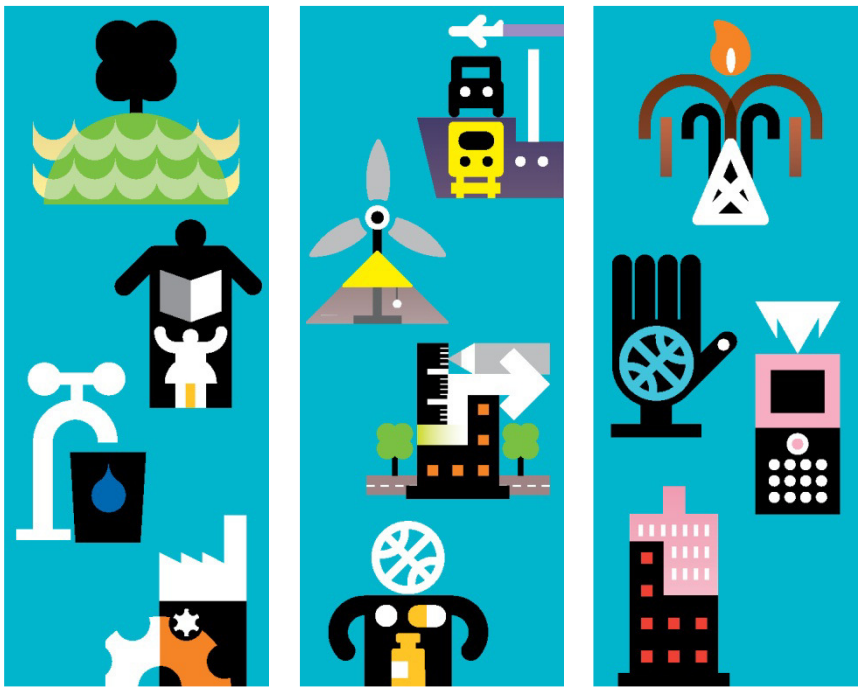
APPENDIX 2.1 - MID WALES CONJOINED WIND FARM INQUIRY – CONNECTION OPTIONS REVIEW



Mid Wales Conjoined Wind Farm Inquiry

Grid Connection Options Review

December 2013

Vattenfall, FWL, RES and RWE

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Contents

Summary and Conclusions

The Mid Wales (Powys) Conjoined Wind Farms Public Inquiry is currently considering the section 36 applications to construct and operate five wind farms in mid Wales. Together, these wind farms would provide up to 482 MW of generating capacity, and all have accepted connection offers from SP Manweb, the local Distribution Network Operator (DNO). Only one of these offers is for a connection to their existing distribution network, the other four are to a new 400/132 kV substation which National Grid proposes to construct at Cefn Coch. This substation would also provide connection to other proposed wind farms in mid Wales – SP Manweb currently have connection agreements for a further 236 MW of generation, in addition to that being considered by the present Inquiry.

This report has looked at possible connection options which consider only the five wind farms subject to the present Inquiry. In particular, the report has considered how connection might be achieved using only 132 kV transmission, instead of establishing the 400/132 kV substation at Cefn Coch. Various connection combinations are detailed in Section 3.

The report shows that up to 160 MW of wind generation, most probably in SSA C, could be connected to SP Manweb's 132 kV network at Welshpool. To connect more generation in SSA C and generation in SSA B would require one or two 132 kV circuits from SSA B to Legacy about 70 km distant from SSA B, an unusually long way at this voltage level for this amount of generation. There are technical issues concerning voltage regulation, summarised in Appendix A, which are on the limit of acceptability but which can probably be satisfactorily managed.

There would also be significantly more power lost in transmission at 132 kV compared with 400 kV, and the magnitude of this is estimated in Appendix B.

On balance, if all five wind farms are to be connected, the alternative of the 400/132 kV hub at Cefn Coch is preferable. It would also allow for the connection of future wind generation without the need for further long 132 kV circuits.

1 Introduction

The four wind farm developers: Vattenfall, Fferm Wynt Llaithddu Cyf ("FWL"), RES UK & Ireland Limited ("RES") and RWE Npower Renewables Limited ("RWE"); are each planning to build wind farms in mid Wales. They have each made an application under section 36 of the Electricity Act 1989 to the Department of Energy and Climate Change for consent to construct and operate wind turbine generating stations in Powys, Mid Wales. The Vattenfall scheme is referred to as Llanbadarn Fynydd, the FWL scheme as Llaithddu, the RES scheme as Llanbrynmair and the RWE scheme as Carnedd Wen.

