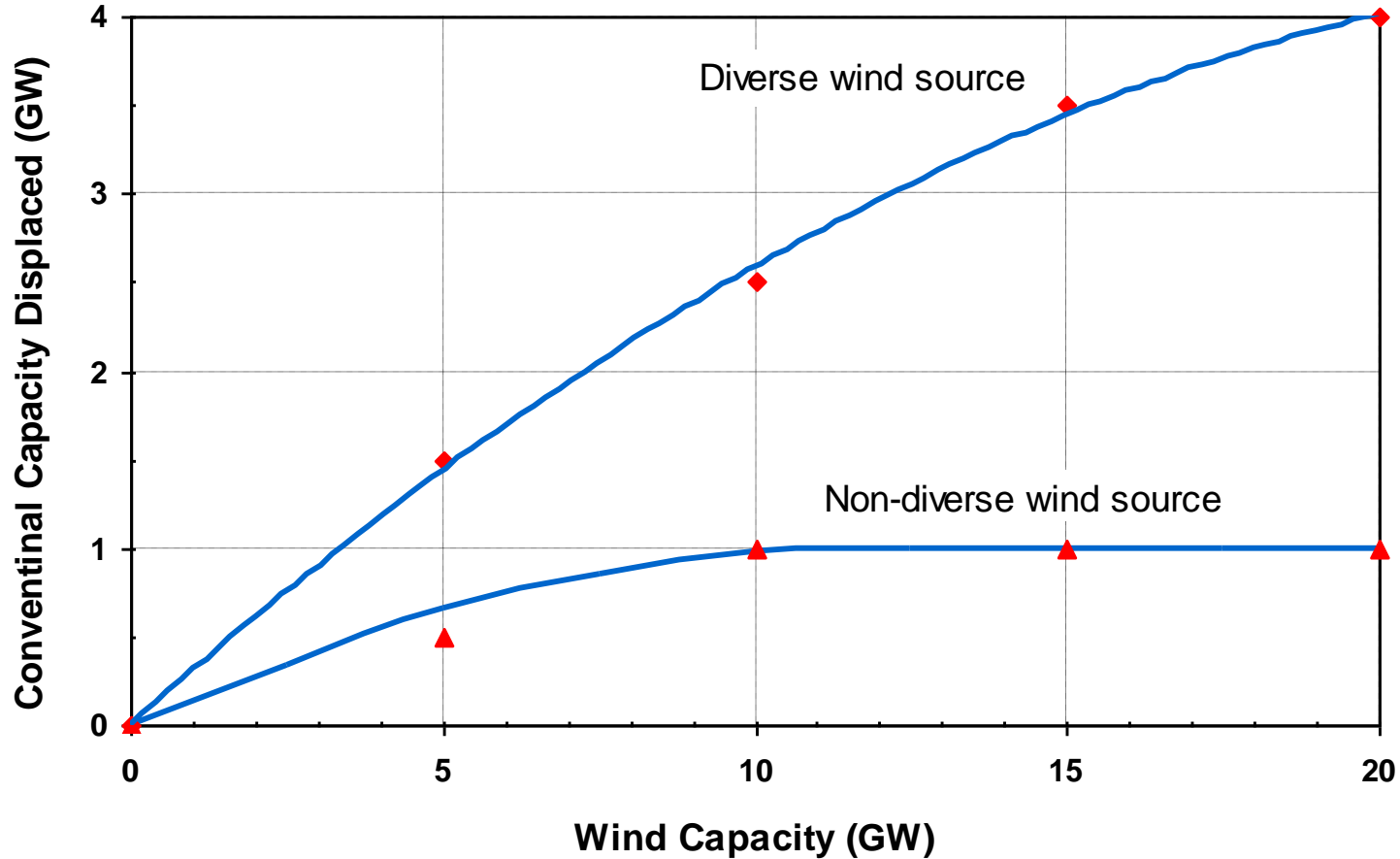
Absence of wind for only one day during peak demand periods (seven days of peak) will reduce the capacity value of wind for almost 50%. Given the significant impact of calms on the capacity value of wind (and corresponding transmission capacity), this needs more detailed investigations

Oswald Consulting (2006): “wind fails to deliver when it is cold”