Each of the four developers has entered into an agreement with SP Manweb Plc to connect their respective generating station to SP Manweb's electricity distribution system via a hub sub-station to be constructed in the location of Cefn Coch. SP Manweb's present view on the location of the hub and the route of lines from the generating stations to the hub is to be found at http://spmidwalesconnections.info/. National Grid's current proposals for connecting the sub-station hub to the National Grid at Lower Frankton, Shropshire can be found at http://www.midwalesconnection.com/.

In addition to the developers' applications an application has also been made under section 36 by Celtpower Limited ("Celtpower") for consent to construct and operate a wind turbine generating station at Llandinam in Powys, Mid Wales. It is not proposed that this generating station connect to the hub, instead it will export electricity via a new 132 kV overhead electric line connection to Welshpool substation. An application has been made by SP Manweb under section 37 of the Act to install this new line.

All six applications (the five wind farms and the SP Manweb 132 kV line) are currently the subject of a conjoined public inquiry which the Secretary of State has appointed Mr Andrew Poulter to undertake. The inquiry is divided into different sessions with the proposed wind farms in SSA[1] C (being Vattenfall's, FWL's and Celtpower's proposed wind farms) being considered in session 1 and those in SSA B (being RWE's and RES' proposed wind farms) being considered in session 2. The cumulative and in combination effects of the developments in SSA B and SSA C will be considered in session 4. Supplementary Environmental Information (SEI) for session 4 must be submitted on or before 24 December 2013, and this report forms part of that assessment.

[1] SSAs are the Strategic Search Areas as defined in Technical Advice Note (TAN) 8: Planning for Renewable Energy, published by the Welsh Government in July 2005.

2 Scope

The developers are each required to produce SEI to the Inquiry in relation to the likely cumulative impacts of the wind farms in combination with the following grid infrastructure:

1. The overhead lines from the respective generating stations to the hub;
2. The construction of the hub; and
3. The 400 kV overhead line from the hub to the grid supply point.

These impacts will include not only the routes of the lines but also the types of pole/pylon and number required.

The SEI will need to take into account secondary and indirect effects of those connections. In this respect it should be noted that there are a number of other proposed wind farms with agreements or offers to connect to the hub. The wind farms that currently have connection agreements with SP Manweb total about 720 MW of generation, and these are detailed in the Third Strategic Optioneering Report which is available at: http://spmidwalesconnections.info/.

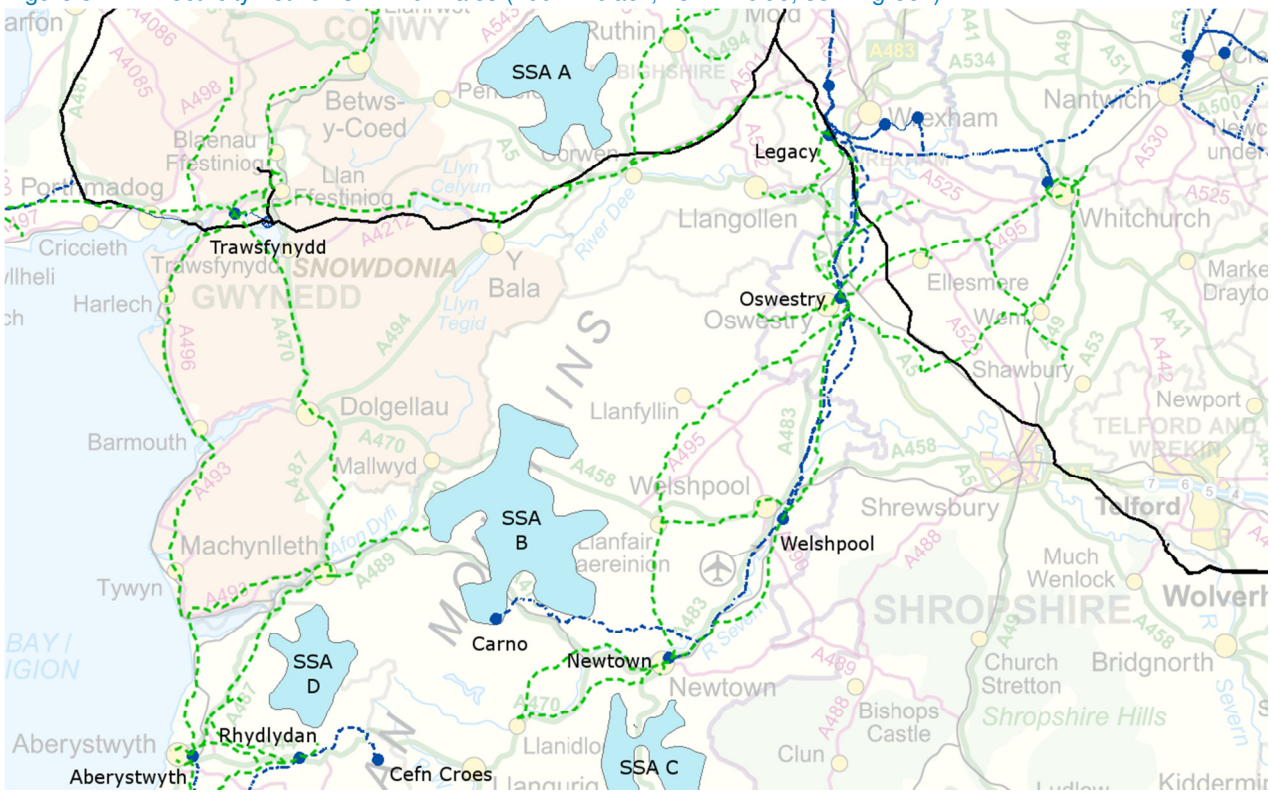
To inform the work of providing this SEI, this report provides a technical assessment of the options available for connecting to the grid and the infrastructure that this may require. In particular, it endeavours to answer the question of what form the various connections are likely to take if only some of the developments are permitted.