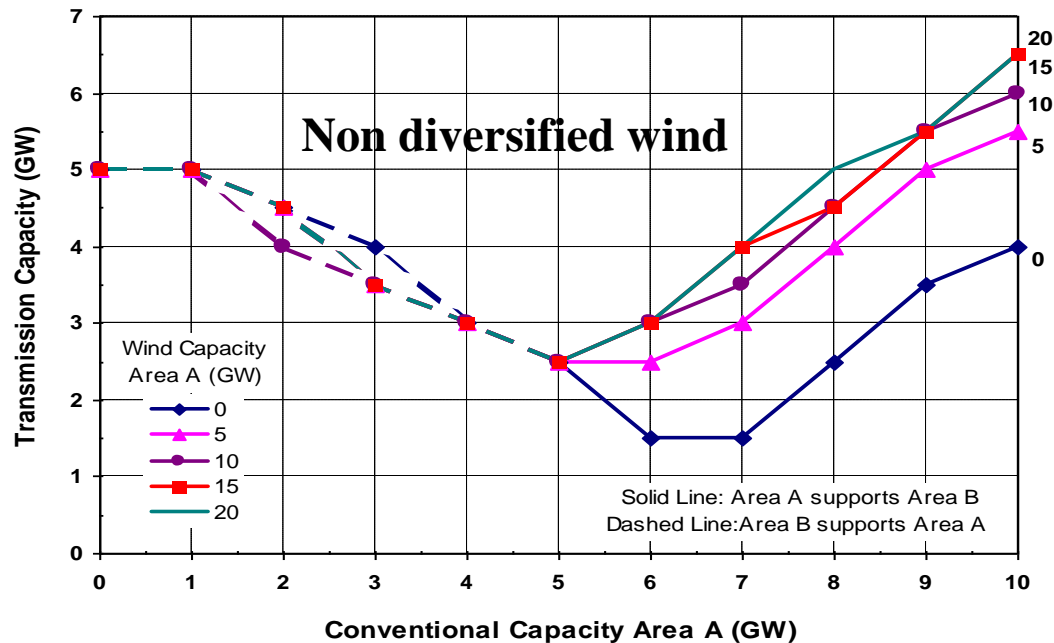
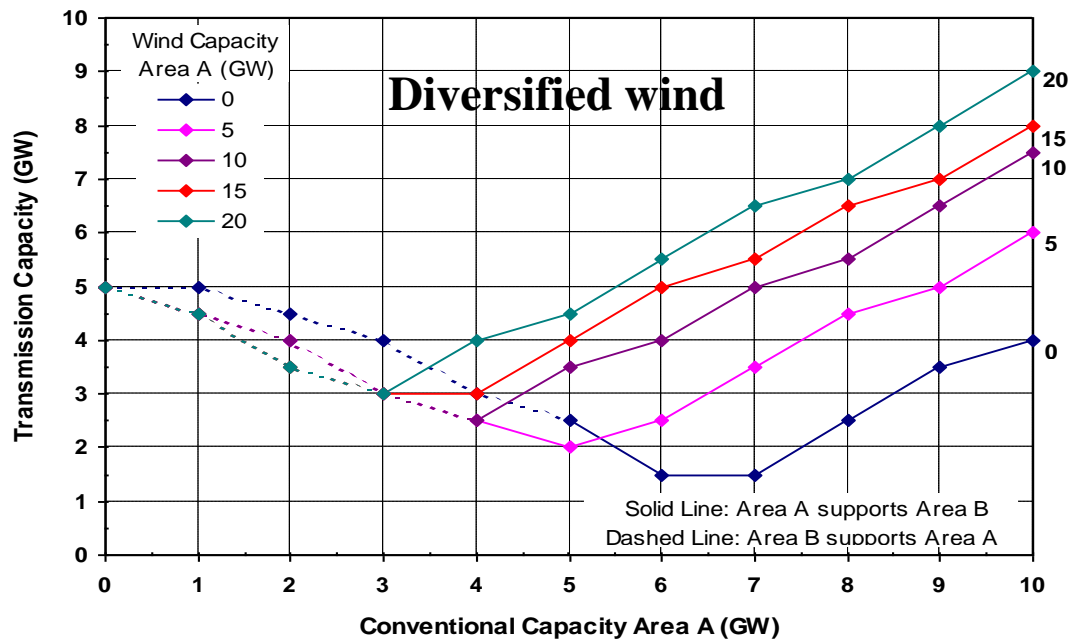
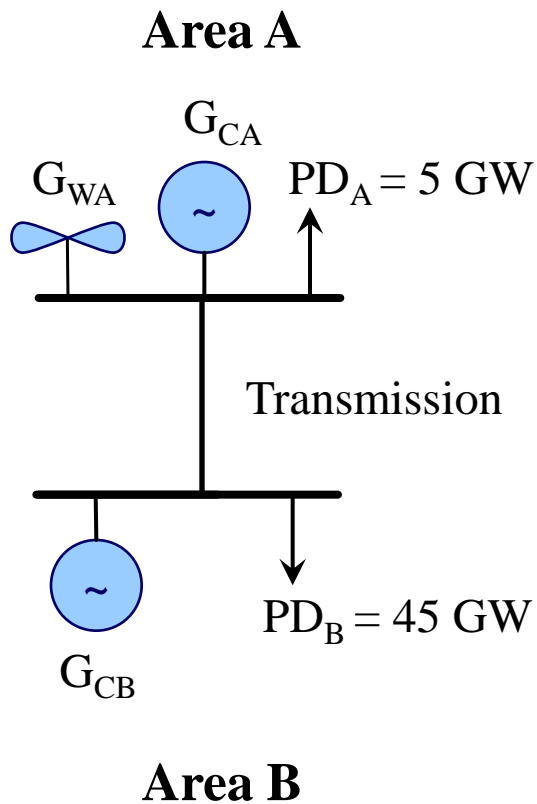


Capacity value of wind

Peak Demand = 50 GW, Risk Level ≤ 0.09
Conventional Plants Availability = 0.85



Need for Transmission



Scaling factors for wind obtain from generic studies using one year wind profiles of 35% annual load factor

	Low penetration	High penetration
Low diversity	35%	20%
High diversity	<i>45% - 50%</i> (N/A)	30%

These are to be compared with the current 60% from the GB SQSS

Further analysis of historical wind behaviour would be helpful to evaluate more precisely the contribution factors

Summary of reliability driven transmission capacity in systems with wind power and suggestions for way forward

- Wind is primarily an energy source with limited capacity value
- Contribution of wind to reliability of supply is limited and the amount of transmission that wind will drive will not be significant (scaling factors between 20 and 30% , ignore wind when considering reliability)
- In our view, Bath/Strathclyde/TNEI (funded by TLEs) and approach of DG&SEE (funded by DBERR) for quantifying the reliability contribution of wind to network capacity will, for the problem in hand, deliver very similar results, given the same input data.
- Further work: wind modelling, risk levels, format of future GB SQSS

Format of future GB SQSS for reliability

- Option I: Evaluate multiple scaling factors for wind to be included in PT while keeping IA curve as it is (using formulas, tables, diagrams)
- Option II: Wind capacity credit to be used in PT, but modify IA accordingly
- Option III: Direct evaluation of transfer capacity from tables / diagrams or software (discontinue to use the concepts of PT and IA)
- Note: given a significant number of factors affecting the transmission capacity requirement in a system with wind power a number of look-up tables & diagrams may be appropriate. This can also be accompanied by a simple software tool (similar to P2/6).