3 Connection Options

3.1 The Distribution Network in Mid Wales

The distribution network in mid Wales consists of a hierarchy of electricity networks: 132 kV, 33 kV, 11 kV and low voltage; with transformers connecting the various voltage 'layers'. There are two principal 132 kV circuits into the area from the supergrid substation at Legacy (near Wrexham): one to Welshpool and the other to Newtown. Both circuits go via Oswestry. There is a third 132 kV circuit into mid Wales from the Western Power Distribution (WPD) network in south Wales, but this is not interconnected with the SP Manweb system. This circuit serves the south west area of mid Wales in and around Aberystwyth and connections to it are subject to constraints determined by WPD. Figure 3.1 shows a map of the 132 kV and 33 kV networks in mid Wales.

Figure 3.1: Electricity networks in Mid Wales (400 kV black, 132 kV blue, 33 kV green)



Source: SP Manweb (Not all 33 kV network shown outside mid Wales)

There is presently a double circuit 132 kV line between Legacy and Oswestry, each circuit with a capacity of about 100 MVA[2], but a third circuit (with a capacity of 124 MVA) was consented earlier this year and is planned to be in service during 2015. From Oswestry a single 132 kV circuit extends to Welshpool and another single circuit extends to Newtown (bypassing Welshpool). Each circuit has a capacity of 89 MVA.

2 Capacities quoted here a based on the summer rating of a circuit.

Just to the north east of Newtown, there is a tee off the Oswestry-Newtown circuit to service the wind farm at Carno; this circuit has a capacity of 119 MVA.

The circuit capacities of the underlying 33 kV network vary, up to a maximum of about 25 MVA, but are typically around 20 MVA.

3.1.1 Generation export capability

The SP Manweb distribution network in mid Wales was developed to supply electricity **to** mid Wales; until about 20 years ago there was essentially no generation in the area, so all the power flow was from Legacy and into the distribution network. Therefore any generation in mid Wales which is connected to the SP Manweb network subtracts from or even reverses this flow. This means that the existing network has the capability of accepting generation up to the rating of the circuits plus the minimum load that is always needed to be supplied locally off those circuits. Minimum load occurs in the summer time, at which time there is less capability to consume the generation locally. Additionally, conditions for the connection of generation are more onerous in the summer due to higher ambient temperatures, therefore minimum network loading and summer ratings for circuits are assumed when considering the connection of generation.

The following table lists the existing mid Wales generation in and around SSAs B and C.

Table 3.1: Existing generation

Wind Farm	Type	Connection kV	MVA
Carno A & B	Wind	132	43.2
Carno 2	Wind	132	15.6
Tir Gwynt	Wind	132	30
Llandinam (Penrhyddlan)	Wind	33	14
Llandinam (Llidiartywaun)	Wind	33	20
Mynydd Clogau	Wind	33	14.5

Source: SP Manweb

There are two existing 132 kV circuits which can be used to export generation from the vicinity of SSAs B and C: Newtown-Oswestry and the Welshpool-Oswestry. Each of these circuits has a capacity of 89 MVA. The Newtown-Oswestry circuit is already fully utilised by the generation at Carno and Tir Gwynt (see Table 3.1), and the proposed Llandinam repowering will similarly utilise the capacity of the Welshpool-Oswestry circuit. This effectively utilises all the generation connection capacity currently available on the SP Manweb distribution network in the area of SSAs B and C.