Economics driven transmission capacity in systems with wind generation

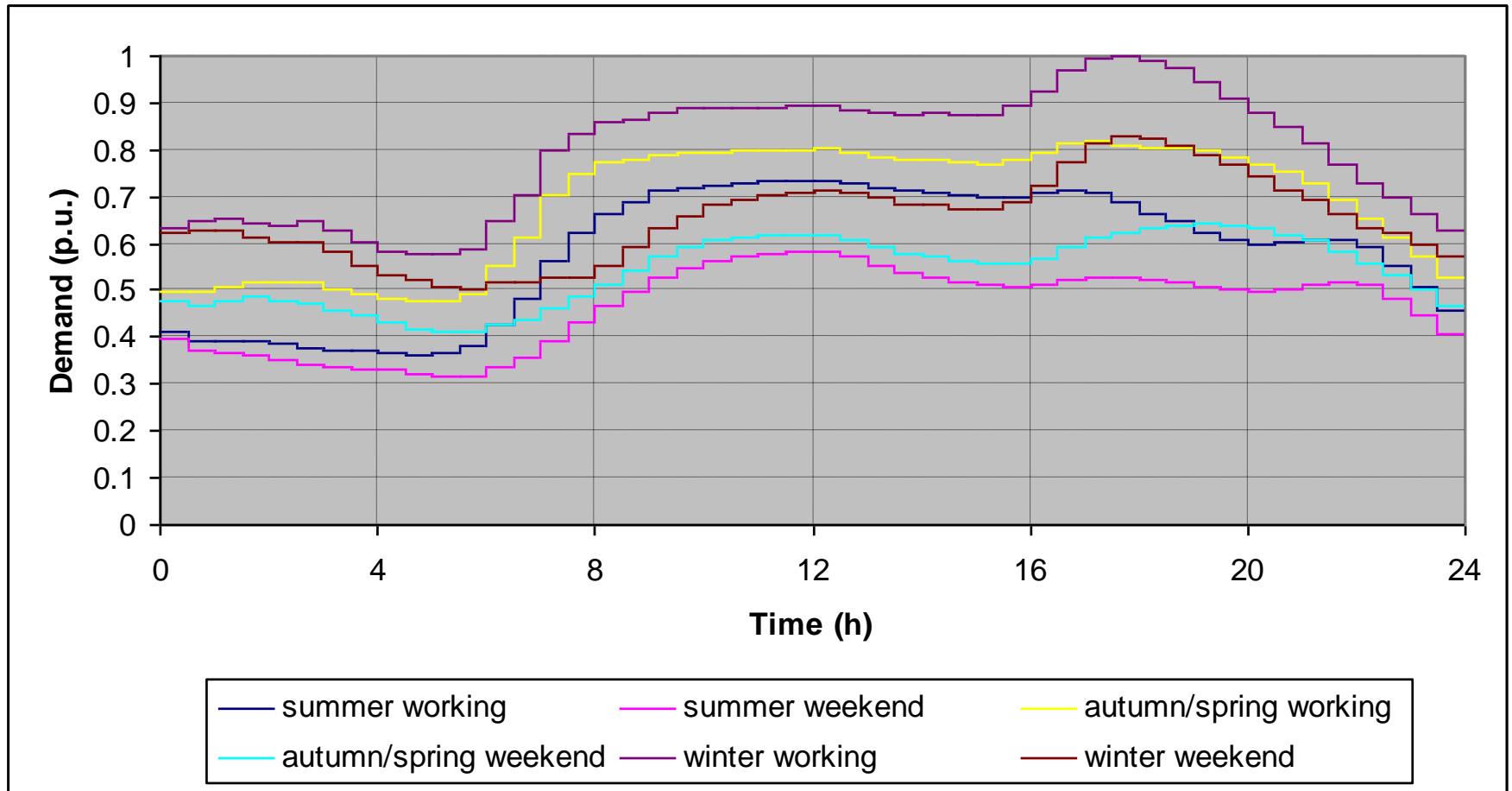
Background

- Historically, reliability driven design of transmission network to meet peak demand requirements, tended to deliver economically efficient solution (limited constraints)
- Transmission system enables (almost) all conventional generation to run at peaks simultaneously.
- With different technologies, particularly with significant penetration of renewables, transmission network capacity should be shared between conventional and renewable generation
 - On windy days, wind will tend to occupy transmission capacity, on non-windy days conventional generation takes over