The SP Manweb networks are designed and generally operated interconnected, and the underlying 33 kV network in mid Wales connects up towards Legacy and Whitchurch. However the export capability of the 33 kV network itself is very limited. There are few circuits and they have a relatively high impedance (compared with the 132 kV circuits), so the generation connected at 33 kV mainly adds to the flows on the 132 kV circuits. Indeed, calculations show that about 90% of any generation connected to the 33 kV

network in the Newtown area will be exported up though the 132/33 kV transformers at Newtown and Welshpool.

3.2 Proposed generation

According to the SP Mid Wales Connections Third Strategic Optioneering Report[3] (SOR3), SP Manweb has connection agreements in place for 720.6 MW of proposed wind generation. Of these wind farms, five are the subject of the Mid Wales (Powys) Conjoined Wind Farms Public Inquiry, and these are listed in Table 3.2.

Table 3.2: Proposed wind generation in the present public inquiry

Wind Farm	Developer	Area	Application MW	SOR3 MW
Llanbrynmair	RES	SSA B	90	90
Carnedd Wen	RWE	SSA B	150	150
Llaithddu	Fferm Wynt Llaithddu Cyf	SSA C	80	74.4
Llanbadarn Fynydd	Vattenfall	SSA C	59.5	61.2
Llandinam repowering	Celt Power Ltd.	SSA C	102	90

SP Manweb proposes (see SOR3) to connect the first four of these wind farms via new 132 kV circuits to the proposed National Grid substation at Cefn Coch, whereas the fifth (Llandinam repowering) would be connected via a new 132 kV circuit to the existing 132 kV substation at Welshpool, which is the nearest point where capacity is available.

SOR3 proposes a single 132 kV Heavy Duty Wood Pole (HDWP) line (capacity 176 MVA) from SSA C to Cefn Coch to connect all the contracted wind generation in SSA C (except Llandinam repowering).

For SSA B, compared with the 240 MW being considered by the present inquiry (see Table 3.2), SOR3 states that the contracted generation totals 465 MW. To connect all this to the 400 kV hub at Cefn Coch, SOR3 proposes mainly HDWP circuits with a short length of double circuit tower line. The main part of the connections to Llanbrynmair and Carnedd Wen would consist of a single HDWP line to each wind farm, and were these to be the only two new wind farms connected in SSA B, it is likely that, instead of the 132 kV tower line, each of these HDWP circuits would extend all the way to Cefn Coch.

Since, as a requirement of their Distribution Licence, SP Manweb is obliged to consider the contracted position, SOR 3 only addresses this situation, which includes wind farms in addition to those covered by the present public inquiry. In the following sections of this report only those wind farms involved in this present inquiry are considered in isolation, and how they might be connected in total, or if only a subset were to be approved.

[3] http://www.spmidwalesconnections.info/english/pdf/Third%20Strategic%20Optioneering%20Report.pdf

3.3 Connection alternatives

There is currently no National Grid network (i.e. 275 kV or 400 kV network) in or near the mid Wales SSAs, so all existing generation is connected to the SP Manweb network at voltages up to and including 132 kV. Generation in mid Wales in excess of local requirements is therefore exported via the 132 kV network, and a significant proportion of its export potential has already been utilised. It is understood that the 132 kV circuit near Aberystwyth which is supplied from the WPD system in south Wales, can accept no more generation; and similarly the 132 kV circuit from Newtown to Oswestry is fully utilised by the existing Carno and Tir Gwynt generation.

This leaves the Welshpool to Oswestry circuit as the only 132 kV circuit able to connect new generation. SP Manweb currently plans (see SOR3) to connect 90 MW of wind generation (from Llandinam) to this circuit, which is the maximum that can be accepted at present due to constraints on the SP Manweb network above Welshpool. However, SP Manweb has provisionally considered that with reinforcement of their network, up to about 160 MW of generation (i.e. 70 MW more than at present) could be accepted. Accordingly, this report has assumed a 160 MW capability, which should be possible following significant system reinforcement beyond Welshpool.

It is clear, therefore, that for more than 160 MW of generation to be connected, additional transmission capacity is required in mid Wales.

In the TAN8 report for the Welsh Government, Garrad Hassan identified 740 MW wind generation potential in mid Wales (SSAs B, C and D). Indeed, as noted in Section 3.2, SP Manweb is presently contracted to connect almost 721 MW of wind generation[4]. This quantity of generation needs access to the National Grid, which would be achieved by the establishment of a 400 kV substation at Cefn Coch as currently proposed.

However, if significantly less than this amount of generation were to be connected, it would be possible to connect to existing National Grid substations (for example at Legacy or Shrewsbury) at 132 kV, but these are about 70 km distant, and transmitting power over this distance at 132 kV has significant limitations.

How this might be achieved is reviewed in the following paragraphs. Only the five wind farms involved in the present Inquiry are considered, 481.5 MW of generation based on the present application or 465.6 MW according to SOR3, and no allowance is made for the possibility of any further generation in the future.

3.3.1 SSA C

Of the three wind farms proposed in SSA C (see Table 3.2 for details), the present proposal (see SOR3) is to connect Llandinam repowering (90 MW) to the existing SP Manweb 132 kV network at Welshpool, and

[4] SOR3 also notes that there is additional wind generation proposed in mid Wales: 30 MW is contracted with WPD (formerly Central Networks); and SP Manweb has made connection offers (not yet accepted) for further generation totalling 155.5 MW and is also aware of 185.5 MW of other wind generation that is under consideration by developers.

the other two wind farms (up to 140 MW) to the Cefn Coch hub. 90 MW is the maximum that SP Manweb can currently accept onto its network at Welshpool, however, they have indicated that, after the construction of the (now approved) Legacy to Oswestry third 132 kV circuit as well as other significant network reinforcement, that limit can be increased to 160 MW.

The two largest wind farms in SSA C (Llaithddu and Llandinam repowering) total 164.4 MW (SOR3) or 182 MW (application). Since up to 160 MW of generation could be connected at Welshpool following upgrades by SP Manweb, essentially any two of the wind farms in SSA C could be connected via a 132 kV HDWP circuit to Welshpool. This assumes the possibility of generation being constrained at times of minimum system load, if those two wind farms were to be Llaithddu and Llandinam repowering. Based on the SOR3 figure, it is likely that very little, if any, restriction on generation would be required in practice, but might be unacceptable for the higher level of generation proposed in the application.

The remaining wind farm would need another 132 kV circuit to connect to the National Grid. In the absence of a 400 kV substation at Cefn Coch, the nearest 400/132 kV substation would be Shrewsbury, about 70 km away from SSA C. However a more likely prospect would be to connect to a 132 kV hub substation in SSA B, which would be needed for the wind farms in that area. Depending on which two wind farms connect to Welshpool, up to 80 MW of generation would need to be connected via a 132 kV circuit to SSA B. In order to ensure acceptable power flows on their 132 kV network, SP Manweb would not normally operate with these two circuits electrically connected in SSA C, therefore two of the wind farms would export via the Welshpool circuit, and the third via SSA B.

3.3.2 SSA B

Any wind farm in SSA B is very unlikely to be able to be connected to the existing SP Manweb network. Although 160 MW of generation can be connected at Welshpool (see Section 3.3), this will be utilised by one or two of the wind farms in SSA C (see Section 3.3.1). Therefore to connect any wind farm in SSA B (assuming no 400 kV hub at Cefn Coch) would require a 132 kV circuit to Legacy, a distance of about 70 km. The two wind farms in SSA B total 240 MW of generation, but there is also the possibility of a further 80 MW of generation coming from SSA C (see Section 3.3.1) bringing the total to 320 MW.

The two sizes of 132 kV HDWP lines used by SP Manweb have summer ratings of 124 MVA and 176 MVA. At a 0.95 power factor, these ratings represent generation levels of 117.8 MW and 167.2 MW respectively (see Appendix A), therefore, using the higher rated circuit, it appears just feasible to export all the generation on two 132 kV HDWP circuits to Legacy from a 132 kV (only) hub substation in SSA B. Alternatively, a double circuit L4 steel lattice tower line could be used instead of the two HDWP lines, since it can carry the same conductor, and hence has the same rating.

Note that 70 km is at the technical limit for transmitting this amount of power at 132 kV. Appendix A shows the voltage drop/rise for 132 kV circuit lengths up to 70 km. It is probable that additional voltage control measures would need to be employed to achieve satisfactory operation of this arrangement.

In normal operation there are two 240 MVA 400/132 kV transformers in service at Legacy. Therefore, if the proposed wind generation is connected in this way, under outage conditions (i.e. only one of these

transformers in service at Legacy) it may be necessary to constrain the generation during times of minimum load.

3.3.3 132 kV connection summary

The following table summarises the possible connections.