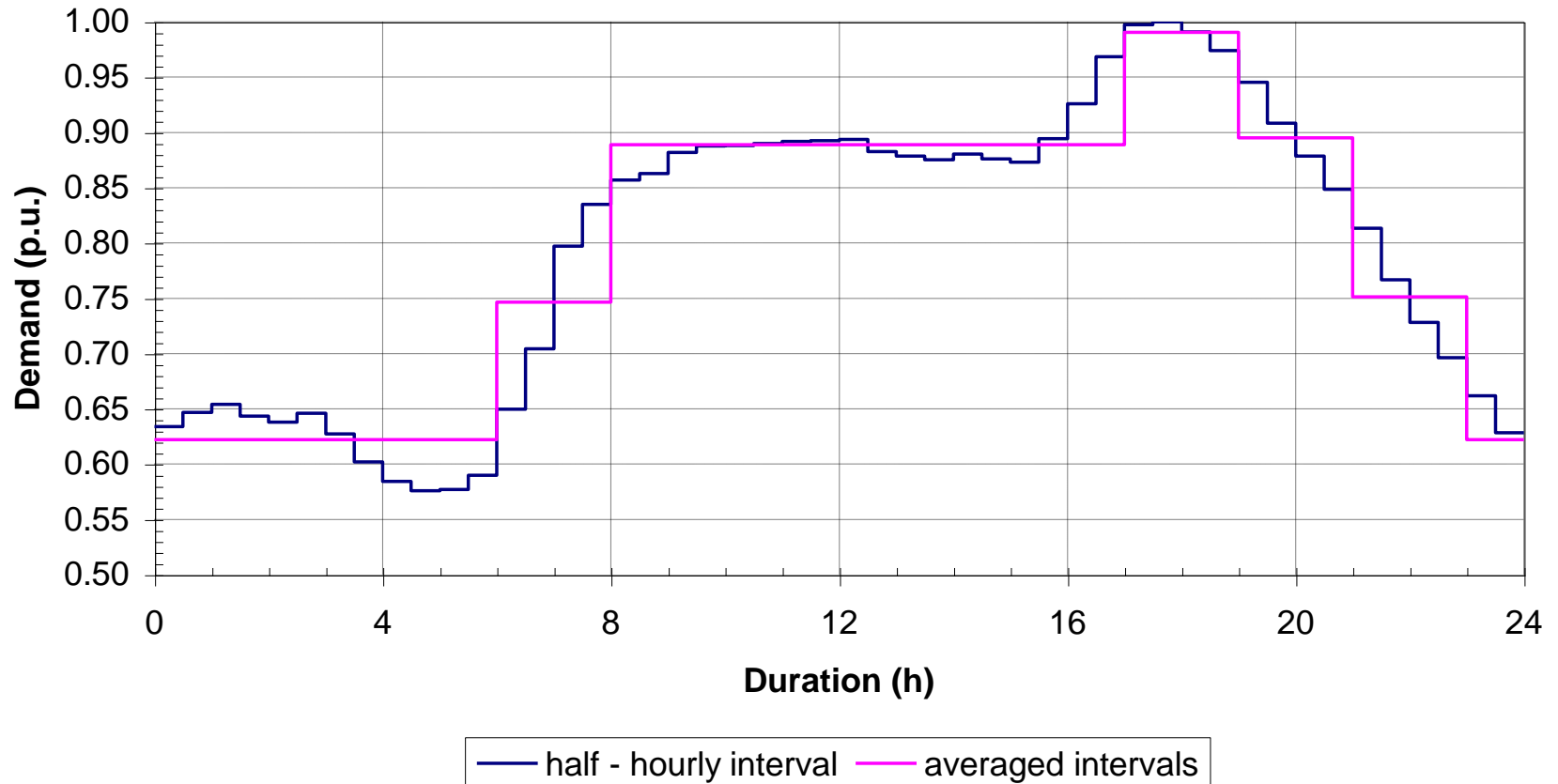
Economics driven transmission capacity

- Cost-benefit analysis: balancing cost of transmission investment against the benefits of reinforcement, i.e. reduction of constraint costs over the life span of the investment (approach adopted in the development of SQSS for offshore networks)
- Multi-year-round assessments of the system operation should be carried out by considering daily and seasonal variations in generation and demand (for a spectrum of credible backgrounds)
- Whole system needs to be considered (boundary approach may not be appropriate as it may underestimate the transmission cost and hence overestimate the need for transmission).