Table 3.3: Possible connection options, in the absence of Cefn Coch 400 kV substation

Option	Scenario	Connection
1.	Up to 160 MW (one or two wind farms) in SSA C; no wind farms in SSA B.	132 kV HDWP line from SSA C to connect to the SP Manweb network at Welshpool. Requires significant SP Manweb reinforcements north of Welshpool.
2.	Over 160 MW (all three wind farms) in SSA C; no wind farms in SSA B[5].	The connection to Welshpool, as outlined in option 1, plus a 132 kV HDWP connection to Shrewsbury, the nearest 400/132 kV substation.
3.	Over 160 MW (all three wind farms) in SSA C; at least one wind farm in SSA B[6].	The connection to Welshpool, as outlined in option 1, plus a 132 kV HDWP from SSA C to SSA B. This assumes there must be (at least) one circuit to Legacy (see the following options)
4.	Up to 160 MW (one wind farm) in SSA B; no wind farms in SSA C.	132 kV HDWP circuit to Welshpool from SSA B.
5.	Up to 117.8 MW[7] or 167.2 MW (one wind farm) in SSA B; two wind farms in SSA C of up to a total of 160 MW.	132 kV HDWP circuit (124 MVA or 176 MVA) to Legacy from SSA B, plus connection option 1.
6.	Up to 87.2 MW (Llanbrynmair) in SSA B; all three wind farms in SSA C.	132 kV HDWP circuit (176 MVA) to Legacy from SSA B, plus connection option 1, plus 132 kV HDWP between SSA B and SSA C.
7.	Both wind farms in SSA B; up to 160 MW (two wind farms) in SSA C.	2 x 132 kV HDWP circuits to Legacy from SSA B, plus connection option 1.
8a.	All five wind farms.	2 x 132 kV circuits (2 x HDWP or an L4 tower line) to Legacy from SSA B, plus a 132 kV circuit between SSA B and SSA C, plus connection option 1.
8b.	All five wind farms.	National Grid 400 kV circuit to Lower Frankton from National Grid 400/132 kV substation at Cefn Coch, plus a 132 kV HDWP circuit between SSA B and SSA C, plus option 1.

[5] Two wind farms in SSA C may exceed 160 MW if one includes Llandinam. Therefore this connection arrangement could apply to two wind farms in SSA C, if constraining generation at times of minimum load is not acceptable.

[6] Two wind farms in SSA C may exceed 160 MW if one includes Llandinam. Therefore this connection arrangement could apply to two wind farms in SSA C, if constraining generation at times of minimum load is not acceptable.

[7] The MW limits are based on the respective circuit ratings with the generation at 0.95 power factor.

Appendices

Appendix A. Voltage Regulation

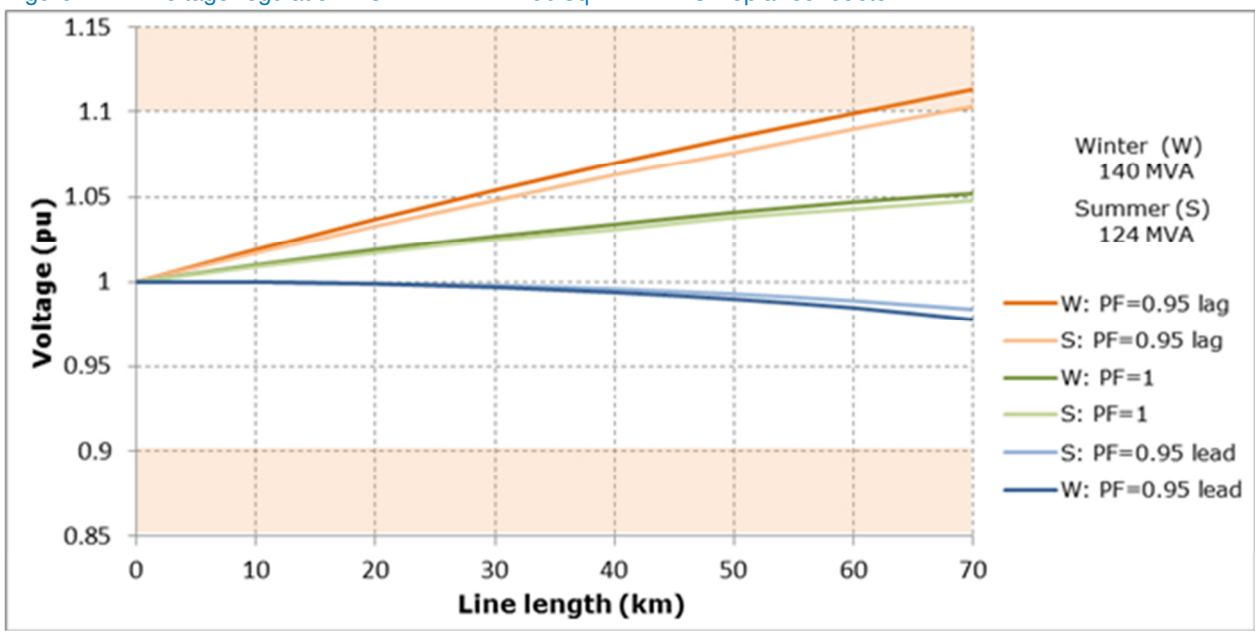
The voltage drop or rise along any circuit increases directly with circuit length and loading. Increasing the rating of a circuit, i.e. increasing the size (cross section) of the conductor, has little effect on voltage regulation since this is a function of line reactance which depends primarily on conductor spacing.

There is theoretical limit on the power that can be transmitted along any circuit, and increasing to this level causes 'voltage collapse'. This theoretical limit cannot be achieved in practice, since as the limit is approached the system becomes progressively less stable. Active voltage control is required, at additional cost, to achieve such high power transfers. The statutory voltage limits on the 132 kV network are ±10% of nominal voltage.

The two highest rated wood pole 132 kV circuits available to SP Manweb employ 200 sq mm AAAC 'Poplar' and 300 sq mm AAAC 'Upas' conductors respectively, and the voltage drop/rise for circuits operating at their maximum (thermal rating) is shown in the following figures. The graphs show the voltage drop/rise for circuits up to 70 km long, operating under three different loading conditions for both winter and summer rating levels.

The UK Grid Code requires wind generators to be capable of operating at power factors between 0.95 leading (consuming reactive power) to 0.95 lagging (supplying reactive power). The figures below show the voltages for these limits as well as for unity power factor (zero reactive power at the generator).

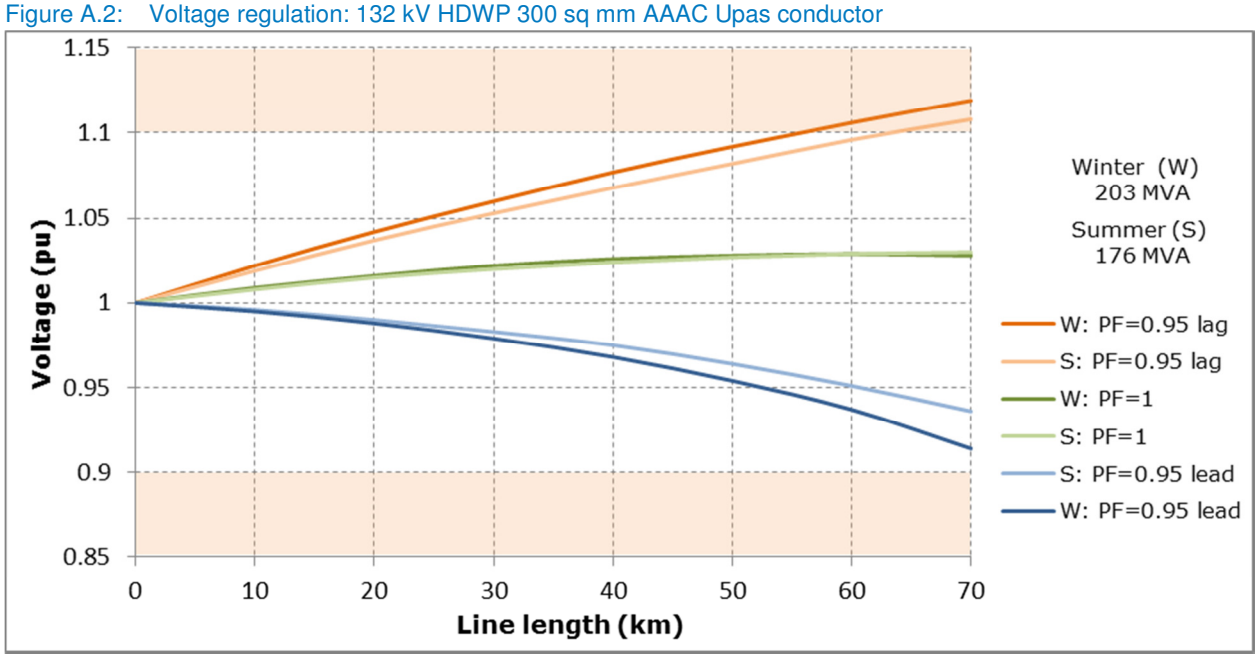
Figure A.1: Voltage regulation: 132 kV HDWP 200 sq mm AAAC Poplar conductor



In Figure A.1 above, at the winter loading of 140 MVA: the generation at unity power factor is 140 MW, 0 MVAr; at 0.95 PF lag is 133 MW, 43.7 MVAr; and at 0.95 PF lead is 133 MW, –43.7 MVAr. At the summer loading of 124 MVA: the generation at unity power factor is 124 MW, 0 MVAr; at 0.95 PF lag is 117.8 MW, 38.7 MVAr; and at 0.95 PF lead is 117.8 MW, –38.7 MVAr.