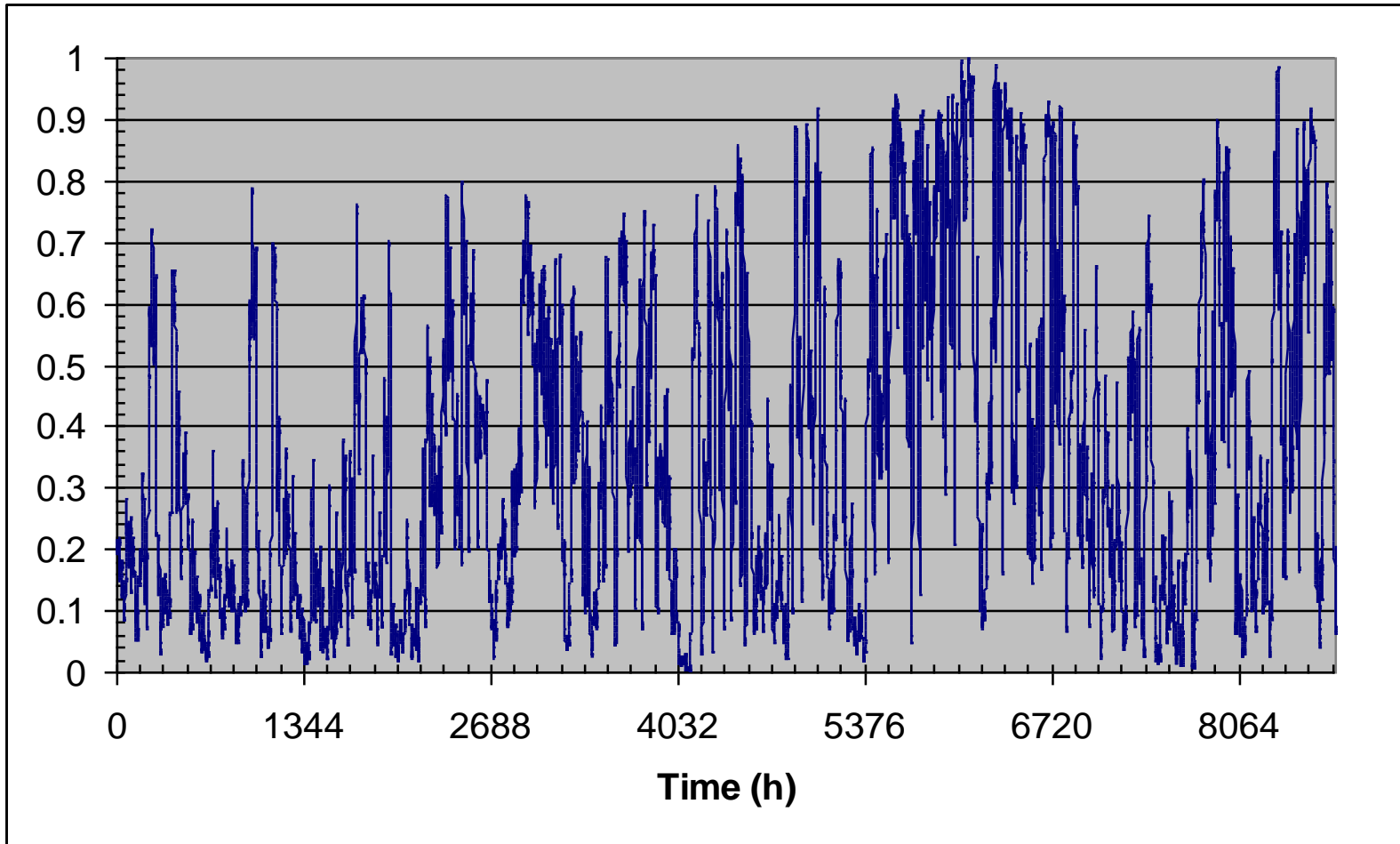
Characteristic Daily Profiles



Data Resolution

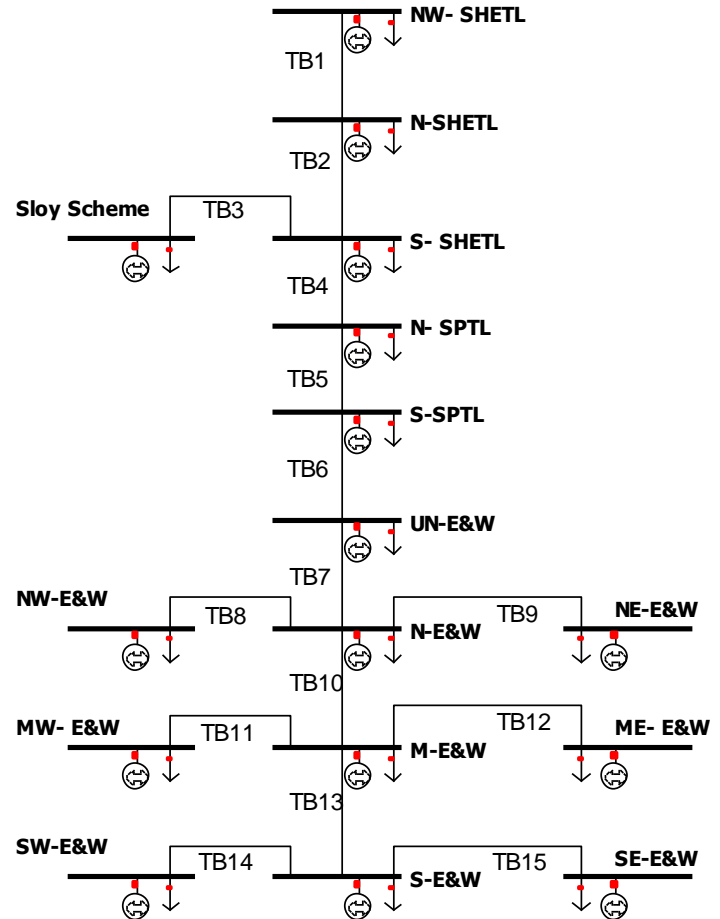
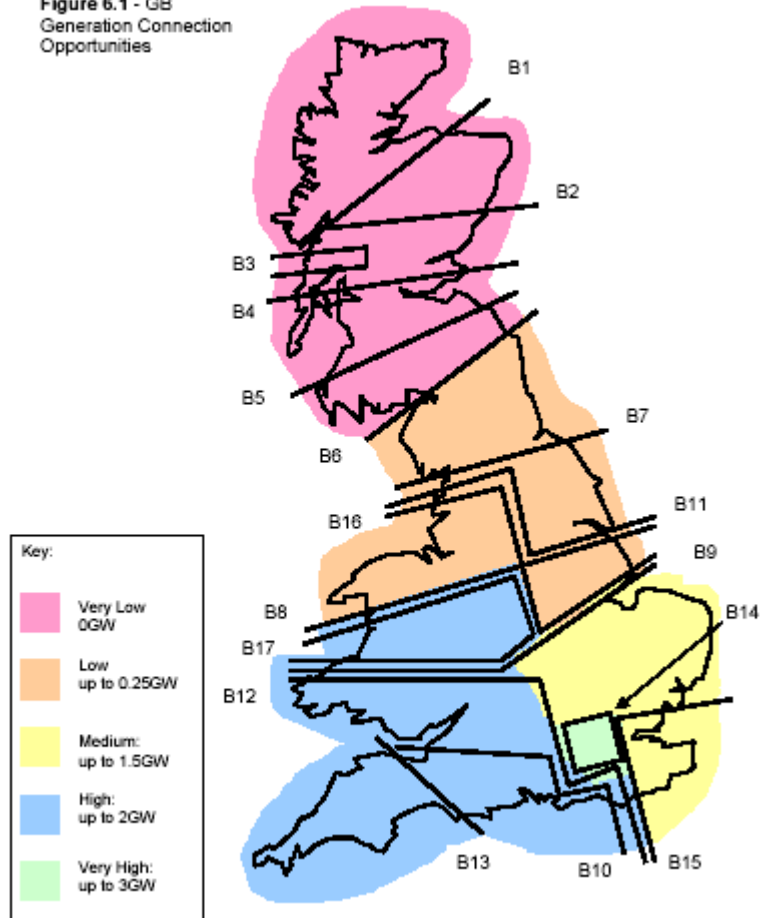


Annual Wind Profile



Generic GB Transmission System

Figure 6.1 - GB Generation Connection Opportunities



Source of data: Interim GB SYS Nov 2004

Example of the CBA applied to the simplified GB network model

- Scenario:
 - 10 GW of wind in Scotland
 - No other conventional generating plant in Scotland decommissioned
- All conventional generation grouped into categories:
 - Nuclear, coal, gas, oil, hydro
- Generation dispatch and constraint cost evaluations
 - Generation running patterns
 - Load factors of various generation technologies considered
 - Fuel costs or re-despatch costs (generic, but technology specific)
- Demand and wind generation output models derived to capture relevant changes in loading conditions

Results and comparison

From	To	Security	Economics
NW-SHETL	N-SHETL	2100	2437
N-SHETL	S-SHETL	3500	3571
S-SHETL	N-SPTL	3300	4110
N-SPTL	S-SPTL	4100	3564
S-SPTL	UN-E&W	4300	5357
UN-E&W	N-E&W	4700	4935
NW-E&W	N-E&W	2400	1942
NE-E&W	N-E&W	5600	2218
N-E&W	M-E&W	8700	7870
MW-E&W	M-E&W	6800	4798
ME-E&W	M-E&W	5400	4459
M-E&W	S-E&W	8100	8434
SW-E&W	S-E&W	3400	2781
SE-E&W	S-E&W	5100	1438

Results are driven by both model and input data assumptions

Observations

- Network that is design to provide economic transmission only, may not be secure (security evaluations needed to provide a base line investment)
- In systems with wind generation, economics likely to drive larger transmission capacities than reliability considerations
 - Depending on the relative magnitude of (marginal) cost of constraints (incurred by constraining conventional generation in Scotland on windy days), versus (marginal) cost of transmission
- Conventional generation and wind generation should share transmission capacity

Shared transmission capacity between conventional and renewable generation (key reason for the Transmission Access Review)

- The total installed capacity of generation (conventional plus wind) in Scotland, in the study, is 19.5GW and local load of 6.5GW.
- We observe that economically optimal network capacity across this boundary (boundary number 5) should be set at 5.4GW
- This result provides clear evidence that it is not economically efficient to invest in transmission to accommodate simultaneous peak outputs from both wind and conventional generation and that transmission capacity should be shared between conventional and wind generation.
- On windy days the capacity of transmission corridor between Scotland and England is primarily used to transport wind power, while on non-windy days, this capacity would be used to export energy from conventional plant.

Change in importance of reliability and economic consideration in systems with significant penetration of wind

- Wind power will displace energy produced conventional plant (reduce fuel burnt), but its ability to displace conventional plant is limited
- As the capacity value of wind power is limited, reliability driven transmission network capacity by wind power will be limited
- The economics efficiency consideration in future system with significant contribution of wind power (and other renewables) will dominate the decisions associated with network investment
- If we are to update GB SQSS the key focus of work should be on the development of appropriate CBA process, models and data to inform this.

Issues to be considered /1

Capacity driven by economics

- Detailed methodology and process for conducting CBA should be specified
 - Modelling assumptions (time horizons and number of demand periods)
- The system on which the CBA is carried out should be specified (some form of a simplified *entire* GB system should be considered, assessments based on boundaries may be inadequate)
- Future generation and demand scenarios need to be specified considering changes during the life time of the transmission assets (e.g. commissioning of new and decommissioning of old generating plant)

Issues to be considered /2

Capacity driven by economics

- Generation running orders and load factors should be considered
 - Sensitivity studies suggest that the assumptions on the generator annual load factors may have a significant impact on the need for transmission (e.g. assuming load factors for nuclear of 100% would drive significantly more transmission capacity than load factors of 75%)
- Cost of re-dispatching plant
 - Cost of constraints (market based or fuel cost based or a mix of both?) will need to be estimated for the life span of the assets.
- Maintenance requirements considerations

Issues to be considered /3

Capacity driven by economics

- Form of the standard:
 - Fixed scaling factors derived from a single set of assumptions unlikely to be appropriate
 - Flexible format to take into account changes in key assumptions in future (changes in prices, running orders, level of penetration of wind etc)
 - Centre for DG&SEE plans to make a simplified GB model available on the web

Recommendations

- Given the increased importance (dominance) of CBA in network investment decisions, the implementation details should be made more transparent
- There is no fundamental disagreement in the concept and role of CBA in assessing the need for transmission
- Parameters of the CBA process need to be agreed (e.g. format, modelling assumptions, scenario assumptions, running orders, cost data assumptions, time horizons)
- CBA is difficult: we urge the GB SQSS review group to start considering how economic considerations can be included in the update of GB SQSS

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