In Figure A.2 below, at the winter loading of 203 MVA: the generation at unity power factor is 203 MW, 0 MVAr; at 0.95 PF lag is 192.9 MW, 63.4 MVAr; and at 0.95 PF lead is 192.9 MW, –63.4 MVAr. At the summer loading of 176 MVA: the generation at unity power factor is 176 MW, 0 MVAr; at 0.95 PF lag is 167.2 MW, 54.0 MVAr; and at 0.95 PF lead is 167.2 MW, –54.0 MVAr.

Figure A.2: Voltage regulation: 132 kV HDWP 300 sq mm AAAC Upas conductor



It is evident from these graphs that, over a single 70 km 132 kV circuit, about 170 MW is the maximum that can be exported without the introduction of additional voltage control measures. Even so, the wind generation in SSA B would never be able to operate at a fixed power factor, since it would always be required to control the 132 kV system voltage at the points of connection. The 132 kV voltage at Legacy is under transformer tap-change control.

It would also be necessary to confirm that the proposed wind farm controllers were capable of ensuring that the generation remained dynamically stable at all times.

Appendix B. Line Losses

Power losses in transmission and distribution lines are mainly caused by the current flowing through them, and is the result of Ohmic heating. These losses are proportional to the circuit resistance (R) and to the square of the current (I^2), and are colloquially referred to as "I squared R" losses. Since the resistance of a circuit is directly proportional to its length, the longer the circuit, the greater the losses. Losses can be reduced by employing a conductor of lower resistance – doubling the cross sectional area of the conductor will halve the losses. Halving the current, however, by operating at twice the voltage, will reduce losses by a factor of four (two squared). So all other things being equal, (loading, conductor size, etc.) a 132 kV circuit will have about nine times the losses of a 400 kV circuit. In fact, it is economic to use larger conductor sizes at the higher voltages, so a somewhat greater reduction in transmission losses can generally achieved at the higher voltages.

Wind generation varies with wind availability, and the 'capacity factor' of a wind farm is the average output it achieves over time, expressed as a percentage of its maximum capability. For the calculation of losses a capacity factor of 35% is assumed to be a realistic estimate of what future wind farms in mid Wales are likely to achieve. However, since losses vary in proportion to the square of the current, assuming a line loading of 35% would actually underestimate the total losses. The appropriate loading to use is the RMS (root mean square) value of the generation output over time, and so a 45% loading has been assumed in the calculations[8].

If it is assumed that the wind farm size matches the summer rating of the circuit, then a 176 MVA 132 kV circuit will have 167.2 MW connected, and a 124 MVA 132 kV circuit will have 117.8 MW connected. Since losses depend on current magnitude, variation in the power factor (ratio of reactive power to apparent power) of the generation also has some influence on the losses. Taking an average over the power factor range specified in the Grid Code, the calculated losses for a 70 km 132 kV line loaded at 45% are about 3.6% of the corresponding wind farm output for the 176 MVA circuit and 3.8% for the 124 MVA circuit.

For a 400 kV circuit of similar length, the transmission losses are considerably lower. First of all, the voltage ratio (about 3:1) means that the losses go down by a factor of 9, but the conductor size is likely to be about four times greater, and it is a double circuit line, which makes the currents lower so the 'squaring' effect is less. Assuming about 335 MW[9] of wind generation connected to the 400 kV hub, the losses on the 400 kV circuit are estimated to be about 0.105% of the wind farm output.

However, the 132 kV connection to Legacy would be to existing 400/132 kV transformers. Therefore I^2R (copper) losses in those transformers would probably be reduced overall because the load current and generation current will subtract from each other. Also the new 400/132 kV transformers at Cefn Coch will introduce additional no load (iron) losses.

8 The RMS loading depends on the shape of the generation-duration curve. For a capacity factor of 35% it can be shown that the RMS loading will be in the range of 35% to 59.1% (i.e. from the extremes of continuous 35% generation, to 100% generation for 35% of the time).

9 This is the amount of generation that could be exported to Legacy from SSA B over two 176 MVA HDWP circuits.

Glossary

AAAC	All Aluminium Alloy Conductor
DNO	Distribution Network Operator
HDWP	Heavy Duty Wood Pole
km	Kilometre
kV	Kilovolt (one thousand volts)
MVA	Megavolt Ampere (one million volt amperes)
MVAr	Megavolt Ampere reactive (one million volt amperes reactive)
MW	Megawatt (one million watts)
PF	Power factor
SOR	Strategic Optioneering Report
SSA	Strategic Search Area
sq mm	Square millimetre
TAN	Technical Advice Note
WPD	Western Power Distribution